The Prospects of System of Rice Intensification Adoption in Sri Lanka: A microeconomic and sociopolitical perspective[1]

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ABSTRACT

The yield gains in rice during the pre-World War II period in Japan and Taiwan, and subsequently during the green revolution were based on heavy applications of chemical fertilizers and pesticides. Today, there is increasing interest world-wide as well as in Sri Lanka in assessing the potential for maintaining or increasing rice yields by sharply reducing or eliminating all together the use of chemicals and by decreasing irrigation requirements. The System of Rice Intensification (SRI) first developed in Madagascar and now being tested in many countries, is an example of such an approach. The system is based largely on organic farming principles with heavy application of compost and additional requirements for spacing and transplanting of seedlings. Some proponents claim that SRI will revolutionize the method of rice production while others see it as a fad.

In Sri Lanka, we have undertaken a study to systematically examine the experience of both SRI and non-SRI adopters. Data was obtained in two locations from 120 farmers, half of whom were SRI adopters. We found a wide variation in the way that farmers practiced SRI, with the majority of SRI adopters using the practice on only a portion of their farms, and using some chemical inputs, particularly urea. SRI farmers reported about a 40 percent yield increase and returns for crop budgets were higher even charging a relatively high rate for labor. However, as found in other studies, many farmers dis-adopted after a season or two largely because of heavy labor requirements. But the poorer farmers with a low opportunity cost for labor and rainfed farmers, reluctant to use heavy application of chemicals due to weather risks, were more likely to continue with SRI. Thus we conclude that SRI is a niche technology suitable for a limited number of farmers, but that due to the high management requirements the spread of SRI will require a concerted extension effort.

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1. INTRODUCTION

The South Asian region has been transformed from a state of severe food shortages and starvation of large members of its people during 1960s, mainly due to the poor productivity of two of its staple cereals (i.e., rice and wheat) to surplus production although distribution is still a problem. The main factors behind this transformation process were introduction of short-stature, fertilizer-responsive, lodging- and disease- resistant and high-yielding varieties; investments in irrigation infrastructure; massive use of chemical fertilizers, herbicides, insecticides and fungicides, and government support through extension and micro-credit provisions. This process may simply be described as the *conventional system of production intensification*. This system of production intensification has made it possible to achieve food security at a national level, but has had serious negative social and environmental externalities such as (i) depletion of water tables, (ii) decline in soil fertility, (ii) aggravation of air pollution, and (iv) resistance of weeds to certain herbicides (Stoop et al, 2002).

There is a growing interest in what some regard as a *new* intensification process but what farmers will tell you is in fact a very *old* process – farming without chemicals or with a minimum use of chemicals and/or farming to reduce water requirements. This is known by different labels such as low external-input sustainable agriculture, organic farming, ecological farming, intermitent irrigation, alternate wetting and drying, aerobic rice cultivation, etc. The *system of rice intensification* (SRI) shares one or more of the aspects of these methods of production.

1.1 Definition of SRI

What exactly is the SRI? The system was developed in Madagascar by Fr. De Laulanie, a French priest and agriculturist through working with farmers (Uphoff et.al, 2002). Many have given definitions and descriptions of SRI[2]. All of these definitions underline the importance of conceptualizing SRI as a system rather than as a technology as it is not necessarily a fixed set of practices. Therefore, SRI is not a package of fixed technical specifications; it is rather a system of production formed based on certain core principles from soil chemistry and biology, rice physiology and genetics and the principles of sustainability with the possibility of adjusting the exact technical components based on the prevailing biophysical and socioeconomic realities of an area. This definition calls for research and adaptation of the system to specific conditions of an area rather than trying to impose practices relevant to one location on the other injudiciously.

SRI practices are still evolving and concerns are more about improving factor productivity of land, labor, water, and nutrients and harnessing potential of soil biology for pushing up further the yield plateau of rice. The main components of SRI are (1) planting method, (2) soil fertility management, (3) weed control, and (4) water (irrigation) management. These components should always be tested and varied according to local conditions rather than simply adopted.

Planting method refers to the spacing configurations and age of seedlings. Under SRI, the rice plant is transplanted 8-15 days after germination, which is much earlier than the usual three to four weeks. Transplanting should be done quickly and carefully, preferably within 15-30 minutes of uprooting on texturally finer soils. One or two rice seedlings are transplanted per hill, not in clumps of more than three seedlings as usually the case, and damage to the roots is carefully avoided. Planting is done on a square grid of 25x25 cm or even larger (up to 50x50 cm), which is

[2] For descriptions and definitions of SRI see http://ciifad.cornell.edu/sri/index.html

much sparser than the usual 15x15cm or 20x20 cm. Some also suggest 30 x 30 cm in the main season and 25 x 25 cm in the off-season as an appropriate spacing. The spacing should be adjusted according to the local edaphic conditions but must facilitate weeding.

Concerning the **soil fertility management**, nutrients should be added to the soil, preferably in the form of organic matter such as compost or mulch. The use of chemical fertilizer should be minimized and gradually avoided as the nutrient status of the soil develops. **Weed control** is best done with mechanical weeder often called 'rotating hoe', starting 10 days after transplanting and then weeding every ten days at least 2 or 3 times, but if possible until canopy closure. This is necessary for growing rice when fields are not kept continuously flooded. Weeding is done often not only to control weeds but also to aerate the soil around the plants.

Irrigation Water Management is practiced in such a way that the soil is kept well drained rather than continuously flooded and saturated during the vegetative growth period. Two possibilities are suggested (1) application of a small quantity of water daily but leaving the field dry for several short periods (2-6 days) to the point of surface cracking during tillering, and (2) flood and dry the field for alternating periods of 3-6 days each which is known as Alternate Wetting and Drying (Barker et al ., 2001).

1.2. Objectives and Scope of the Study

Following the reports of its dramatic yield and water productivity advantages in Madagascar, SRI has recently generated interest and discussions among researchers, development practitioners and policy makers in other countries. These discussions have often resulted in polarized views with one group advocating for the wider dissemination of the practice and another group questioning the plausibility of the reported advantages. On-farm and on-station experiments have been setup in Africa, Asia and Latin America to substantiate the alleged advantages[3]. These experiments vary in design and rigor from simple un-replicated on-farm trials conducted by NGOs either alone or in cooperation with NARES to meticulously designed factorial trials. The yield advantages reported from these experiments range from 19 to 270 percent with yield levels as high as 15 to 20 t/ha (McHugh et al, 2002; Bonlieu, 1999). About 50 percent water savings are also reported with little or no reduction in yield (Thiyagarajan et al, 2002). But, the results of these studies do not always converge and it is difficult to compare the results from one experiment with another[4]. For instance, an experimental result from the IRRI showed disappointingly low performance of SRI. Similar study done at Rice Research and Development Institute at Batalagoda in Sri Lanka showed no significant difference between SRI and the conventional system of rice production (Wickramasinghe, 2002 pers. commu.). Except for the Mosher and Barrett's (2002) work in Madagascar, most studies on SRI so far are limited to experimental and demonstration activities. Hence, there is a need for directly documenting farmers' own independent experience with SRI.

This study tries to fill this research gap based on Sri Lankan SRI farmers' experience. During the year 2002, more than 3000 farmers in 18 districts of Sri Lanka were estimated to be practicing

[3] For detailed information regarding this issue see http://ciifad.cornell.edu/sri/index.html

[4]The experiments were not standardized and the resulting yield figures were not standardized. Some reports for instance give figures for yield advantage based on results from different plot size for SRI and conventional.

SRI in small plots of about 0.2 ha on average (Batuwitage, 2002)[5]. The specific objectives of the study were:

1. To assess the dynamics and determinants of adoption of the System of Rice Intensification
2. To evaluate the farm-level productivity, economics, resources conservation and water saving impacts of the System of Rice Intensification adoption
3. To assess the poverty outreach of SRI adoption, and
4. To derive research, extension and policy implications.

The paper is organized as follows. The next section deals with methodology; Section 3 provides a brief site description. Section 4 and 5 presents the pattern of adoption, and determinants of adoption and dis-adoption in the two study areas. Section 6 compares the benefits and costs of SRI with conventional practices. Section 7 shows the poverty impact of SRI. The final section presents the conclusions and implications.

2. METHODOLOGY AND DATA

Data for this paper were obtained from surveys in two localities of Sri Lanka. The data generation process followed two inter-related steps. First, focus group interviews and key informant surveys were undertaken at various times during September and November of 2002. A team of agricultural economists led by a principal researcher from the International Water Management Institute made visits to farmers' fields, the National rice breeding station, an ecological farming center (a training center undertaking farmer training on SRI), Agriculture Development Authority branch offices and Ceylon Electricity Board (CEB) to assess the views of various stakeholders regarding the prospects of SRI in Sri Lanka.

Second, the views and perceptions of the stakeholders obtained in the first step were distilled into specific research questions and hypotheses for empirical testing using structured (formal) questionnaire survey. A questionnaire was developed and pre-tested for administration to a randomly selected set of SRI and non-SRI farmers. The structured questionnaire survey was implemented in January/February 2003 by the research team with the help of trained enumerators.

2.1 Operational Definition of SRI Adoption

In the present case, *SRI adopters* (or SRI farmers) are those farmers who tried SRI at least once during the last five years (1998 to 2002) on whole or part of their paddy fields. Thus, the definition includes partial adopters and those farmers who have tried SRI and then abandoned it or disadopters. *Disadopters* are those SRI adopters who have discontinued practicing or those who have not practiced SRI during the last *Yala* and *Maha* seasons. The *non-adopters* (or Non-SRI farmers) are those who have not practiced SRI during the above reference period[6]. SRI adoption intensity refers to the proportion of farmers' total paddy fields allotted to the SRI practice.

[5] Comprehensive descriptions of the SRI practices were published in the January/February 2000 issue of "Javaya", a newspaper published by the Ministry of Agriculture.
[6] Henceforth, adopters and SRI farmers, and Non-adopters and Non-SRI farmers are used interchangeably.

2.2 Sampling Design and Procedure

Two stage stratified random sampling design was used to select 120 farmers in total (i.e., 60 each from the two study locations and 30 each from SRI and Non-SRI farmers per location). The two study locations were purposively selected based on the prevalence of SRI farmers for which the sampling frame was solicited from Ministry of Agriculture office, Colombo. In Ratnapura (Kalthota Irrigation Scheme) according to the CEB, there were 66 farmers practicing SRI. According to a register of SRI farmers, compiled by the Ministry of Agriculture, 45 percent of all practicing SRI farmers in the country were in Kurunegala district.

2.3 Analytical Framework

The data generated at the household and field levels were subjected to descriptive analyses to characterize the sample farmers' rice crop management practices. Multivariate statistical analyses such as *logit* and *tobit* regression models were used to assess factors influencing the incidence and intensity of adoption and disadoption of SRI. Enterprise budgeting technique was used to assess the economics of SRI *vis à vis* conventional system of rice production in the two locations (Figure 1) for *yala* and *maha* seasons of the year 2002.

3. DESCRIPTION OF THE STUDY AREAS

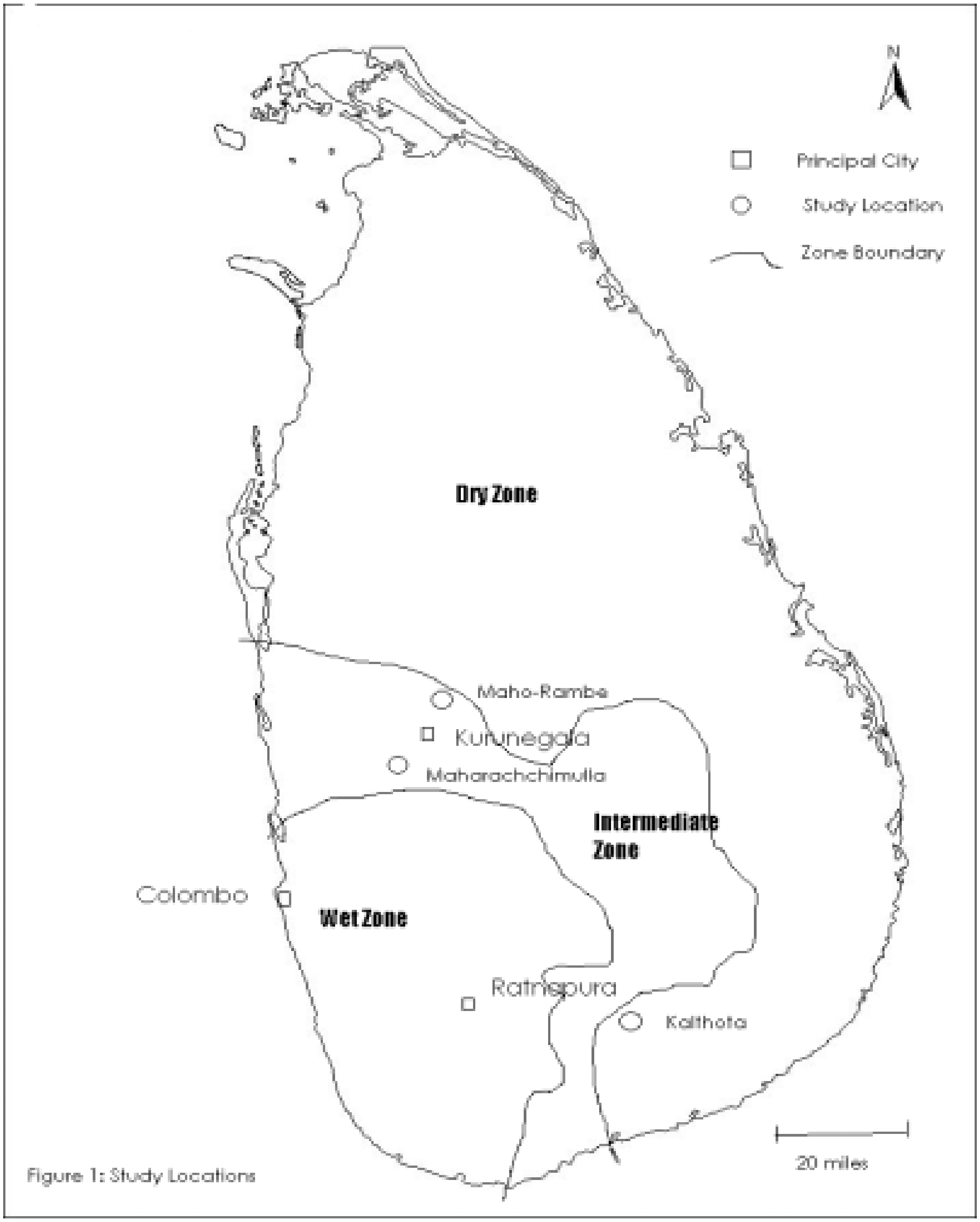
3.1. Kaltota Irrigation System

Kaltota is situated in Ratnapura district and in the Balangoda sub-district. The district is predominantly a Wet Zone district while southeastern parts of it fall within the intermediate and dry zones. Agricultural activities in Ratnapura are mainly based on plantation crops and mixed home-gardens generating spices. Kaltota irrigation system is a river diversion system in the Walawe River, one of the major rivers in the country. The system irrigates 1000 ha of lowland through two conveyance channels, situated in either side of the river. The left bank irrigates 128 ha of paddy lands in three tracts while the right bank canal irrigates 728 ha situated in seven tracts, one of which is the ancient settlement where farmers have large land holdings. A majority of the command area is cultivated in both seasons. Amount of water available at the system has reduced since the construction of a reservoir for electricity generation above the water diversion point of the system As Kaltota farmers were historical users of water, their right to use water from the river is recognized by the power authorities. Farmers are eligible for a special irrigation release calculated on the basis of historical water use. A leak from the reservoir also increases the amount of water available at the diversion. However, CEB wants to minimize the amount of water released for non-electricity generating uses as this result in revenue loss. Hence, programs to reduce the demand for irrigation releases were introduced to farmers. SRI appeared to be a potential water saver so CEB took steps in promoting SRI among farmers in the irrigation system.

3.2. Kurunegala district

Kurunegala district is situated in the northwestern part of Sri Lanka. It is the third largest district in terms of land area. About 75 percent of the area of the district falls within the Intermediate Zone while its northern part fall within the Dry Zone and southern part in the Wet Zone. Coconut cultivation in plantations as well as in small-holdings and paddy cultivation under minor irrigation are characteristics of the district. In the southernmost parts of the district, ginger is grown as an annual crop mainly in paddy lands. Kurunegala is a major paddy-producing area in the country. During 2000 to 2002, the district accounted on average for 10.6 percent of the national rough rice production. The district has 12,621 ha of major irrigation under 15 irrigation schemes and 33,804 ha under 4188 minor tanks and 657 minor river diversion schemes. About 29,028 ha of paddy land are rainfed.

The Ministry of SAMURDHI, responsible for poverty alleviation took a special interest in promoting SRI through farmer training programs. These programs were more effective in Kurunegala district mainly due to its proximity to the "Nature Farming Center", a training and research center on ecological farming and initiative by one regional farmer federation to produce and distribute hand weeders, an essential tool for practicing SRI.



Locations of Study in Rathnapura District

4. THE SPATIAL AND TEMPORAL DYNAMICS OF SRI ADOPTION IN SRI LANKA

4.1 Adoption trends

System of Rice Intensification has only five years of history in Sri Lanka. Only one farmer has reported to have first time learned about SRI in 1998. The majority of the SRI sample farmers in Kurunegala have learned about it in the year 2000. SRI sample farmers from Kalthota lagged behind Kurunegala farmers by about 2 years in awareness. Even though about 11.7 percent of the SRI sample farmers are aware of SRI during 1998/99 actual practice commenced first in Kurunegala in the year 2000. The temporal dynamics of SRI awareness among adopters and non-adopters are quite similar (see Figures 2 and 3).

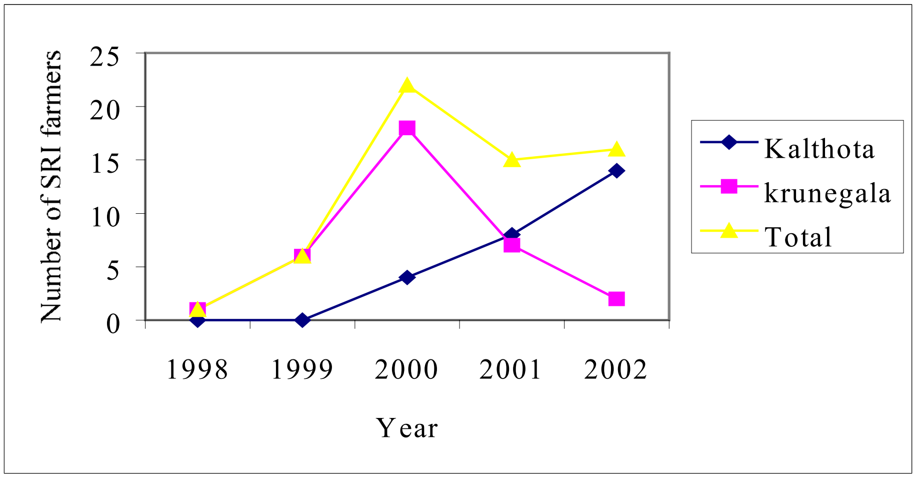


Figure 2. Year the farmers first learned about SRI

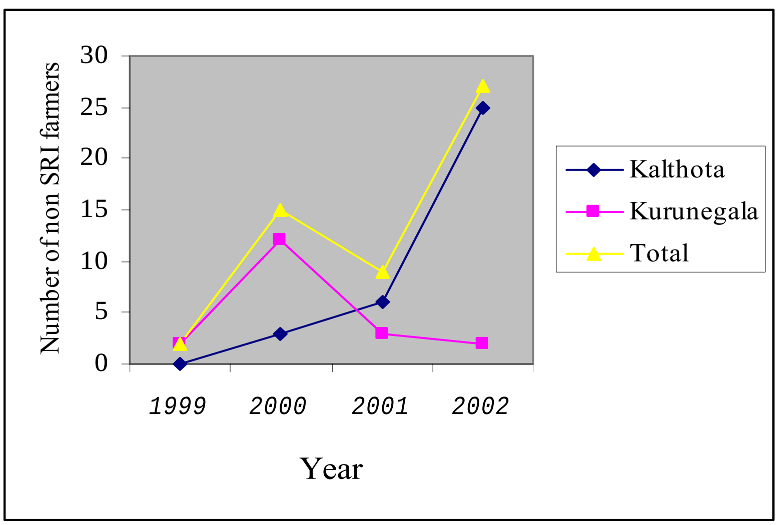


Figure 3. Year of awareness of SRI farmers

The non-SRI sample farmers who were aware of SRI, but have not shown interest to practice it were asked why they do not intend to practice. The response or reasons they gave are summarized in Table 1. Consistent with the practicing farmers' observations, the non-SRI farmers reported that the major obstacle to SRI adoption is the high labor demand and the tedious nature of the associated management practices such as transplanting and manual weeding

Table 1. Reasons for unfavorable attitude of Non SRI farmers towards SRI

Reasons	Locations (%)		
	Kalthota	Kurunegala	Total
Requires more labor and effort	68.2	38.1	53.5
Climate is not good for SRI cultivations	4.5	0.0	2.3
Lack of necessary inputs	4.5	4.8	4.7
Water shortage and lack of suitable field	13.6	4.8	9.3
Land tenure problem	4.5	0.0	2.3
Difficulties of getting organic fertilizer	4.5	0.0	2.3
Difficult to do management practices	0.0	23.8	11.6
No benefit	0.0	9.5	4.7
Field is located very far from home	0.0	4.8	2.3
Other SRI farmers failed	0.0	9.5	4.7
Lack of proper training	0.0	4.8	2.3
N	22	21	43

4.2 Farmers' Perceptions of the Merits and Demerits of SRI

The advantages and disadvantages of SRI were elicited from the practicing farmers and the results are summarized in Tables 2 and 3. The most significant merits of SRI as compared to conventional system are (1) improved quantity and quality of paddy yield, (2) savings in irrigation water and seed, (3) reduced demand for external cash inputs like inorganic fertilizers and herbicides, and (4) enhanced tolerance to biotic (e.g. diseases and insects) and abiotic stresses (e.g., lodging and low moisture stress). These views are quite consistent with the findings reported based on on-station and on-farm experimentation with SRI in some Asian, African and Latin American countries.

Table 2. Advantages of SRI relative to Conventional-farmers assessment

No	Criteria	Percent reporting yes	N
1	More yield	83.0	53
2	Saves water	89.7	58
3	Saves seed	100.0	60
4	More milling output	77.4	53
5	Less disease and pest attack	88.1	59
6	Less lodging of rice	91.4	58
7	Reduced demand for herbicide	91.7	60
8	Reduced demand for inorganic fertilizer	86.2	58
9	Less labor for harvesting	79.6	54
10	Less labor for transplanting	78.0	59
11	More tillers	98.3	59
12	Improves seed quality	90.9	55
13	Reduces input costs	85.0	60
14	Less labor for bund cleaning and construction	76.3	59
15	Environment friendly	5.0	60

Table 3. Disadvantages of SRI relative to conventional-farmers' assessment

No	Criteria	Percent responding yes	N
1	Weed control problem	60.0	60
2	Transplanting is difficult	36.7	60
3	SRI transplanting requires special skill	25.0	60
4	Requires skilled labor for management	31.7	60
5	Demand more labor input	50.0	60
6	Requires additional workdays	65.0	60
7	Requires more effort	74.6	59
8	Organic matter not available	57.9	57
9	Transporting organic matter is problematic	50.9	57
10	Problems of MW handling and availability	76.7	60
11	Mice attack due to unclean bunds	1.7	60
12	SRI requires well drained soils	69.0	58
13	Does not work on flooded fields	55.9	59

The most important demerits of SRI relate to its extremely high demand for labor, problems of weed control, and organic matter availability. 77 percent of the practicing farmers complain that the rotary weeder recommended for use in the SRI system is not readily available and even if available not easy to handle.

5. FACTORS INFLUENCING ADOPTION AND DISADOPTION

5.1 Determinants of SRI Adoption

The two most popular functional forms used for dichotomous discrete choice adoption models are the *logit* and the *probit* models. The advantage of these models is that the probabilities are bounded between 0 and 1. The *logit* model is selected here. The odds of SRI adoption are defined as the ratio of the probability of adoption (p_i) to the probability of non-adoption ($1-p_i$).

Specifically the model is:

$$\ln\left(\frac{p_i}{1-p_i}\right)=\beta_0+\beta_1X_1+\beta_2.X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\beta_7X_7+\beta_8X_8+\beta_9X_9+\beta_{10}X_{10}+\beta_{11}X_{11}+\beta_{12}X_{12}$$
$$+\beta_{13}X_{13}+\beta_{14}X_{14}+\beta_{15}X_{15}$$

The Xs are the hypothesised explanatory variables as defined in table 4. The variables hypothesized to influence adoption of SRI were derived from own informal assessment and literature reviews (Moser and Barrett, 2002; McHugh et al., 2002). Since these variables are unlikely to operate independently, a variable-by-variable analysis of relationships with farmers' adoption of SRI is likely to be misleading (Feder et al., 1985). Hence *logit* analysis which uses a number of independent variables has been used to predict the probability of farmers' SRI adoption.

Table 4. Factors hypothesized to influence the adoption of SRI

Variable code	Description
DEPRA(X1)	Proportion of children whose age is lessthan 7 in the family (dependency ratio)
PCHIL (X2)	Proportion of children whose age is between 7 and 14 years in the household
FAMIS(X3)	Family Size
AGEHH(X4)	Age of the household head in years
YSCHH(X5)	Years of schooling of the household head
NFTPA (X6)	Number of training programs attended during last five years
NEXCY(X7)	Number of extension contact since last yala
PRICE (X8)	Proportion of income form rice in the total annual family income
PRNIN (X9)	Proportion of non-farm income in the total annual family income
FYLWS(X10)	Frequency of rice yield loss due to low moisture stress during last 10 seasons.
POSOL(X11)	An index of social or political capital constructed from farmers past and present membership or leadership in farm, community, political and religious organisations (0 to 20 scale)[7].
POVGR(X12)	Grouping of the sample households into poverty tercile based on household specific poverty index constructed using PCA (A categorical variable, 1 if the household is poor, 2 if the household is middle and 3 if the household is rich or a refernce category).
LOCFA(X13)	Location of the farm (A categorical variable, 1 if the farm is located at the head, 2 if the farm is located at the middle and 3 if the farm is located at the tail and 4 if the farm is rain fed or refernce category).
LABAV(X14)	Labour availability (an index number ranging from 0 to 13, 0 indicating sever labor shortage and 13 indicating the abundance of labour in the community)[8] .
CATTL(X15)	Number of cattle owned.

The logistic regression model fitted to analyze the effect of these variables on the adoption decisions of farmers is presented in the table 5. Dependency ratio (DEPRA), age of the household head (AGEHH) and proportion of annual income from non-farm activities (PRNIN) reduces the likelihood of a farmer being SRI adopter. By contrast, family size (FAMIS), years of schooling (YSCHH) and participation in agricultural training programs (NFTPA) significantly increase the probability of a farmer being SRI adopter. For instance, as the family size of the farmer increases by a unit, the likelihood of being SRI farmer increases by 1.45 times (see the exp (ß) for variable FAMIS). The proportion of children between 7 and 14 increases the likelihood of SRI adoption. This is consistent with our field observation-- children were actively participating in the transplanting of SRI fields[9]. Moreover, studies in other countries showed that women and

[7] Five organizations were identified and farmers were asked to confirm whether they are ordinary members or leaders of these organizations in the past and at present. Thus each farmer can score a minimum of zero (meaning not a member of any organization in the past and at present) and a maximum of 20 (meaning the farmer is a member and plays leadership role in all organizations in the past and at present, i.e., 5x2x2)

[8] This index was constructed from a set of questions designed to elicit farmers' opinion regarding labor supply in his or her village or community.

[9] Whether this may be considered as a possible negative social effect of SRI or not depends on the situation of the without SRI scenario regarding children and women participation in the labor force in any particular locality.

children are particularly suited for handling the transplanting of small and delicate rice seedlings (Rena Pervez, 2002).

Location of the farm along the irrigation canal and generally the type of farming system (i.e., irrigated or rainfed farming system) had remarkable influence on the adoption pattern of SRI. These important patterns are revealed by the variables LOCFA and FYLWS. The model showed that the probability of adoption of SRI among irrigated farms is lower than that of rainfed farms. Why are rainfed farmers more likely to adopt SRI than irrigated farmers? This might be due to (1) the observed production risk differential among the two types of farming systems (2) the wage difference between rainfed and irrigated areas, and (3) Increased water holding capacity of the soil due to improvement in organic matter content and hence enhanced low moisture stress tolerance of the rice crop. The rainfed rice farming faces risk and uncertainty regarding the availability and distribution of rainfall. Therefore, rainfed paddy farmers are cautious about investments in cash inputs such as fertilizer, herbicides, and pesticides. Hence, for them, SRI, which decreases the demand for high-risk cash inputs is an ideal alternative rice productivity-enhancing strategy. Moreover, as elaborated in the section 5.1 of this paper, SRI involves the addition of huge amount of organic fertilizer, which improves the water-holding capacity of the soil and hence easing the risk of low-moisture stress. On the other hand, high labor input forms the characteristic feature of SRI practice, thereby making it attractive in those areas were there is abundant labor with relative lower wages. The positive sign of labor availability (LABAV) and family size (FAMIS) variables further corroborates this argument.

The model shows that there is no significant difference between farmers located at the head of the irrigation canal and rain-fed farmers regarding SRI adoption. But the probability of adoption of middle and tail farmers is significantly lower than that for rainfed farmers. At the first glance this may seem to contradict the widely held view that SRI saves water. But this finding underlines the importance of irrigation water supply uncertainty. In the advent of supply uncertainty, farmers may be reluctant not to flood their paddy fields when water is available. Why are farmers located along the head of the canal more likely to adopt SRI than those situated in the middle and tail ends? This may be due to the fact that, at least for irrigated farmers, there must be some degree of certainty regarding the availability of irrigation water (or control over water supply) for successful adoption of SRI (McHugh et al., 2002). Farmers at the middle and the tail maintain a water layer on their fields as buffer; in case irrigation water arrive at large intervals. Keeping the field drained is very risky if they have no control over water.

Another important variable having almost significant positive impact on SRI adoption is cattle or buffalo ownership through its effect on manure availability. The model also shows that there is no significant difference in SRI adoption between poor and rich farmers.

Table 5. Determinants of SRI adoption -Results of logit regression analysis

Variable Code	β	SE	Exp(β
CONSTANT	-2.3134	2.9217	-

Dependency Ratio (DEPRA)	-0.0454*	0.0277	0.955
Proportion of Children in the Family(PCHIL)	0.0462*	0.0285	1.047
Family Size (FAMIS)	0.3095*	0.1791	1.362
Age of the Household Head (AGEHH)	-0.0509	0.0359	0.950
Years of Schooling of the Household Head (YSCHH)	0.1645*	0.0861	1.178
Number of Training Programs Attended (NFTPA)	0.1760*	0.0901	1.192
Number of Extension Contact (NEXCY)	0.0343	0.5146	1.034
Proprotion of Income from Rice (PRICE)	0.0048	0.0117	1.004
Proportion of Non-farm Income (PRNIN)	-0.0039	0.0124	0.996
Incidence of Yield Loss due to Low Water Stress (FYLWS)	0.0575	0.1509	1.059
An Index of Social & Political Capital (POSOL)	0.0327	0.0821	1.033
Poverty Group (Poor)	0.0464	0.6746	1.047
Poverty Group (Middle)	-1.1770*	0.6857	0.308
Povert Group (Rich)-reference category			
Location of the Farm or Field (Head)	-0.2209	0.9935	0.801
Location of the Farm or Field (Middle)	-1.5452*	0.9161	0.213
Location of the Farm or Field (Tail)	-1.9079**	0.9309	0.148
Location of the Farm or Field (Rain fed)-reference category			
An Index of Labour Availability Perception (LABAV)	0.1334	0.1438	1.142
Number of Cattle Owned (CATTL)	0.5139	0.3380	1.671

Notes: significant at 10% probability level, ** significant at 5% probability level*
-2 Log Likelihood = 108.98
Model Chi-square = 46.284 (df = 18, p=0.0003)
Cox and Snell R^2=0.385[11]
Nagelkerke R^2=0.513
Percent correctly predicted = 76.79
N=112

5.2 Intensity of Adoption of SRI

The intensity of adoption once the farmer has decided to practice SRI was evaluated using the proportion of SRI area in the total paddy cultivated during *maha* and *yala* seasons and the proportion of farmers who allotted 100 percent of their paddy field to SRI. These are shown in figures 4 and 5. The proportion of paddy area allotted to SRI ranges from about 39 percent in *Kalthota* to about 61 percent in *Kurunegala* during *Yala* season. Some farmers have also allotted their total rice field to SRI. The proportion of such farmers ranges from as low as 10 percent in Kalthota to as high as 50 percent in Kurunegala (see figure 5). The proportion of SRI farmers with 100 percent of their paddy fields SRI is higher during *Yala* than during *Maha* in Kurunegala. This is in line with the presumption that *Yala* season is more water scarce than *Maha* season, and one of the advantages of SRI is to save water as has been elaborated in the previous sections.

[11] In OLS models, the R^2 statistic represents the proportion of variability in the dependent variable that can be explained by the independent variables. For **logit** regression model, an easily interpretable measure of the strength of the relationship between the dependent variable and the independent variables is not available. **Cox and Snell and Nagelkerke R^2** are attempts to imitate the interpretation of R^2 in OLS regression. They are attempts to measure strength of associations.

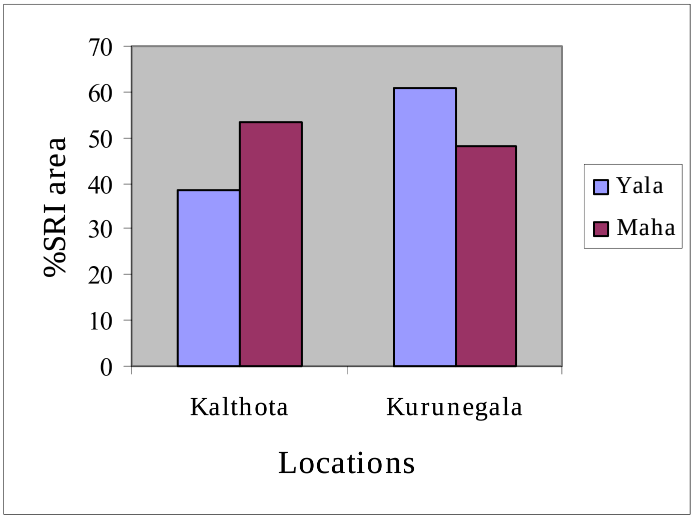


Figure 4. Proportion of Rice area allotted to SRI in 2002

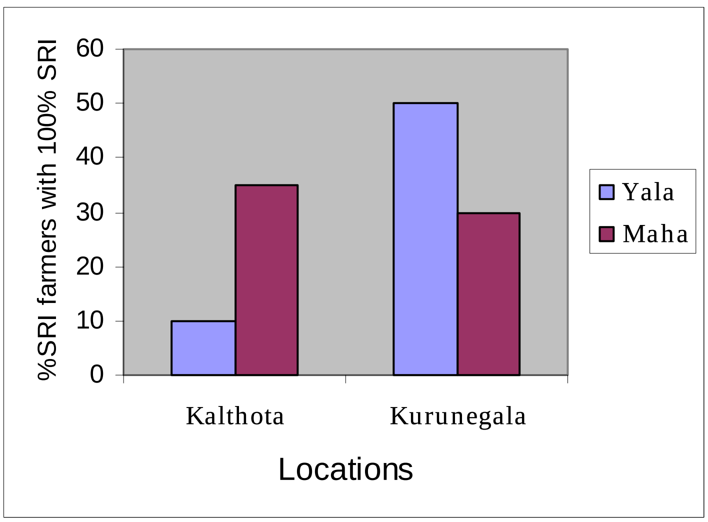


Figure 5. Proportion of SRI farmers who allotted 100 percent of paddy area to SRI in 2002

In the previous section, determinants of SRI adoption decision were assessed. However, the extent or intensity of adoption once the adoption decision is made is important information for research, extension and policy. This issue was evaluated using *tobit* regression model, which allows the estimation of the likelihood of adoption as well as the extent or intensity of adoption. It is preferable to *logit* adoption model when the decision to adopt also involves simultaneously a choice regarding the intensity of adoption, as it does with SRI practice. The model can be specified as:

$$y_i^* = \beta' x_i + \varepsilon_i$$

where y_i^* is a latent variable representing the use of the SRI; **X** is a vector of independent variables described in table 4, β is a vector of unknown parameters; and ε_i is a disturbance assumed to be independently and normally distributed with zero mean and constant variance; and i = 1, 2,…*n* (n is the number of sample households).

Denoting y_i (the proportion of SRI area in the total cultivated rice area) as the observed dependent (censored) variable:

$$y_i = \begin{cases} y_i^* & if \quad y_i > 0 \\ 0 & if \quad y_i \leq 0 \end{cases}$$

The proportion of paddy area allotted to SRI was regressed against various factors hypothesized to influence SRI adoption. A common mistake made when interpreting *tobit* coefficients is to treat them as effects of the independent variable for cases above the limit. To avoid this drawback, the *tobit* coefficients were decomposed following McDonald and Moffitt (1980) and the results are presented in table 6.

In the incidence of adoption model (i.e., *logit* model) discussed in the previous section, informational variables such as participation in training program and extension contact, poverty status, location of the farm, the farming system (i.e., irrigated vs. rainfed farming), and level of education were important variables in predicting SRI adoption. In the *tobit* model, which estimates both the incidence and intensity of adoption, the informational variables have lost their explanatory power. Instead, variables related to labor availability (DEPRA and PCHIL) and organic matter availability (CATTL) are more relevant.

Table 6 also shows the decomposition of the total elasticity of the variables[12]. The decomposition consists of two components, the probability of adopting in the first place, and the potential increase in the area allotted to SRI once the decision to adopt has been made. For example, the total elasticity value for the years of schooling (YSCHH) is 0.974, meaning that a 10 percent increase in the years of schooling is expected to result in about 9.7 percent in adoption and use intensity of the SRI practice. The probability of adoption will increase by 7.3 percent while the intensity of adoption will increase by 2.4 percent. The other variables in the table can be interpreted in an analogous manner.

[12] An elasticity of adoption measures the responsiveness to a particular variable, and is equal to the relative change in adoption of a technology with respect to a small relative change in a given variable from current levels. The elasticities obtained from the tobit model take into account that a change in the explanatory variable will simultaneously affect the number of SRI adopters and the proportion of acreage under SRI.

Table 6. The determinants of the extent or intensity of adoption of SRI- results of probit regression analysis

Variable	Coefficient	t-statistic	Marginal effect	probability of adoption	Intensity of adoption	Total elasticity
Intercept	-1.2736	-1.82*	-0.3402			
Poverty Grouping (POVGR)	-0.0870	-1.21	-0.0232	-0.283	-0.094	-0.377
Dependency Ratio (DEPRA)	-0.0091	-1.58*	-0.0024	-0.395	-0.131	-0.526
Location of the Farm (LOCFA)	-0.0312	-0.50	-0.0083	-0.119	-0.039	-0.158
Family Size (FAMIS)	0.0654	1.80*	0.0175	0.488	0.162	0.650
Age of the Household Head (AGEHH)	-0.0007	-0.10	-0.0002	-0.051	-0.018	-0.069
Years of Schooling of the Household Head (YSCHH)	0.0551	2.79***	0.0147	0.731	0.243	0.974
Number of Extension Contact (NEXLY)	0.0102	1.04	0.0027	0.038	0.012	0.050
Number of Farm Training Programs Attended (NFTPA)	0.0092	1.37	0.0025	0.050	0.016	0.066
Proprotion of Income from Rice (PRICE)	0.0002	0.06	0.0000	0.014	0.004	0.018
Proportion of Non-farm Income (PRNON)	-0.0011	-0.37	-0.0003	-0.035	-0.012	-0.047
An Index of Social & Political Capital (POSOL)	0.0275	1.55	0.0073	0.333	0.111	0.444
Episodes of Water Stress (FRWSH)	-0.0339	-0.94	-0.0091	-0.079	-0.026	-0.105
Labor Availability (LABAV)	0.0384	1.22	0.0103	0.533	0.177	0.710
Number of Cattle (CATTL)	0.1431	2.04**	0.0382	0.053	0.018	0.071
Proportion of Children in the Family (PCHIL)	0.0108	1.79*	0.0029	0.309	0.103	0.412

N=120

5.3 Determinants of SRI Disadoption

Disadoption is one important aspect which have not been given due consideration in past adoption research. Information on the reasons why certain group of farmers failed to stick to the technology recommended for use is of crucial importance for researchers, extension workers and policy makers. For instance, research may draw upon the drawbacks of the technology and improve upon those drawbacks to increase the chance of acceptability and wider dissemination of the technology among the intended beneficiaries.

In light of this fact, a *logit* model was fitted to the data on SRI farmers. Most of the variables in the SRI adoption modeling of section 5.1 were also included here. The additional variables incorporated in the current model are:

(1) An index of positive perception of farmers towards SRI (POSIP) constructed based on the reported advantages of SRI vis-à-vis the conventional system of rice production presented in table 2. The value of the variable ranges from 0 to 15, where 0 indicates lowest positive attitude of the SRI practitioners towards SRI and 15 shows the strongest positive attitude towards SRI. This variable is expected to have a negative relationship with disadoption since those farmers who had positive attitude towards SRI are expected to continue with SRI.

(2) An index of negative perception of farmers towards SRI (NEGAP) constructed based on the reported disadvantages of SRI vis-à-vis conventional system of rice production presented in table 3. The value of the variable ranges from 0 to 13, where 0 indicates lowest negative attitude of the SRI practitioners towards SRI and 13 shows the strongest negative attitude towards SRI. This variable is expected to have a positive relationship with disadoption since those farmers who had a negative attitude towards SRI are expected to cease practicing SRI.

(3) Average realized SRI yield (kg/acre) for SRI farmers while they were practicing. We expect that those farmers who had better paddy yield during their first season(s) of experimenting with SRI will continue with SRI. Contrarily, a low level of realized yield would lead to disadoption.
(4) The other important variable is the perception of farmers regarding the cost of capital or availability of cash (CASHR). This variable is particularly important in the sense that one of the cases for promoting SRI is due to its lesser reliance on external inputs, hence lesser requirement for cash or capital. The value for this variable ranges from 1 to 5, where 1 indicates severe cash constraint and 5 indicates the absence of cash constraint. We expect this variable to have positive relationship with disadoption.

Table 7. Determinants of disadoption of SRI-Results of logit regression analysis

Variable	**β**	**SE**	**exp(β)**
INTERCEPT	5.935	5.565	377.943
An Index of Degree of Positive Perception (POSIP)	-0.262	0.300	0.769
An Index of Degree of Negative Perception (NEGAP)	0.064	0.231	1.066
Average Realized Yield (AVERY)	-0.002**	0.001	0.998
Episodes of Rice Yield Loss due to Water Stress (FRRYL)	0.310	0.451	1.364
Labor Availability (LABAV)	-0.424	0.312	0.655
Proportion of Children in the Family (PCHIL)	-0.032	0.062	0.968
Poverty Group (Poor)	-3.021**	1.505	0.049
Poverty Group (Middle)	-2.504	1.618	0.082
Number of Extension Contact (NEXCY)	-0.314	0.215	0.730
Dependency Ratio (DEPRA)	0.052	0.057	1.053
Years of Schooling of the Household Head (YSCHH)	-0.065	0.187	0.937
Proprotion of Income from Rice (PRICE)	-0.016	0.020	0.985
An Index of Labor Availability Perception (CASHR)	0.766	0.591	2.151

Note: ** means the coefficient is significant at 5% significance level
–2 Log likelihood = 37.43
Cox and Snell R^2 *= 0.48*
Nagelkerke R^2 *= 0.66*
Percent correctly predicted = 86.7

All of the variables included in the disadoption model had the expected signs (table 7). However, only average realized yield during the first season(s) of practicing SRI (AVERY) and poverty status (POVGR) variables had statistically significant effect on disadoption. Hence, the success or failure of farmers during initial adoption process determines the acceptance and the pace of dissemination of a technology. In the adoption model (table 5), there is no significant difference in the probability of adoption of SRI between poor and rich farmers. However, the probability of disadoption among poor farmers is significantly lower than that among rich farmers. This implies that once the poor farmers adopt SRI, they have higher probability of continuing with it than rich farmers.

Among the perception variables, farmers' perceived cash availability (CASHR), labor availability (LABAV), frequency of rice yield loss due to water shortage (FRRYL), and an index of farmers' positive attitude towards SRI (POSID) respectively had strong coefficients. However, these were not statistically significant.

6. THE MICROECONOMICS OF SRI

6.1 Rice agronomy and irrigation water management

Farmers' agronomic practices, level of cash input utilization, and irrigation water management differentiated by system of production (SRI vs. conventional) and seasons (wet-maha and dry-yala) are shown in table 8. Expectedly, there is substantial difference between the two systems of rice production regarding planting method, fertility management and weed control practices. For instance, an average SRI-farmer transplants one 8-days-old rice seedling per hill, on a square grid of about 23 by 23 cm. While most conventional fields were planted by way of broadcasting, few conventional farmers have practiced transplanting. However, the SRI transplanting differs from the conventional transplanting in many ways. The conventional farmers planted on average four 18-days-old rice seedlings in a clump per hill, on a square grid of 15 by 15 cm, which is narrower than that for SRI.

Concerning soil fertility management, significant differences are noted between the two systems. Generally, SRI farmers used lesser doses of inorganic and higher doses of organic fertilizer per unit area as compared to conventional farmers. Moreover, a considerable number of SRI farmers abandoned altogether the use of inorganic fertilizers; instead they put a lot of organic fertilizers. The main sources of organic fertilizers include cow dung, tree leaves, straw, poultry manure, compost, and rice bran.

Weed control method is another important aspect differentiating the two systems of production. SRI farmers use herbicides rarely, instead they make use of a mechanical weeder and/or hand weeding. The conventional farmers rely heavily on herbicides and they flood their paddy fields with water as a means of weed control. It is important to flood the field at the correct stage.

One of the main advantages of SRI is its water saving with little or no reductions in the paddy yield (Thiyagarajan et al, 2002). We attempted to have an indirect and rough idea of the magnitude of on-farm or field-level water savings through farmer estimates of number of irrigation and hours of irrigation per unit area[13]. On average, number of irrigations and hours of irrigation per unit area of SRI-fields are respectively about 24 percent and 23 percent lesser than the conventional paddy fields. However, the difference between SRI and conventional regarding hours of irrigation is not statistically significant. Consistent to our a priori expectations, the per hectare hours of irrigation (for both SRI and Conventional fields) during yala season is greater than that of *Maha* season. This is because *Yala* season is relatively water scarce as compared to *Maha* season (see figure 7).

[13] Farmers were asked the number of irrigation done for each rice field they owned during *Yala* and *Maha* seasons. Moreover, they were asked to give approximate hours elapsed during successive irrigation. Then the number of irrigations was multiplied by the hours elapsed and divided by the area of the field to give an estimate of hours of irrigation per unit area. We admit that for more conclusive results an exact field-level measurement needs to be done preferably for a number of farmers.

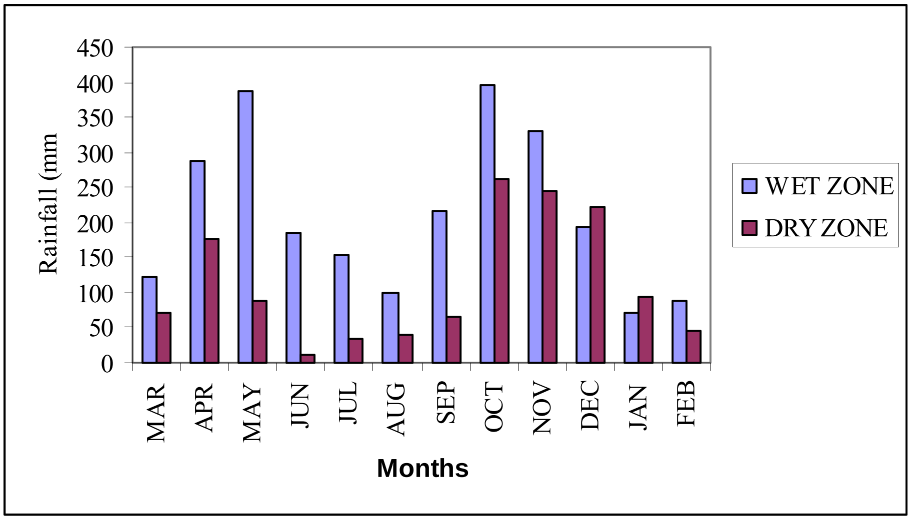


Figure 7.Monthly rain fall distribution for the Dry and Wet Zones of Sri Lanka (1961-1990)

Table 8 also clearly indicates that generally SRI fields demand higher amount of human labor (about 3 times more). This arises from planting (about 37 man-days per ha), weeding (about 31 man-days per ha), bund construction and cleaning (about 4.1 man-days per ha), and organic fertilizer collection and transportation (12.6 man days per ha). The corresponding figures for conventional fields are 8.1 man-days for planting (broadcasting), 1.6 man-days for weeding, 11.4 man-days for bund construction and cleaning, and 7.3 man-days per ha for organic matter collection and transportation. The amount of bund construction and cleaning labor for SRI is significantly lower than that for conventional fields. This is because the SRI farmers were advised not to clean bunds in order to harbor beneficial organisms as an integrated pest management strategy.

Table 8. Input utilization by system of rice production

	Practices or Inputs	SRI						Conventional					
		Yala			Maha			Yala			Maha		
		Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N[14]
Land preparation	Tractor hours per ha	26	23.2	32	24	18.7	32	28	18.3	129	28	18.9	145
	Bullock hours per ha	24	43.8	32	17	35.0	32	19	47.5	129	17	38.0	145
Planting	Transplanting hours per ha	244	152	32	352	262	32	114	144	37	271	181.0	38
	Broadcasting hours per ha	-	-	-	-	-	-	67.8	42.0	87	63	44.4	106
	Number of seedlings per hill	1.1	0.3	32	1.4	0.7	32	4.0	1.2	35	3.7	0.9	36
	Age of seedlings in days	7.6	1.9	32	8.4	2.7	32	18	3.5	38	18.5	3.9	38
	Spacing between plants in inches	9.5	1.3	31	9.4	1.3	32	5.9	1.5	19	5.9	1.3	23
	Spacing between rows in inches	9.7	1.2	32	9.6	1.1	32	6.0	1.6	19	6.2	1.5	23
	Seed rate kg per ha	14	10.0	32	17	12	32	117	38	112	114	38.0	132
Fertilization (Inorganic)	Urea per ha	77	73.0	32	78	80.4	32	141	86.2	128	133	81.5	147
	TDM kg per ha	76	130.5	32	51.6	78.2	32	97	80.0	128	96	75.6	147
	NPK kg per ha	57	105.6	32	45	74.1	32	104	71.8	128	100	74.9	147
	TSP kg per ha	-	-	-	-	-	-	13	120.8	128	4	19.9	147
	MOP kg per ha	-	-	-	-	-	-	0.3	3.3	128	0.5	4.3	147
Fertilization (Organic)	Cow dung in kg per ha	2024	3066	32	1422	2541	32	153	617.8	129	152	594.2	145
	Tree leaves in kg per ha	1013	1443	32	733	2513.3	32	247	1620.0	129	131	510.2	145
	Straw in kg per ha	951	1900.4	32	261	799.0	32	170	706.4	129	287	1022.6	143
	Poultry manure in kg per ha	73	258.5	32	39	149.6	32	31	349.5	128	75	659.8	145
	Compost in kg per ha	62	349.5	32	23	131	32	-	-	-	-	-	-
	Rice bran in kg per ha	23	94.5	32	8	43.7	32	-	-	-	-	-	-
Weeding	Herbicides liter per ha	0.15	0.87	32	0.08	0.31	32	2.29	3.25	129	2.14	3.07	144
	Hours of Mechanical Weeding per ha	283	281	32	213	260	32	3	23.3	127	2	17.50	145
	Hand Weeding Hours per ha	69	93.4	32	57	90.6	32	4	21.7	129	15	54.3	145
	Hours of bund construction and cleaning per ha	28	48.0	32	38	51	32	88	86.2	129	94	100.3	144
Irrigation	Mean Number of Irrigation	24	17.9	24	22	17.2	25	32	25.9	103	29	25.8	111
	Hours of irrigation per ha	1942	2425	21	1720	2116	23	2589	4038	97	2154	2993	103
Harvesting	Per ha hours of harvesting	328	266.2	31	326	376.7	13	355	254.6	115	265	181.7	84

[14] N refers to the number of fields. Since most of the farmers had more than one conventional rice fields the number of sample households and the number of fields may vary. All of the SRI farmers had only one SRI field. Moreover, not all of the original 60 SRI sample farmers had practiced SRI during 2002.

6.2 Yield Comparisons

The mean paddy yields obtained during the last three years differentiated by the system of production and seasons are listed in table 9. The mean SRI yield, even though not as dramatic as figures reported from many sources, is about 44 percent more than that for the conventional method (F value = 4.74, P=0.031). The reported conventional yields are well within the range of figures estimated by Sri Lanka Department of Census and Statistics. The Department's estimate of paddy yields for the country lies between 2.5 and 4.1 t per hectare depending on the type of farming system (i.e., rainfed or irrigated rice farming) and the type of irrigation scheme (Kikuchi et al., 2002).

Table 9. Rice yields under SRI and conventional system of management (Kg/ha)

Year	Sri			Conventional			%yield increase
	Yala	Maha	Mean	Yala	Maha	Mean	
2000	4097	6236	5488	3635	3644	3641	50.7
2001	5056	5327	5215	3516	3749	3633	43.5
2002	5737	5977	5811	4189	3832	4041	43.8
Mean	5299	5763	5524	3910	3757	3836	44.0

However, the yields reported in table 9 above conceal the effects of location, and adoption status[15]. The highest paddy yield (8.1t /ha) was recorded for SRI in Kalthota area during *Maha* season for adopter group, while the lowest (2.1t/ha) was recorded for disadopters during *Yala* season in Kurunegala (Table 10). Generally, disadopters experienced the lowest paddy yield during the first year of adoption forcing them to discontinue the SRI practice. The disadoption model of Section 5.3 also corroborates this fact. Location-wise the yields recorded for Kalthota area are significantly better than those recorded for Kurunegala farmers irrespective of the system of production. From table 10 one can also infer that the prospect of harvesting better paddy yield is higher for the *Maha* season than the *Yala* season, which is in line with the usual expectation.

Table. 10 Paddy yield per acre by adoption status, season, year and location (kg/ha)

Location	Year	SRI				Conventional			
		Adopters		Disadopters		Adopters		Disadopters	
		Yala	Maha	Yala	Maha	Yala	Maha	Yala	Maha
Kurunegala	2000	5726	7217	2102	4668	3501	3063	3769	4372
	2001	6011	5499	4100	4628	4040	3628	2942	3851
	2002	5619	5977	NA	NA	3071	3702	3863	3911
	Mean	5785	6231	3101	4648	3537	3464	3524	4045
Kalthota	2000	NA	NA	NA	NA	NA	NA	NA	NA
	2001	NA	8154	NA	NA	6795	NA	NA	NA
	2002	5806	NA	NA	NA	4900	NA	NA	NA
	Mean	5806	8154	NA	NA	5848	NA	NA	NA

NA means not applicable

[15]. The original SRI sample farmers who have not practiced SRI during *Yala* or *Maha* seasons of the year 2002 are regarded as disadopters. By these criteria 20 of the 60 SRI sample farmers are disadopters.

SRI is usually considered as a practice that gives substantial yield without the use of inorganic fertilizer (Barison, 2002). Despite the advice not to use inorganic fertilizer, some farmers have continued to use it with varying intensities. The SRI farmers' level of utilization of inorganic fertilizer has been arbitrarily classified into four strata, starting with zero level of utilization and the corresponding paddy yields recorded for each stratum are reported are shown in Table 11. Interestingly, the SRI farmers who did not apply any form of inorganic fertilizer recorded better or comparable yields to those farmers who applied up to and above 200 kg of fertilizer in *Yala* and up to 200 kg during *Maha*. Another important observation is that while the paddy yield response to the applied fertilizer levels has slowed (i.e., the marginal product has shown declining trend) during *Yala*, the yield response to additional levels of fertilizer has not reached optimum level during *Maha*. The reason for this remarkable response difference may be due to variations in the level of available water during the two seasons. Therefore, the two seasons might need different fertilizer recommendations.

The scenario for conventional paddy fields is different in that the response to the applied levels of fertilizer has been linear, i.e., zero-inorganic fertilizer fields gave on average lower yields than the successive levels of fertilization especially during maha season (table 12). The reason for this difference is due to the fact that on SRI fields the added inorganic fertilizer was supplementary to the organic fertilizer, while for conventional fields chemical fertilizer was mostly the main source of nutrients.

Table 11. Yield comparison by level of fertilizer application (kg/ha)-SRI farmers

Inorganic fertilizer (kg/ha)*	**Yala**			**Maha**		
	Mean	SD	N	Mean	SD	N
0	5792	2715	5	4349	2460	2
0 to 100	4851	2133	9	4159	3279	4
100 to 200	5954	2350	3	5362	2202	2
200 & above	6481	2755	13	9133	1977	4
Grand mean	5825	2506	30	6049	3218	12
F value	1.741(P=0.195)			4.985 (P=0.035)		

*The inorganic fertilizers were UREA, TSP, NPK, and MOP

Table 12. Yield comparison by level of fertilizer application (kg/ha) - conventional farmers

Inorganic fertilizer (kg/ac)*	**Yala**			**Maha**		
	Mean	SD	N	Mean	SD	N
0	3970	1786	9	1821	1136	5
0 to100	4153	1699	28	3797	1615	30
100 to 200	4384	1975	68	3805	1930	35
200 & above	5052	2153	20	4449	1522	10
Grand mean	4409	1936	125	3758	1786	80
F value	1.058 (p=0.370)			2.625 (P=0.056)		

*The inorganic fertilizers include UREA, TSP, NPK, and MOP

6.3 Profitability Comparisons

The microeconomics of the two systems of rice production was assessed using enterprise budgeting technique [16]. Net returns were estimated for each farmer using the following relationships:

$$NR = GR - TC$$

$$VC = \sum_{i}^{n} P_i X_i$$

$$TC = VC + F$$

$$GR = RY * RP$$

Where, NR= Net Returns; GR= Gross Returns; VC= Variable Cost; RY= Rice yield for SRI and conventional system; RP= Rice price; P_i = per unit price of the i^{th} input and
X_i= quantity of the i^{th} input; F is fixed cost and TC is total cost.

The individual budgets prepared for each and every sample farmers differentiated by system of production and seasons (i.e., SRI and conventional) were averaged to facilitate easy comparisons (see table 13). Moreover, the budgets were prepared under three wage-rate scenarios i.e., zero wage rate or family labor, on-going farm wage rate, and non-farm wage rate. It is interesting to note that contrary to the survey farmers' own subjective assessment and reports from different angles, the cost of production per unit area for SRI is higher or at least comparable to that of conventional rice production[17]. Even though SRI reduces or avoids the use of cash inputs such as fertilizer and herbicides, the resulting savings can not fully compensate for the additional costs born due to greater labor input for weeding, transplanting, and organic matter collection and transporting. However, the costs per unit of paddy output (Rupees per Kilogram) are lower than those of conventional due to significant increases in yield. Consequently, the estimated profit figures for SRI is almost double that of conventional practice for both seasons. But, it may be noted that this level of profitability is achieved with a lot of drudgery.

In addition to the reported positive profitability figures, table 13 also shows that some farmers experienced loss during both seasons. This shows the advantage of budgeting for each farm than for average farm. Two inferences may be made. First, the incidence of loss is higher for *Yala* than for *Maha* season. Secondly, the incidence of loss among SRI farmers is substantially lower than that for conventional farms irrespective of the season.

In Sri Lanka, it is usually claimed that the competitiveness of rice sector has been worsen by the relative high wage rate. Careful scrutiny of the costs and revenues of paddy production systems under three wage rate regimes presented in the table 13 tempts us to believe this claim.

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[16] Enterprise budgeting technique was preferred to Partial Budgeting because SRI involves a major overhaul of the conventional rice production system. Had the changes in the production system been minor, partial budgeting would have been the natural choice according to CIMMYT (1988).

[17] The costs include both cash and imputed labor and material costs.

Table 13. Summary Results of the Enterprise budgets

Production system	Season	Wage rate	Gross Revenue (RS)	Total cost (RS)	Net Revenue (Rs)	Cost/kg (RS)	Incidence of loss
SRI	Yala	Zero	34899	6506	29371	3.6	1
		farm	34899	18907	15992	11.1	4
		Non-farm	34899	24842	10223	15.0	6
	Maha	Zero	36720	5291	34575	2.2	0
		farm	36720	20435	16285	8.7	1
		Non-farm	37620	26493	13374	11.4	2
Conventional	Yala	Zero	27017	10742	16032	7.6	9
		farm	27017	18600	8417	13.3	27
		Non-farm	27017	22248	4215	15.5	29
	Maha	Zero	23871	9503	14373	6.8	0
		farm	23871	16381	7490	11.9	15
		Non-farm	23871	19687	4369	14.0	22

7. CONCLUSIONS AND IMPLICATIONS

1. The main advantages of SRI include yield increase, reduced number of irrigations or irrigation-hours per irrigation and per unit area (i.e., increase in water productivity), reduced demand for cash inputs, improved seed quality, and higher milling ratio. In addition to these private benefits, SRI embodies added societal or environmental benefits due to reductions in the use of environment-unfriendly inputs such as herbicides and fertilizers. It is not clear, however, if the observed on-farm water productivity can be translated into net water-saving at watershed or basin level, which is an issue requiring further analyses. This can be realized only if the practice is widely adopted and the farmers do not increase acreage.
2. The System of Rice Intensification has a short history in Sri Lanka. Its adoption process is dynamic in the sense that the adopters may quit the practice for some time and then reuse it when the circumstances allow. This is because the practice involves little capital investment during initial adoption decision.
3. The main variables influencing the incidence of SRI adoption are (i) location of the farm, (ii) the type of farming system (i.e., irrigated Vs rain-fed farming) (iii) poverty status of the farmer (iv) participation in training programs (v) education status and (vi) the size and demographic structure of the farm family.
4. The absence of significant difference in SRI adoption probability between farmers located at the head of irrigation canal and rain-fed farmers, and the observed lower probability of SRI adoption among those located at the middle and tail end of irrigation canal underlines the importance of irrigation water supply risk and uncertainty variable in SRI adoption decision. Hence, contrary to the ideal SRI practice, farmers at the middle and tail maintain a water layer on their field as a buffer, to offset the risk of irregularity regarding irrigation water arrival. This may also be done to reduce weed growth. On the other hand, the total dependence on rain for paddy cultivation means that the farmers are more cautious in

investing in conventional yield enhancing cash inputs. Therefore, SRI which minimizes or avoids the use of such inputs is the logical alternative for rain-fed farmers.

5. SRI adopters mai nly come from the lowest and the highest poverty terciles of the farming population. In other words, there is no significant difference in SRI adoption probability between rich and poor farmers. But, poor farmers are likely to persist with SRI once they practice SRI than the rich farmers. Moreover, low realized yield during the first experiment with SRI is the major factor behind discontinuing the SRI practice.
6. The main variables affecting the intensity of adoption of SRI are cattle ownership, which is a proxy for organic mater availability, education status and the size and demographic structure of the farm family.
7. The main problems associated with SRI practice are the demand for skills and high amount of labor for weed control and transplanting, non-availability of organic manure and limited availability of the rotary weeders.
8. The most appropriate domain (target group) for SRI adoption are those farmers:
    a. With limited land holdings,
    b. Having bigger family size with high proportion of the family members capable of engaging in work,
    c. Who are cash constrained,
    d. For whom rice constitutes the lion's share of annual income and consumption,
    e. With limited alternative employment opportunities,
    f. With relative certainty regarding irrigation water supply, and
    g. Practicing rainfed paddy cultivation.
9. Generally, SRI demands higher amounts labor per unit area (a lot of drudgery is involved) and induces the active participation of children between 7 and 14 years of age and women. However, whether this is a significant social disutility is a matter for further scrutiny.

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