# Technical Efficiency of Paddy Farming in Low Country Wet Zone

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# FOREWORD

Paddy sector in Sri Lanka has played a major role for supplying food requirement in the country. Although Sri Lanka is self sufficient in rice production, the yield has stagnated over the last decade. Paddy sector contribution to Gross Domestic Product is 1.6 percent while 10.8 percent in total Agriculture sector contributed to the GDP in 2013. Even though 11 percent out of the total paddy production in Sri Lanka is produced by Low Country Wet Zone and this contribution has gradually decreased from 21 percent (1982) to 7 percent (2013) during past three decade. Low yield and yield variation due to environmental conditions, input allocation and management practices are the main factors affecting on paddy production.

The main focus of this report has been to analyze input use efficiency of paddy farming in the LCWZ and its determinants. Study reveals that there is great possibility to enhance yield by 28 percent without increasing input level. Management practices such as land levelling, fertilizer application at the required time, pest and disease control are important areas where attention needs to be paid for reaching optimum yield level. In addition Promotion of small scale machinery is essential to minimize the impact of labor scarcity.

This report provides a set of useful information for the paddy sector which would be useful to policy makers and researchers in the agriculture sector.

Haputhanthri Dharmasena
Director

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# EXECUTIVE SUMMARY


Low Country Wet Zone (LCWZ) has long been perceived as a zone where paddy cultivation is less productive, unprofitable and has a high variability of yield among its districts. The yield gap between the LCWZ and other agro ecological zones is high, around 50% with dry zone, 28% with intermediate zone and up country wet zone and 21% with mid country wet zone. There are many factors which affect this situation such as the environment, input allocation and management practices. Inefficient use of resources may lead to yield variation. A method to determine whether output reached its optimal level in production process is to measure the Technical Efficiency (TE).Therefore, this study attempts to estimate technical efficiency of paddy farming in the LCWZ.

The study locations were Colombo, Gampaha, Kalutara, Galle, Matara, Ratnapura and Kegalle districts with a total sample of 495 farmers selected by using multi stage random sampling technique. Primary data was collected with respect to 2013 *yala* season and secondary data was through key informant interviews and a literature review.

Findings revealed that average technical efficiency is 72 percent, which indicates that there is a scope for further increasing of output by 28 percent without increasing the level of input. Decreasing returns to scale indicate that proportionate changing of input may lead to change of output less than input change. Average productivity is 905kg /ac with the cost of production of Rs. 30.25/kg (without imputed cost) with a break-even yield of 1032kg/ac. It was seen that productivity varied across districts ranging from 740kg/ac in Galle to 1255kg/ac in Gampaha district.

The analysis suggests that management practices such as land levelling, fertilizer application at the required time, pest and disease controlling are among the important areas where attention needs to be paid for enhancing the output without increasing the level of input. In addition, degree of mechanization too positively correlates with production with small machinery being more preferable for the region due to the water logging nature of paddy fields. Use of 3.5 month paddy varieties demonstrated a high yielding capacity than 3 month varieties.

The study put forward a number of remedies; the need to establish demonstration farms with full time farmer/s in each AI region as model farmer/s who utilizes the available resources effectively; encourage farmers to apply fertilizer at the required time to enhance yield; encourage mechanization to avert labour scarcity.

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# ABBREVIATIONS

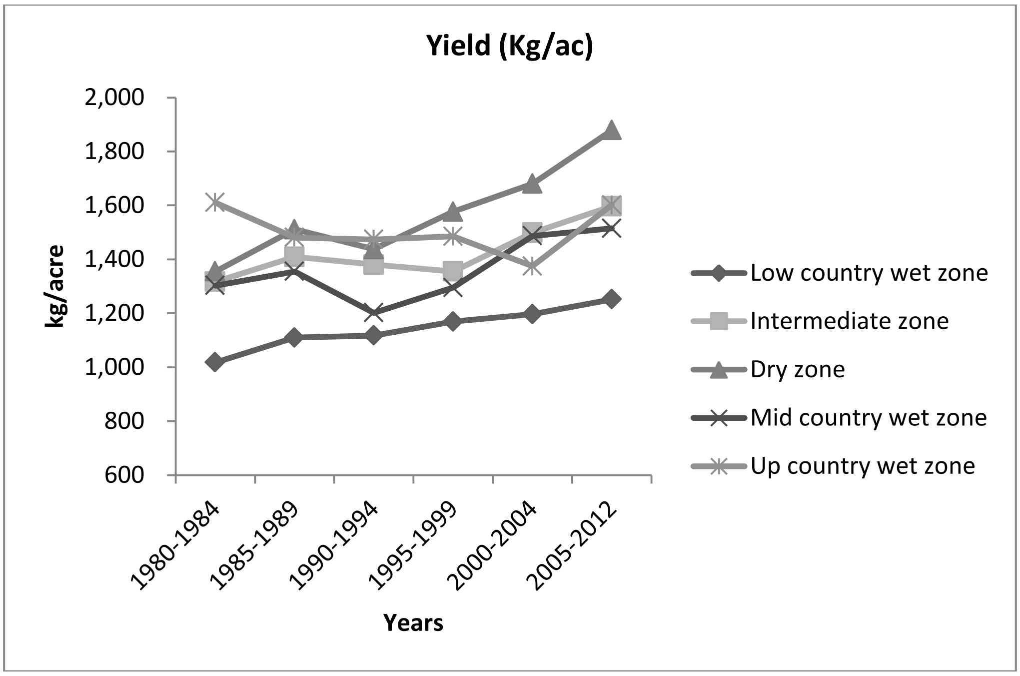
| | | |
|---|---|---|
| AI | – | Agriculture Instructor |
| ASC | – | Agriculture Service Centre |
| OLS | – | Ordinary Least Square |
| LCWZ | – | Low Country Wet Zone |
| ML | – | Maximum Likelihood |
| TE | – | Technical Efficiency |

# CHAPTER ONE

# Introduction

## 1.1 Background of the Study

Paddy sector in Sri Lanka is largely supported through the provision of fertilizer subsidy and a guaranteed price scheme implemented along with the purchase of a share of the total paddy harvest of the country[1]. This sector is heavily dependent on government support. For instance, Rs 36,456 million (Central Bank 2012) has been spent on the fertilizer subsidy alone. Increasing production cost, low yield, adverse weather conditions and lack of labour, marketing problems are key impediments of the paddy sector in the country.




Source: Department of Census and Statistics

**Figure 1.1: Average Yield in Agro-ecological Zones**

In the Low Country Wet Zone (LCWZ) the yield is the lowest compared to the other zones (Figure 1.1) in the country. Therefore it can be argued that paddy farming is unprofitable in the LCWZ. The yield gap between the LCWZ and other agro-ecological zones is considerably high. Around a 50% productivity gap with dry zone, 28% with intermediate zone and up country wet zone, 21% with mid country wet zone have been highlighted during 2005-2012. Furthermore, yield variation in districts of LCWZ was highlighted even if some farmers obtained a better yield and some farmers received a low yield in a same plot. However, the average yield is 1252 kg/acre in

[1] The subsidies provided for fisheries, agriculture and other areas amounted to Rs. 48 billion of which Rs. 36 billion was for fertilizer subsidy (Ministry of Finance and Planning, 2012). It was increased from Rs. 2.4 billion to Rs. 36 billion during past decade (2002-2012).

LCWZ during 2005-2012. On the other hand, unfavourable weather conditions, problems of soil condition such as iron toxicity, salinity and acidity, low temperature, floods, bog and half bog soils, water logging problem are some of the major natural obstacles to obtain a better yield in the LCWZ.

Reduction of yield gap among districts in LCWZ is a significant issue which has to be given priority. It is revealed that instability of paddy production in the Wet Zone (WZ) is much lower than Intermediate Zone (IZ) and Dry Zone (DZ) (Fernado *et al*, 2009). Although the DZ is highly vulnerable to adverse weather conditions it is a major contributor while the WZ is considered to be a buffer zone in production. Therefore it is timely to pay attention to address the issue of yield fluctuation among districts in the LCWZ.

## 1.2 Significance of the Study

The resource use inefficiency in paddy farming has contributed to such variations in the productivity across the LCWZ districts. Technical Efficiency (TE) is used as an indicator to determine whether output reached is at its optimal level in production. Both technical and socio-economic factors may impact the resource use inefficiencies. On the other hand, if it is possible to identify characteristics of efficient farmers and inefficient farmers, it would be helpful to improve the efficiency of paddy production. While, there are many studies which examine the technical efficiency of paddy farming in the dry and intermediate zones while there is a dearth of literature on LCWZ. Therefore it is imperative to study technical efficiency of paddy farming in order to provide policy directions on optimum use of agricultural resources in paddy farming of Low Country Wet Zone.

## 1.3 Objectives

The main objective of this study is to analyze input use efficiency of paddy farming in the Low Country Wet Zone and determine the socio-economic factors that affect the efficient use of resources in paddy farming.

Specific objectives are;

i. To estimate the technical efficiency of paddy farming and returns to scale in the LCWZ.
ii. To identify socio-economic factors that affect the efficient use of resources of paddy farming in the LCWZ.
iii. To propose policy recommendations for improving the efficiency of resource use in paddy farming in the LCWZ.

## 1.4 Methodology

### 1.4.1 Study Locations

Study locations have been selected from all Low Country wet zone districts which are Colombo, Gampaha, Kalutara, Kegalle, Ratnapura, Galle and Matara. The total number of paddy farmers in the LCWZ was considered as the study population. There are 187,474 of paddy farmers (Total number of farmers who had received fertilizer subsidy in 2012 *yala* season, source: Department of Agrarian Development) in the region. Sample size was determined on the basis of survey random sample calculator and accordingly 495 farmers were selected subject to 5% sampling error. The study locations and the selected sample have been shown in table 1.1.

Multi-stage sampling technique was employed to select the sample. In the first stage, three Agriculture Service Centres (ASC) were selected considering highest extent cultivated of each district in 2013 *Yala* season. At the second stage, two villages were selected from each ASC with respect to the highest extent at village level. At the final stage, farmers were randomly selected representing a proportionate sample size in each ASC division.

**Table 1.1: Study Locations and Sample Size**

| Districts | Agrarian Service Centres | Sample Size (No) | Total Sample Size (No) |
|---|---|---|---|
| Kegalle | Baminiwatta | 24 | 58 |
| | Paragammana | 17 | |
| | Daliwala | 17 | |
| Ratnapura (Figure 1.2) | Pelmadulla | 48 | 84 |
| | Elapatha | 23 | |
| | Ahaliyagoda | 13 | |
| Kalutara | Matugama | 34 | 85 |
| | Agalawatta | 27 | |
| | Millaniya | 24 | |
| Galle | Uragasman Handiya | 33 | 80 |
| | Karandeniya | 25 | |
| | Aluthwala | 22 | |
| Matara (Figure 1.2) | Akurassa | 44 | 109 |
| | Malimbada | 37 | |
| | Wilpita | 28 | |
| Gampaha | Galahitiyawa | 18 | 49 |
| | Meerigama | 17 | |
| | Ja-ela | 14 | |
| Colombo | Homagama | 12 | 30 |
| | Kasbewa | 10 | |
| | Padukka | 8 | |
| Total | | 495 | 495 |

As Ratnapura and Matara districts consist of other climatic zones than LCWZ the highest extent was considered in the selection of ASC's of the two districts. Therefore the highest extent within LCWZ was considered when selecting the ASCs in Ratnapura and Matara districts.

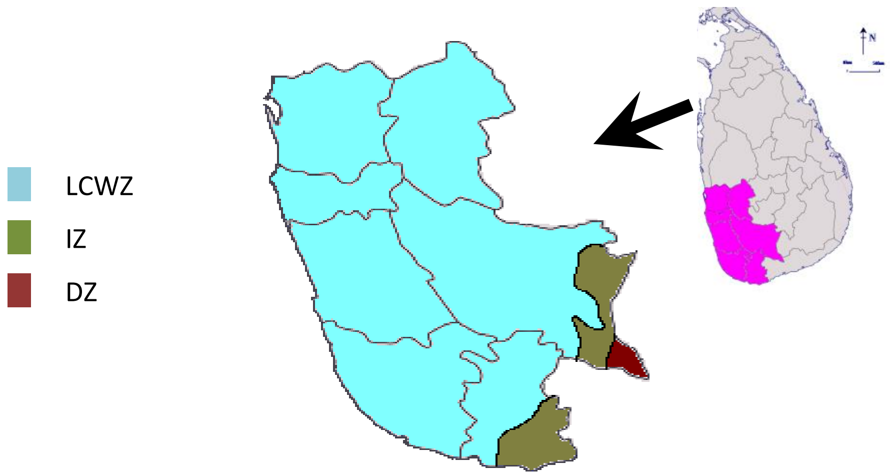



**Figure 1.2: Districts in Low Country Wet Zone**

### 1.4.2 Data

The sample survey focused on collecting primary data needed for this study. The data was gathered with respect to 2013 *yala* season through a structured pre tested questionnaire which was designed to achieve study objectives. Agriculture Instructors (AIs) were interviewed to gather necessary information through a structured questionnaire.

Secondary information was obtained from the Department of Census and Statistics, Department of Agrarian Development, Provincial Agricultural Departments, Agriculture Service Centers (ASC) and published and unpublished reports and other relevant documents.

### 1.4.3 Data Analysis and Presentation

Collected data from the sample survey was analyzed by using SPSS 20 and STATA 12 statistical packages. The analyzed data are presented in tabular and graphical forms. Descriptive statistics and inferential statistics are presented in the report.

### 1.4.4 Model Specification

The original specification involved a production function specified for cross-sectional data with an error term which has two components, one to account for random effect and another for technical inefficiency. The model can be presented in the following form (Coelli, 1996).

$$Yi = Xi\, \beta + \varepsilon i$$
$$\varepsilon i = V_i - U_i$$

Where Yi is the production of the $i^{th}$ farmer;

Xi is a kx1 vector of input quantities of the $i^{th}$ farmer;

β is an vector of unknown parameters;

$V_i \sim N(0,\sigma_v^2)$ - random variables which are assumed to be independent and identically distributed (iid).

$U_i \sim |N(0,\sigma_u^2)|$ - non- negative random variables which are assumed to account for technical inefficiency in production and often assumed to be independent and identically distributed (iid).

The parameter $\gamma$, which replaces $\sigma_v^2$ and $\sigma_u^2$ with $\sigma^2$. So that $\sigma^2 = \sigma_v^2 + \sigma_u^2$

Thus $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$

If the null hypothesis that $\gamma$ equals zero, is accepted, this will indicate that $\sigma_u^2$ is zero and hence that $U_i$ term should be removed from the model, leaving a specification with parameters that can be consistently estimated using OLS. On the other hand, $\gamma = 1$ indicates that the difference is entirely due to inefficient use of technology (Coelli, 1996).

### 1.4.5 Empirical Model

The Cobb-Douglas production function is defined as stochastic production function. The model can be specified;

$$\ln Y_{ij} = \ln\beta_0 + \beta_1 \ln X_{1ij} + \beta_2 \ln X_{2ij} + \beta_3 \ln X_{3ij} + \beta_4 \ln X_{4ij} + \beta_5 \ln X_{5ij} + \beta_6 \ln X_{6ij} + \alpha_1 D_1 + \varepsilon_{ij} \text{ -------- } (1)$$

Where ln denotes logarithms and

$Y$ = Total output (kg/ac)

$X_1$ = Family labour (man days/ac)

$X_2$ = Hired labour (man days/ac)

$X_3$ = Quantity of fertilizer (NPK) (kg/ac)

$X_4$ = Expenditure on agro-chemicals (Rs/ac)

$X_5$ = Cost of machinery (Rs/ac)

$X_6$ = Non paddy income (Rs/month/household)

$D_1$ = Age of varieties; 3 ½ month varieties=1, 3 month varieties = 0

$\varepsilon_{ij} = V_{ij} - U_{ij}$

Subscript i and j refer to the $i^{th}$ farmers and the $j^{th}$ inputs respectively. $\beta_0, \beta_1 \dots \beta_6$ and $\alpha_1$ are parameters to be estimated. V and U are assumed to be independent of each other.

V is the symmetric (two-sided) component, normally distributed random error ($Vi \sim N(0,\sigma v^2)$) and U is the one-sided efficiency component with a half-normal distribution ($Ui \sim |N(0,\sigma u^2)|$) which is non negative random variable. Therefore Maximum Likelihood (ML) approach was employed to estimate production function. Technical efficiency for each farmer was derived from estimating the production function (equation 1).

After that using that it was derived the technical efficiency for each farmer, which was used for estimating the linear Tobit Regression Model (equation 2) to analyze the effect of certain socio-economic factors on the technical efficiency of the farmer (Egbetokun and Ajijola, 2008).

Model specification is;

$$\mathbf{TEi = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \theta_1 ZD_1 + \theta_2 ZD_2 + \theta_3 ZD_3 + \theta_4 ZD_4 + \in_I} \text{-------} \mathbf{(2)}$$

Where TE is the technical efficiency index for farmer i

$Z_1$ = Land size (ac)

$Z_2$ = Age of the farmers (years)

$Z_3$ = Level of education (years of schooling)

$Z_4$ = Quantity of fertilizer (kg)

$ZD_1$ = Extension awareness; awareness =1, otherwise = 0

$ZD_2$ = Ownership; Own paddy land = 1, otherwise = 0

$ZD_3$ = Type of primary employment; Full time farmer = 1, part time farmer = 0

$ZD_4$ = Quality of seed paddy; Certified seed = 1, otherwise = 0

$\in_i$ = error term

Simple budgeting techniques to estimate costs and returns were applied to analyze economics of paddy farming in LCWZ.

**Organization of the Report**

The introductory chapter discusses the significance of the study, main and specific objectives and the methodology. Second chapter provides an overview of the literature on technical efficiency and its determinants. Third chapter discusses socio-economic background of the selected sample. Characteristics of Input use are described in chapter four. Chapter five examines the yield, cost and returns of the paddy farming. Efficient use of resources is discussed in Chapter Six. Last chapter draws conclusions and recommendations.

# CHAPTER TWO

# Literature Review

This chapter describes the yield variation in LCWZ as well as in other parts of the country. It also details out an analysis of previous studies done with regards to technical efficiency and its determinants.

## 2.1 Agro-Ecological Background and Yield of Paddy Farming in LCWZ

In order to achieve optimum rice yield, optimum levels of the agro-ecological conditions are required which are water availability, ability of soil to retain standing water, nutrient availability, sufficient rate of percolation, oxygen availability, adequate soil depth, workability of land, absence of soil toxicity, absence of flood hazards and erosion, temperature over 20 °C, solar radiation greater than 300 calories per $cm^2$ per day, lack of noxious weeds and lack of pests and diseases (Somasiri and Ratnayake, 1988). However, rain is the primary source of water with an annual rainfall greater than 2500 mm in LCWZ is reported. The annual rainfall of the zone is 1450-2540 mm and there is a clear bimodal distribution pattern of rainfall in all the regions. Quantity and frequency of rainfall and length of the rainy season is one of the major characteristics in this zone and drainage associates in rainfall.

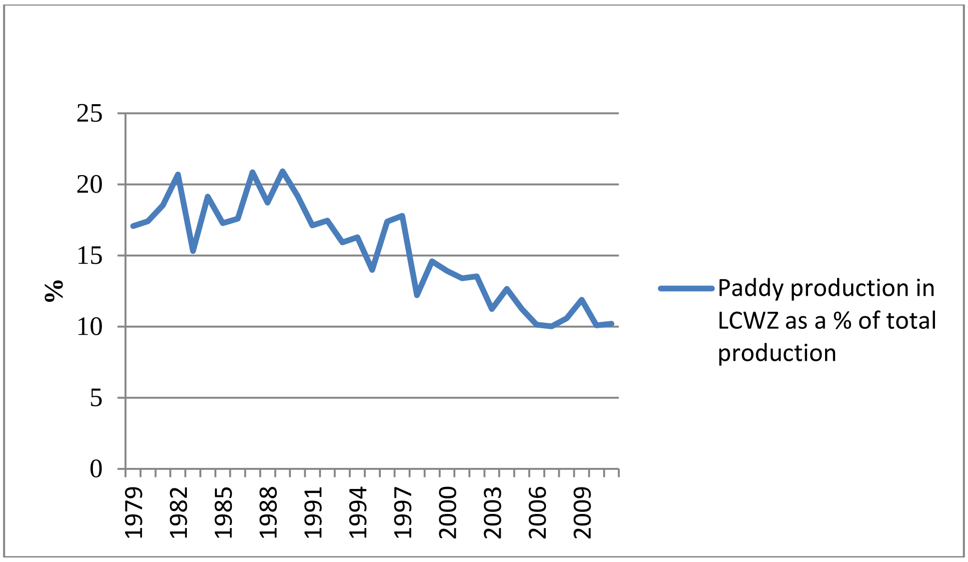
**Table 2.1: Agro-ecological Regions and its Characteristics**

| Agro-ecological zones | Annual Average Rainfall | Soil types | Expected Yield (kg/acre) | Main Problems Associated with Rice Growing |
|---|---|---|---|---|
| **WL1** | 2540 mm | Red Yellow Podsolic soil situated in rolling and undulating terrain and also some River Alluvial soils in flat terrain. | 810-2024 kg/ac | Being flood prone in low lying areas, Iron toxicity and the organic soils in certain areas |
| **WL2** | 1900 mm | Red Yellow Podzolic soil with strongly mottled sub soil, Low Humic Gley (LHG) and some Alluvial soils situated in rolling and undulating terrain | 1215 – 1619 kg/ac | Iron toxicity problem may occur in certain areas |
| **WL3** | 1520 mm | Red Yellow Podzolic soils in soft latarite and Alluvial soils in almost flat terrain in various drain agerial classes | 1619 – 2024 kg/ac | Mineral soils. Iron toxicity in some of the rice fields |

Source: Department of Agriculture

Three agro-ecological zones which are WL1, WL2 and WL3 in LCWZ and its main characteristics present in table 2.1. Accordingly expected yield varies from 810 kg/acre to 2024 kg/acre. According to the Department of Agriculture, the environmental condition is a major factor to determine the yield in Sri Lanka. Accordingly, "Solar radiation is not a limiting factor for rice growth in almost all rice growing zones in Sri Lanka. However, when all other conditions such as water, nutrients and temperature are non-limiting, the intensity of sunlight may determine the yield level depending on the location and season. For example, in the Wet zone, solar radiation may limit the rice yield during *Yala* season due to high cloud cover arising from the southwest monsoonal circulation whereas a similar situation could expect in the Dry zone during *Maha* season due to overcast conditions that may result in due to weather systems formed in the Bay of Bengal and northeast monsoonal circulation" (www. agridept.gov.lk)

Though, around 65 percent of total paddy production in Sri Lanka is produced in the Dry Zone, 22 percent produced in the Intermediate Zone and 13 percent out of the total is produced in the Wet Zone. The main contributor in Wet Zone is LCWZ which provides 11 percent from total paddy production during year 2005 to 2012. However, LCWZ contribution for the total paddy production in the country is gradually decreasing (Figure 2.1) during the past three decades.




Source: Department of Census and Statistics

**Figure 2.1: LCWZ Contribution to Total Paddy Production in Sri Lanka**

Low yield is a pressing problem for the paddy farmers in this zone compared to that of Dry Zone and Intermediate Zone. Although, during the past ten years (2003-2012) it was observed that the yield of LCWZ has increased marginally (Table 2.2) wide fluctuations in yield across districts in the zone.

**Table 2.2: Paddy Yield in LCWZ (2003 and 2012)**

| Districts | Yield | |
|---|---|---|
| | 2003 | 2012 |
| Colombo | 1,226 kg/ac | 1,376 kg/ac |
| Gampaha | 1,219 kg/ac | 1,378 kg/ac |
| Kalutara | 984 kg/ac | 1,230 kg/ac |
| Matara | 1,285 kg/ac | 1,371 kg/ac |
| Galle | 1,255 kg/ac | 1,359 kg/ac |
| Ratnapura | 1,157 kg/ac | 1,377 kg/ac |
| Kegalle | 1,312 kg/ac | 1,380 kg/ac |

Source: Department of Census and Statistics

Low yield may lead to diminish the profitability level of paddy farming in Sri Lanka. However, an analysis of paddy production data demonstrated that average yield in Sri Lanka is 1762 kg/ac but average yield across districts varied from 1085 kg/ac (Jaffna) to 2055 kg/ac (Hambantota) in year 2012 (Annex Table 1).

## 2.2 Theoretical Background

Productivity is measured as the ratio of final output. Agriculture productivity refers to the output produced by a given level of inputs. More formally it can be defined as "the ratio of value of total farm outputs to value of total inputs used in farm production" (Liverpool-Tasie *et al*, 2011).

Efficient uses of resources in the production process have two dimensions; technical efficiency and allocative efficiency (Economic efficiency). The allocative efficiency tries to capture producers' ability to apply the input in optimal proportions with respective prices (Khai and Yabe, 2011). Technical Efficiency (TE) is used as an indicator to measure whether the output reaches its optimal levels with the given technology.

It is assumed that a firm uses two inputs (input 1 & 2) to produce a single output under the assumption that there are constant returns to scale. Isoquant curve represents the full efficient firms could allow measurement of technical efficiency and isocost line shows the allocative efficiency (figure 2.2).

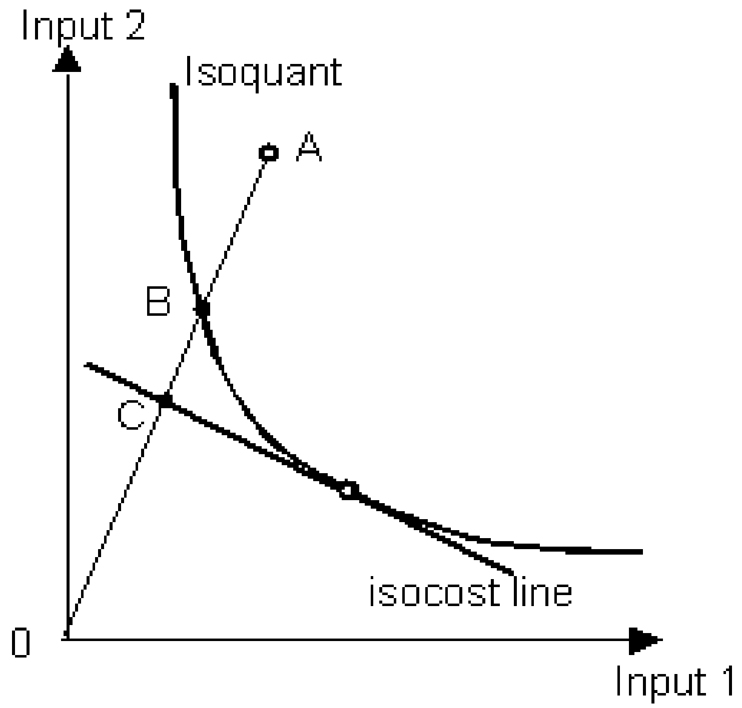



**Figure 2.2: Technical and Allocative Efficiency**

## 2.3 Resource Use Efficiency and Its Determinants

Productivity could be defined as the ratio of output per input for a particular production situation. Increase in production denotes that either more output is produced with the same amount of input or less input is required to produce the same level of output which is called efficiency. The concept of productivity is closely associated with efficiencies (Bhavan and Maheswaranthan, 2012). Many studies have focused on the efficient use of resources. The production function approach can be used as a tool to assess the relationship between inputs and output.

Output is a function of its inputs that is called production function. Cobb-Douglas production function is well known and mostly used for estimating the production frontier.

$$Q = f(X_i; \beta)$$

Where Q is the quantity of cowpea output, $X_i$ is a vector of input quantities, and $\beta$ is a vector parameter.

Egbetokun and Ajijola (2008) used farm size ($X_1$-hectars); seeds ($X_2$), hired labour cost ($X_3$), family labour ($X_4$ -man days), fertilizer ($X_5$) and pesticide ($X_6$ -litres) as inputs for production frontier.

$$\ln Y_{ij} = \ln \beta_o + \beta_1 \ln X_{1ij} + \beta_2 \ln X_{2ij} + \beta_3 X_{3ij} + \beta_4 X_{4ij} + \beta_5 X_{5ij} + \beta_6 X_{6ij} + \in$$

Subscript *i* and *j* refer to the $i^{th}$ cowpea produce and the $j^{th}$ input respectively and $\in = V_{ij} - U_{ij}$ is the composed error term. The two components v and u are assumed to be independent of each other, where v is the symmetric (two-sided) component, normally distributed random error. ($V \sim N(0,\sigma^2_v)$ which captures variations in output due to factors outside the control of the farmer such as fluctuations in input/prices and u is the one-sided efficiency component with a half-normal distribution ($U \sim |N(0,\sigma^2_u|$) which is non–negative random variable called technical inefficiency effect associated with technical efficiency.

They considered socio-economic factors such as farm size, age, gender, extension awareness, level of education, corporative membership and farmer's farming experience while estimating Tobit regression model.

Dlamini *et al* (2012) aimed at estimating technical efficiency of maize production and determining the factors affecting technical efficiency. The stochastic frontier approach was used to estimate technical efficiency and Tobit model was used to determine the factors affecting technical efficiency of the farmers.

$$Y=\beta_0 X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5} e^{vi-ui}$$

Y=Maize output (kg/ha); $x_1$- amount of seed used (kg/ha); $x_2$- amount of fertilizer used (kg/ha); $x_3$- total amount of pesticide used (kg/ha); $x_4$- labour used (man days/ha); $x_5$- farm size (ha); $v_i$ – random error associated with measurement errors of production; $u_i$ – non negative random variables associated with technical inefficiency production by farmers.

$$Y_i = \beta_0 + \beta_1 Z_{1i} + \beta_2 Z_{2i} + \beta_3 Z_{3i} + \beta_4 Z_{4i} + \beta_5 Z_{5i} + \beta_6 Z_{6i} + \beta_7 Z_{7i}$$

Where $Y_i$ = technical efficiency (ratio); $Z_{1i}$ = farmer's age; $Z_{2i}$ = off farm income (0=no 1=yes); $Z_{3i}$ = formal schooling (years); $Z_{4i}$ = farmers experience (years); $Z_{5i}$ = household size; $Z_{6i}$ =seed type (0=hybrid 1=non-hybrid); $Z_{7i}$ = farming system (0= monocropping 1=intercropping). They found to be positively associated with farmer's age, having off farm income, farmer's experience, intercropping and use of hybrid seeds.

Majumder *et al* (2009) attempted to measure and compare resource use efficiency and relative productivity of farming under different tenure conditions. The study explored the difference in the efficiency and productivity among owner, cash tenant and crop share tenant. Cobb-Douglas production function was used to estimate effects of various inputs such as labour, seeding, fertilizer, and insecticides. Summation of all production coefficient indicators returns to scale.

Abedullah *et al* (2007) studied on future investment strategy that can enhance the production of rice in Punjab using stochastic frontier production approach. The results showed that pesticide is insignificant probably due to heavy pest infestation while fertilizer is found to have negative impact on rice production mainly improper combination of N, P and K nutrients. The results of inefficiency model suggest that investment on mechanization could significantly contribute to improve farmer's technical efficiency.

A stochastic frontier production function has been estimated to determine technical efficiency of individual farmers and regression analysis has been carried out to find the influence of socio-economic factors (Narala and Zala, 2010). It has been found that factors such as operational area, experience, education and distance of field from canal structure are most influential determinants of technical efficiency, while the variable number of working family members has shown a significant but negative relationship with technical efficiency.

Farm specific technical efficiency was calculated using a translog stochastic production frontier and estimated by Maximum Likelihood estimation methods (Seidu, 2012). The results showed that smallholder rice farmers are technically inefficient. There is a significant difference between mean technical efficiency for irrigators and non irrigators as well as male and female farmers. Credit availability, family size and non-farm employment significantly determine the technical efficiency of small holders. Amount of labour, land, animal power, chemical fertilizer, capital inputs including all cash expenditure for transporting and storing, fertilizer, seed, and machine hire and irrigation facilities had been used to estimate production function.

Shantha *et al*, (2012) found that age of farmers, paddy farming experience, water management knowledge, education level, distance of field from canal irrigation structure, sowing time, right of entry formal credit and contact with extension agencies as factors determining of technical efficiency of paddy farming.

The empirical analysis on smallholder maize farmers in Tanzania by Musya *et al* (2008), low level of education, lack of extension services, limited capital, land fragmentation and unavailability and high input prices have had a negative effect on technical efficiency. The farmers who use agrochemicals were found to be less efficient.

Education of the farmer and supplementary irrigation provided during water stress days have been identified as the factors which could enhance the technical efficiency (Suresh and Reddy, 2006). This study has further examined the resource productivity and allocative as well as technical efficiency of paddy production. Cobb-Douglas production function was estimated and chemical fertilizer, farm yard manure and human labour have been observed significant and positive.

Kularatne *et al* (2012) were examined the factors affecting the technical efficiency of irrigated rice farmers in village irrigation systems in Sri Lanka using stochastic translog production frontier. The most influential factors of technical efficiency are membership of farmer organization (FOs) and participatory rate in collective actions organized by FOs.

## 2.4 Estimation of Technical Efficiency in Sri Lanka

Misallocation of resources was showed in Mahaweli System H in Sri Lanka. Land with high elasticity of production was found to be seriously under utilized by almost all farmers especially during the *Maha* (Karunaratne and Herath, 1989).

The calculation of returns to scale parameters showed constant and increasing returns to scale for both *Maha* and *Yala* seasons. Frontier production function analysis showed that the farmers were more efficient during the *Yala* than during the *Maha.*

Chandrasiri and Karunagoda (2008) also revealed that a significant relationship between output and land, agrochemicals, fertilizer and machinery cost. The stochastic frontier production functions in Cobb-Douglas form is used to estimate the technical efficiency. TEs estimated in 2007 Maha and Yala Season in the North Central and North Western Provinces were 0.75 and 0.64 respectively (Chandrasiri and Karunagoda, 2008). The above data indicates a technical inefficiency of 30 percent in paddy sector which highlights the fact that there is a potential for increasing the output of paddy without increasing the inputs. Average technical efficiency of paddy farming has been estimated as 0.72 in Kurunegala district (Mohottalagedara, *et al*, 2012) and 0.69 in 2009/10 Maha Season in Trincomalee district (Shantha *et al,* 2012).

The linear Tobit regression model (Bhavan and Maheswaranthan, 2012) was employed to examine relationship efficiency score and socio-economic factors such as training for farmers, age, fertilizer subsidy, irrigation, farmers' experience, family size, and household. Gunaratne and Thiruchelvam (2002) have investigated the relationship between resource use characteristics and technical efficiency of paddy production. Results of the study indicated substantial differences in productivity, resource use and technical efficiency. The study also revealed that average technical efficiency of major irrigation scheme was greater than minor irrigation scheme. The low level of assets processed by the farmers and poor participation in farmer organization activities had significant influence on the technical efficiency. It was further highlighted that part time farming was associated with a higher level of inefficiency.

Udayanganie et al (2006) assessed the technical efficiency of paddy production in one of the major irrigation schemes in Sri Lanka with special emphasis on the usage of agro chemicals and determinants of technical efficiency.

The presence of technical inefficiency and its causality was investigated using a stochastic production frontier model. The results show a negative relationship between yield and the cost of pesticides indicating an overuse of pesticides. Among the determinants of technical efficiency estimated considered, the importance of credit and extension services on improving efficiency of farmer stands out while the farmers from neighbouring villages appear efficient than farmers settled in the villages.

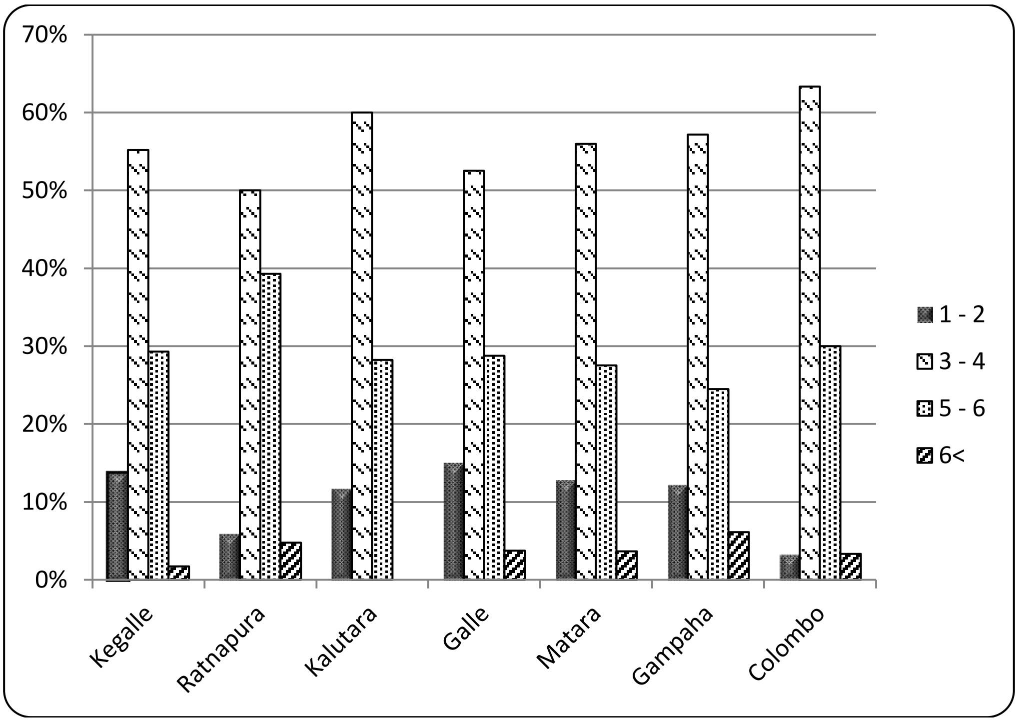
# CHAPTER THREE

## Socio-economic Background of Paddy Farming in LCWZ

Socio-economic background of the selected sample is discussed in this chapter. This information includes demographic characteristics of the respondents, family background and economic status of them.

### 3.1 Family Size

The distribution of family size among the selected households is important as agricultural activities in Sri Lanka largely depend on family labour. As shown in the figure 3.1, majority of the households (more than 50% of the total sample in each district) comprise 3-4 family members. Percentage of households with 3-4 members in the total sample was 56 whilst another 30 percent have 5-6 members in their families.

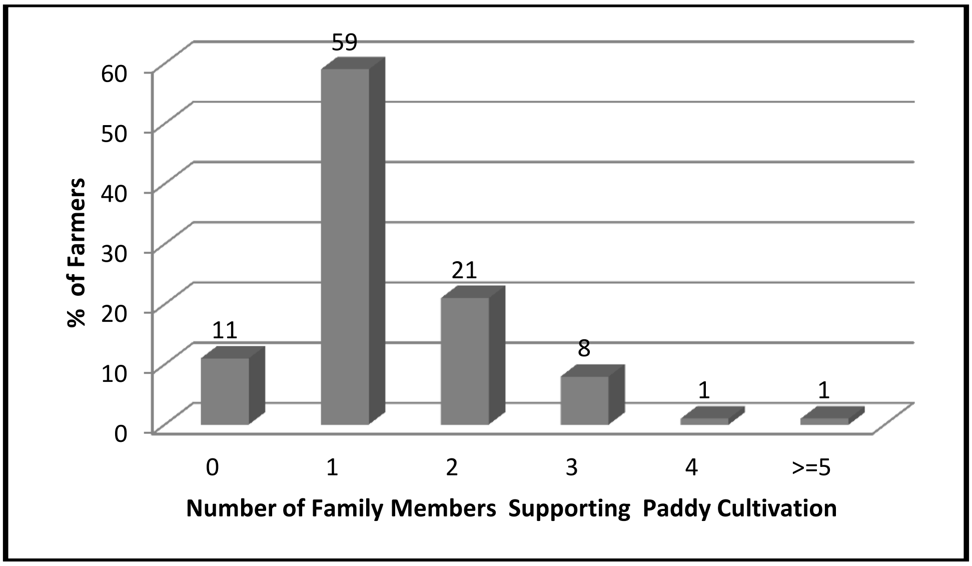



Source: HARTI Survey Data, 2013

**Figure 3.1: Family Size of Selected Households**

### 3.2 Household Labour Supporting Agriculture

As shown in the figure 3.2, 59 percent of the total sample families have at least one household member to support in agricultural activities whilst 21 percent of farmers have got the support from two family members and 11 percent had no support from family members.

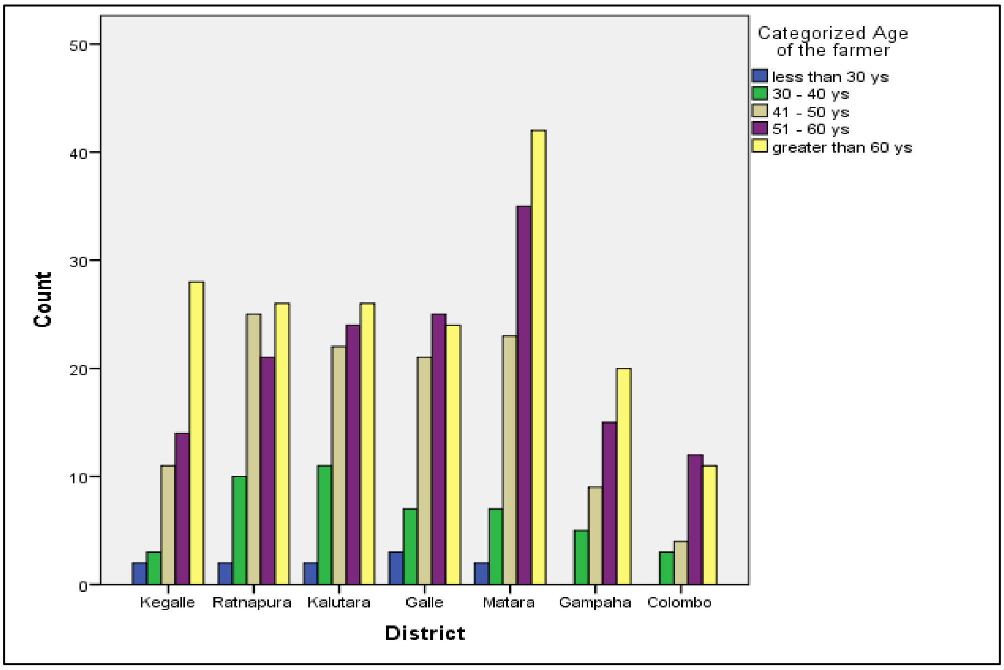



Source: HARTI Survey Data, 2013

**Figure 3.2: Availability of Supporting Household Labour for Paddy Cultivation (% of total sample)**

## 3.3 Age Distribution and Education Level

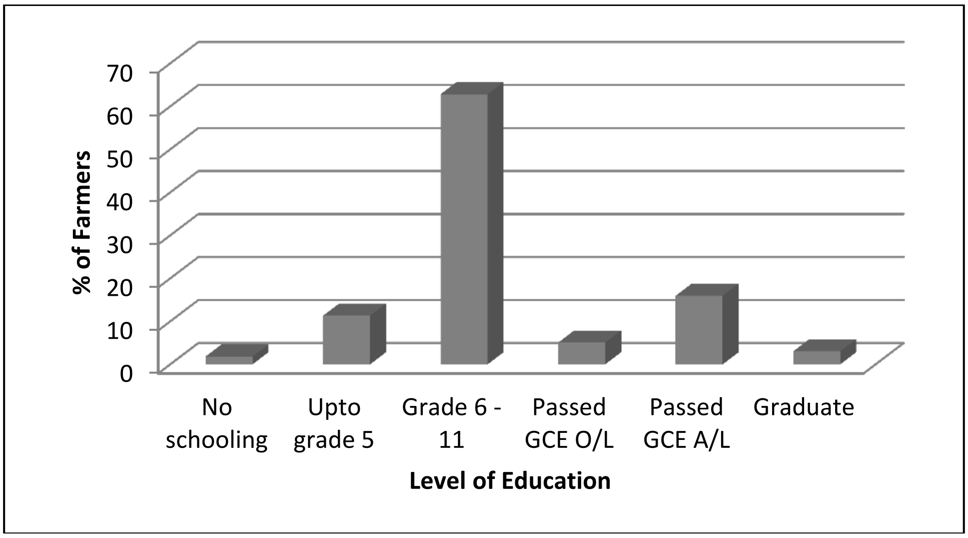
The majority of the farmers (66%) were above fifty years of age. The number of paddy farmers is greater than 30 years of age thus proving the point that younger generation of farmers are not involved in paddy cultivation. A similar pattern could be identified in all districts in the zone, which is majority of the farmers are over 50 years (Figure 3.3).




Source: HARTI Survey Data, 2013

**Figure 3.3: Age Distribution of Sample Farmers**

As shown in figure 3.4 only 21 percent of farmers had passed GCE Ordinary, Advanced Level schooling and those who have graduated were (3%) while 24 percent of the farmers had received a satisfactory level of education. Meanwhile 2 percent of farmers have never attended school. Proportion of farmers who have never had school education was only two percent.




Source: HARTI Survey Data, 2013

**Figure 3.4: Education Level of Sample Farmers (% of total sample)**

### 3.4 Employment

Survey results revealed that, 54 percent farmers from the total sample were engaged in farming on a full time basis and farming was their main income source. On the other hand, 46 percent farmers from the total sample were part time farmers and table 3.1 presents a breakdown of the types of employment that the farmers were involved in. However, Ratnapura, Gampaha and Colombo districts over 50% of the farmers were part time farmers.

**Table 3.1: Farmers by Type of Farming among Districts**

| District | Type of farming (% of Farmers) | |
|---|---|---|
| | Full Time | Part Time |
| Kegalle | 62 | 38 |
| Ratnapura | 33 | 67 |
| Kalutara | 55 | 45 |
| Galle | 59 | 41 |
| Matara | 64 | 36 |
| Gampaha | 49 | 51 |
| Colombo | 47 | 53 |
| Total Sample | 54 | 46 |

Source: HARTI Survey Data, 2013

Table 3.2 indicates secondary income sources of part time farmers. According to this table most of the farmers engaging in farming as a part time job were public or private sector employees (51%) whilst only 2 percent of farmers were engaged in agriculture related employment such as agricultural labour.

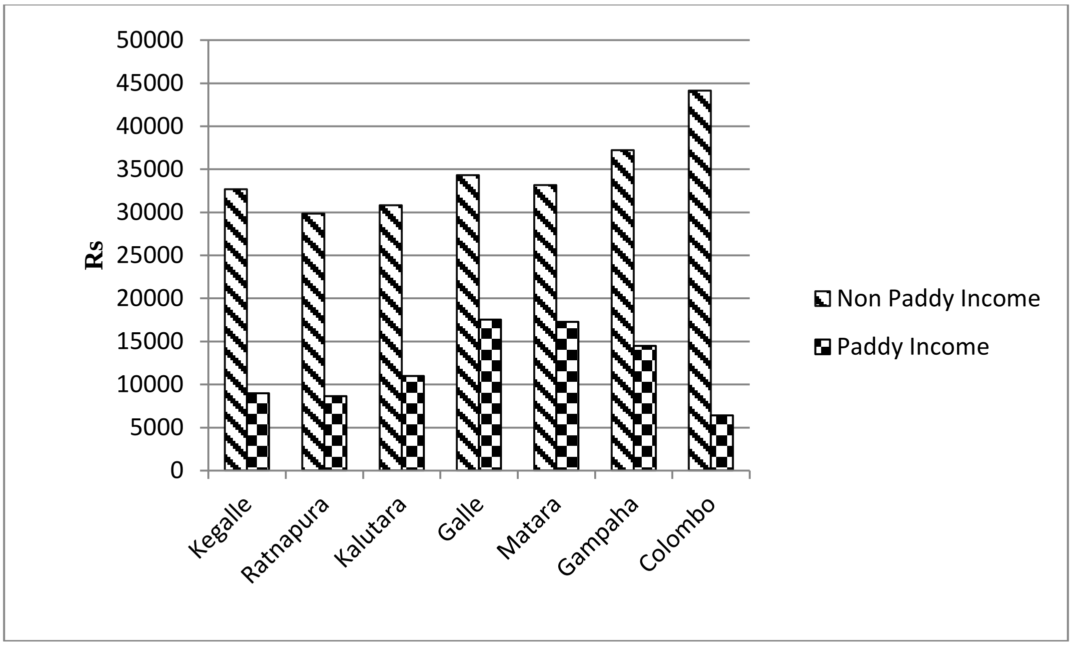
**Table 3.2: First Income Sources of Part time Farmers**

| Type of Employment | No. of Part time Farmers | % of Part time Farmers |
|---|---|---|
| Public/Private sector employment | 117 | 51 |
| Technical Jobs | 27 | 12 |
| Business | 27 | 12 |
| Non Agricultural Labour | 46 | 20 |
| Self Employment | 9 | 4 |
| Agricultural Labour | 4 | 2 |
| Overall | 230 | 100 |

Source: HARTI Survey Data, 2013

### 3.5 Family Income

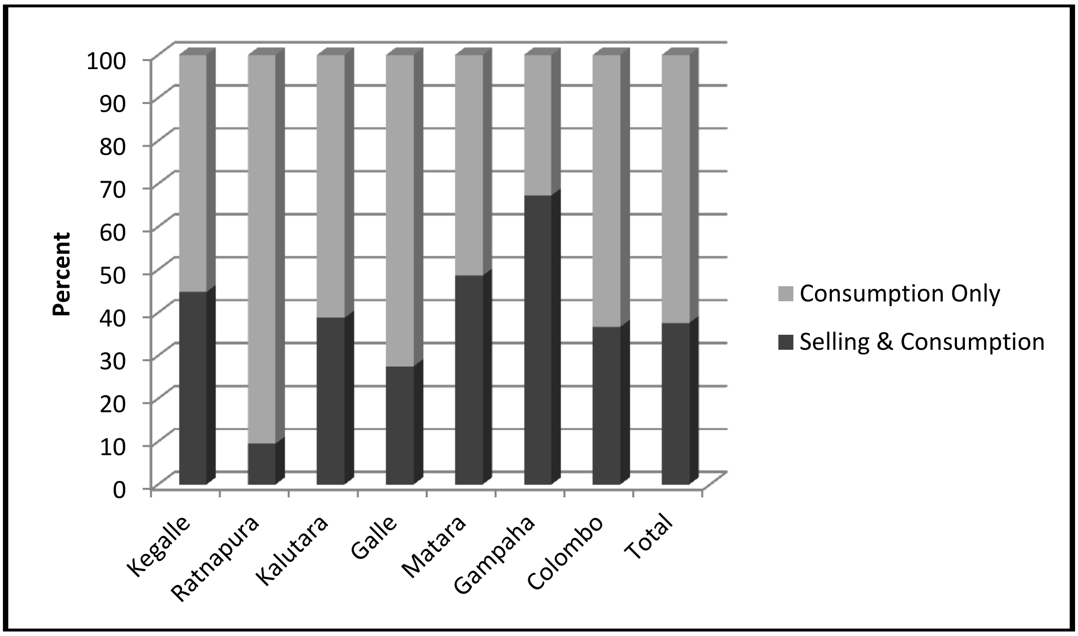
For an understanding of the total family income it is necessary to consider all the family income sources (both primary and secondary occupations) and the income of all family members. Figure 3.4 shows the pattern of non paddy income and paddy income distribution of the households in the sample.




Source: HARTI Survey Data, 2013

**Figure 3.5: Average Paddy and Non-Paddy Monthly Income of the Households**

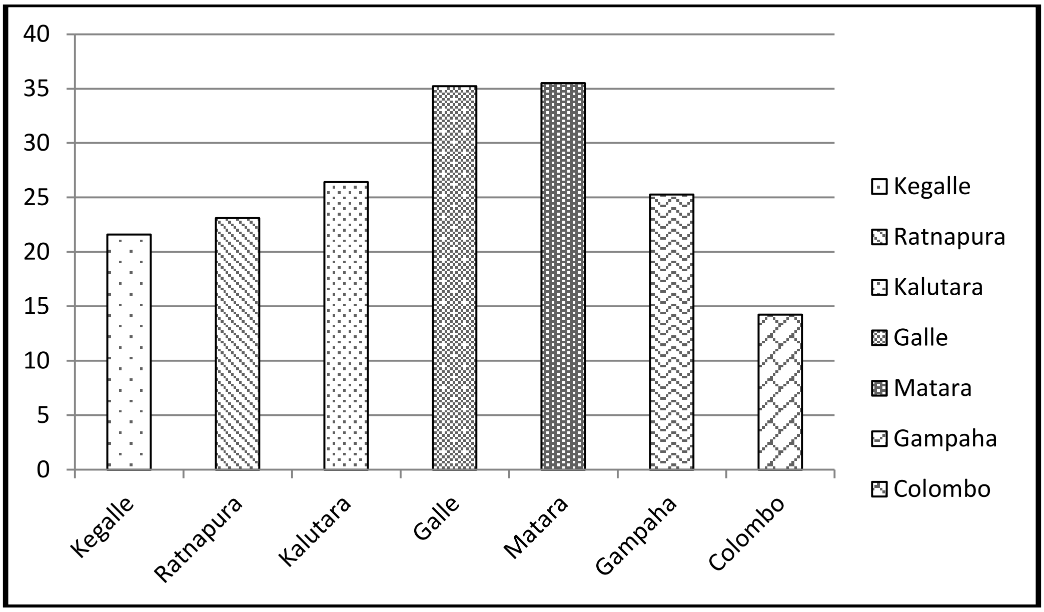
As shown in the figure 3.5, more than 50 percent (62%) farmers in the total sample cultivated paddy only for consumption and the situation was common in each district except in Gampaha district where 67 percent farmers had cultivated paddy for both consumption and selling purposes. These results prove that most of the farmers in LCWZ were not commercial level farmers and they were doing paddy farming at a subsistence level. This situation could be further explained by the Figure 3.6.




Source: HARTI Survey Data, 2013

**Figure 3.6: Purpose of Cultivating Paddy among LCWZ Farmers**

According to the Figure 3.7, income received from selling of paddy was less than 40 percent of the total household incomes in all the districts of LCWZ proving that farmers were depending on other income earning sources rather than depending solely on the paddy income.




Source: HARTI Survey Data, 2013

**Figure 3.7: Paddy Income as a Percentage of Total Household Income**

# CHAPTER FOUR

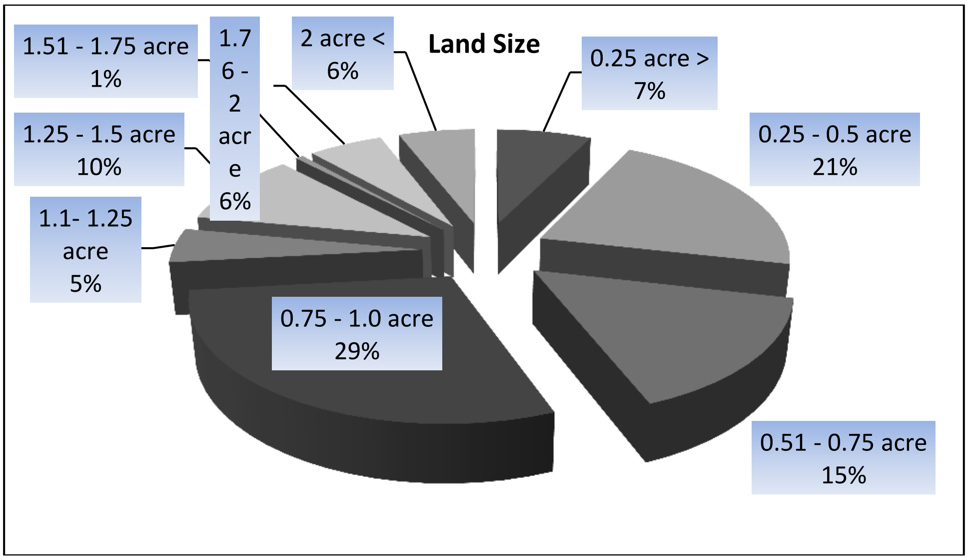
## Characteristics of Input Use in LCWZ

This chapter presents the characteristics of input usage in paddy production in LCWZ and constraints faced by farmers in using available resources in the area. Land; family labour; hired labour; machinery usage; seeds; fertilizer and agro-chemicals are considered as available resources. Although climatic factors such as temperature, oxygen availability, solar radiation and rainfall are assumed to be similar in the agro ecological region and the season which were considered in the study were unique.

### 4.1 Land

The soils in the LCWZ are classified as mineral and organic soils (Thedchanamoorthy, 2005) the major constraints in the wet zone where rainfall is high and well distributed are iron toxicity, flooding and acid sulphate conditions.

As shown in the figure 4.1, more than 70 percent of farmers have lands less than one acre while for 45 percent it was 0.5 – 1 acre and 28 percent of farmers have lands smaller than 0.5 acre.




Source: HARTI Survey Data, 2013

**Figure 4.1: Land Size in the LCWZ**

Efficiency required for land development and maintenance are related to land ownership-tenure ship. Individual property rights also would affect efficiency directly.

In the sample around 65 percent of farmers (Table 4.1) were having their own paddy lands while the balance (around 35%) was “Ande” and “Thattu Maru” tenure systems.

**Table 4.1: Ownership of the Paddy land**

| Ownership- Tenure Arrangement | Frequency | Percent |
|---|---|---|
| Owned | 324 | 65.5 |
| Co-ownership | 15 | 3.0 |
| Borrowed on 'Ande" | 133 | 26.9 |
| lease hold | 2 | 0.4 |
| "Thattu Maru" | 20 | 4.0 |
| Lent on "Ande" | 1 | 0.2 |
| Total | 495 | 100.0 |

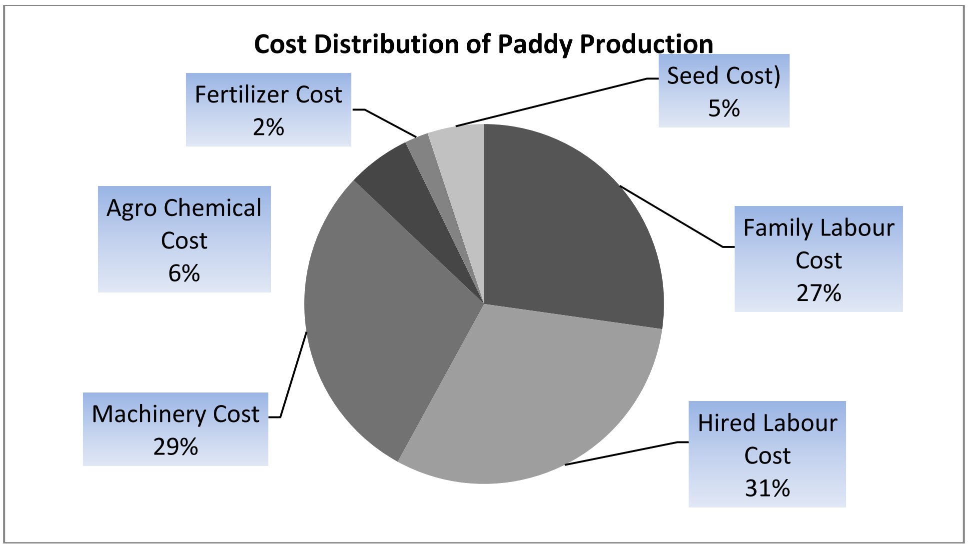
Source: HARTI Survey data, 2013

Problems relating to paddy land as identified by the farmers are soil infertility, irrigation, iron toxicity, salinity, flooding, water logging, and solar radiation. Specially, gem mining in the paddy lands in Ratnapura district brings negative implications such as soil erosion, paddy land not being totally restored for paddy farming and also the cost of re-established being high.

## 4.2 Labour

### 4.2.1 Family Labour

Labour is one of the critical factors in paddy production because paddy is a labour intensive crop still in Sri Lanka. Machinery usage in LCWZ seems to be lower when compared with other regions in Sri Lanka. Combine harvester was the predominantly used machine in this region which has reduced the labour requirement for activities of harvesting threshing drawing and winnowing. There is a combined harvester called chain type (small) which can be used in water logged soils. The largest cost component is the cost incurred for labour which amounts to 58 percent of which 31 percent is hired labour cost.




Source: HARTI Survey data, 2013

**Figure 4.2: Input Cost Distribution as a Percentage of Total Cost (Rs/acre)**

Operations that use more family labour were general land preparation, first and second ploughing, plastering of bunds, levelling, broadcasting, harvesting, drawing and threshing with thresher. Use of family labour varies with the method of plant establishment.

**Table 4.2: Distribution of Family Labour by District and Method of Plant Establishment**

| Districts | Average Family labour (man days/acre) | | | |
|---|---|---|---|---|
| | Transplanting | Broadcasting | "Parachute" | Seeder use for planting |
| Kegalle | 19.9 | 16.2 | 17.6 | |
| Ratnapura | | 16.4 | | |
| Kalutara | 6.1 | 12.6 | | |
| Galle | 4.5 | 9.1 | | |
| Matara | | 7.8 | | |
| Gampaha | | 12.4 | | 4.6 |
| Colombo | | 12.5 | | |
| Overall | 16.7 | 11.6 | 17.6 | 4.6 |

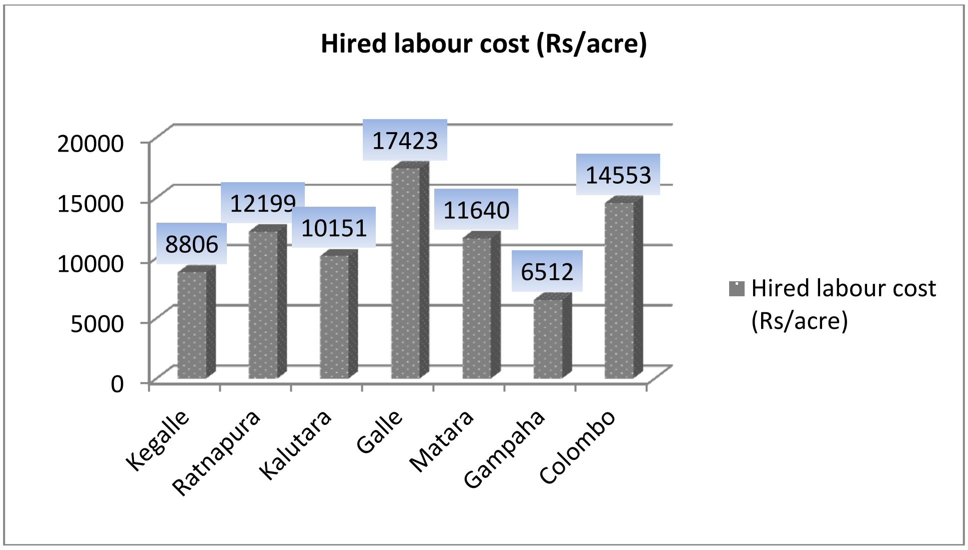
Source: HARTI Survey data, 2013

Table 4.2, farmers in Kegalle and Ratnapura districts use more family labour than other districts in the sample. Parachute and transplanting method of plant establishments requires more labour days.

The survey results further revealed that more labour units were consumed during the period of plant establishment. Kalutara and Galle farmers used more hired labour for transplanting compared to other districts.

### 4.2.2 Hired Labour

Though the amount of hired labour used in paddy cultivation varied across districts, it has played an important role in paddy cultivation in LCWZ by contributing around 31 percent (Figure 4.2) to the total cost. Accordingly, highest hired labour cost per acre has been reported in the Galle district (17,423 Rs/ac) and Colombo district (14,553 Rs/ac). This is due to the fact that for farmers in Galle district cultivation of cinnamon and its related activities is the main source of income, therefore farmers use hired labour for paddy cultivation whereas in Colombo district the availability of other employment has had an impact on the cost of hired labour. According to the farmers, it is profitable to use hired labour in paddy production and engage in cinnamon cultivation than utilize family labour for paddy production.




Source: HARTI Survey data, 2013

**Figure 4.3: Distribution of Hired Labour Cost in LCWZ**

The highest wage rate for hired labour was recorded in Colombo district. Although the prevailing demand for hired labour for agriculture was higher in the area, skilled labourers were reluctant to engage in paddy production in LCWZ due to several reasons such as seasonality in employment and availability of more employment opportunities in other sectors.

**Table 4.3: Hired Labour Cost Distribution among Districts (Rs/day)**

| Districts | Average hired labour cost (Rs/day) | | | | |
|---|---|---|---|---|---|
| | Mean | Percentile 05 | Percentile 25 | Median | Percentile 75 |
| Kegalle | 448 | - | - | 500 | 746 |
| Ratnapura | 613 | - | 588 | 730 | 795 |
| Kalutara | 803 | - | 800 | 973 | 1000 |
| Galle | 813 | 568 | 749 | 843 | 912 |
| Matara | 853 | - | 800 | 957 | 1000 |
| Gampaha | 537 | - | - | 780 | 1000 |
| Colombo | 910 | - | 989 | 1057 | 1200 |

Source: Survey data, 2013, HARTI

Lack of hired labour for paddy farming was a major problem identified in the region. Age of the people who were involved in paddy farming was the main contributory factor for this situation as majority of farmers are over fifty years of age.

## 4.3 Machinery

As in other districts in Sri Lanka land preparation and harvesting are mechanised operations for paddy cultivation. For land preparation two wheel and four wheel tractors are used while the combine thresher and harvester are used for harvesting. Although the results of the survey revealed that farmers in the region were not paying much attention to levelling of their paddy fields, according to the literature, land levelling is an important practice as it improves the water and fertilizer use efficiency and also it helps in effective weed and pest management (Thedchanamoorthy, 2005). Machines used for harvesting of paddy varied across districts. Combine Threshing machines were mostly used in the Kegalle district while combine harvesters were popular in Galle, Matara and Kalutara districts and farmers in the Ratnapura district and few in Galle district preferred the Agrimec machine.

**Table 4.4: Distribution of the Machinery Usage Cost**

| Districts | Machinery cost (Rs/acre) | | | |
|---|---|---|---|---|
| | **Mean** | **SD** | **Median** | **Mode** |
| Kegalle | 11065 | 5099 | 10600 | 14000 |
| Ratnapura | 8529 | 3640 | 9337 | 3000 |
| Kalutara | 11504 | 4291 | 11725 | 11800 |
| Galle | 9163 | 3382 | 90 80 | 11000 |
| Matara | 12711 | 4149 | 13377 | 13800 |
| Gampaha | 14112 | 5073 | 14345 | 11200 |
| Colombo | 12631 | 4725 | 12000 | 10000 |

Source: HARTI Survey data, 2013

As shown in the table 4.4, machinery cost was lowest in the Ratnapura district followed by Galle district while the highest cost for machines was reported in Gampaha district.

## 4.4 Materials

Fertilizer usage in paddy cultivation has not varied considerably among districts due to the subsidy, however, quality and quantity of seeds and agrochemical use varied among the districts. As per the survey results, 61 percent of the total sample has used certified seeds with more than 50 percent of farmers in all the districts except Ratnapura (32%) have used certified seeds. Farmers pointed out that there were a multitude of problems in obtaining seeds such as lack of quality seeds, obtaining quality seeds in time and the increasing price of the seed paddy.

According to the results, application of weedicide was more prominent than the application of pesticide among farmers in the region. As illustrated by figure 4.3 around 60 percent of farmers had not applied pesticide while 10 percent of the total sample had not used any type of agrochemical for their cultivation. More than 75 percent of the farmers had used chemicals for weed controlling due to convenience in application, high effectiveness and less labour usage. About 43 percent of the farmers had applied weedicides before the first plough while another 24 percent had practised it within 7-9 days of broadcasting.

**Table 4.5: Percentage of Farmers Using Seed Paddy**

| District | No of farmers used seed paddy (%) | | |
|---|---|---|---|
| | Certified | Not certified | Total |
| Kegalle | 57 | 43 | 100 |
| Ratnapura | 32 | 68 | 100 |
| Kalutara | 55 | 45 | 100 |
| Galle | 65 | 35 | 100 |
| Matara | 83 | 17 | 100 |
| Gampaha | 69 | 31 | 100 |
| Colombo | 67 | 33 | 100 |
| Total | 61 | 39 | 100 |

Source: HARTI Survey data, 2013

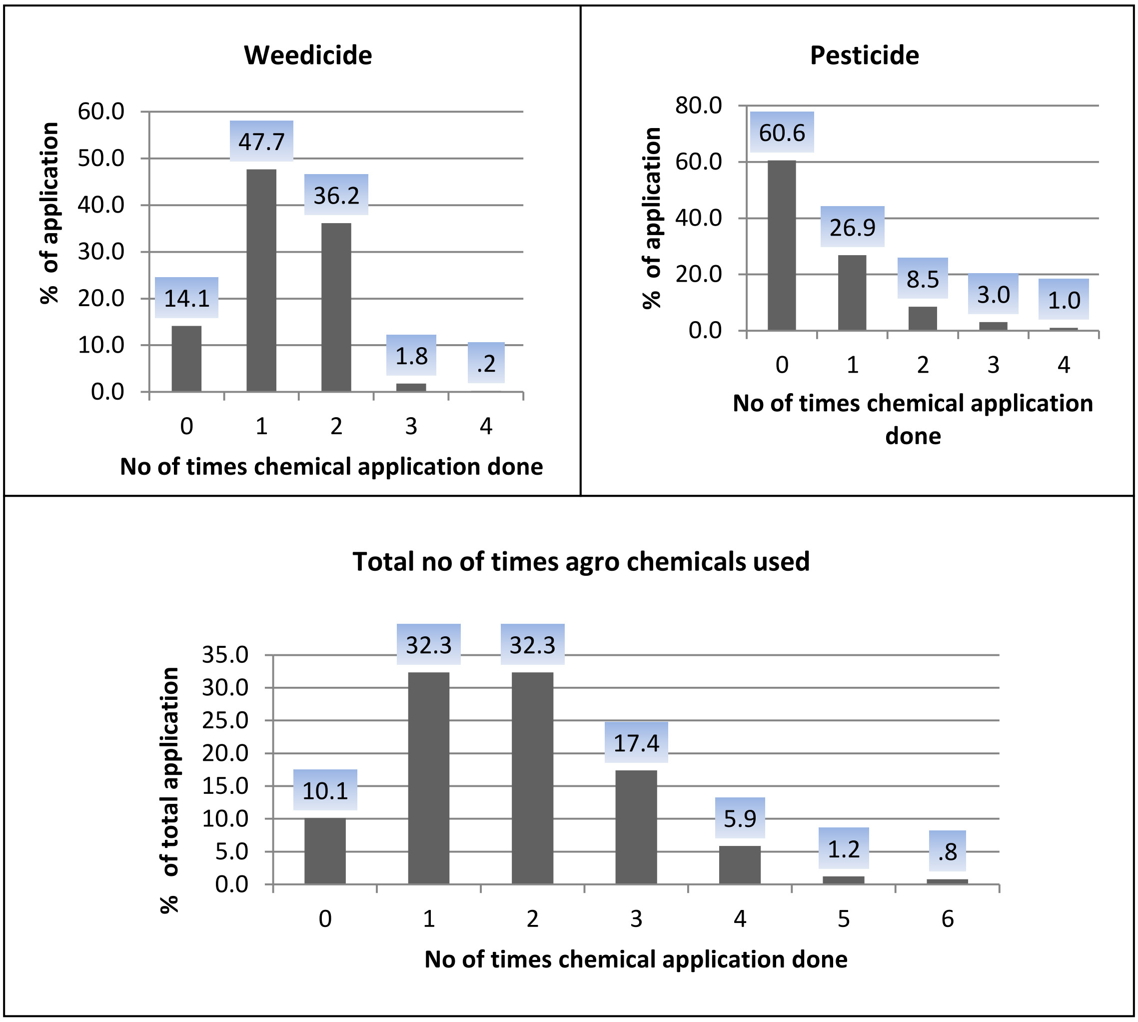



**Figure 4.4: Agro Chemicals Application**

# CHAPTER FIVE

## Yield, Cost and Returns of Paddy Farming in LCWZ

This chapter expresses the yield variation in LCWZ and provides the inferential statistics regarding the district-wise paddy yield. And also analysis of cost and returns is explained briefly in a comparative manner.

### 5.1 Yield

Yield depends on the production as well as land size. However, land size is a fixed factor and a constant supply. Consequently paddy production is the main component to change the productivity in the present situation. Profitability of paddy production may also differ based on obtainable production per unit area of land. Favourable natural environmental conditions, input allocation for paddy and management practices of paddy farming are the main factors affecting harvest in given technology. By considering agro ecological region, we therefore assumed that all the natural elements impact is same on the all districts of the LCWZ during 2013 *Yala* season.

**Table 5.1: Mean Comparison of Paddy Productivity in LCWZ**

**ANOVA** Yield (kg/ac)

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Districts | 10936284.708 | 6 | 1822714.118 | 10.057 | .000 |
| Within District | 85723758.177 | 473 | 181234.161 | | |
| Total | 96660042.885 | 479 | | | |

Source: HARTI survey data, 2013

As shown by the analysis of variance (ANOVA) there are significant differences in yield amongst districts (Table 5.1). It has varied from 740 kg/ac in Galle district to 1255 kg/ac in Gampaha district. The average productivity in the LCWZ was 905 kg/ac. Table 5.2 provides the district-wise distribution of paddy yield. Accordingly, average yield of all the districts is higher while Ratnapura, Colombo and Galle districts demonstrate less productivity compared to other districts. Farmers were involved in non agricultural activities such as gem mining in Ratnapura and cinnamon industry in Galle district. Therefore, they have given priority to non agricultural activities rather than to paddy cultivation.

**Table 5.2: Distribution of the Yield in LCWZ (kg/acre)**

| District | Mean (kg) | No of Observation |
|---|---|---|
| Colombo | 803 | 26 |
| Gampaha | 1255 | 49 |
| Kalutara | 894 | 82 |
| Galle | 740 | 79 |
| Matara | 953 | 106 |
| Kegalle | 1007 | 58 |
| Ratnapura | 761 | 80 |
| LCWZ | 905 | 480* |

* - after removing outliers
Source: HARTI survey data, 2013

The average yield in Gampaha, Kegalle, and Matara districts is higher than the average yield of LCWZ. Paddy farmers in these districts, who are over 40 percent, are cultivating for the purpose of selling and consumption compared to other districts. Weed and pest control are comparatively better than other districts. Farmers in these districts have a tendency to use certified seeds when compared to other districts.

## 5.2 Costs and Returns

Average size of the paddy land is less than one acre. Hired labour and machinery cost per acre were the main expenditure of paddy farming in *Yala* 2013. Cost calculated with and without costs for family labour and inputs shows that to cultivate one acre the cost is Rs 27,000 excluding imputed cost, whereas the gross income is Rs 23,000 which shows that the farmer losses Rs 4,000. The gap between total cost with imputed cost and gross income has further widened due to cost of family labour. This shows that farmers in the LCWZ cultivate paddy mainly for consumption rather than for economic reasons.

**Table 5.3: Descriptive Analysis of the Paddy Cultivation of LCWZ**

| Variables | Mean | Std. Deviation |
|---|---|---|
| Paddy yield (kg/ac) | 905 | 449 |
| Extent Cultivated (ac) | 0.83 | 0.37 |
| Family Labour Cost (Rs/ac) | 10445 | 8469 |
| Hired Labour Cost (Ra/ac) | 11793 | 9541 |
| Machinery Cost (Rs/ac) | 11161 | 4614 |
| Agro Chemical Cost (Rs/ac) | 2187 | 1304 |
| Fertilizer Cost (Rs/ac) | 818 | 196 |
| Seed Cost (Rs/ac) | 1951 | 839 |
| Total Cost (Rs/ac)* | 40607 | 10936 |
| Total Cost (Rs/ac)** | 27330 | 10265 |
| Gross Income (Rs/ac) | 23210 | 11422 |

*-including imputed cost, **-excluding imputed cost
Source: HARTI survey data, 2013

Farmers have spent Rs 30.25 to produce one kilo of paddy in *Yala* 2013 excluding their own input costs (table 5.4). However, farmers received only Rs 26.54 for one kilo. When considering the districts variation, the cost and returns, paddy faming was not profitable in *Yala* 2013 in all the districts except Gampaha. The possible way of minimizing cost per unit, is either to increase productivity or reduce the costs. But reduction of the cost per unit is not straight forward because input costs are increasing marginally. Thus attention should be paid in the direction of enhancement of productivity.

**Table 5.4: Average Cost and Returns per unit of Paddy Production**

| District | Per unit cost (Rs/kg)* | | Per unit cost (Rs/kg)** | | Returns per kg (Rs/kg) | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| LCWZ | 46.46 | 20.40 | 30.25 | 14.68 | 26.54 | 3.28 |
| Kegalle | 46.90 | 20.78 | 26.78 | 16.33 | 24.12 | 2.76 |
| Ratnapura | 51.08 | 18.83 | 29.38 | 15.22 | 27.43 | 2.41 |
| Kalutara | 47.29 | 19.94 | 31.40 | 15.42 | 24.61 | 2.68 |
| Galle | 50.54 | 22.49 | 35.52 | 14.13 | 30.30 | 2.49 |
| Matara | 40.76 | 17.85 | 30.12 | 12.86 | 25.34 | 2.52 |
| Gampaha | 38.71 | 21.63 | 24.87 | 13.45 | 26.13 | 2.38 |
| Colombo | 57.58 | 18.30 | 35.90 | 12.45 | 28.54 | 2.73 |

*-including imputed cost, **-excluding imputed cost
Source: Authors' computation

There is a negative relationship between yield and per unit cost excluding imputed cost (Table 5.5). Therefore, it is necessary to enhance yield per acre to minimize production cost in the LCWZ. Break-even yield in LCWZ was 1032 kg per acre in *Yala* 2013.

**Table 5.5: Correlation between Productivity and per Unit Cost**

| Correlation | Per unit cost (Rs/kg)** | Productivity (kg/acre) |
|---|---|---|
| Per unit cost (Rs/kg)** | 1 | |
| Productivity (kg/acre) | -0.3702* | 1 |

*-correlation is significant at the 0.01 level
**-excluding imputed cost
Source: Authors' computation based on survey data

According to data table 5.4, paddy production in districts such as Colombo, Galle, Kalutara and Matara is costlier than that of other districts due to hired labour cost. Therefore, farmers are not willing to engage in the paddy sector with paddy lands being abandoned and there has been a marginal increase in abandon lands. Therefore, it is difficult to retain farmers in paddy cultivation unless action is taken to enhance productivity.

# CHAPTER SIX

## Resource Use Efficiency of Paddy Farming in Low Country Wet Zone

This chapter presents main part of this study which is the estimation of the model with different type of estimating techniques to show the relationship between input and output. Technical efficiency and its determinants also discuss in LCWZ paddy farming.

### 6.1 Relationship between Input and Output of Paddy Farming

The empirical model was estimated by using Cobb-Douglas production (Equation 1-section 1.4.5) function. With different types of planting methods such as transplanting, broadcasting, "parachute" and mechanized seeding being used by the sample farmers, a majority used broadcasting with less than 7 percent using other methods. Therefore, for the estimated model one cluster is broadcasting farmers not because it is the majority group but because their practices and input use are different. On the other hand, to capture the variation of planting methods the reported cases are not adequate. The data set has to be specified considering the age of the variety. Around 3 percent of the total sample had cultivated paddy varieties for over three and a half months.

The empirical results (OLS estimation) show the Cobb-Douglas production frontier for selected paddy farmers are presented in Table 6.1. Estimated $R^2$ is 0.226 means that around 23 percent of the variation in paddy yield among farmers in the LCWZ can be explained by selected explanatory variables fitted to the model. Environmental conditions which were not captured in this model have a great impact to determine output level. Hired labour, fertilizer, machinery cost and age of the varieties are significant. Family labour, chemical cost and non paddy incomes are not significant in the Ordinary Least Square model.

### 6.2 Maximum Likelihood Estimation

Maximum likelihood estimates of the stochastic production frontier are presented in Table 6.2. The estimates of Gamma ($\gamma$) is 0.764 which indicates that a vast majority of error variation is due to the technical inefficiency of error variation ($U_{i)}$ and not due to random error ($V_i$). A high value of $\gamma$ indicates the presence of significant inefficiencies in production frontier. There is a 24 percent difference between observed and maximum production frontier output. The significance of log likelihood test ($\sigma u = 0$) provides sufficient evidence to suggest that technical inefficiency is present in the data. Therefore most appropriate technique to estimate production function is Maximum likelihood (ML) approach. However, the results of the ML estimates provides approximately the same results as OLS output. But non paddy income is statistically significant.

**Table 6.1: Empirical Estimation of Ordinary Least Square (OLS)**

| Variables | Parameter | Coefficient | Std. Error | t-ratio | P>t |
|---|---|---|---|---|---|
| Intercept | $\beta_0$ | 3.126*** | 0.443 | 7.06 | 0.00 |
| Family labour (man days/ac) | $\beta_1$ | -0.001 | 0.021 | -0.07 | 0.95 |
| Hired labour (man days/ac) | $\beta_2$ | -0.060*** | 0.021 | -2.92 | 0.00 |
| Fertilizer (kg/ac) | $\beta_3$ | 0.098* | 0.052 | 1.90 | 0.06 |
| Chemicals (Rs/ac) | $\beta_4$ | 0.001 | 0.013 | 0.05 | 0.96 |
| Machinery (Rs/ac) | $\beta_5$ | 0.314*** | 0.040 | 7.86 | 0.00 |
| Non paddy income (Rs/month/household) | $\beta_6$ | 0.021 | 0.013 | 1.54 | 0.13 |
| Age of varieties (3 ½ month=1, 3 month=0) | $\alpha_1$ | 0.172*** | 0.054 | 3.19 | 0.00 |
| F( 7, 328) | | 13.71 | | | |
| Prob. > F | | 0.000 | | | |
| R-squared | | 0.226 | | | |

***, ** and * denote significant at 1%, 5% and 10% respectively
Source: Authors' computation, 2013

**Table 6.2: Maximum Likelihood Estimates for Parameters of the Stochastic Frontier Production Function**

| Variables | Parameter | Coefficient. | Std. Error | z-ratio | P>t |
|---|---|---|---|---|---|
| Intercept | $\beta_0$ | 3.509*** | 0.456 | 7.70 | 0.00 |
| Family labour (man days/ac) | $\beta_1$ | 0.004 | 0.021 | 0.19 | 0.85 |
| Hired labour (man days/ac) | $\beta_2$ | -0.047** | 0.020 | -2.28 | 0.02 |
| Fertilizer (kg/ac) | $\beta_3$ | 0.091* | 0.056 | 1.63 | 0.10 |
| Chemicals (Rs/ac) | $\beta_4$ | 0.011 | 0.013 | 0.82 | 0.41 |
| Machinery (Rs/ac) | $\beta_5$ | 0.296*** | 0.041 | 7.30 | 0.00 |
| Non paddy income (Rs/month/household) | $\beta_6$ | 0.028** | 0.013 | 2.10 | 0.04 |
| Age of varieties (3 ½ month=1, 3 month=0) | $\alpha_1$ | 0.157*** | 0.054 | 2.91 | 0.00 |
| $\sigma v$ | | 0.247** | 0.044 | | |
| $\sigma u$ | | 0.444** | 0.079 | | |
| $\sigma^2 = \sigma_v^2 + \sigma_u^2$ | | 0.258** | 0.051 | | |
| $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$ | | 0.764** | 0.002 | | |
| Log likelihood | | -133.28 | | | |
| Likelihood-ratio test of sigma $\sigma u$ =0 | | 4.35** | | | 0.018 |

***, ** and * denote significant at 1%, 5% and 10% respectively
Source: Authors' computation, 2013

Hired labour shows the negative relationship with output. Therefore increasing hired labour in paddy yield per acre in low country wet zone is not economical. The negative sign reveals that hired labour does not effectively contribute to paddy production.

Family labour is also not significant in the model. The factor of hired labour poses many drawbacks; lack of hired labour during peak periods, lack of skilled labour, farmers' complaints that the work not being satisfactory. Given this scenario increasing hired labour by 10 percent may decrease the yield by 0.47 percent.

When the cost of machinery is increased by 10 percent it may lead to increase in output by 2.96 percent. The average yield of the three and a half month varieties is greater than 15.7 percent (0.157*100) when compared to 3 month rice varieties.
Fertilizer application among farmers showed a drastic variation including less use rather than the subsidy quota. However, 10 percent increase in the application of fertilizer (NPK) may lead to an increased paddy production which is up by 0.91 percent. It shows that effect of changing the fertilizer quantity per acre has influenced the change of paddy yield by a small percentage.

Agro chemicals and non paddy income do not significantly contribute to the production frontier. Agro chemical usage among LCWZ paddy farmers is less because most of them cultivate for consumption purpose.

Additional non paddy income increases by 10 percent for a household per month and it may result in an improve paddy yield, around 0.28 percent. On the other hand, there is a positive relationship of non paddy income and the paddy yield. Having an additional non paddy income for a household will increase paddy production which reveals that additional non paddy income encourages paddy farming in the LCWZ.

### 6.3 Economies of Scale of Paddy Production in Low Country Wet Zone

The summation of elasticity of production provides information about the returns to scale, that is, the response of output to a proportionate change in the input. If this sum is 1, then there are constant returns to scale, that is, doubling the inputs will double the output, tripling the inputs will triple the output, and so on. If the sum is less than 1, there are decreasing returns to scale; doubling the input will be less than double the output. Finally, if the sum is greater than 1, there are increasing returns to scale; doubling the inputs will be more than double the output (Gujarati, 2007).

According to our empirical evidence which is presented in Table 6.3, decreasing returns to scale is available in low country wet zone. The possibility to develop paddy sector in LCWZ is difficult in this background. If policymakers pay their attention to develop paddy sector in this zone, their effort may not be worthwhile due to decreasing returns. The stamp size paddy lands, unfavourable weather condition and small scale paddy farming are major constraints in this zone.

**Table 6.3: Testing for the Level of Returns to Scale in LCWZ**

| Null hypothesis ($H_0$) | Alternative hypothesis ($H_a$) | Estimated value | z-values | P values |
|---|---|---|---|---|
| $B_1+\beta_2+\beta_3+\beta_4+\beta_5+\beta_6+\alpha_1=1$ | $B_1+\beta_2+\beta_3+\beta_4+\beta_5+\beta_6+\alpha_1\neq 1$ | -0.460*** | -4.85 | 0.00 |

*** denote significant at 1%
Source: Authors' computation, 2013

What was tested in table 6.3 is the linear combination of the coefficient. Summation of the all coefficient equals one which is called constant returns to scale, less than one is called decreasing returns to scale and greater than one is increasing returns to scale.

## 6.4 Technical Efficiency in Low Country Wet Zone

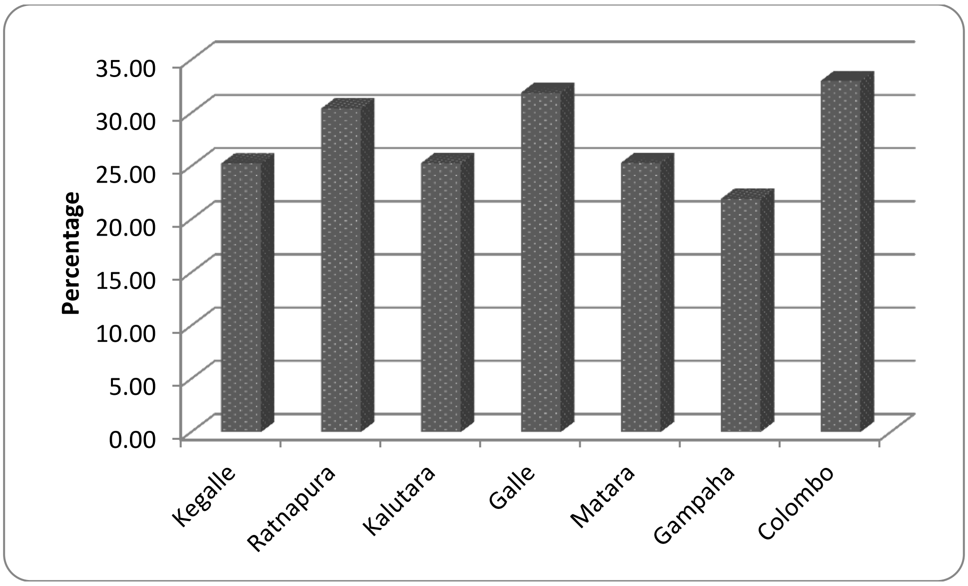
Average technical efficiency of farmers in LCWZ is 72 percent. Technical inefficient level is around 28 percent. Therefore, it is possible to improve the yield by 28 percent by following efficient resource management practices without increasing the level of input. It could be observed that majority of the farmer's are at 81-90 percent efficiency level. Technical efficiency among selected farmers is distributed from 32.8 percent up to 91.6 percent under given technology.

**Table 6.4: Distribution of Sample Paddy Farmers under Different Level of Technical Efficiency**

| Efficiency (%) | No of Farmers | Percentage of the Total |
|---|---|---|
| 31.7 - 40 | 4 | 1.19 |
| 41-50 | 22 | 6.55 |
| 51-60 | 41 | 12.20 |
| 61-70 | 67 | 19.94 |
| 71-80 | 91 | 27.08 |
| 81-90 | 110 | 32.74 |
| 91-100 | 1 | 0.30 |
| Total | 336 | 100 |
| Mean efficiency (%) | | 72.39 |
| Mean inefficiency (%) | | 27.61 |

Source: Authors' computation, 2013

It is observed that on average most inefficient farmers are from the Colombo, Galle and Ratnapura districts (Figure 6.1) with Gampaha district farmers being the least inefficient in the region. Kegalle, Matara and Kalutara paddy farmers are moderately inefficient under the given technology.



Source: Survey data HARTI, 2013

**Figure 6.1: Distribution of Mean Technical Inefficiency in LCWZ**

## 6.5 Determinants of Technical Efficiency

In terms of the level of technical efficiency under the given technology, some farmers were able to achieve maximum technical efficiency whereas some farmers have achieved relatively low efficiency. Therefore, it is better to identify the factors that have affected technical inefficiency. A number of studies have suggested that efficiency of farmers is determined by various socio-economic and demographic factors.

The results of the regression analysis are presented in Table 6.5. However, in the efficiency model, the estimated coefficients of all selected variables were not statistically significant. The model fails to explain total variation of technical efficiency of paddy farmers with regard to the socio-economic and demographic factors in LCWZ.

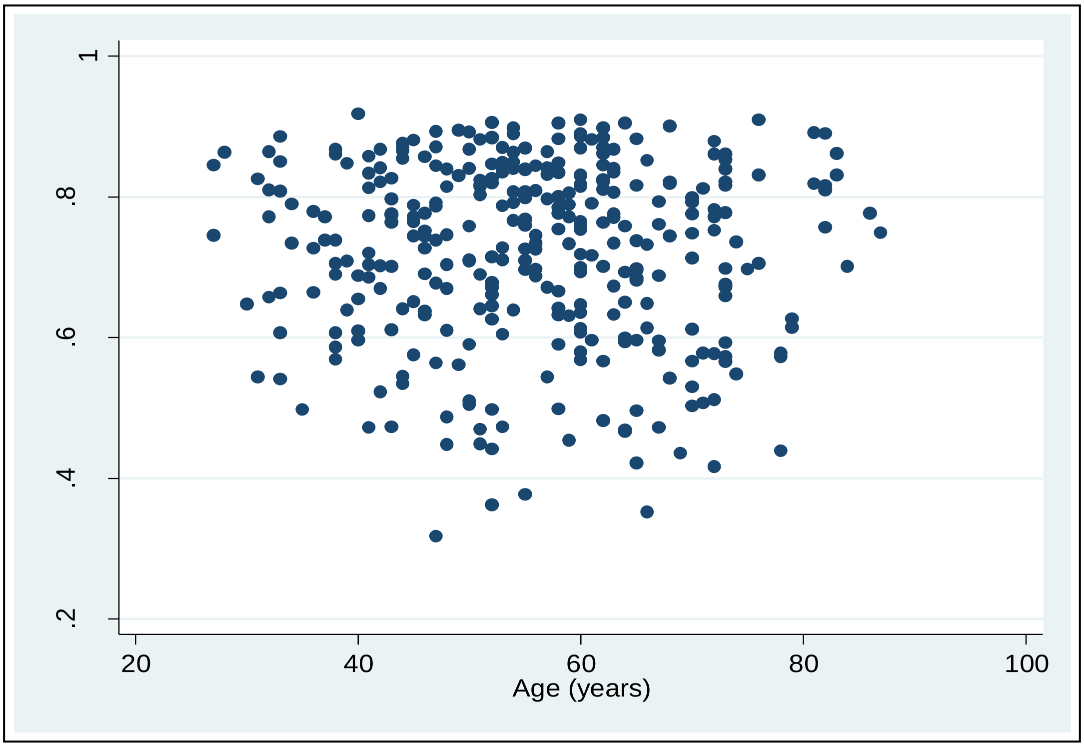
Paddy land size does not affect the technical efficiency and it is further highlighted in the model. Age of the farmers should have a significant relationship with efficiency but in this case it is not statistically significant.

**Table 6.5: Determinants of Technical Efficiency**

| Variable | Parameter | Coefficient | Standard error | t values |
|---|---|---|---|---|
| Constant | $\alpha_0$ | 0.765 | 0.18 | 4.27 |
| Land size | $\alpha_1$ | 0.013 | 0.02 | 0.62 |
| Age of farmers | $\alpha_2$ | -0.020 | 0.03 | -0.67 |
| Level of education | $\alpha_3$ | 0.016 | 0.01 | 1.14 |
| Quantity of fertilizer | $\alpha_4$ | 0.000 | 0.02 | 0.02 |
| Extension awareness | $\theta_1$ | -0.015 | 0.02 | -0.93 |
| Ownership | $\theta_2$ | 0.000 | 0.01 | 0.02 |
| Type of primary | $\theta_3$ | 0.021 | 0.01 | 1.45 |
| Quality of seeds | $\theta_4$ | -0.001 | 0.01 | -0.10 |

* denote significant at 1%
Source: Authors' computation, 2013

The reason behind this would be the age structure of farmers which is clearly illustrated in the figure 6.2. Accordingly, a negative pattern could be observed that is 90 percent of the farmers in the sample were older than 40 years. Around 75 percent of the sample farmers were included the age category of above 50 years thus explains the relationship behind the age structure and efficiency. This also explains the fact that the young generation does not like to engage in paddy farming in low country wet zone. Consequently, abandoned paddy lands will increase in next few decades. Thus paddy cultivation sector in LCWZ will be highly vulnerable due to the aging of paddy farmers.




Source: Survey data HARTI, 2013

**Figure 6.2: Scatter Diagram of Age and Technical Efficiency**

The efficiency model has tested the effect of the fertilizer application on the technical efficiency. Even if there is an increase in fertilizer which increases paddy output in the production frontier there is no effect on technical efficiency. Hence, the given amount of fertilizer subsidy is adequate to maintain the present level of output.

Extension awareness is also not significant in efficient model. What tested was how extension awareness of farmers had contributed to technical efficiency. The extension officers stressed that most of them do not seek instructions at the required time; advice was sought at the last moment when the disease could not be contained or when chemicals have been applied according to instructions of seller. Thus extension officer's contribution may not be efficient.

Technical efficiency would not change based on ownership of land in LCWZ and it is statistically not significant. The fact that whether quality of seeds which is certified or not was considered in the efficiency model. But it was also not statistically significant. Therefore in the low country wet zone, certified seeds do not affect the technical efficiency.

### 6.6 Comparison between farmers in General and Seed Paddy Farmers

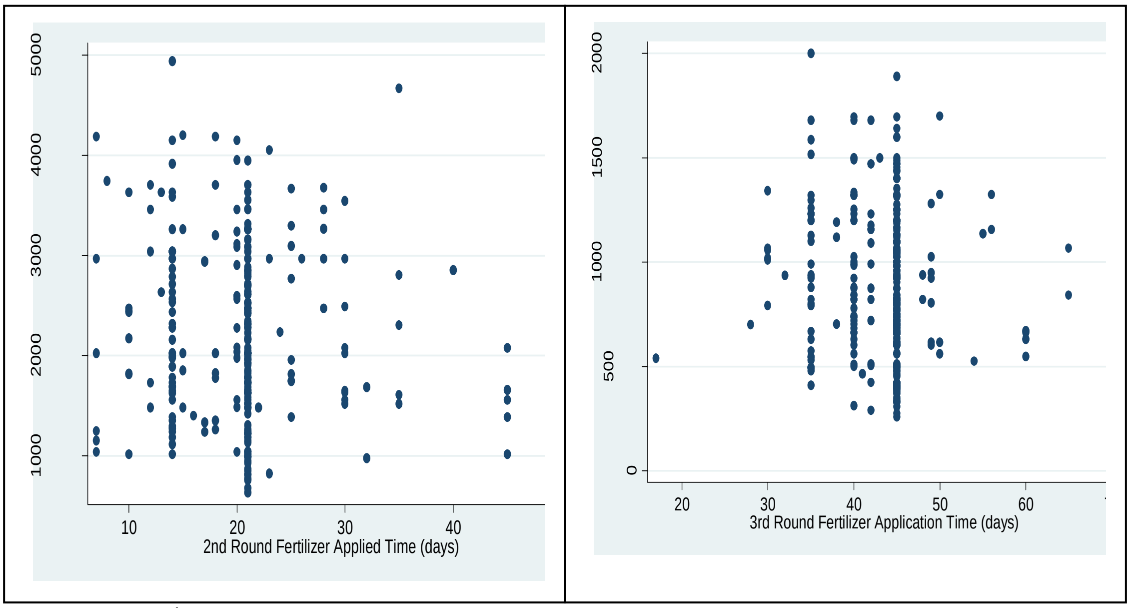
Seed paddy farmers could be assumed to be optimum resource users both effectively and efficiently. The mean technical efficiency of seed paddy producers is higher than other farmers. However, according to Table 6.6, on average a significant difference in input use between these two groups could not be observed except in terms of chemical usage. Weeds and pests controlling cost of seed paddy farmers are greater than that of other farmers. Accordingly, management practices of seed paddy farmers may lead to technical efficiency than other farmers in LCWZ.

**Table 6.6: Difference between Farming Groups**

| Component | General Farmers (n=329) | Seed paddy farmers (control group n=7) |
|---|---|---|
| Technical efficiency (mean) | 0.723 | 0.840 |
| Technical inefficiency (mean) | 0.277 | 0.160 |
| Productivity (kg/acre) | 892 | 1355 |
| Land size (acre) | 0.995 | 1.329 |
| Family labour (man days/acre) | 13 | 9 |
| Hired labour (man days/acre) | 12 | 16 |
| Fertilizer (kg /acre) | 92 | 91 |
| Agro chemical cost (Rs/acre) | 2219 | 3167 |
| Machinery cost (Rs/acre) | 11391 | 11332 |
| Seed rate (kg/acre) | 37 | 36 |
| Non paddy income (Rs/month/household) | 29759 | 40431 |

Source: Authors' computation, 2013

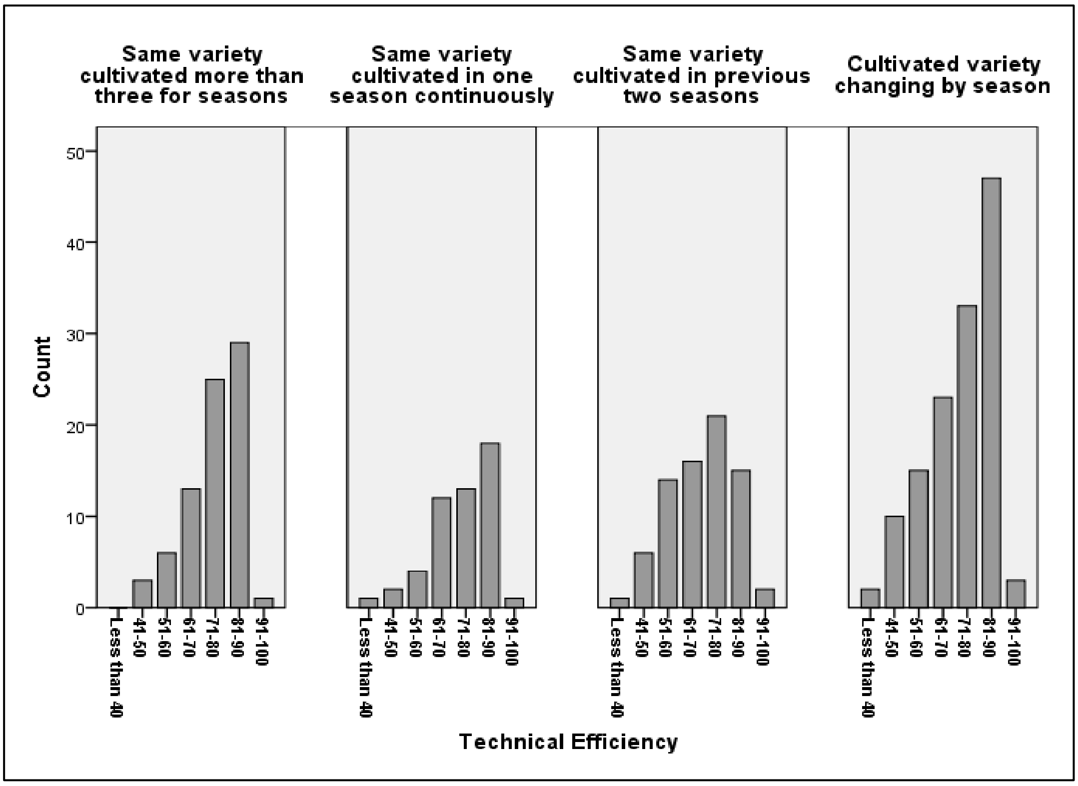
But there was some variation as shown in figure 6.3. Agriculture Instructors (AI) also highlighted that farmer did not apply fertilizer at the required time because their priority was on other income generating activities. Fertilizer usage per acre does not change in both groups, though certain variations of fertilizer applied time could be observed. Both groups had applied the first round of fertilizer at the time of sowing or before crop establishment. However, in the second round, some farmers had applied 14 days after sowing while others had applied 21 days after sowing in the meantime during the 3rd round of fertilizer, most of the farmers applied fertilizer 45 days after sowing. But there was some variation as shown in figure 6.3. Agriculture Instructors also highlighted that farmers did not apply fertilizer at the required time since priority was given to their other employment which gives them an additional income.




Source: Survey data HARTI, 2013

**Figure 6.3: Scatter Diagram of Productivity and Fertilizer Application Time**

The average seed rate of seed producers and other farmers does not change significantly. However, figure 6.4 shows that technical efficiency of farmers who cultivated by changing rice varieties in seasons is efficient than of those cultivate same variety in all the seasons.




Source: Survey data HARTI, 2013

**Figure 6.4: Distribution of Technical Efficiency and Changing of Cultivated Rice Variety in the Last Five Seasons**

# CHAPTER SEVEN

# Conclusions and Recommendations

## 7.1 Findings

- Mean technical efficiency of the paddy farmers in the Low Country Wet Zone is 72 percent in *Yala* 2013. Therefore, it is possible to improve the yield by 28 percent by following efficient resource management practices without increasing the level of input application. Inefficiency level of paddy farmers is 28 percent.

- Decreasing returns to scale exist in the Low County Wet Zone. Thus proportionate changing of input may lead to change of output less than input change.

- Most inefficient farmers are in the Colombo, Galle and Ratnapura districts and the farmers in the Gampaha district are the least inefficient within the region. Kegalle, Matara and Kalutara paddy farmers are moderately inefficient under constant technology.

- The farmers in LCWZ were not paying attention to applying fertilizer in the recommended period of time. Therefore, required nutrition level was not received for the paddy cultivation at correct time. Thus, it led to inefficient use of fertilizer.

- Changing rice varieties seasonally may lead to enhance the efficiency of resource use in paddy farming.

- There are significant yield differences among districts in the zone. Minimum productivity recorded in the Galle district is 740 kg per acre and maximum productivity observed in Gampaha district is 1255 kg per acre. However, average productivity in the LCWZ was 905 kg per acre. Break-even yield was 1032 kg per acre in the LCWZ.

- Farmers who are cultivating paddy in the region has to spend around 27,000 rupees per acre excluding their own input cost (cash cost) and including the imputed cost was around 40,000 rupees per acre.
- Farmers have expended Rs 30.25 to produce one kilo of paddy in *Yala* 2013 without their own input cost. However, farmers received only Rs 26.54 per kilo gram in Y*ala* 2013 in the LCWZ.

- Mechanization of paddy in the region is essential. On one hand, hiring labour and family was not effective. On the other hand, using machine for cultivation tends to enhance yield by 2.96 percent while increasing the machinery cost by 10 percent.

- It was observed that when applying fertilizer farmers use less or excess quantities than the recommended level. However, increasing the quantity of fertilizer (NPK) by 10 percent may lead to increase in the paddy production by 0.91 percent.

## 7.2 Conclusions

In comparison with other agro-ecological regions of the country, paddy cultivation in LCWZ has long been perceived as a zone where there is low yield, unprofitable and high variability of yield. It was the general trend to re-cultivate abandoned paddy lands due to ad hoc motivation by the Government while others give up paddy cultivation for the reasons discussed above. Therefore, in spite of the keen attention paid to re-cultivate abandoned paddy lands in the region, no remarkable increase could be observed in the sown extent over time. On the other hand, detrimental alternatives such as arbitrary filling of paddy lands are gradually progressing. This is the concealed truth of the present situation. The only justifiable reason for farmers to involve in paddy cultivation, according to them, is that paddy production continues merely for food security than for economic gains.

Nevertheless, the national significance of paddy cultivation in LCWZ is sealed in its dual role as 'green lungs' and as a buffer zone over major paddy producing zones which are highly vulnerable to vagaries of weather. Therefore, preservation of paddy lands in the LCWZ is viewed as a national priority.

However, dearth of information vital to understand the reasons for low yield, unprofitability, inefficiency and variability of paddy production in this zone has hindered making optimal resource allocation decisions on paddy cultivation in the LCWZ.

The literature reveals that environmental factors, input allocation and management practices are key to variability in production of any crop. Though much critical, the variability due environmental factors could be assumed constant within a particular agro-ecological region for a particular crop. With regard to paddy production in the LCWZ, input allocation and management practices appear to be the key determinants.

Thus, allocative efficiency, the measure of how farmers are able to allocate inputs optimally and the technical efficiency that reflects the farmers' ability to achieve the maximum output with given and obtainable technology were the core concerns of the study. Based on that, the specific concerns were to assess the level of and factors determining the technical inefficiency.

The study revealed that on average, the paddy production in LCWZ is less productive (905kg/ac); the cost of production was high which amounts to Rs. 30.25/kg (without imputed cost); with achieving a break-even yield of 1032kg/ac; technical efficiency is 72%; has a high variability in paddy yield across districts and decreasing returns to scale.

This study found that significant differences exist in paddy yield across districts ranging from 740kg/ac in the Galle district to 1255kg/ac in the Gampaha district with an average yield of 905kg/ac.

Cost of production of paddy too varies across districts with an average cost of Rs.27, 000/ac (without imputed cost) and Rs.30.25/kg. Labour and machinery cost are the key cost components amounting to 58% and 29 % respectively. The most number of farmers who practised paddy cultivation both for consumption and selling were found from the Gampaha district with the least number of farmers from Ratnapura district.

Efficient use of resources is a must in any production process. In economics the available resources are limited; therefore, scarce resources should be efficiently used without wasting. However, the literature reveals that farmers in the developing countries fail to use resources in an optimally efficient way.

The average technical efficiently of farmers in the LCWZ is 72 percent. There is potential to enhance production by 28 percent without increasing input under the given technology.

The estimated level of technical inefficiency of farmers in LCWZ (28%) depicts that inconsistent resource management practices owing to changing socio-economic circumstances of the farming community in the LCWZ has maintained a deficit in reaching the optimal level of paddy production. The data establishes that the management practices such as land levelling, fertilizer application at the required time, pest and disease controlling are among the important areas needing attention to increase the output of paddy in this region without increasing the level of input.

In addition, the degree of mechanization too positively correlates with production and therefore mechanization when and where appropriate would enhance the paddy yield in the region. Small machinery are preferable for the region due to water logging nature of paddy fields.

Use of paddy varieties aged 3.5 months such as BG 358, BG 350, BG 360, LD 355, LD 356, AT 362 and BW 361 demonstrating the high yielding capacity in the LCWZ than using 3 months varieties such as BG 300, BW 272-6B was observed. Further, economically well-off farmers who have access to non farm income sources have the capacity to achieve higher TE. As evident from the survey, timely adoption of good crop management practices such as pest and disease controlling, fertilizer application, land preparation and levelling, weed controlling are encouraged if non-farm sources of income are available.

The highest estimated efficiency is reported from the Gampaha district whereas the least efficiency is from the Colombo district. However, the proposed model failed to explain the relationship between TE and socio-economic variables.

## 7.3 Recommendations

Based on the findings, this study proposes the following recommendations that help derive or exceed the break-even yield from paddy cultivation in the LCWZ.

- Given the unprofitable nature of paddy production in the LCWZ, both the extent of abandoned and uncultivated paddy lands may be increasing over time. Therefore understanding the multiple advantages of paddy production in the LCWZ, appropriate measures should be taken at least to achieve the break even yield or exceed the same in order to ensure maximum utilization of paddy lands by the farmers in the region. This requires training of farmers on efficient use of available resources, what they are through farmer organizations as most of the farmers are members of the same. It could be done at the 'Kanna' meeting held before the commencement of each cultivation season.

- Establishment of demonstration farms with full time farmer/s in each AI region as model farmer/s who utilizes the available resources effectively and efficiently. This will help easy sharing of good management practices through success stories. This will also ensure horizontal diffusion of technical knowledge among farmers in the region.

- Both inefficiency and paddy cultivation for consumption purpose have shown the same direction and therefore market oriented paddy production programmes may help reduce the inefficiency of input use. Production of traditional varieties for niche markets, export oriented paddy production, organic paddy are few such examples.

- Farmers should be encouraged to apply fertilizer at the required time to enhance the yield and distribution from ASC centres should be coordinated with time of application with no delays.

- It is essential to encourage mechanization of paddy cultivation in the region in order to reduce the adverse effects of labour scarcity on paddy production (to seize technical inefficiency associated with labour scarcity) and to ensure efficient use of labour resource (reduce allocative inefficiency). Therefore, mechanization interventions should not only be user friendly (simple machines such as paddy cutter, small scale combine harvesters that suit water logged conditions of paddy lands in the LCWZ) but also be cost effective replacements for scarce and costly labour resource in the region.

  Agrarian Development Centres should initiate, direct and facilitate the mechanization process in collaboration with other responsible organizations such as Farm Mechanization and Research Centre (FMRC), the National Engineering Research and Development Centre (NERDC) and the Provincial Agricultural Extension Services.

  Further research is suggested in order to differentiate technical efficiency from inefficient farmers/areas while exploring the reasons for the same, as our Tobit model has failed.

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# ANNEXES

## Table 1: Paddy Statistics in Year 2012

| District | *Maha* Season Average Yield(kg/acre) | | | | *Yala* Season Average Yield(kg/acre) | | | | Average Yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|
| | Major | Minor | Rain fed | Total | Major | Minor | Rain fed | Total | |
| Colombo | 1443 | 1419 | 1397 | 1408 | 1294 | 1294 | 1187 | 1215 | 1376 |
| Gampaha | 1443 | 1409 | 1383 | 1398 | 1516 | 1274 | 1179 | 1319 | 1378 |
| Kalutara | 1424 | 1398 | 1356 | 1363 | 1090 | 1047 | 956 | 971 | 1230 |
| Kandy | 2041 | 1564 | 1429 | 1688 | 1596 | 1401 | 967 | 1474 | 1625 |
| Matale | 2003 | 1667 | 1660 | 1775 | 1798 | 1296 | 1314 | 1492 | 1721 |
| Nuwaraeliya | 1711 | 1606 | 1433 | 1620 | 1445 | 1220 | 1093 | 1250 | 1557 |
| Galle | 1575 | 1525 | 1387 | 1389 | 1245 | 1245 | 1245 | 1245 | 1359 |
| Matara | 1631 | 1464 | 1419 | 1479 | 1458 | 1152 | 1164 | 1235 | 1371 |
| Hambantota | 2206 | 1840 | 1587 | 2104 | 2109 | 1581 | 1070 | 1991 | 2055 |
| Jaffna | - | - | 1085 | 1085 | - | - | - | - | 1085 |
| Killinochchi | 1341 | 1270 | 1135 | 1238 | 1522 | 1473 | - | 1522 | 1262 |
| Mannar | 2029 | 1341 | 1146 | 1943 | 1605 | 1428 | - | 1534 | 1921 |
| Vavuniya | 1806 | 1584 | 1251 | 1608 | 1473 | 1373 | - | 1453 | 1586 |
| Mulativu | 1248 | 1176 | 1148 | 1212 | 1633 | 1461 | - | 1632 | 1351 |
| Batticaloa | 1672 | 1560 | 1377 | 1511 | 1632 | 1512 | 1484 | 1605 | 1541 |
| Ampara | 2139 | 1768 | 1456 | 2035 | 1932 | 1468 | 1464 | 1915 | 1980 |
| Trincomalee | 1952 | 1874 | 1450 | 1815 | 1811 | 1725 | - | 1804 | 1811 |
| Kurunegala | 2007 | 1540 | 1440 | 1593 | 1721 | 1263 | 1166 | 1382 | 1548 |
| Puttalam | 1841 | 1556 | 1460 | 1655 | 1571 | 1173 | 1096 | 1450 | 1599 |
| Anuradhapura | 2103 | 2042 | 1607 | 2017 | 1717 | 1496 | - | 1639 | 1942 |
| Polonnaruwa | 2085 | 1872 | 1603 | 2059 | 1721 | 1263 | - | 1700 | 1911 |
| Badulla | 2041 | 1756 | 1548 | 1828 | 1836 | 1443 | 1047 | 1704 | 1791 |
| Monaragala | 2109 | 1667 | 1561 | 1724 | 1936 | 1182 | 1084 | 1602 | 1691 |
| Ratnapura | 1840 | 1281 | 1262 | 1363 | 1821 | 1339 | 1124 | 1396 | 1377 |
| Kegalle | - | 1527 | 1439 | 1469 | - | 1160 | 1074 | 1104 | 1380 |
| Udawalawe | 2591 | - | - | 2591 | 2045 | - | - | 2045 | 2357 |
| Mahaweli 'H' | 2492 | - | - | 2492 | 2152 | - | - | 2152 | 2464 |
| Sri Lanka | 2057 | 1719 | 1408 | 1799 | 1821 | 1357 | 1153 | 1678 | 1762 |