Impact of Treadle Pump Irrigation Technology on Smallholder Poverty and Food Security in Malawi: A Case Study of Blantyre and Mchinji Districts

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ABBREVIATIONS AND ACRONYMS

ADMARC	: Agricultural Marketing and Development Corporation
ATC	: Agricultural Trading Company
CADECOM	: Catholic Development Commission in Malawi
DOI	: Department of Irrigation
DP	:Depth of Poverty
EPA	: Extension Planning Area
EU	: European Union
FSP	: Food Security Program
GDP	: Gross Domestic Product
HFCDP	: Horticultural Food Crop Development Project
HI	: Headcount Index
HIPC	: Highly Indebted Poor Countries
LMD	: Lilongwe Mechanical Development
MASAF	: Malawi Social Action Fund
MIRTDC	: Malawi Industrial Research and Technology Development Center
MK	: Malawi Kwacha
NASFAM	: National Smallholder Farmers Association of Malawi
NFI	: Net Farm Income
NGO	: Non-Governmental Organization
PRA	: Participatory Rural Appraisal
PSI	: Poverty Severity Index
RDP	: Rural Development Project
RR	: Relative Risk
US$	: United States Dollar
WFGM	: Whole Farm Gross Margin

ABSTRACT

Malawi has an irrigation potential estimated at 400,000 ha, but currently only 16 percent of the potential has been developed for irrigation. This dismal record of irrigable land development is happening against a background of persistent drought, food shortages and grinding poverty and food insecurity among the smallholder farmers in rural areas.

Currently, the Malawi Government has intensified the use of treadle pumps to increase agricultural production and enrich the livelihoods of resource poor farmers. The treadle pump as a result is gaining popularity among smallholder farmers throughout the country. This study was conducted in two purposively selected districts of Blantyre in the Southern Region and Mchinji in the Central Region of Malawi. A total of 50 treadle pump and 50 non-treadle pump farmers were interviewed in each district to assess the impact of the treadle pump on food security and poverty. Secondary data sources were also used to understand level of adoption; organizations involved in treadle pump distribution and dissemination as well as major suppliers and manufacturers of the treadle pumps.

The results showed that maize, beans, tomatoes, onion and leaf vegetables are the key crops grown using treadle pumps. Economic analysis using gross margin analysis showed that treadle pump adopters had significantly higher Net Farm Incomes (NFI) as well as NFIs/ha for both irrigated and rain-fed than non-adopters. The treadle pump adopters also reported a number of material gains realized during the period of adoption such as food security, building good houses, payment of school fees and graduation from loans from neighbors. The adopters also created employment to fellow villagers and owned livestock, working tools and ox-carts for transportation.

Well-being measurements and analyses of poverty revealed serious poverty levels among non-adopters compared to adopters. The non-adopters also had greater relative risk of falling into deeper poverty than adopters. Transition matrices depicting movement in and out of poverty showed that from 2004 to 2005, some poor adopters moved out of poverty while some non-adopters dropped from being non-poor to being poor. No adopter moved from non-poor to poor.

These analyses demonstrate that the treadle pump is key to generation of income, reduction of poverty and maintenance of food security among smallholder farmers in Malawi. To fully realize this potential, some constraints such as water shortage; relatively high treadle pump price and spare parts; lack of capital for manufacturing of the treadle pumps; and lack of well-organized markets, to the dissemination of the treadle pump need to be resolve.

IMPACT OF TREADLE PUMP IRRIGATION TECHNOLOGY ON SMALLHOLDER POVERTY AND FOOD SECURITY IN MALAWI: A CASE STUDY OF BLANTYRE AND MCHINJI DISTRICTS

INTRODUCTION

Agriculture is the backbone of Malawi's economy, providing livelihoods for 85 percent of the population, contributing 36 percent of the Gross Domestic Product (GDP) and accounting for 90 percent of the foreign exchange earnings (Imani Development, 2004). The country and its people have historically relied on rain-fed agriculture to meet these needs. This strategy has faced many challenges over the years, with the obvious shortfall of food often arising from natural and economic disasters.

Because Malawi has a huge potential for irrigation, irrigated agriculture has great promise to alleviate the food deficit problem. According to government statistics, there are 400,000 hectares of irrigable land in Malawi. In addition, the country is best known for its excellent drainage system, which has one of the most popular lakes and rivers in Africa and the world, namely, Lake Malawi, and the Shire River, respectively. This resource provides Malawi with an excellent opportunity for intensifying irrigation-led agricultural production and diversification. No excuse whatsoever can be made for the persistent drought and dry spells Malawi experiences.

Although the potential of irrigation contribution has long received recognition, its realization remains elusive, because the country has done very little to unleash its potential and prosper socially and economically. Presently, with 40 years of existence as a Republic, out of the national irrigation potential, the country has only developed about 62, 000 hectares of which 48, 000 hectares (12 percent) are under estate and the remainder of 14,000 hectares (4 percent) are under smallholder agriculture i.e. only16 percent of the potential is under irrigation (Maweru, 2004; Mangisoni, 2004). These figures clearly demonstrate a gross underutilization of the country's resources of water, land and labor. The consequences have been obvious, persistent food shortages, poverty and higher prevalence of nutritionally related diseases.

Smallholder micro-irrigation in the form of treadle pumps offers tremendous opportunities to dramatically increase agricultural production while enriching the livelihoods of many resource poor farmers in Malawi. The attractiveness of micro-irrigation to attain smallholder economic empowerment lies in its ability to meet the following criteria: potential to increase participation of the rural poor; firm control and ownership by individual households; socially acceptable among all groups; potential to increase agricultural productivity; high potential for market demand and growth; potential to increase food security, income and wealth; potential for value-adding of products/services under irrigation; opportunities for linkages/leveraged interventions; potential for employment generation; high interest by government, NGOs and the donor community; and technology appropriateness and affordability.

In light of this understanding, the Ministry of Agriculture and Food Security has prioritized irrigation development in Malawi. At policy level, the Ministry developed the National Irrigation Policy and Development Strategy in 2000 and enacted through Parliament an Act on Irrigation Development in 2001. This was done to lay a foundation for guiding Irrigation Development in the country. Of particular importance, the strategy outlines the Government plan of expanding smallholder irrigation agriculture by 100,800 hectares over the next 8 years. This is in line with the Malawi Poverty Reduction Strategy Paper, which is aimed at achieving the overall Government priority objective of reducing poverty and hunger in Malawi. Some of the activities to be implemented under this program include; intensification of the use of treadle pumps; excavation of canals from water bodies to the farmers' fields to improve access to irrigation waters; promotion of motorized pumps; rehabilitation of old irrigation schemes to enable farmers use them to the fullest potential; training of extension workers and farmers to build capacity for effective implementation of programs; and organizing farmers to empower them to make appropriate decisions especially when it comes to marketing of their products and selection of enterprises (Maweru, 2004).

Currently, the Malawi Government has intensified the use of treadle pumps among smallholder farmers in the country. This report is a first attempt to analyze the impact of

the treadle pumps on food security and poverty reduction among the smallholder farmers, using Blantyre and Mchinji districts as case studies.

METHODOLOGY AND SAMPLING DESIGN

The Study Locations[1]

The study was conducted in Mchinji and Blanytre districts of Malawi (Figure 1). However, for administrative convenience, the study was restricted to Extension Planning Areas (EPAs) with the highest concentration of treadle pump farmers in each of the two districts.

Mchinji district is one of the nine districts in the Central Region of Malawi. It has a land area of 3,356 square kilometers (335,600 hectares). It is bordered by Kasungu district in the north, Lilongwe district in the east, Zambia in the West and Mozambique in the South. The district headquarters is located along the main road (M12) connecting Lilongwe and Zambia. The district is some 110 km from Lilongwe City and 10 km from the Zambian border at Mwami.

Mchinji lies between 1,200 and 1,829 meters above sea level. It has two distinct terrains. The hilly western part, consisting of Mchinji mountain ranges, and the gentle slopes, that are 1,600-1,830 meters above sea level. Almost all rivers found in the district originate from the hills. The remaining part, which forms the major portion of the district, lies within a plain of mostly arable land. Wetlands (*dambos*) and waterways drain the plains into Bua, Ludzi and Rusa rivers.

The hilly areas are generally cool and wet. Mean temperatures range from 17^0C to 19^0C per annum. Lowest temperatures are experienced in June while highest temperatures are registered during the months of October and November. In contrast, the plains are generally warm and dry. Mean temperatures vary from 19^0C to 21^0C.

[1] Based on Malawi Government, Mchinji District Socio-economic Profile, Mercia Industries Limited, Blantyre, 2002 and Blantyre Rural Development Project, 2005.

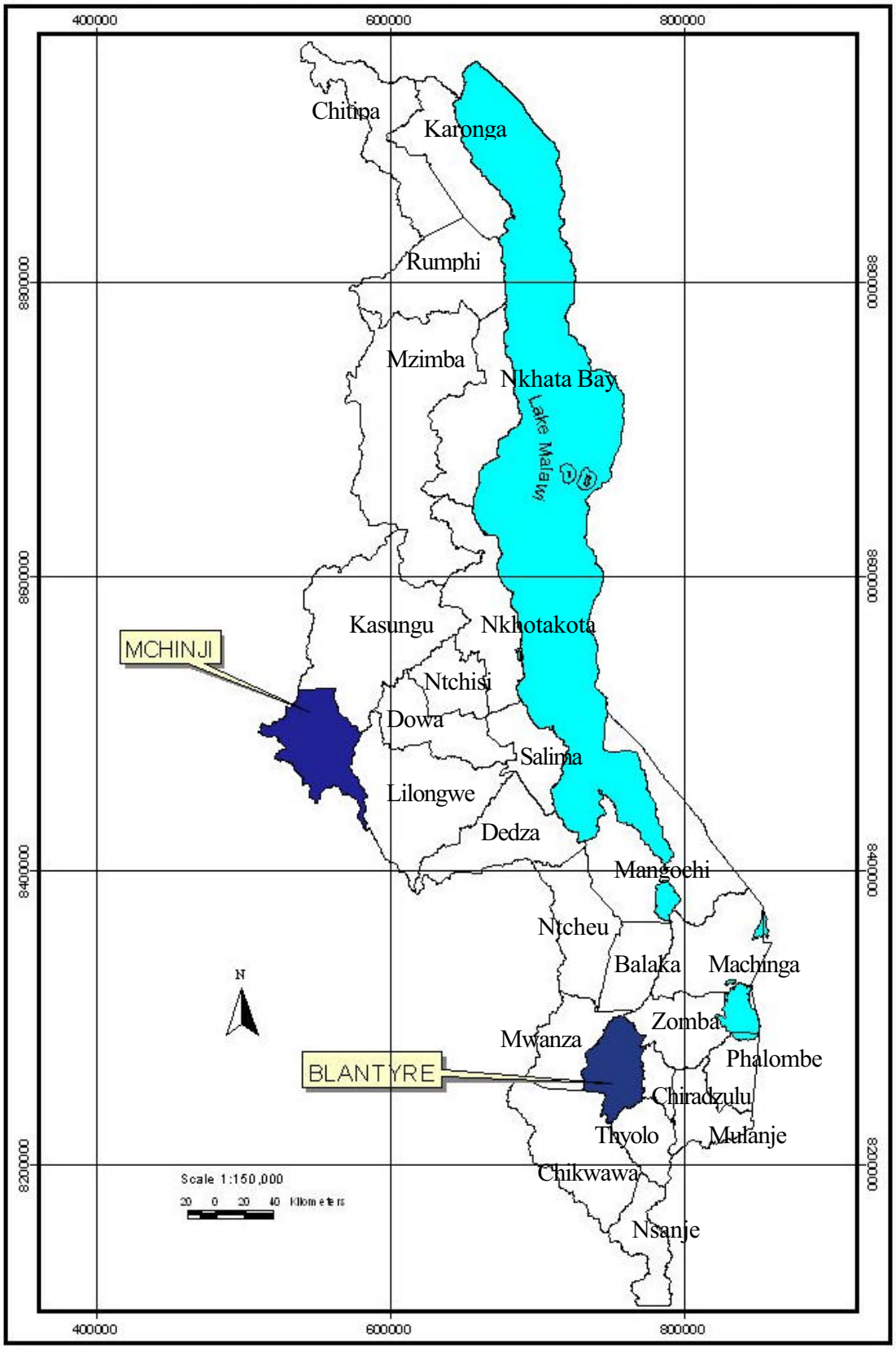

Figure 1: Map of Malawi showing Blantyre and Mchinji districts

Like most districts in Malawi, Mchinji has three seasons. The dry season runs from August to October, the wet/rainy season from November to April and the winter season from May to July. The hilly areas receive an average rainfall of between 1,000 mm and 1,230 mm per annum. The plains receive less rainfall, generally ranging between 800mm to 1,030mm per annum.

The district has been experiencing significant climatic changes over the past 20 years. Rains have been erratic in some years particularly in the northern and eastern parts of the district. With the seasonal droughts, most communities have experienced shortage of water for drinking, livestock and crop production (Malawi Government, 2002).

According to Mchinji Rural Development Project (RDP) (2004), soils in the district are classified as ferallitic and ferruginous but specific soil classes exist within the Extension Planning Areas (EPAs) of the district. There are a total of 116,981 farm families with an average arable farm size per family of 2.2 ha (Mchinji RDP, 2004). The main crops grown in the district include maize (hybrid, local and composite), tobacco (burley, sun air and northern division dark fired), groundnuts (*Chalimbana* and CG7), soybeans, ground beans, common beans, cassava, sweet potatoes, potatoes, sorghum, paprika, cowpeas, pigeon peas, cotton sunflower and leaf vegetables such as mustard, cabbage, tomato and rape. However, only maize, tobacco and groundnuts are considered main crops. In irrigated agriculture, farmers normally grow maize, beans, and vegetables. The most common livestock are chickens, guinea fowls, ducks, goats, sheep, cattle and pigs.

Blantyre is one of the thirteen districts of the Southern Region of Malawi, bordered by Chikwawa in the south, Zomba, Chiradzulu and Thyolo districts in the north and northeast and Mwanza district in the west and northwest. Blantyre district has a population of 590, 664 inhabitants, giving a population of farming families of 92,841. The total land area for Blantyre district is 201,696 ha with an average farm size of less than 1.0 ha. The district is at an altitude of about 800 meters above sea level and has a temperature of cool to hot. The average annual rainfall of the district is 910mm. The most striking physical features of the district are hills, mountains, forests and many rivers and

streams. The soils are of different types. The common ones include clay, loam, sandy loam and gravel or red soils. Smallholder farmers in the district grow a number of annual crops including maize, tobacco, tomatoes, pigeon peas, beans, peas, vegetables, sweet potatoes, okra and rice. The major cash crops in the district are tobacco, cotton, beans, groundnuts and sugar cane. For irrigation agriculture using treadle pumps or watering cans, smallholder farmers grow crops such as maize, cabbages, rape, carrots, onions, tomatoes, okra, egg plants, mustard and local vegetables.

Sampling Design

A household, for purposes of this study, was defined as a group of individuals living under the same roof. By this definition therefore a household comprised the household head, his/her spouse, children, nephews, nieces and other dependants living within the same house. All households interviewed had gardens but some of them had more than one garden. A garden is a piece of land on which production activities are or can be carried out.

Stratified random sampling procedure was used in this study in order to obtain unbiased, efficient and consistent estimates of the target population. It was also cheaper and easier in terms of administration and transportation to deal with administrative districts, which are also used by the Ministry of Agriculture for its activities. Thus, during the study period, two districts of Blantyre in the southern region and Mchinji in the central region were first purposively sampled. Second, EPAs with the largest number of treadle pump farmers were purposively selected. Third, the population of each of the selected EPAs in each district was stratified according treadle pump and non-treadle pump farmers based on the sampling frames provided by the respective EPAs. Having stratified the population a random sample of 50 households was drawn from the treadle pump stratum of each district giving a total of 100 treadle pump farmers interviewed for the study. Similarly, a sample of 50 non-treadle pump farmers was drawn from each district giving a total of 100 non-treadle pump farmers. The sample sizes of treadle pump and non-treadle pump farmers to be interviewed in the entire survey were based on the maximum number of farmers the budget was able to support. Since the main objective of the study was to

assess the poverty and food security impacts and the costs and benefits of treadle pumps as one of the most promising water management technologies in Malawi and the non-treadle pump farmers were only used for comparison, the proportion of treadle pump farmers was purposely over represented to allow for meaningful statistical analyses. The sample of treadle pump farmers was chosen from a total of 1,272 and 2,888 adopters while that of non-treadle pump farmers was similarly chosen from 91,569 and 114,093 non-adopters from Blantyre and Mchinji districts, respectively.

Data collection was done with the help of enumerators. The enumerators were trained for a period of one week preceding the survey on techniques of administering a questionnaire for collecting socio-economic data. The enumerators were later exposed to a prepared questionnaire, which the enumerators extensively practiced before administering it to farmers. This was done to ensure that all the enumerators administered the same questions to the farmers to minimize enumerator bias.

After the training, the questionnaire was taken to the field for pre-testing for three days. Emphasis during pre-testing was placed on detection of ambiguities in the wording of the questions as well as on assimilation of additional answers for coded questions.

Completed questionnaires were taken to base (Bunda College) for preliminary analysis and elimination of ambiguities. Corrections were incorporated in the final questionnaire, which was later used in collecting socio-economic data during the main treadle pump smallholder farmer farm survey in Blantyre and Mchinji districts.

Data Collection

Both primary and secondary sources of data were used in this study. The secondary sources focused on information regarding the treadle pump technology such as first year of adoption, number of treadle pumps distributed annually differentiated by the type of suppliers, list of institutions/organizations engaged in treadle pump marketing and dissemination, number of beneficiaries/adopters and types of crops grown under treadle pump technology. In the primary source, a survey was conducted involving collection of

socio-economic and related data through direct measurements, observations, formal and informal interviews, from smallholder treadle pump and non-treadle pump farmers and from advisory officers in the Mchinji and Blantyre districts using a pre-tested questionnaire for a period of one month.

The selected smallholder treadle pump and non-treadle pump farmers were asked questions on crops grown under treadle pump irrigation and rain-fed conditions; number of harvests under treadle pump technology, output levels, family annual food availability, purchases and payments, sales and receipts, payments of hired labor in cash or kind, year of adoption of treadle pump technology, land tenure, area of land allocated to treadle pump irrigation, farm land allocated to various upland/rain-fed crops, agricultural extension, access to services, marketing and production problems faced.

Furthermore background data on family size, age distribution, gender, level of formal education, and marital status of the respondents were sought from the households.

During interviews, yields of selected major crops (maize, tobacco, groundnuts and sweet potatoes) were recorded in local units of measurement, for example oxcarts for maize and sweet potatoes and 90 kg bags for unshelled groundnuts as given by the households. Shelled groundnuts and tobacco yields were recorded in kilograms sold to the market. For the local units of measurement, conversion factors were used to convert the yield into kilograms (Nankumba, 1988).

The conversion factors were based on average oxcarts for maize and sweet potatoes and the weight of shelled groundnuts generated from a known weight of unshelled groundnuts. Yields of minor crops plus their share of the total cultivated land were ignored from the analysis mainly because these were consumed progressively straight from the field. Besides it was difficult to establish the amount consumed per day by the households and further probing was therefore only going to encourage wild guesses from the farmers. Minor crops included cassava, pumpkins, soybeans and pepper and these were mostly grown in association with the major crops used in the analysis. Although this

tends to underestimate the benefits, it does not affect the comparison between adopters and non-adopters because the exclusion of minor crops was done to both categories of farmers.

Labor availability to both treadle pump and non-treadle pump farmers was estimated by determining gender, age category and availability (whether permanent resident, permanent resident in local employment, permanent resident in full education, polygamist spending part of time in other households or resident hired labor) of each household member. Having established this, conversion rates by age category were employed to estimate labor availability to the households in man-equivalents (Mangisoni, 1999; Nothale, 1980). A figure for mean labor availability per household was calculated for each category and compared using Student's t-test. Because of financial and time constraints, no attempt was made to estimate labor demand for the various crops.

Annual food requirement (mostly maize) was obtained from work done by other researchers. This annual food requirement is based on age as follows: adult person from the ages of 10 to 60 years requires 0.8 kg of maize equivalents per day. Those below 10 years and above 60 years of age are assumed to be 0.5 adult equivalents for consumption requirements because they are agriculturally inactive. On average this translates into 270 kg of maize equivalents per adult per year (Chiligo-Mpoma, *et al*., 1990). This information was used for well-being analysis of the two categories of farmers in the two districts. The well-being measurements were estimated using two measures of poverty and transition matrices, calculated on the basis of a constructed definition of poor and non-poor people in each category of farmers and information provided by the farmers themselves. We also estimated actual per capita consumption for each household, with appropriate adjustments for different household sizes and different requirements for individuals within households.

We set a per capita consumption poverty line at 270 kg of maize equivalents. Computed actual per capita consumption of each household was compared to the poverty line. Households with per capita consumption above 270 kg of maize were considered non-

poor while those below the per capita consumption line were taken to be poor. Using the poverty line and the actual consumption of the households, three poverty indices: poverty or head count index, poverty gap index and poverty severity indices were computed. An estimate of movement in and out of poverty was estimated using transition matrices and food consumption profiles of 2004 and 2005.

Analytical Methodology

Profitability of the farms was estimated using Net Farm Income (NFI). The computation of the NFI starts from calculation of Gross Margins per crop computed as Gross Income minus Variable Costs. The Gross Margins per crop are later summed up to give Whole Farm Gross Margin (WFGM). Subtracting Fixed Costs of assets from WFGM gives NFI. Thus,

NFI = WFGM – FIXED COSTS

The major fixed cost was depreciation of assets such as treadle pumps and water can. Straight line depreciation method was used to calculate the depreciation. Straight line depreciation is simply the estimated total loss of value of the asset divided by its useful life on the farm. The depreciation is written off in equal annual installments. Straight line depreciation is calculated as follows:

$$Annual Depreciation = \frac{Original\ cost\ of\ item - Salvage(Scrap)\ value}{Expected Life\ of\ item}.$$

It was assumed that the expected life of a treadle pump is five years while that of a water can is 2 years.

The NFIs were computed separately for adopters and non-adopters and for each farm as follows: upland crops NFIs, irrigated crop NFI and combined upland and irrigated NFIs. Mean NFIs were then computed for each category of farmer and each type of farming

and were compared using Student t-statistic. This statistic was computed using the following formula:

$$t ? \frac{meanx_1 ? meanx_2}{\sqrt{\frac{?_1^2}{n_1} ? \frac{?_2^2}{n_2}}},$$

where t is the t-statistic used to compare two means, n_1 and n_2 are the number of elements and the squared sigmas are the variances for categories 1 and 2, respectively.

Well-being measurements of headcount index, depth of poverty and poverty severity index were used to assess poverty. Headcount index is the share of the population, which does not reach a given threshold, which was defined as 270 kg of maize equivalents per capita. Headcount index (HI) was computed as follows:

$$HI ? \frac{q}{N},$$

where q is the number of farmers below the 270 kg of maize equivalents per capita poverty line; and N is the number of all farmers in the category being analyzed.

Depth of poverty (DP) or poverty gap gives information on how far off a farmer is from the poverty line. This was computed as the average distance between population and the poverty line taking the distance of non-poor farmers to be zero. The following formula was used to calculate DP:

$$DP ? \frac{? \sum_{i?1}^{np_1} (PL ? PP)}{np ? nnp}$$

where np is number of poor farmers; nnp is the number of non-poor farmers; PL is consumption poverty line; and PP is the per capita consumption of poor people.

The poverty severity index (PSI) is used to add value to the above two indices. This index put more weight on individuals further from the poverty line to demonstrate the extent of

extremely low levels of consumption in a population or inequality among the poor. PSI is the average squared consumption shortfall of the population as a proportion of the poverty line. The PSI was calculated as

$$PSI = \frac{1}{n}\sum_{i=1}^{q}\left[\frac{y_i - Z}{Z}\right]^2$$

where n is total number of farmers in category; q is the number of poor farmers; y_i is the quantity of maize equivalents consumed by the ith farmer; and Z is the consumption poverty line.

To strengthen the three indices above, relative risk of poverty and transition matrices were calculated. Relative Risk (RR) is the probability that members of a group will be poor in comparison with the probability of poverty for non-members of the group. RR is calculated by looking at the headcount index and the share of all poor in the group and these are compared with other groups as follows:

$$RR = \frac{1 - Headcount\ of\ target\ group / Headcount\ of\ Reference\ group}{Headcount\ of\ Reference\ group}$$

Movement in and out poverty helps to identify whether individuals in a group are getting better off or worse off. Calculation of the transition matrix entails having two profiles of the target population. During each profile, proportions of individuals above and below the poverty line are computed. Comparisons are then made between the two profiles to see if there are some individuals who were poor in the first profile but emerged as non-poor in the second profile and vice versa. An individual whose status has not changed is also noted.

RESULTS AND DISCUSSION

Socio-economic and Demographic Characteristics of Treadle Pump and Non-Treadle Pump Adopters

Marital status of the respondents

The average age of the household head in Blantyre district was 35.7 years while that of Mchinji district was 41.8 years. Although, Blantyre district farmers tended to be younger than Mchinji district farmers, the difference in age was not significant at the 1 percent level. The majority of the adopters and non-adopters were married. Some polygamists were present in Mchinji among both adopters and non-adopters but in Blantyre the polygamists were only present among the non-adopters. Singles, widowed, divorced and separated individuals were less common in the districts. There were no significant differences between adopters and non-adopters on marital status at the 1 percent level of significance (Table 1).

Table 1. Marital status of adopters and non-adopters in Blantyre and Mchinji districts, 2005

Status	Blantyre			Mchinji			Total		
	Adopter (%)	Non-adopter (%)	*P-value	Adopter (%)	Non-adopter (%)	*P-value	Adopter (%)	Non-adopter (%)	*P-value
Single	8.2	12.0	0.2643	4.9	0.0	0.0475	6.7	6.0	0.4168
Married	79.6	86.0	0.1977	87.8	74.0	0.0418	83.3	80.0	0.2709
Polygamist	2.0	0.0	0.1587	4.9	10.0	0.0329	3.3	5.0	0.2709
Widowed	6.1	0.0	0.0367	2.4	10.0	0.0630	4.4	5.0	0.4207
Divorced	4.1	2.0	0.2676	0.0	4.0	0.0838	2.2	3.0	0.3632
Separated	0.0	0.0	0.5000	0.0	2.0	0.1711	0.0	1.0	0.1587
Total	100.0	100.0		100.0	100.0		100.0	100.0	
N	49	50		41	50		90	100	

*If p-value is less than 1 percent, reject the null hypothesis (Edriss, 2003).

Education of respondents

In both Blantyre and Mchinji districts, the majority of the respondents in both the adopter and the non-adopter categories were able to read and write in the local language, *Chichewa* (Table 2). There were no significant differences at the 1 percent level between adopters and non-adopters on ability to read and write. This shows that the respondents

were able to read agricultural information materials, which would help them advance their farm activities.

Table 2. Distribution of adopters and non-adopters by ability to read and write *Chichewa* in Blantyre and Mchinji districts, 2005

Reading and writing ability	Blantyre		Mchinji		Total	
	Adopters (%)	Non-adopters (%)	Adopter (%)	Non-adopter (%)	Adopter (%)	Non-adopter (%)
Can read and write	85.7	76.0	75.6	68.0	81.1	72.0
Can not read and write	14.3	24.0	24.4	32.0	18.9	28.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
N	49	50	41	50	90	100

Blantyre district: Not significant at 1 percent: $?^2_{0.01,1 calculated}=1.50 < ?^2_{0.01,1 tabulated}$? 6.63

Mchinji district: Not significant at 1 percent: $?^2_{0.01,1 calculated}=0.6367 < ?^2_{0.01,1 tabulated}$? 6.63

Both districts: Not significant at 1 percent: $?^2_{0.01,1 calculated}=2.18 < ?^2_{0.01,1 tabulated}$? 6.63

Table 3 presents the level of formal education of the literate individuals. Most of the respondents had a primary school education and very few went as far as secondary school and above. At each level of education, there is very little difference between the adopters and non-adopters in both districts. The only relatively large difference between the two categories is with regard to none or no formal education. There were more non-adopters than adopters who had no formal education. However, the difference was not statistically significant at the 1 percent level (Table 3). Some of the non-adopters and adopters obtained reading and writing skills (literacy) through informal education avenues such as adult literacy, home craft courses, and farmer training.

Table 3. Distribution of adopters and non-adopters by level of formal education in Blantyre and Mchinji districts, 2005.

Level of formal education	Blantyre			Mchinji			Total		
	Adopter (%)	Non-adopter (%)	*P-value	Adopter (%)	Non-adopter (%)	*P-value	Adopter (%)	Non-adopter (%)	*P-value
None	6.5	20.0	0.0256	11.4	19.1	0.1711	8.6	19.6	0.0139
Standard 1-5	23.9	26.0	0.4013	40.0	36.2	0.3632	30.9	30.9	0.5000
Standard 6-8	34.8	26.0	0.1711	34.3	34.0	0.4880	34.6	29.9	0.2358
Form 1-2	23.9	12.0	0.061	5.7	4.3	0.3859	16.0	8.2	0.0436
Form 3-4	10.9	14.0	0.4443	5.7	6.4	0.4483	8.6	10.3	0.4880
High school and above	0.0	2.0	0.1587	2.9	0.0	0.1170	1.2	1.0	0.4681
Total	100.0	100.0		100.0	100.0		100.0	100.0	
N	46	50		35	47		81	97	

*If p-value is less than 1 percent, reject the null hypothesis (Edriss, 2003).

Land and labor availability

Information on farm sizes and labor availability was obtained from the households themselves. Better estimates of farm sizes are obtained when physical measurements are made on the farms. The average farm size for adopters in Blantyre was 4.04 ha while that of non-adopters was 3.8 ha. In Mchinji district, the respective averages were 4.53 ha and 3.30 ha. Only Mchinji mean farm sizes between the two farmer categories were significantly different (Table 4). For labor availability to households per day, there were no significant differences between the two farmer categories in Blantyre (Table 4). The results show that in Blantyre district, land and labor availabilities were not significant in explaining adoption of the treadle pump. It appears therefore that unavailability of treadle pumps (due to supply and financial constraints) in the district constrained non-adopters from adopting the treadle pump technology. Discussions with field agricultural officers in Blantyre also showed that most non-adopters are interested in adopting the treadle pump technology but availability of the pumps is the main constraint. According to the field officers, this is so because of five reasons. First, most smallholder farmers cannot afford to buy the treadle pumps on cash basis and there are very few donors who are supporting smallholder farmers. The farmers are only expressing a desire to own treadle pumps but

they do not have the money. Such farmers are looking for donor support. Second, manufacturers are basically responding to effective demand, which is backed by purchasing power. Third, the treadle pumps are imported because the local manufacturers have limited capital for procurement of treadle pump parts. Fourth, the distributors including Malawi Government are faced with transportation bottlenecks for efficient delivery of the pumps. Fifth, the overall economy of Malawi is too weak to effectively subsidize the price of the treadle pumps to meet local demand.

In Mchinji district, although the treadle pump adopters were employing other villagers, the adopters did not have more labor available than non-adopters. Because the amount of land recommended for a treadle pump is 0.3ha (with the majority of the farmers using treadle pumps on 0.1 ha) and most of the irrigation is done in the winter (May to July) and dry (August to October) seasons when very little work is needed in the uplands, the non-adopters should have more labor available for utilization of the treadle pump for irrigation. Again field agricultural personnel in Mchinji district indicate that most non-adopters are interested in the treadle pump technology but they are constrained by prohibitive treadle pump cost and water shortage. The field agricultural officers are therefore advocating water harvesting and other water management practices to raise water tables in shallow wells for irrigation.

Table 4. Average land and labor availability to adopters and non-adopters in Blantyre and Mchinji districts, 2005

Variable	Blantyre		Mchinji		Total	
	Adopter	**Non-adopter**	**Adopter**	**Non-adopter**	**Adopter**	**Non-adopter**
Available land (ha)	4.08 (t-value=0.47)	3.80	4.53*** (t-value=2.18)	3.30	4.25** (t-value=1.68)	3.55
Available labor per household per day (man-days)	1.98 (t-value=0.98)	1.99	2.74 (t-value=0.45)	2.79	2.35 (t-value=0.61)	2.39

*** =significant at 0.01; ** = significant at 0.05, * significant at 0.1.

Number of plots per household

The farms on which agricultural activities are carried out are often fragmented. This fragmentation arises because soil fertility is not uniform and there is a desire by every villager to at least have a *dambo* land for irrigation activities. This however, is not fully achieved.

Because of increasing population pressure, the level of fragmentation has increased as some households have given some of their fragments to daughters and sons. Table 5 shows that nearly 60 percent of all the non-treadle pump households and 42 percent of the treadle pump households had 1 to 2 plots and nearly 93 percent of all the non-treadle pump households and 92 percent of the treadle pump households had 1 to 4 plots. Very few households in both farmer categories had more than 5 plots. These results show that although land is getting scarce, smallholders in Blantyre and Mchinji districts have several plots in different locations for their agricultural production activities.

Table 5. Number of plots per household in Blantyre and Mchinji districts, 2005

Number	Blantyre			Mchinji			Total		
	Adopter (%)	Non-adopter (%)	*P-value	Adopter (%)	Non-adopter (%)	*P-value	Adopter (%)	Non-adopter (%)	*P-value
1-2	38.3	56.1	0.0559	45.2	64.0	0.0233	41.5	60.4	0.0035
3-4	51.1	31.7	0.0392	50.0	34.0	0.0516	50.6	33.0	0.0062
5-6	8.5	12.2	0.2912	2.4	0.0	0.1271	5.6	5.5	0.4880
>6	2.1	0.0	0.1711	2.4	2.0	0.4443	2.2	1.1	0.2709
Total	100.0	100.0		100.0	100.0		100.0	100.0	
N	47	41		42	50		89	91	

*If p-value is less than 1 percent, reject the null hypothesis (Edriss, 2003).

The History of Treadle Pump Technology Dissemination in Malawi

The farming calendar in Malawi runs from July of one year to June of the following year.

Gunnar Barnes, a Norwegian engineer, was the first person to developed treadle pumps in 1981. Actual use started in 1984 in Bangladesh but the treadle pump was first introduced

in Malawi in 1994. The number of pumps distributed from 1994 to date throughout Malawi is presented in Table 6.

Table 6. Number of treadle pumps distributed to smallholder farmers in Malawi, 1994-2005

Year	Number of treadle pumps distributed
1994-2001	4,000
2002	30,000
2003	Not available
2004	Not available
2005	29,672
Total	63,672

Source: Department of Irrigation, 2005

The table shows a modest start in the period 1994 to 2001, with a dramatic rise in 2002 to 30,000 pumps distributed. Data for 2003 and 2004 is not available in the Department of Irrigation but available data shows that in 2005 also close to 30,000 pumps were distributed to smallholder farmers throughout the country.

In Blantyre district, smallholder farmers started using treadle pumps in the 1998/1999 season. At that time, the Malawi Government supplied a total of 17 Ajay treadle pumps to 17 smallholder farmers. Each farmer paid MK2,000 (US$16.39) per treadle pump on cash basis (US$1 = MK122). The price, supplier and manufacturer remained the same till 2001/2002. In 2002/2003, the Malawi Government distributed 908 Ajay treadle pumps to 908 smallholder farmers but the price was increased to MK9,000 (US$73.77). To allow farmers afford the pumps, the Malawi Government introduced a loan scheme under which the farmers were allowed to repay the loan in three installments over a period of 3 years. The price of MK9,000 (US$73.77) per pump and the three year installment arrangement continued till 2004/2005 season. The number of farmers increased to 1,133 and 1,272 in 2003/2004 and 2004/2005, respectively (Table 7).

Table 7. History of treadle pump technology in Blantyre district, 2005

Year	Number of treadle pumps	Number of adopters	Cost of pump (MK)*	Cost of pump (US$)	Mode of payment	Supplier	Manufacturer
1998/1999	17	17	2,000	16.39	Cash	Government	Ajay
1999/2000	108	108	2,000	16.39	Cash	Government	Ajay
2000/2001	243	243	2,000	16.39	Cash	Government	Ajay
2001/2002	318	318	2,000	16.39	Cash	Government	Ajay
2002/2003	908	908	9,000	73.77	3 year installment	Government	Ajay
2003/2004	1,133	1,133	9,000	73.77	3 year installment	Government	Ajay
2004/2005	1,272	1,272	9,000	73.77	3 year installment	Government	Ajay

Source: Blantyre Rural Development Project, 2005

*US$1.00 = MK122.00, MK = Malawi Kwacha.

Malawi Government officials indicated that treadle pumps were first introduced in Mchinji district in the 1998/99 growing season. At that time the Malawi Government, through the Ministry of Agriculture, introduced the treadle pumps to farmers at an introductory demonstration price of MK2,100 (US$17.21). This was basically to attract many farmers to adopt the technology. The price was maintained at this level for three growing seasons till 2000/2001. The total number of treadle pump farmers was 34 and these grew crops on a total land area of two hectares using 11 Advaith treadle pumps manufactured by Delt-Tech Engineering Company. In 1999/2000 season, a total of 12 Advaith treadle pumps was distributed through the Horticultural Food Crop Development Project (HFCDP) to 50 farmers working on 3 hectares of land (Table 8).

In 2000/2001 season, the price of the treadle pumps rose to MK5,000 (US$40.98) but realizing that this would affect food security of households, the Malawi Government intervened by slashing the price back to MK2,100. Government contracted ADMARC

and NASFAM to sell the subsidized treadle pumps to smallholder farmers. The subsidized prices operated till 2001/2002 season. Because they were not making profits, both ADMARC and NASFAM stopped selling the treadle pumps to farmers. As a result the price of the treadle pumps rose back to MK5,000 or US$40.98 (Table 8). This led to a reduction in the uptake of treadle pumps by farmers and this move had a serious negative impact on food security. Because of the adverse impact on food security, the Malawi Government introduced a treadle pump loan scheme to allow smallholder farmers access the treadle pump technology.

In the 2000/2001 season, Government supplied 139 treadle pumps from Delt-Tech Engineering Company to 123 farmers. The farmers had a combined total farm area of 61 hectares. Later in 2001/2002 Concern World Wide distributed 191 treadle pumps to 149 farmers working on a total land area of 54 hectares (Table 8).

The introduction of the Highly Indebted Poor Countries (HIPC) funding assisted in the uptake of treadle pumps in that farmers were offered small starter packs comprising maize seed, vegetable seeds and fertilizers together with a treadle pump. The 1 kg maize seed was enough for 0.1 ha and the vegetable seeds were enough for an area of 36 square meters. Treadle pumps are designed to irrigate a maximum of 0.3 ha (Table 8).

From 2002/2003 to 2003/2004, more and more farmers adopted the treadle pump irrigation technology and the food security situation in Mchinji district started improving.
In 2002/2003, a total of 525 treadle pumps from Delt-Tech Engineering Company were distributed to 525 farmers with a combined farm area of 155 ha. The breakdown of the supplied treadle pumps was as follow: 20 came from the Malawi Government, 205 from EU-Public Works Program, 16 from Concern World Wide Food Security Program and 255 from World Vision Malawi. There was a further increase of the number of farmers receiving treadle pumps in 2003/2004. A total of 1,495 Delt-Tech Engineering Company treadle pumps was supplied to 1,495 farmers. The treadle pumps were used on a total farm area of 258ha. The breakdown of the total number of the treadle pumps was as

follows: 1,165 came from Malawi Government HIPC loan scheme, 282 from EU-Public Works Program and 48 from the Malawi Red Cross Food Security Program (Table 8).

Prior to the introduction of the treadle pumps, most farmers in Mchinji finished their maize produce by November of every year, leaving them with no maize for close to 5 months. With the introduction of the treadle pump irrigation technology, close to 15 percent of the farmers had maize to last to the next harvest season. Non-governmental Organizations (NGOs) such as World Vision Malawi, and Concern World Wide were fully involved in the irrigation program during this period of disseminating treadle pumps to farmers.

From 2003 to date, the price of a treadle pump has been maintained at MK7, 000 (US$57.38) on cash basis and MK9, 000 (US$73.77) on loan basis.

In 2004/2005, there was consolidation of the loan scheme on treadle pumps. This allowed many farmers to engage in treadle pump irrigation and consequently food security situation in Mchinji district was much better than in previous seasons. In this season, a total of 512 Advaith Delt-Tech Engineering Company treadle pumps were distributed to 512 farmers growing irrigated crops on 120 ha. The breakdown was as follows: twenty treadle pumps were supplied by MASAF, 80 by the HFCDP, 92 by Malawi Government Free Distribution Food Security Program and 320 treadle pumps by the Malawi Government Loan scheme (Table 8).

In 2005/2006 a total of 718 treadle pumps will be distributed under the Government Free Distribution Food Security Program. These pumps were already distributed through Members of Parliament to constituencies from October, 2005. The total number of farmers is not yet established because they were distributed to constituencies (Table 8).

Table 8. History of treadle pump distribution in Mchinji District, 2005

Year	Number of Treadle pumps	Number of adopters in year	New area in ha under irrigation in year	Supplier of treadle pump
1998/1999	11	34	2	Malawi Government
1999/2000	12	50	3	Malawi Government
2000/2001	139	123	61	Malawi Government
2001/2002	191	149	54	Malawi Government
2002/2003	525	525	155	20 Malawi Government FSP; 205 EU-Public Works Program; 16 Concern World Wide FSP; 255 World Vision Malawi
2003/2004	1495	1495	258	1165 Malawi Government HIPC Loan Scheme; 282 EU-Public Works Program; 48 Malawi Red Cross Food Security Program
2004/2005	512	512	120	20 MASAF; 80 HCDP, 92 Malawi Government Free Food Security Program, 320 Malawi Government Loan Scheme
2005/2006	718	Not available	Not available	Free treadle pump from Government Food Security to Constituencies through Members of Parliament

Source: Mchinji Rural Development Project, 2005

In 2004/2005, inadequate rains were received in Mchinji district, which led to low water tables and consequently low water levels in rivers and shallow wells. Production of the irrigated crops especially of maize and potatoes is expected to be lower in 2005/2006 than in the previous year. Because of this experience, the Department of Irrigation is putting emphasis on change in cropping patterns and water harvesting. On cropping patterns, the Department is advising farmers to start growing irrigated crops as early as April/May so that last harvesting takes place by October. This would allow farmers at

least have two harvests of irrigated crops every year. On water harvesting, the Department is placing emphasis on construction of earth dams, excavation of shallow wells, proper land husbandry practices and soil conservation measures. These are expected to raise water tables and allow farmers generate the required minimum of two irrigation harvests per season.

Because of the prohibitive cost of the treadle pump, availability of the pumps, labor and water shortage, no one ever gets more than two treadle pumps. Water shortage is the most serious constraint because around October of every year, water recedes and it becomes extremely difficult to pump it when the water table is low. Furthermore, for each treadle pump, a minimum of three people is required so that two people do the pumping and the third person directs the water to the crop field. To acquire two or more treadle pumps would entail more labor demand and supervision becomes a problem.

There are some farmers with larger farms (estates) that use motorized pumps in both Mchinji and Blantyre districts. However, Kadyampakeni *et al*. (2005) reported from a study conducted in Chingale Area Development Program of Southern Malawi that motorized pumps give negative gross margins compared to treadle pumps on smallholder farms. This was so because to be cost-effective, motorized pumps should be used on large farms of 5 ha or more. Motorized pumps need fuel, which is extremely expensive in Malawi. The introduction of the treadle pumps was actually to solve the fuel cost problem. It may be possible to use motorized pumps if a number of smallholder farmers came together to acquire one motorized pump and grow high value crops such as strawberries.

There are seemingly differences in price policies in the two districts because of political interference, differences in distance from suppliers, and differences in availability of projects with different arrangements on use and repayment of treadle pump loan. Mangisoni (2004) also observed that there is lack of collaboration among the different players involved in treadle pumps with farmers, each with different terms of sale. This has created variations in prices on the market.

During interviews with farmers, the adopters also noted that there are huge variations in the prices farmers paid for the treadle pumps. This is because of the different suppliers and the different terms of purchase. In the past, treadle pumps were sold at subsidized government prices through ADMARC and NASFAM. In other years such as 2005/2006, Malawi Government embarked on free distribution of treadle pumps to smallholder farmers through members of Parliament. Some suppliers offer treadle pumps on cash basis while others provide the pumps on loan. All these variation induce variations in the unit price of a treadle pump as visualized by smallholder farmers. This picture on the adopters' side is portrayed in Table 9.

Table 9. Distribution of smallholder treadle pump adopters by price paid for a treadle pump in Blantyre and Mchinji districts, 2005

Price (MK/pump)	Blantyre (%)	Mchinji (%)	Total (%)
< 1,000 (<US$8.20)	10.4	20.0	14.5
1, 000 to 3,000 (US$8.20 to 24.59)	33.3	8.6	22.9
3,001 to 5,000 (US$24.60 to 40.98)	6.3	2.9	4.8
5,001 to 7,000 (US$40.99 to 57.38)	0.0	2.9	1.2
7,001 to 9,000 (US$57.39 to 73.77)	47.9	45.7	47.0
Greater than 9,000 (Greater than US$ 73.77)	2.1	20.0	9.6
Total	100.0	100.0	100.0
N	48	35	83

The Table reveals that the majority of the smallholder farmers (about 90% for both Blantyre and Mchinji districts) paid a price of MK9,000 (US$73.77) per pump or less. This is because the main source of the pumps to the farmers is the Ministry of Agriculture and NGOs who provide the pumps to the farmers at reduced prices either on loan or cash basis. The adopters who paid more than MK9,000 (US$73.77) obtained them on loan from organizations such as the Malawi Rural Finance Company (Table 10).

Mode of Payment

The adopters paid for the treadle pumps through three ways: cash, loan and gift (free) from the Malawi Government or NGO. Table 10 shows that the majority of the adopters obtained the treadle pumps through loans. More farmers in Mchinji than in Blantyre obtained the treadle pumps free of charge and on loan while the opposite is true for cash payment. This difference is explained by the availability of NGOs involved in treadle pump distribution in Mchinji district. The results also demonstrate the importance of loan schemes for the speedy adoption of treadle pump technologies.

Table 10. Distribution of treadle pump adopters by mode of payment for treadle pump in Blantyre and Mchinji districts, 2005

Mode of payment	Blantyre (%)	Mchinji (%)	Total (%)
Cash	45.8	12.2	30.3
Loan	47.9	63.4	55.1
Free of charge	6.3	24.4	14.6
Total	100.0	100.0	100.0
N	48	41	89

For the farmers who paid for the treadle pumps on cash basis, the major source of money for the transaction was sale of rain-fed crops. Treadle pump generated cash and sale of livestock were more important in Mchinji district than in Blantyre district (Table 11). These results demonstrate that upland crop production; treadle pump irrigation and livestock financially empower farmers to own assets such as treadle pumps.

Table 11. Distribution of adopters by source of money used to purchase treadle pump on cash basis in Blantyre and Mchinji districts, 2005

Source of cash	Blantyre (%)	Mchinji (%)	Total (%)
Sale of upland crops	100.0	100.0	100.0
Treadle pump generated cash	4.5	40.0	11.1
Sale of livestock	0.0	40.0	7.4
Employment	13.6	20.0	14.8
N	22	5	27

The majority of the smallholder farmers, who received loans to purchase the treadle pumps, were able to payback the loan in three years or less, with Blantyre district recording 100 percent repayment in three year time period (Table 12). This shows that the treadle pump was more profitable to Blantyre farmers than to Mchinji farmers probably because of their proximity to the more lucrative Blantyre/Limbe market and their concentration on high value crops such as horticultural products.

Table 12. Distribution of adopters of treadle pump technology by period of loan repayment in Blantyre and Mchinji districts, 2005

Loan repayment period	Blantyre (%)	Mchinji (%)	Total (%)
Less than one year	0.0	38.5	20.4
One to three years	100.0	34.6	65.3
Four to six years	0.0	23.1	12.2
More than six years	0.0	3.8	2.0
Total	100.0	100.0	100.0
N	23	26	49

The interest rate charged on the loan was mostly up to 20 percent, with more adopters in Blantyre than in Mchinji district exposed to such interest rates (Table 13). About 14

percent of all the adopters reported exorbitant interest rates of greater than 30 percent. The adopters who reported interest rates of up to 20 percent received the loans from the European Union supported projects or from the Malawi Government through its proxies such as ADMARC while those reporting exorbitant interest rates received the loans from private companies such as the Malawi Rural Finance Company. About 31 percent of the adopters in Mchinji did not pay interest on the loan amount. These are likely to be farmers who got money from relatives.

Table 13. Distribution of adopters by interest charged on treadle pump loan in Blantyre and Mchinji districts, 2005

Interest rate (%)	Blantyre (%)	Mchinji (%)	Total (%)
Less than 10 percent	60.0	7.7	35.7
10 to 20 percent	6.7	38.5	21.4
21 to 30 percent	20.0	7.7	14.3
31 to 40 percent	6.7	7.7	7.1
Greater than 40 percent	6.7	7.7	7.1
None	0.0	30.8	14.3
Total	100.0	100.0	100.0
N	15	13	28

First Year of Adoption of Treadle Pump

The adopters of treadle pumps were asked to indicate the year they first adopted the treadle pump technology. Table 14 shows the distribution of the adopters in Blantyre and Mchinji districts by first year of adoption.

Table 14. Distribution of adopters in Blantyre and Mchinji districts by year of adoption of irrigation technology, 2005

Year	Blantyre (%)	Mchinji (%)	Total (%)
2005	0.0	22.2	10.5
2004	2.0	31.1	15.8
2003	20.0	20.0	20.0
2002	44.0	26.7	35.8
Earlier than 2002	34.0	0.0	17.9
Total	100.0	100.0	100.0
N	50	45	95

The results show that 78 percent of the interviewees in Blantyre adopted the treadle pump technology three or more years ago compared with only about 27 percent of the interviewees in Mchinji district. However, in recent years more farmers in Mchinji district appear to be adopting the treadle pump technology compared to the farmers in Blantyre district. These results can be explained in two ways. First, during Participatory Rural Appraisal (PRA), field officers in Blantyre district indicated that many smallholder farmers in the district are interested in adopting the treadle pump irrigation technology because the potential adopters have seen the benefits accruing to adopters. However, such interested farmers are handicapped because the current price of the treadle pump is beyond their economic reach. For instance, MIRTDC is currently selling a treadle pump at MK14,000 (US$114.75) while Agricultural Trading Company (ATC), Agri Hort and Pipeco are selling the pumps at MK12,000 (US$98.36). The Ministry of Agriculture sells at MK7,000 (US$57.38) on cash basis.

The interested smallholder farmers prefer to acquire the pumps, especially Ajay and Pipeco treadle pumps, on loan basis. Such pumps could be used for the production of food e.g. maize and cash crops e.g. horticultural crops for the lucrative Blantyre/Limbe market (Blantyre Rural Development Project, 2005).

Second, in Mchinji district, the droughts experienced in the recent past have encouraged more and more smallholder farmers to adopt the treadle pump to supplement their food suppliers. The overall picture in the two districts shows that, probably because of the price factor in recent years, more farmers adopted the treadle pump earlier than later. Mchinji district has tended to benefit from NGO and donor-supported programs.

Institutions/Organizations engaged in Treadle Pump Marketing and Dissemination

Treadle pumps are mainly differentiated by conformation of their cylinders. Treadle pumps with long cylinders are wooden and have smaller diameters. Those with short cylinders are metallic and have bigger diameters. Unpublished research has revealed that treadle pumps with short cylinders and bigger diameters have relatively greater discharge and are easier to pedal.

At the national level, suppliers of treadle pumps are mainly Delt-Tech Engineering Company, Agriculture Equipment Limited, Valiant Glass Works Ltd, Saifro and Lilongwe Mechanical Development (LMD). Organizations/institutions involved in treadle pump dissemination/distribution include Action Aid Malawi; the European Union; NASFAM, CADECOM, Concern Universal, World Vision Malawi, ADMARC and Concern World Wide.

In Mchinji district, the key institutions involved in treadle pump marketing and dissemination are Delt-Tech Engineering Company of Lilongwe who manufacture and market Advaith treadle pumps. Local artisans also fabricate and market treadle pumps. The most popular local artisan is Samala Vitsotso Welding Shop located in Mchinji, owned by Mr Gilson S. Vitsotso. The Malawi Industrial Research and Technology Development Center (MIRTDC) trained the proprietor. MIRTDC is an organization established to promote research and development of appropriate technologies for farmers and other users in Malawi.

In terms of dissemination of the treadle pumps, the key players in Mchinji district are ADMARC and NASFAM for smallholder farmers interested to purchase treadle pumps

on cash basis. FAO and World Vision Malawi have in the past provided treadle pumps as grants to smallholder farmers in Mchinji district. In certain cases, the Malawi Government and the EU Public Works Program make loans available to smallholder farmers for the purchase of treadle pumps. In yet other instances, the Malawi Government, MASAF and the Horticulture and Food Crop Development Project (HFCDP) have distributed treadle pumps free of charge to farmers. All the institutions together with the Department of Irrigation and Ministry of Agriculture and Food Security have been involved in the dissemination of the treadle pump technology in the district.

In Blantyre district, the key player remains the Malawi Government. Other institutions are Pipeco, MIRTDC, ATC, Agri Hort and ADMARC.

Interviews with the adopters in both Blantyre and Mchinji districts reinforced the fact that the main supplier of the treadle pumps to farmers is the Malawi Government accounting for about 67 percent of all the adopters. However, more adopters (84%) in Blantyre district received the treadle pumps from the Ministry of Agriculture and Food Security than their counterparts in Mchinji district. Other suppliers of treadle pumps were NGOs, including Total Landcare, the Malawi Rural Finance Company, and the European Union supported projects (Table 15).

Table 15. Distribution of smallholder treadle pump adopters by type of supplier in Blantyre and Mchinji districts, 2005

Supplier	Blantyre (%)	Mchinji (%)	Total (%)
Ministry of Agriculture	84.0	48.9	67.4
Total Landcare	2.0	0.0	1.1
Other NGOs	4.0	37.8	20.0
Malawi Rural Finance Company	10.0	11.1	10.5
European Union supported project	0.0	2.2	1.1
Total	100.0	100.0	100.0
N	50	45	95

The main NGOs involved in treadle pumps in Mchinji district are World Vision Malawi and Concern World Wide. Although the survey did not capture Total Land Care in Mchinji district, it should be noted that Total Land Care is actively involved in treadle pump distribution and training of farmers in Central Region districts such as Lilongwe and Nkhotakota. Malawi Rural Finance Company is a bank that provides seasonal, and medium-term loans to smallholder farmers and other small businesses. The farmers who claimed to have received the treadle pumps from Malawi Rural Finance Company obtained such pumps on loan from the Company.

Type of Treadle Pump used by Farmers

The adopters indicated that five types of treadle pumps are available on the market. The adopters know the treadle pumps either by the name of the manufacturer, or distributor or the country of origin. Table 16 presents the types of treadle pumps used in Blantyre and Mchinji districts by adopters.

Table 16. Distribution of adopters by type of treadle pump used in Blantyre and Mchinji districts, 2005

Type of treadle pump	Blantyre (%)	Mchinji (%)	Total (%)
Advaith	12.2	91.8	55.6
Agro-engineering	0.0	4.1	2.2
Pipeco	0.0	4.1	2.2
Shire Limited	17.1	0.0	7.8
Balaji India	70.7	0.0	32.2
Total	100.0	100.0	100
N	41	49	90

The most popular treadle pump in Mchinji district is the Advaith produced by Delt-Tech Engineering Company while Balaji India is common in Blantyre. Other types of treadle pumps are Agro-engineering, Pipeco and Shire Limited.

Ownership of Treadle Pumps

Because of the cost and limited supply of treadle pumps in Malawi, group ownership (groups of up to 5 individuals) of the treadle pump is sometimes advocated. In the case study districts of Blantyre and Mchinji, close to 32 percent of the farmers shared the treadle pumps. However, as seen in Table 17 individual ownership appears to be gaining popularity among the households because of problems associated with group ownership of assets. In groups, it becomes difficult to determine who gets priority during critical periods such as flowering stage of crops. Free-rider problems when it comes to repairs and maintenance also make group ownership less preferred by adopters. Jere and Bunderson (2004) also noted that group ownership is helpful when the group obtains loan. This is so because group credit is more sustainable (high repayment rates) for annual enterprises. However, because of accountability, repairs and maintenance costs, medium term credit is more sustainable when disbursed to individuals than to groups. Borrowing treadle pumps is not common in the case study districts (Table 17).

Table 17. Distribution of adopters by ownership of treadle pumps in Blantyre and Mchinji districts, 2005

Ownership	Blantyre (%)	Mchinji (%)	Total (%)
Group ownership	36.7	27.3	32.3
Individual ownership	63.3	70.5	66.7
Borrowing	0.0	2.3	1.1
Total	100.0	100.0	100.0
N	49	44	93

Season Treadle Pump is used

The treadle pump is mostly used in the winter (May to July) and dry seasons (August to October) (Table 18). Farmers in the case study districts rarely used the treadle pump during the rainy season (November to April) for supplemental irrigation, particularly when dry spells are experienced. This is so because farmers do not practice water harvesting or other water conservation measures such as dams. When there is a dry spell in the uplands, it means there is no source of water for irrigation. That is why the Ministry of Agriculture and Food Security in conjunction with the Department of Irrigation is introducing rainwater harvesting to complement the treadle pump. If water was readily available the farmers would be pumping it for supplementary irrigation. The adopters who reported using supplementary irrigation in the two districts had a reliable water source nearby. Note that the treadle pump is often used in wetlands where water is available.

More farmers in Blantyre district than in Mchinji district use the treadle pump during the winter season (Table 18). This is so because during the dry season (August to October), farmers in Blantyre concentrate on upland agriculture. In Mchinji district, like in other central region districts, most farming activities particularly land preparations in the uplands do not start until the onset of the first rains in November. This is why more farmers in Mchinji district continue using the treadle pump in the dry season (August to October).

Table 18. Distribution of treadle pump adopters by season in which treadle pump is used in Blantyre and Mchinji districts, 2005

Season	Blantyre (%)	Mchinji (%)	Total (%)
Winter (May to July)	56.5	52.3	54.4
Rainy season (November to April) as supplemental irrigation	26.1	2.3	14.4
Dry season (August to October)	17.4	45.5	31.1
Total	100.0	100.0	100.0
N	46	44	90

The treadle pumps are often used once, twice or three times a week to water crops. Very few farmers use the treadle pumps to water crops daily (Table 19). This shows the importance of the treadle pump, because farmers who use watering cans water their crops almost every day, which makes the watering can extremely labor demanding.

Table 19. Distribution of adopters by frequency of watering crops using treadle pumps in Blantyre and Mchinji districts, 2005

Frequency of watering	Blantyre (%)	Mchinji (%)	Total (%)
Once a week	21.3	19.5	20.5
Twice a week	34.0	65.9	48.9
Three times a week	34.0	9.8	22.7
Daily	10.6	4.9	8.0
Total	100.0	100.0	100.0
N	47	41	88

Agricultural Extension

Most treadle pump farmers received formal training on how to use the treadle pump. There were more adopters in Mchinji district than in Blantyre district that received training on the use of the treadle pump (Table 20).

Table 20. Training on use of treadle pumps in Blantyre and Mchinji districts, 2005

	Blantyre (%)	Mchinji (%)	Total (%)
Received training	56.5	66.7	61.5
Did not receive training	43.5	33.3	38.5
Total	100.0	100.0	100.0
N	46	45	91

The adopters who received formal training got it from government irrigation staff, NGO extension staff and fellow farmers (Table 21). Government irrigation staff was the most important accounting for over 50 percent of the respondents in both Blantyre and Mchinji districts. The least source of training was fellow farmers in the villages. The fact that some farmers received training from fellow farmers demonstrates the potential of farmer-to-farmer extension. Because of time and financial constraints imposed on irrigation extension staff, farmer-to-farmer extension may prove the most cost-effective irrigation extension method.

Table 21. Provider of training to adopters in Blantyre and Mchinji districts, 2005

Provider	Blantyre (%)	Mchinji (%)	Total (%)
Government irrigation staff	57.7	50.0	53.6
NGO staff	46.2	46.7	46.4
Fellow farmers	3.8	6.7	5.4
N	26	30	56

Total percentage is greater than 100 because of multiple responses.

Gender of Adopter

The majority (83.0%) of the adopters in Blantyre district were female while the opposite was true for Mchinji (Table 22). In Blantyre district some men, are often involved in trading farm products such as vegetables while females work in the field. In addition, Blantyre is the major city in Malawi and as such some males work in the cities leaving women and children to work on the farm. Food security is a major consideration for females and they are going for treadle pumps to ensure that their families are food secure.

The results in Mchinji are due to three reasons. First, because males are dominant in decision making and Mchinji being far from Lilongwe city, the males engage in farming together with their wives. Second, Mchinji being a more rural area tends to have strong cultural values. For instance, field officers indicate that women in rural Mchinji district wrap themselves with a piece of cloth called *chitenje* as opposed to wearing trousers. For the females, pedaling the treadle pump violates their dress code as it makes them expose their thighs to men. This is a design problem. Third, women in Mchinji district expect men to be the first people to adopt new technologies. According to field officers, female participation was also low in other programs such as the FAO-supported Special Program on Food Security. These problems are however slowly fading away in Mchinji districts. In the more urban districts such as Blantyre, the situation is different because the women there have more exposure and do not see any problem with pedaling the treadle pump. In Blantyre women are actually dragging men to adopt treadle pump irrigation.

Table 22: Gender of adopter in Blantyre and Mchinji districts, 2005

Gender	Blantyre (%)	Mchinji (%)	Total (%)
Male	17.0	79.0	48.0
Female	83.0	21.0	52.0
Total	100.0	100.0	100.0
N	50	50	100

In all cases, all members of the family including husband, wife and children assist in pumping the water and directing it to the field and crops.

The Costs and Benefits of the Treadle Pump Technology

Assessment of the benefits associated with treadle pumps on the smallholder fields was done using gross margin analysis. A gross margin is the difference between gross revenue or return and total variable costs. This analysis entailed computation of gross margin per crop grown on the farm, which were later summed up to generate Whole Farm Gross Margin (WFGM) per farm. This was done for all the crops the adopters grew using rain-fed agriculture and treadle pump irrigation. Likewise, for the non-adopters, WFGMs were computed for combined rain-fed and irrigated crops. From the respective WFGMs, fixed costs such as depreciation were subtracted to obtain Net Farm Income (NFI), which was used as a proxy for profitability. The non-adopters of treadle pumps used in this study were farmers who engaged in watering can/bucket irrigation. This was taken as the base technology with the treadle pump used as the next step on the irrigation technology ladder. To make the analysis more interesting, the NFIs were further calculated on a per hectare basis and the mean NFIs/ha for the two categories were compared using t-statistic. The results of this effort are presented in Table 23.

Table 23. Mean Net Farm Incomes of smallholder treadle pump adopters and non-adopters in Blantyre and Mchinji districts, 2005

Variable	Blantyre		Mchinji		Total	
	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter
Land area	4.08	3.80	4.53***	3.30	4.25**	3.55
(ha)	t-value= 0.47		t-value= 2.18		t-value=1.68	
Mean NFI	70,544.24***	18,487.71	62,865.80***	23,646.06	67,628.38***	20,988.73
(MK/farm)	(US$578.23)	(US$151.54)	(US$515.29)	(US$193.82)	(US$554.33)	(US$172.04)
	t value=2.49		t-value= 3.95		t-value=4.58	
Mean	23,826.09***	5,304.56	17,217.60***	9,065.05	21,316.54***	7,127.82
NFI/ha	(US$195.30)	(US$43.48)	(US$141.13)	(US$74.30)	(US$174.73)	(US$58.42)
	t value =2.02		t-value= 3.03		t-value=3.40	

Notes on table:
1. t-values are computed t-values used to compare two means.

2. *** significant at 0.01 percent; ** significant at 0.05%; * significant at 0.10 percent.
3. MK = Malawi Kwacha, US$1 = MK122, at the time of the survey.

The results show that in Blantyre district there was no significant difference in farm sizes between adopters and non-adopters. However, both the mean NFI and mean NFI per hectare were significantly higher for treadle pump adopters than for the non-adopters. In fact, the mean NFI and mean NFI/ha for adopters were about four times the respective means for non-adopters. This clearly shows the benefit of the treadle pump to the adopters in Blantyre district. In Mchinji district, the adopters had significantly more land available than non-adopters. Similarly, both the mean NFI and the mean NFI per hectare for adopters were significantly higher than those for the non-adopters (Table 23).

This observation is mainly because, unlike watering cans and buckets, treadle pumps allow farmers to irrigated larger areas and supply crops with adequate water for their smooth growth and development. During reconnaissance survey, farmers pointed out that with the aid of a treadle pump they are able to irrigate once a week and twice a week during critical periods such as crop emergency and flowering and provide adequate water to the plants. With a watering can or a bucket, watering is done almost daily and inadequate water is provided to the plants.

Table 23 also reveals that the mean NFI and mean NFI per hectare were larger for Blantyre adopters than for Mchinji adopters. This can be explained by the availability of the more lucrative Blantyre/Limbe city market, which is not the case with the more rural Mchinji district. For non-adopter, no pattern has been established between the two districts.

The following table presents comparisons of NFIs by farming system practiced by adopters and non-adopters.

Table 24. Mean Net Farm Incomes of smallholder treadle pump adopters and non-adopters by farming system in Blantyre and Mchinji districts, 2005

Farming system	Blantyre		Mchinji	
	Adopter	Non-adopter	Adopter	Non-adopter
Irrigated	47,137.69***	10,697.33	24,366.47***	6,090.04
Mean NFI	(US$386.37)	(US$87.68)	(US$199.73)	(US$49.92)
MK/farm	t-value= 3.18		t-value= 3.41	
Rain-fed	26,161.94***	7,313.12	39,936.43***	17,837.92
Mean NFI	(US$214.44)	(US$59.94)	(US$327.35)	(US$146.21)
(MK/farm)	t value=3.96		t-value= 1.49	
Irrigated	122,854.69***	15,986.90	51,858.21***	16,089.79
Mean NFI/ha	(US$1,007.00)	(US$131.04)	(US$425.07)	(US$131.88)
(MK/ha)	t value =3.57		t-value= 2.98	
Rain-fed	19,496.90***	3,344.17	16,895.96	10,083.72
NFI/ha	(US$159.11)	(US$27.41)	(US$138.49)	(US$82.65)
(MK/ha)	t-value=4.93		t-value=1.16	

Notes on table:
1. t-values are computed t-values used to compare two means.
2. *** significant at 0.01 percent; ** significant at 0.05%; * significant at 0.10 percent.
3. MK = Malawi Kwacha, US$1 = MK122, at the time of the survey.

Like Table 23, Table 24 also shows higher returns for adopters than adopters in both districts. The returns from treadle pump irrigation are higher in Blantyre than in Mchinji district.

Costs of disseminating treadle pumps

Delivery of treadle pumps to smallholder farmers in rural Malawi involves a number of steps depending on whether the farmers are new adopters or old adopters of the treadle pump. For new adopters, four steps are involved. First, the treadle pumps are procured in either Lilongwe for Mchinji district farmers or in Blantyre/Limbe city for Blantyre district farmers. A truck is then hired to transport the treadle pumps from suppliers to Mchinji or Blantyre Agricultural Office where the pumps are kept temporarily in warehouses. Second, the treadle pumps are transported to a field office close to the

farmers where they are also kept in a warehouse in readiness for delivery to farmers. Third, farmers who expressed interest in the treadle pumps are contacted to receive the treadle pumps on loan, cash or free distribution basis and undergo training on the use and maintenance of the pumps. Fourth, after training, irrigation field officers embark on field support visits to assist farmers with any problems regarding the treadle pump and irrigation agronomy. Field support visits for new farmers take place every fortnight. For old adopters of the treadle pump technology, field support visits are reduced to once a month or to "when need arises".

The following table present the average cost of disseminating/distributing the treadle pumps to farmers. The analysis assumes a consignment of 100 treadle pumps and the furthest distance of 200 km from an urban location either in Lilongwe or Blantyre city to the remotest part of the case study districts.

Table 25. Average cost of disseminating treadle pumps in case study districts, 2005

Cost category	Amount (Malawi Kwacha)	Amount (US$)
Hiring a truck to delivery 100 treadle pumps from supplier in Lilongwe to Mchinji Rural Development Project office/from supplier in Blantyre to Blantyre Rural Development Project Office	40,000.00	327.87
Loading and off-loading costs	6,000.00	49.18
Storage cost	10,000.00	81.97
Hiring a truck from Mchinji/Blantyre Rural Development Office to a Field office (Extension Planning Area)	35,000.00	286.89
Loading and off-loading costs	6,000.00	49.18
Storage costs	10,000.00	81.97
Farmer training	26,300.00	215.57
New adopters field support visits	390,000.00	3,196.72
Old adopters field support visits	180,000.00	1,475.41
Total cost	**703,300.00**	**5,764.75**
Cost per treadle pump	**7,033.00**	**57.65**

Source: Blantyre and Mchinji Rural Development Projects, 2005

US$1.00 = MK122, MK = Malawi Kwacha

The table shows that the total cost for a consignment of 100 treadle pumps is MK703,300 (US$5,764.75), giving an average cost per treadle pump of MK7,033.00 (US$57.65).

The Food Security Impacts of the Treadle Pump Technology

Farmers' perception of the treadle pump

About 83 percent of all the adopters perceived the treadle pump to be very useful or useful (12.0%) to their agricultural activities and their lives, including food security. Very few farmers in Blantyre (8.2%) and Mchinji (2.3%) reported that the treadle pump was not useful (Table 26). The farmers in Blantyre district who reported that the treadle pump is not useful were newer adopters and had unreliable sources of water mostly emanating from the drought, which the country suffered in the 2004/2005 season. This made them use much effort to pump the water. Further more, Mchinji district is much flatter than Blantyre, thereby making it easier in Mchinji than in Blantyre to pump water during drought periods, i.e. more lift is required in Blantyre than in Mchinji district.

Table 26. Distribution of adopters by perception of treadle pump in Blantyre and Mchinji districts, 2005

Perception	Blantyre (%)	Mchinji (%)	Total (%)
Very useful	79.6	86.0	82.6
Useful	12.2	11.6	12.0
Not useful	8.2	2.3	5.4
Total	100.0	100.0	100.0
N	49	43	92

The tangible improvements the treadle pump has brought to the lives of the farmers in terms of material gains are presented in Table 27.

Table 27. Material gains of treadle pump adopters in Blantyre and Mchinji districts, 2005

Material gain	Blantyre (%)	Mchinji (%)	Total (%)
No longer seeks loan from neighbors	60.4	32.4	48.8
Has enough food	27.1	50.0	36.6
Pays school fees for children	0.0	2.9	1.2
Build a house	4.2	0.0	2.4
Bought livestock	4.2	5.9	4.9
Now hires and pays casual labor	4.2	8.8	6.1
Total	100.0	100.0	100.0
N	48	34	82

The major gains are graduation from loans from neighbors, food security, livestock purchases, payment of school fees, and creation of employment. Some adopters have managed to build houses.

With regard to food security, over 70 percent of all the adopters noted that they were food insecure before adoption of the treadle pump. More Mchinji adopters (about 80%) were, prior to adoption of treadle pumps, more food insecure than Blantyre adopters (Table 28). Thus, food insecurity increased the adopters' propensity to adopt the treadle pump irrigation so that they could grow more maize for their families.

Table 28. Distribution of adopters by food security status before adoption of treadle pump technology in Blantyre and Mchinji districts, 2005

Food security status	Blantyre (%)	Mchinji (%)	Total (%)
Food secure	32.7	20.4	26.5
Food insecure	67.3	79.6	73.5
Total	100.0	100.0	100.0
N	49	49	98

Prior to adoption of the treadle pump, nearly half of all the adopters depleted their food stocks between October and December, four to six months before the next harvest. More farmers in Mchinji than in Blantyre district reported this. Note that harvesting in Malawi takes place around May, which implies that by May of every year about 90 percent of the adopters were food insecure prior to adoption of the treadle pump technology Table 29).

Table 29. Distribution of adopters by month food stocks were depleted prior to adoption of treadle pump technology

Month	Blantyre (%)	Mchinji (%)	Total (%)
April to June (Harvest time)	6.1	12.8	9.7
July to September	21.2	15.4	18.1
October to December	36.4	67.7	52.8
January to March	36.4	5.1	19.4
Total	100.0	100.0	100.0
N	33	39	72

Unlike non-adopters, the majority of the adopters (91.0 percent), including some of those who were food insecure prior to adoption of the treadle pump, noted that they are now food secure i.e. they have enough food to last till the next harvest in May of every year. There are slightly more farmers who are now food secure in Mchinji district (94.0%) than in Blantyre district (Table 30). These results imply that adoption of the treadle pump has greatly improved the food security status of the adopters because they are able to grow food and cash crops several times in a year. Chi-square test showed that differences between adopters and non-adopters were significant at 1 percent. Thus, the treadle pump irrigation technology does help to supplement rain-fed/upland food production of households.

Table 30. Distribution of adopters and non-adopters by current food security status in Blantyre and Mchinji districts, 2005

Current food security status	Blantyre		Mchinji		Total	
	Adopter (%)	Non-adopter (%)	Adopter (%)	Non-adopter (%)	Adopter (%)	Non-adopter (%)
Food secure	88.0	44.0	94.0	36.0	91.0	40.0
Food insecure	12.0	56.0	6.0	64.0	9.0	60.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
N	50	50	50	50	100	100

Blantyre district: Significant at 1 percent: $?^2_{0.01,1\,calculated}=21.58 > ?^2_{0.01,1\,tabulated}$? 6.63

Mchinji district: Significant at 1 percent: $?^2_{0.01,1\,calculated}=36.98 > ?^2_{0.01,1\,tabulated}$? 6.63

Both districts: Significant at 1 percent: $?^2_{0.01,1\,calculated}=57.56 > ?^2_{0.01,1\,tabulated}$? 6.63

Coping mechanisms in times of food shortage

The food insecure households take some drastic measures to reduce the impact of the food shortage. The measures include reducing the number of meals taken per day, *ganyu* or off-farm casual work, and obtaining gifts (Table 31).

Table 31. Coping mechanism of households in Blantyre and Mchinji districts, 2005

Mechanism	Blantyre			Mchinji			Total		
	Adopter (%)	Non adopter (%)	*P-value	Adopter (%)	Non-adopter (%)	*P-value	Adopter (%)	Non-adopter (%)	*P-value
Reduce meals	100.0	100.0	0.5000	100.0	100.0	0.5000	100.0	100.0	0.5000
Ganyu	83.3	78.6	0.3974	66.7	87.5	0.1611	77.8	83.3	0.3409
Sell items	16.7	57.1	0.0329	33.3	34.4	0.4840	22.2	45.0	0.1003
Gifts	66.7	71.4	0.4090	66.7	68.8	0.4681	66.7	70.0	0.4207
N	6	28		3	32		9	60	

Total percentage is greater than 100 because of multiple responses.

*If p-value is less than 1 percent, reject the null hypothesis (Edriss, 2003).

For all households, reducing the number of meals taken per day is the most important strategy. A large number of the households also resort to off-farm work.

Maize deficit of households

Ninety-one percent of the adopters reported no maize deficit compared to only 40 percent of the non-adopters. No adopter had a deficit of more than 1,000 kg. Overall, the proportion of adopters with deficits was lower than that of non-adopters for each deficit category (Table 32). The differences were significant at the 1 percent level for 0, 501-1000 and >1,000kg deficit categories for Blantyre district; for 0, 301-500 and >1,000kg for Mchinji district and for 0, 301-500, and >1,000kg for the entire sample i.e. combined Blantyre and Mchinji districts. These results strengthen the argument that treadle pumps improve the food security of participating households.

Table 32. Maize deficit of households in Blantyre and Mchinji districts, 2005

Maize deficit (kg)	Blantyre			Mchinji			Total		
	Adopters (%)	Non-adopters (%)	*P-value	Adopters (%)	Non-adopters (%)	*P-value	Adopters (%)	Non-adopters (%)	*P-value
0	88.0	44.0	0.0001	94.0	36.0	0.0001	91.0	40.0	0.0001
1-300	8.0	2.0	0.0838	2.0	12.0	0.0250	5.0	7.0	0.3372
301-500	2.0	4.0	0.2776	2.0	28.0	0.0003	2.0	16.0	0.0073
501-1000	2.0	20.0	0.0002	2.0	8.0	0.0838	2.0	14.0	0.0139
>1000	0.0	30.0	0.0001	0.0	16.0	0.0016	0.0	23.0	0.0001
Total	100.0	100.0		100.0	100.0		100.0	100.0	
N	50	50		50	50		100	100	

*If p-value is less than 1 percent, reject the null hypothesis (Edriss, 2003).

The Poverty Impacts of the Treadle Pump Technology

Assessment of the poverty impacts of the treadle pump technology was based on an assessment criteria designed in collaboration with smallholder farmers and field agricultural personnel. This assessment takes into consideration what smallholder farmers themselves view as symbols of wealth and poverty. To carry out the assessment four poverty assessment components were use. The first component was food security. A household is regarded as non-poor if it has enough food to last them till the next harvest. The other components were ownership of brick, iron roofed house; livestock and farm implements and transport such as ox-carts and bicycles. The following table shows a breakdown of the households with regard to the components.

Table 33. Ownership of assets and transport among adopters and non-adopters in Blantyre and Mchinji districts, 2005

Poverty assessment component	Blantyre			Mchinji			Total		
	Adopter (%)	Non-adopter (%)	*P-value	Adopter (%)	Non-adopter (%)	*P-value	Adopter (%)	Non-adopter (%)	*P-value
Food security	88.0	44.0	0.0001	94.0	36.0	0.0001	91.0	40.0	0.0001
Good housing	16.0	10.0	0.2119	50.0	20.0	0.0013	33.0	15.0	0.0005
Livestock e.g., cattle	10.0	4.0	0.1190	80.0	30.0	0.0001	45.0	45.0	0.5000
Employment creation	80.0	46.0	0.0003	60.0	10.0	0.0001	70.0	28.0	0.0001
Working tools	66.0	20.0	0.0001	100.0	70.0	0.0001	83.0	45.0	0.0001
Good clothing	90.0	50.0	0.0001	90.0	30.0	0.0000	90.0	40.0	0.0000
Bicycles	14.0	12.0	0.3859	70.0	20.0	0.0001	42.0	16.0	0.0001
Radio	90.0	90.0	0.5000	70.0	50.0	0.0197	80.0	70.0	0.0516
Ox-cart	0.0	0.0	0.5000	56.0	10.0	0.0000	28.0	5.0	0.0000
N	50	50		50	50		100	100	

*If p-value is less than 1 percent, reject the null hypothesis (Edriss, 2003).

Clearly, treadle pump smallholder adopters are more food secure than their counterparts in both districts. Although the figures are not as high, overall treadle pump farmers own good houses, livestock, bicycles and ox-carts compared to non-treadle pump farmers. In a rural set up in Malawi, individuals who employ fellow villagers are considered non-poor or well to do. In Table 32, more treadle pump adopters create employment than the non-treadle pump adopters. In Blantyre district, there was no marked difference in the

ownership of ox-carts, radios, and bicycles between adopters and non-adopters but ownership of ox-carts and bicycles was significant at the 1 percent level in Mchinji district. The differences are due to differences in culture and perception of wealth between the two districts. In Mchinji district like in most districts in central Malawi, farmers highly value ox-carts and bicycles for transportation.

Well-being measurements and analysis

The poverty analysis was taken a step further through the computation of well-being measurements. Because in Malawi treadle pumps are not targeted to a selected group of smallholder farmers, this analysis helps to assess the impact of the treadle pump irrigation technology on the adopters. Table 34 below presents poverty indices by type of farmer. The head count index shows that non-adopters had the most serious poverty levels compared to adopters and the difference was significant at the 1 percent level. Although more than 60 percent of the adopters were above the consumption poverty line, the results show that poverty is quite high in the two districts because the average head count index was 58.5.

Table 34. Poverty index by type of farmer in Blantyre and Mchinji districts, 2005

Type of farmer	Headcount index	Poverty Gap	Poverty Severity
Blantyre adopter	38.0	15.3	8.4
Blantyre Non-adopter	76.0***	34.9***	19.1***
	(t-value = 26.21)	(t-value = 51.58)	(t-value = 27.36)
Mchinji adopter	40.0	18.2	10.5
Mchinji Non-adopter	80.0***	42.3***	25.3***
	(t-value = 37.04)	(t-value = 37.66)	(t-value = 30.20)

*** Differences between adopters and non-adopters were significant at 1 percent.

The National Economic Council (2000) estimated a headcount index of 68 for the Southern Region of Malawi, where Blantyre is and an index of 63 for Central Region where Mchinji is. Although the National Economic Council used income to analyze the incidence of poverty in Malawi, the results in this study are consistent with the findings of the National Economic Council, which showed poverty incidence in Malawi to be highest in the Southern Region. The fact that the poverty incidence in the two districts is an average of 59 shows that about 60 percent of all the farmers in the two districts are in food deficit.

The depth of poverty or poverty gap index also depicts a similar picture. The poverty gap index is used to determine how far off a household is from the consumption poverty line. This measure estimates the average aggregate consumption shortfall in the population in relation to the threshold or poverty line. The computation of this measure assumes that the non-poor have a consumption shortfall equivalent to zero. For this reason, only the consumption shortfalls of the poor are aggregated and divided by the poverty line to estimate the index. This index measures the total amount of resources required to allow the poor to have the threshold consumption. The results in Table 34 show that twice as much resource would be required to bring the non-adopters in each district to the threshold consumption compared to the adopters in respective districts and this difference was significant at the 1 percent level. This result demonstrates the positive impact of the treadle pump technology on poverty reduction since fewer resources are needed to bring treadle pump farmers to threshold consumption than the non-treadle pump farmers.

The poverty severity index complements the other measures because it furnishes more information on the extent of inequality among the poor themselves. This measure does this by putting more weight on the households further from the poverty line. This measure is best used to assess poverty in concert with the poverty gap index and the head count index. This is important because a low poverty incidence may be associated with a huge poverty gap or a high poverty severity index. In the current analysis, there is consistence among the groups in that the groups that have low poverty incidence are also the same groups that have low poverty gap and poverty severity indices. The differences

in the indices between adopters and non-adopters were significant at the 1 percent level. These results are important in interpreting the impact of the treadle pump technology in the case study districts. The results show that not only does the treadle pump technology help to reduce the number of poor people or incidence of poverty but it is also effective in reducing poverty gap and poverty severity.

The poverty analysis of the groups was extended to assess the relative risk of being poor for the different farmer groups. The importance of this measure is that it gives us an idea of the probability with which households in a given group will fall into poverty compared to all the households belonging to other groups. This analysis starts by looking at the way the different farmer groups contribute to the total poverty. The calculation is based on each group's population share, incidence of poverty in the group as presented in Table 34, and the share of all poor people contributed by the group. The non-adopters in Mchinji district were used as a benchmark for the analysis. Table 35 presents the results of the analysis.

Table 35. Relative risk of poverty among households in Blantyre and Mchinji districts, 2005

Variable	Blantyre		Mchinji		Total
	Adopter	Non-adopter	Adopter	Non-adopter	
Population share (%)	25.0	25.0	25.0	25.0	100
Headcount index (%)	38.0	76.0	40.0	80.0	68.0
Share of all poor (%)	16.2	32.5	17.1	34.2	100
Relative risk (%)	+44.1	-11.8	+41.2	-17.6	

The results show that Mchinji non-treadle pump households have the greatest risk of being poor compared to other households. Blantyre treadle pump households have the least risk of not meeting the consumption threshold. These results clearly show that in the face of drought and population pressure non-treadle pump households would fall deeper and deeper into consumption shortfall because they would be unable to produce enough for their consumption needs.

Movement in and out of poverty

Two observations were made in 2004 and in 2005 among the households in the two districts to analyze how the different households moved in and out of poverty. This analysis is useful because it helps to trace changes in household welfare. Although the best way to analyze such transitions is for longer periods of time e.g. one or more years, the comparisons here helped to gain an insight into how vulnerable the different groups were on a seasonal basis. In the rural areas, some households may have a seasonal risk to consumption poverty while others may be poor all year round. An understanding of such vulnerabilities helps to devise good strategies to combat such poverty. Table 36 presents a transition matrix comprising all the four farmer categories.

Table 36. Transition matrix depicting movement in and out of poverty in Blantyre and Mchinji districts, 2005

Technology	*Cell %* *STATUS IN 2004	STATUS IN 2005 Poor	Non poor	Total
Blantyre Adopters	**Poor**	? 12.0	55.3	67.3
	Non-poor	? 0.0	? 32.7	32.7
	Total	12.0	88.0	100.0
Blantyre Non-adopters	**Poor**	? 30.0	0.00	30.0
	Non-poor	? 26.0	? 44.0	70.0
	Total	56.0	44.0	100.0
Mchinji Adopters	**Poor**	? 6.0	73.5	79.5
	Non-poor	? 0.0	? 20.5	20.5
	Total	6.0	94.0	100.0
Mchinji Non-adopters	**Poor**	? 37.0	0.0	37.0
	Non-poor	? 27.0	? 36.0	63.0
	Total	64.0	36.0	100.0

Notes on table:
*Calculations based on information supplied by Blantyre and Mchinji Rural Development Projects

Blantyre adopter: Not significant at 1 percent: $?^2_{0.01,1 calculated}=6.57 < ?^2_{0.01,1 tabulated}$? 6.63.

Blantyre non-adopter: Significant at 1 percent: $?^2_{0.01,1 calculated}=33.67 > ?^2_{0.01,1 tabulated}$? 6.63.

Mchinji adopter: Not significant at 1 percent: $?^2_{0.01,1 calculated}=1.65 < ?^2_{0.01,1 tabulated}$? 6.63.

Mchinji non-adopter: Significant at 1 percent: $?^2_{0.01,1 calculated}=33.03 > ?^2_{0.01,1 tabulated}$? 6.63.

The table shows that in Blantyre district 12 percent of the adopters who were poor in 2004 remained poor in 2005 while 32.7 percent of those who were non-poor in 2004 remained non-poor in 2005. About 55.3 percent of those who were poor in 2004 became non-poor in 2005 and nobody who was non-poor in 2004 became poor in 2005. A similar

pattern is observed for adopters in Mchinji district. Chi-square test showed no significant difference because the majority of households maintained their non-poor status in the adopter category.

The story is different for the non-adopters. In Blantyre district, 6 percent of the non-adopters who were poor in 2004 remained poor in 2005 while 26 percent who were non-poor in 2004 became poor in 2005. Furthermore, none of the poor non-adopters in 2004 emerged out of poverty but 44 percent of the non-poor households remained non-poor in 2005. Mchinji non-adopters portray a similar pattern. Chi-square test showed significant differences at the 1 percent level in the non-adopter categories because there were considerable numbers of non-poor households who became poor in 2005.

The results demonstrate that adopters of treadle pumps in both districts had the greatest resilience against poverty while non-adopters were more vulnerable to falling into deep poverty.

Main Constraints to the Dissemination of the Treadle Pump Technology

Adopters in both Blantyre and Mchinji districts reported a number of constraints they face when using treadle pumps. The problems relate to effort, servicing, breakdown and water shortage (Table 37).

Table 37. Distribution of adopters by main problem faced when using treadle pump in Blantyre and Mchinji districts, 2005

Problem	Blantyre (%)	Mchinji (%)	Total (%)
Requires much effort	87.8	59.1	74.2
Servicing	8.2	27.3	17.2
Breakdown	0.0	2.3	1.1
Sharing	4.1	0.0	2.2

Water shortage	0.0	11.4	5.4
Total	100.0	100.0	100.0
N	49	44	93

Discussions with field officers revealed that dissemination of the treadle pump technology in Malawi is hampered by the following constraints.

- ?? Lack of proper farmer organization required for mobilizing self-work and self-governing management for the operation and maintenance of irrigation projects.
- ?? Distribution of the pumps to farmers is a costly exercise since the pumps have to be transported to different areas throughout the country.
- ?? Customary land tenure system, where individuals have free access to community resources, is seriously affecting control of water and cropping patterns. The farmers are not respecting the need for riverbank protection to prevent flooding, gullying and changing of river coarse. In certain cases, farmers have developed technologies, to go with the treadle pumps that require impounding water. This has led to quarrels among farmers because lower riparians do not receive adequate water for their use.
- ?? Lack of funds is affecting acquisition, operation and maintenance of treadle pumps and irrigation infrastructure as well as field support programs.
- ?? Lack of well-organized markets for agricultural products produced using the treadle pump irrigation and rain-fed agriculture.
- ?? Lack of irrigation culture. Marketing opportunities are frequently missed as most farmers still emphasize on rain-fed agriculture. In most cases, crops are planted towards the onset of rains in September-November so that they can develop with the rainwater.
- ?? Treadle pumps are manually operated which is a strenuous activity. This becomes a problem for old men and women as well as the sick such as people living with HIV/AIDS.
- ?? Inadequate coordination between/among stakeholders involved in smallholder agriculture irrigation creates confusion.

?? High cost of treadle pump spare parts.

?? Lack of organized markets for treadle pumps and their parts.

?? High cost of farm inputs such as fertilizer, seed, pesticides and sprayers.

?? Lack of capital for undertaking the manufacturing of treadle pumps by local district artisans.

?? Limited access to treadle pump irrigation technology.

?? Inadequate irrigation water. Treadle pumps have a limitation of not more than 7.5 meters on total dynamic head of delivery. This becomes a problem when the water tables drop below this level particularly in the dry season months of September and October.

?? Chronic food shortage is affecting labor output and acquisition of farm inputs and treadle pumps.

?? Mismatching parts. Treadle pumps made from India in most cases are incomplete, i.e. have mismatching spare parts. For example, bolt size may not match nut size. Sometimes, delivery pipes and suction pipes are not absent in the consignment, thereby making the treadle pump incomplete and unusable.

?? Area irrigated using treadle pumps is quite small. One pump irrigates a maximum of 0.3ha. This reduces the amount of crop a farmer could have produced if the pump was able to irrigate larger areas.

?? Price of treadle pump. The average price of a treadle pump is MK9,000 (US$73.77). Most smallholder farmers in Malawi cannot afford this kind of money. This problem is compounded by the recent drought, which has increased the price of maize, the staple food for Malawians. Many people would rather buy food than pay for a treadle pump.

The Future Potential of the Treadle Pump Technology

There is still potential for treadle pump use in the future. The pumps are operated manually making them a cheaper option for smallholder farmers to pump water for irrigation. Adoption rate for the technology is almost 100 percent and the adopters have now switched from watering can to treadle pump.

The treadle pump technology has tremendous future in Malawi as long as the weaknesses are sorted out. The majority of the people are demanding the pumps on loan basis. The farmers have developed an interest in the pumps because they have seen the prosperity of the treadle pump farmers. In Blantyre, farmers use the treadle pumps for irrigating horticultural crops such as mustard, cabbage and rape.

However, because of the erratic rainfalls experienced in the past years water recedes pretty fast in the *dambos* leading to lower water tables. This makes it difficult to pump the water using treadle pumps particularly from August to the start of the rains in November. This forces farmers to have one harvest of crops such as maize per season as oppose to the potential of three or more harvests. For this reason, any future advancement of the treadle pump technology should go along with water conservation technologies including water harvesting and water management. The potential will in future be limited by population growth which in turn will lead to scramble for land in the *dambos*.

CONCLUSIONS AND RECOMMENDATIONS

The study was conducted to assess the food security and poverty impact of the treadle pump technology, which is gaining popularity among smallholder farmers in Malawi. In addition, the study aimed to analyze the cost and benefits associated with the treadle pump as well as to outline institutions and organizations involved in treadle pump dissemination and marketing in Malawi.

The study has demonstrated that Malawi has a huge irrigation potential of 400,00 ha but only 62,000 ha have been developed. The consequences of this have been persistent food shortages, poverty and higher prevalence of nutritionally related diseases.

Since treadle pumps were introduced in Malawi in 1994, the main player in the distribution of the pumps to farmers continues to be the Malawi Government, through the Department of Irrigation and the Ministry of Agriculture and Food Security. Other organizations and institutions involved are NGOs such as World Vision Malawi, and Concern World Wide. Donors such as the European Union and FAO are also involved in

the distribution of the treadle pumps through their supported projects. The Malawi Government uses a combination of loans; cash sales and free distribution while donors such as the EU supported projects use loan schemes. Delt-Tech Engineering Company and some local artisans manufacture the treadle pumps used in Mchinji district. The Delt-Tech Engineering Company pumps are Advaith treadle pumps. In Blantyre, the main manufacturer is Ajay but treadle pumps from Shire Limited, and Balaji India are also available.

Interviews with adopters and non-adopters from case study districts of Mchinji and Blantyre showed that the treadle pump is mostly used in the winter (May to July) and dry seasons (August to October) in Mchinji district while in Blantyre district the pump is also used in the rainy season for supplemental irrigation. The main crops grown under treadle pump irrigation are maize, beans, tomatoes, onions and leaf vegetables such as mustard, rape and cabbages.

Comparison of treadle pump adopters and non-adopters using gross margin analysis revealed that treadle pump adopters made significantly more money from farming than the non-adopters in both Blantyre and Mchinji districts. This means that treadle pumps are essential for income generation among adopters. The adopters reported a number of material gains such as food security, building houses, paying school fees, and graduation from loans from neighbors. The adopters also created employment to other villagers and owned livestock, working tools and ox-carts for transportation. On food security, most adopters who were food insecure before adoption became food secure after adoption.

Well-being measurements and analyses of poverty revealed serious poverty indices (headcount, poverty gap and poverty severity indices) for non-adopters compare to adopters. The non-adopters also had greater relative risk of being poorer than adopters. Transition matrices showed that from 2004 to 2005, some poor adopters moved out of poverty while some non-adopters dropped from being non-poor to being poor. Thus, the treadle pump technology helps farmers to move out of poverty or to maintain their status of being non-poor.

The major constraints to the dissemination of treadle pumps in Malawi include water shortage or inadequate irrigation water especially during drought years; high price of treadle pumps and spare parts; lack of capital for manufacturing treadle pumps to increase their supply on the market; and lack of well-organized markets for selling irrigated crops. Resolving these constraints will help smallholder farmers fully realize the potential of the treadle pumps.

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