RESEARCH REPORT

75

Prospects for Adopting System of Rice Intensification in Sri Lanka

A Socioeconomic Assessment

Regassa E. Namara, Parakrama Weligamage and Randolph Barker

International Water Management Institute

COMPREHENSIVE Assessment of water management in agriculture

FUTURE HARVEST
IWMI is a Future Harvest Center supported by the CGIAR

Research Reports

IWMI's mission is to improve water and land resources management for food, livelihoods and nature. In serving this mission, IWMI concentrates on the integration of policies, technologies and management systems to achieve workable solutions to real problems—practical, relevant results in the field of irrigation and water and land resources.

The publications in this series cover a wide range of subjects—from computer modeling to experience with water user associations—and vary in content from directly applicable research to more basic studies, on which applied work ultimately depends. Some research reports are narrowly focused, analytical and detailed empirical studies; others are wide-ranging and synthetic overviews of generic problems.

Although most of the reports are published by IWMI staff and their collaborators, we welcome contributions from others. Each report is reviewed internally by IWMI's own staff and Fellows, and by external reviewers. The reports are published and distributed both in hard copy and electronically (www.iwmi.org) and where possible all data and analyses will be available as separate downloadable files. Reports may be copied freely and cited with due acknowledgment.

Research Report 75

Prospects for Adopting System of Rice Intensification in Sri Lanka: A Socioeconomic Assessment

Regassa E. Namara, Parakrama Weligamage and Randolph Barker

International Water Management Institute
P O Box 2075, Colombo, Sri Lanka

IWMI receives its principal funding from 58 governments, private foundations, and international and regional organizations known as the Consultative Group on International Agricultural Research (CGIAR). Support is also given by the Governments of Ghana, Pakistan, South Africa, Sri Lanka and Thailand.

The authors: Regassa E. Namara is a post doctoral scientist; Parakrama Weligamage is an agricultural economist; and Randolph Barker is a principal economist, respectively at the International Water Management Institute.

Acknowledgments: The authors appreciate the cooperation extended by farmers who participated in the survey; Gamini Batuwitige of the Sri Lanka Ministry of Agriculture and H. S. Somathillake of the Ceylon Electricity Board for suggestions on survey sites; Sunanda Padmini, Amara Damayanthi, Kaushalya Moragaspitiya, Samantha Udukumbura and Janaka Dayaratne for research assistance; Priyantha Chandrasena and Shantha Kumara for the excellent work as drivers, which made the intensive field surveys more efficient; and David Molden, M. Samad, Norman Uphoff and anonymous reviewers for their invaluable comments on earlier drafts of this paper.

This research contributes to the Comprehensive Assessment of Water Management in Agriculture (*www.iwmi.org/assessment*) and was supported by a grant from the Government of Netherlands to the Comprehensive Assessment.

Namara, R. E.; Weligamage, P.; Barker, R. 2003. *Prospects for adopting system of rice intensification in Sri Lanka: A socioeconomic assessment.* Research Report 75. Colombo, Sri Lanka: International Water Management Institute.

rice / system of rice intensification / water management / sustainable agriculture / farming systems / technology adoption / soil fertility / weed control / soil moisture / irrigated farming / irrigation water / poverty indicators / transplanting / households / water resources / environment / paddy fields / Sri Lanka

ISSN 1026-0862
ISBN 92-9090-535-2

Please send inquiries and comments to: iwmi@cgiar.org

Contents

Summary

These days the demand for water resources is becoming intense as a result of population pressure, competitions among different uses and users, and the inefficiencies of the developed water infrastructures. As agriculture currently consumes the bulk of the available water resources, the efficiency and productivity of water use in this sector may contribute to the relaxation of the demand for water. The *System of Rice Intensification* (SRI) first developed in Madagascar and now being tested in many countries, is an example of an on-farm water productivity enhancing approach. The system is based largely on organic farming principles and additional requirements for the timing of transplanting and spacing of seedlings, and irrigation scheduling.

The SRI recently generated interest and discussions among researchers, development practitioners and policymakers in Sri Lanka. This has often resulted in polarized views. Some proponents claim that SRI will revolutionize the method of rice production, while others see it as a fad. Studies in Africa, Asia and Latin America provide mixed results. But most of these studies are anecdotal in nature or are limited to experimental and demonstration activities. Only one other study that we are aware of (conducted in Madagascar) applies an appropriate methodology that would assess the farmer' experience. This study contributes to filling this research gap based on Sri Lankan farmers' experience. The study specifically assesses the adoption pattern, economics and the poverty outreach of the SRI, and draws research, extension and policy implications.

The data for the study were obtained from focus group interviews and structured questionnaire surveys conducted in the Ratnapura and Kurunegala districts of Sri Lanka. The sample farmers were selected using a two-stage stratified random sampling design. The total sample size was 120 farmers, 60 from each of the two study locations, and from each location 30 each, from SRI and non-SRI farmers. The resulting data were analyzed using descriptive statistics, econometrics of qualitative dependent variables, enterprise budgeting, and indicator-based poverty assessment tools.

There was a wide variation in the way that farmers practiced the SRI, with the majority of the adopters using the methodology on only a portion of their farms. However, as found in other studies, many farmers disadopted after a season or two largely because of heavy labor requirements (about 3 times more than that for conventional rice cultivation), due mainly to transplanting, weeding, bund construction and cleaning, and organic fertilizer collection and transportation. Among nonusers, 87.5 percent reported having heard about the SRI, mostly from other farmers, and of these, only 25.4 percent confirmed that they intend to practice SRI. Consistent with the practicing farmers' observations, the non-adopters reported that the major obstacle to the adoption of SRI was the high labor demand and the tedious nature of the associated management practices, such as transplanting and manual weeding.

The determinants of adoption of SRI were identified using logistic regression analysis. Labor availability, years of schooling, access to training programs, farm or field location, and the poverty status of the household were the main determinants. Households with a large family size and greater labor availability were more likely to adopt SRI, which reflects SRI's higher demand for labor. There was no significant difference in the SRI adoption probability between farmers situated at the head of the irrigation canal and rain-fed

farmers. On the other hand, farmers at the middle and tail of irrigation systems are less likely to adopt SRI than rain-fed and head farmers. For rain-fed farmers, the opportunity to minimize cash costs due to weather risks was an incentive for the adoption of SRI. In a parallel analysis of determinants of disadoption of SRI, average realized yield during the first season(s) of adoption and poverty group membership were statistically significant variables. One of the controversies surrounding the SRI is whether it is suitable for adoption by poorer households. The analysis showed that the rich and the poor farmers were equally likely to practice SRI, though for different reasons. The rich are more educated and more inclined to experiment with new methods; the poor have more urgent need to raise the productivity of their limited land and their relatively more abundant labor. Their net benefit per hectare was somewhat less than for richer farmers. Once they adopted SRI, the poor were more likely to continue using it.

SRI farmers in Sri Lanka reported a yield increase of 44 percent, which is lower than that reported by many other countries. Returns to crop budgets were higher even when charging a relatively high rate for labor. The cost of production per hectare was not lowered with the SRI methods. However, given that production was significantly increased, the cost of production per unit of paddy output was considerably lower. Consequently, the estimated average profits for SRI was almost double that of the conventional practice. But not all farmers registered positive profit figures. Some had net losses. The incidence of losses among the SRI farmers was substantially lower than that for conventional rice cultivators. The reduction in inorganic fertilizer and other agrochemical use under SRI are environmental benefits, which only a few farmers appreciate, or are concerned with. But these societal benefits could justify public efforts to support the spread of SRI.

Thus we conclude that the System of Rice Intensification, like its closely related practices, such as organic farming, ecological farming, and low-input sustainable agriculture, is a niche production method, and without widespread adoption, there is little, if any, water saving at a system or basin level. The main avenues for making SRI more viable for rice farmers in Sri Lanka are: (1) improving the efficiency of or mechanizing the transplanting and weeding operations; (2) research into an alternative source or method of soil fertility management; and (3) improving the reliability of irrigation supply. Whether or not to pursue these avenues and promote SRI remains an open question. However, this study will provide policymakers with a realistic appraisal of the potentials and limitations of SRI in Sri Lanka. Hopefully, it will stimulate further systematic research efforts to assess the potential benefits and limitations of SRI adoption in diverse climatic and socioeconomic environments.

Prospects for Adopting System of Rice Intensification in Sri Lanka: A Socioeconomic Assessment

Regassa E. Namara, Parakrama Weligamage and Randolph Barker

Introduction

In the 1960s South Asia suffered acute food shortages due to the poor productivity of its two staple foods – rice and wheat. Since then, the situation has been turned around to one of surplus production, though distribution problems still persist. The main factors behind this transformation process were the 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 had serious negative social and environmental externalities such as (1) depletion of water tables, (2) decline in soil fertility, (3) aggravation of air pollution, and (4) resistance of weeds to certain herbicides (Stoop et al. 2002). The massive increase in production and the increases in the relative prices of cash inputs that constitute core elements of the conventional intensification process have depressed the prices of outputs and hence the returns that the producers normally get. At the moment, buffer stocks of wheat and rice are held by governments at high cost. Hence, technologies that lower costs, are favorable to the environment, save resources such as water, and improve returns are currently in high demand.

In Sri Lanka, most land resources suited to the production of rice have already been exploited, and most of the readily manageable water resources have been developed to irrigate paddy fields. The dominant practice in rice production is flooded irrigation, which requires large amounts of water. Therefore, any further increase in the production of rice depends heavily on intensification in existing rice lands. But the intensification process must avoid the environmental, resource, health and social malaises of the conventional system of production intensification, described above. The new intensification process is known with 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.

Definition of SRI

What exactly is the SRI? The system was developed in Madagascar by Rev. Fr. De Laulanie, a French priest and agriculturist who worked closely with farmers (Uphoff et al. 2002).

There are many definitions and descriptions of SRI.[1] All of these definitions underline the importance of conceptualizing SRI as a system rather than as technology because it is not a fixed set of practices. Therefore, SRI is not a package of fixed technical specifications; it is rather a system of production formulated 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 the potential of soil biology for pushing up the yield plateau of rice further. 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 3 to 4 weeks. Transplanting should be done quickly and carefully, preferably within15-30 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 25 x 25 cm or even larger (up to 50 x 50 cm), which is much sparser than the usual 15 x 15 cm or 20 x 20 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 called a "rotating hoe,"— starting 10 days after transplanting and then weeding every 10 days at least two or three 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).

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. These discussions have often resulted in polarized views with one group advocating for the wider dissemination of the practice and another group

---

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

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 claimed advantages.[2] These experiments vary in design and rigor from simple un-replicated on-farm trials conducted by NGOs, either alone or in cooperation with National Agricultural Research and Extension Systems, 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 and 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.[3] For instance, an experimental result from IRRI (International Rice Research Institute) showed disappointingly low performance of SRI. A similar study done at Batalagoda rice research and development institute in Sri Lanka showed no significant difference between SRI and the conventional system of rice production. Except for the Moser 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 2002, more than 3,000 farmers in 18 districts of Sri Lanka were estimated to be practicing SRI in small plots of about 0.2 ha on average (Batuwitage 2002).[4] The specific objectives of the study were:

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

Methodology and Data

Data for this paper were obtained from surveys in two localities in Sri Lanka. The data collection process followed two inter-related steps. First, focus group interviews and key informant surveys were undertaken at various times during September and November 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

---

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

[3] 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 sizes for SRI and conventional systems.

[4] Comprehensive descriptions of the SRI practices were published in the January/February 2000 issue of "*Javaya*,“ a newspaper published by the Ministry of Agriculture.

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.

Operational Definition of SRI Adoption

Numerous theories have been advanced by social science and other disciplines to explain and measure technology or innovation adoption (Feder et al. 1982 and Rogers 1995). Much of the literature on adoption of innovations concerns itself with the long-term rate of adoption, which is usually represented by an S-shaped cumulative frequency curve and the factors that influence the adoption decisions. For rigorous empirical analyses, however, a precise definition of adoption (adopter) is required, and as recent CIMMYT (International Wheat and Maize Research Institute) experience on crop variety adoption research in East Africa indicates is a complicated question with no obvious, correct answer (Doss 2003). Usually a distinction is made between the degree of use (intensity of adoption) and incidence of adoption. The intensity of adoption refers to the extent of use of an innovation by the adopting unit once the adoption decision has been made. In this sense adoption is a continuous measure (e.g., percentage of rice area under SRI). The incidence of adoption refers to the situation where the adopting unit has used or not used the innovation during a reference time. In this case adoption is a discrete state with binary variables (a farmer is either an adopter or is not). Thus, a farmer may be classified as an adopter and still use the old innovation on part of his or her farm. This approach is appropriate when farmers practice new technology or old technology but not both at the same time. In the situations where farmers are increasing the intensity of use of new innovations while continuing to practice the old one, then a continuous measure of adoption is appropriate. Hence, the definition of adopter (adoption) has important implications for the type of econometric model to be followed in the analyses of data as detailed under *The Adoption of SRI in Sri Lanka: The Spatial and Temporal Dynamics.*

The main limitation of early adoption research was the implication that innovation should be diffused more rapidly because it was viewed unquestionably as improvements over its predecessor and that it should neither be modified nor rejected or discontinued (Rogers 1995). However, rejection, discontinuance and modification of innovations are rational and appropriate behaviors from the farmers' point of view (Moser and Barrett 2003). Thus, in defining an adopter, we may also be interested in farmers' history of innovation use. To develop such histories, we must ask not only whether a farmer is currently using a particular technology, but also whether he or she has ever used it. This helps to distinguish farmers who have at some point in time tried a technology from those who tried it and discarded (disadopters). In many studies, both categories are treated as non-adopters, which may conceal important differences.

In the present case, "SRI adopters" (or SRI farmers) are those farmers who tried SRI at least once during the last 5 years (1998 to 2002) on whole or part of their paddy fields. It must be noted here also that the SRI adopters are people who "say they have tried SRI" and that what they practice under the system of SRI varies widely from farm to farm. 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* (minor agricultural season from April to August) and *maha* (major agricultural season from September to March) seasons. The non-adopters (or non-SRI farmers) are those who have not practiced SRI during the above reference period.[5] SRI adoption intensity refers to the proportion of farmers' total paddy fields allotted to the SRI practice.

Sampling Design and Procedure

A 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 the Ministry of Agriculture office, Colombo. In Ratnapura (Kalthota Irrigation Scheme) according to the CEB (Ceylon Electricity Board), 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 the Kurunegala district. Study locations are depicted in figure 1.

In Ratnapura SRI farmers were stratified into two categories based on their location relative to the irrigation scheme (namely left and right bank). A simple random sampling design was used to select 15 SRI farmers from each bank, ultimately giving a total of 30 SRI farmers. The non-SRI farmers were selected in two stages. First, two farmer organizations (FOs) from the left bank and four from the right bank were selected. Then in the second stage seven to eight farmers from each FO were selected, making a total 30 non-SRI farmers.

In Kurunegala, SRI farmers are dispersed over substantial areas of the district. Some villages have only a single farmer practicing SRI. To economize survey logistics and time farmers' location was sorted by postal area, and postal areas with less than three SRI farmers were removed in the first stage. It was observed that the majority of the remaining postal zones are located in two clusters, one to the northeast of Kurunegala (Maho-Rambe) and the other towards the southwest of the town (Maharachchimulla). Farmers in these two locations accounted for 68 percent of all practicing SRI farmers in the district. A separate list of SRI farmers was prepared for each location, which then served as a sampling frame. Ultimately, 15 SRI farmers each from Maho-Rambe and Maharachchimulla were selected. Concerning the non-SRI sample, two villages or Farmer Organizations from each location were selected to represent the dominant type of water regime of paddy farming in the respective area. These were Dagama (from Hakwatuna major irrigation scheme) and Ponnilawa Maha wewa (15 ha minor tank scheme) in the Maho-Rambe area, and Wilgamuwa wewa (32 ha minor irrigation scheme) and Kandegedera (a rain-fed paddy tract of 41 ha) in Maharachichimulla area. Finally, seven to eight non-SRI farmers were selected from each village. Ultimately 30 SRI and 30 non-SRI farmers were sampled.

The structured questionnaire survey was implemented in January and February 2003 by the research team with the help of trained enumerators.

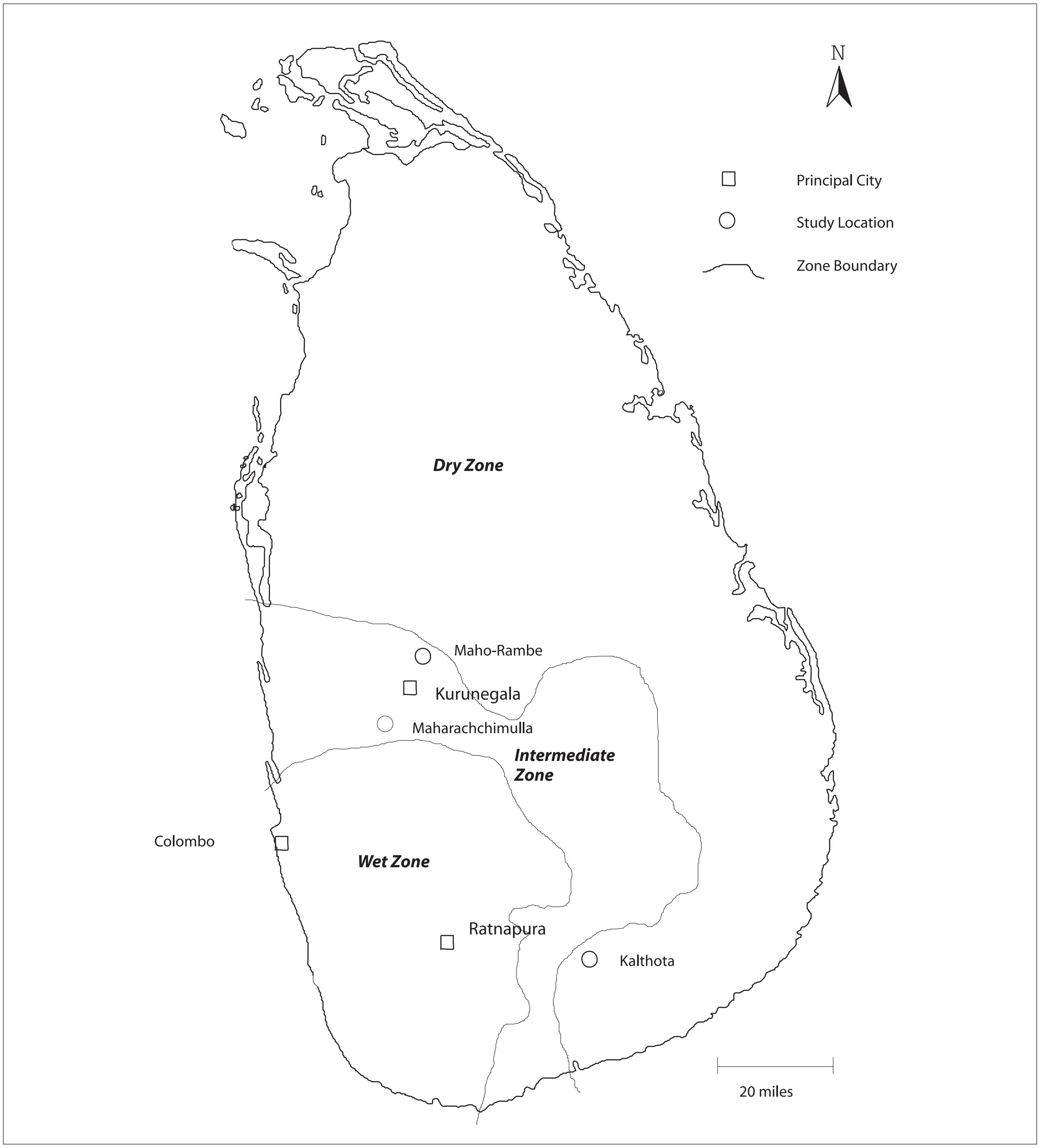
Analytical Framework

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 and principal component analyses were

---

[5] Henceforth, adopters for SRI farmers, and non-adopters for non-SRI farmers are used interchangeably.

FIGURE 1.
Study locations.



Source: The map is based on Panabokke (1996) and Sri Lanka Department of Survey Maps.

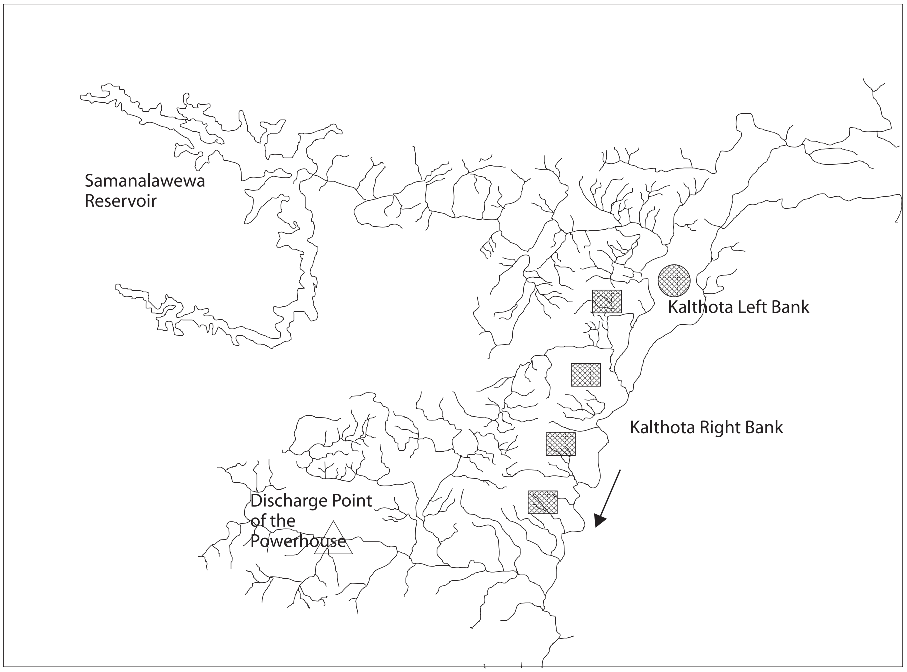
used to assess factors influencing the incidence and intensity of adoption and disadoption of SRI and the poverty outreach of SRI adoption, respectively. The enterprise budgeting technique was used to assess the economics of SRI vis à vis the conventional system of rice production in the two locations for yala and maha seasons of the year 2002.

Description of the Study Areas

Kalthota Irrigation System

Kalthota is situated in the Ratnapura district and in the Balangoda subdistrict. Agricultural activities in Ratnapura are mainly based on plantation crops and mixed home-gardens generating spices. The district is predominantly a wet zone area, while southeastern parts of it fall within the intermediate and dry zones. Kalthota irrigation system is a river diversion system in the Walawe River, one of the major rivers in the country. The area falls within low land dry zone one (DL1) agro-ecological region and the irrigation system is managed by the Irrigation Department. The ancient irrigation system in the area was restored by the British in the 1880s and expanded in the late 1950s as a part of government programs promoting agriculture. Developed lands were allotted to peasant settlers, selected from highly populated and thus land-scarce wet zone villages in the same district. Today, the system irrigates 1,000 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 landholdings. A majority of the command area is cultivated in both seasons. A schematic diagram of the system is presented in figure 2.

FIGURE 2.
Location of the Study in the Ratnapura District.



Kalthota farmers had the freedom of using the flow of the Walawe River until 1990 as there were no major upstream developments to divert water from the original river course. Construction of a reservoir upstream as the storage facility for a 120 MW hydropower generation complex affected the flow of water at the diversion point as the discharge after power generation is at a point below the water uptake to the system. Since this intervention, the Kalthota irrigation system is experiencing a shortage of water.

However, as Kalthota 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. Power authorities face the problem of minimizing the amount of water released for nonelectricity generating uses, as such releases reduce the amount of water available for electricity generation and hence are a contributor to revenue loss. The CEB tried various strategies to minimize the amount of water released. First among them was paying compensation for foregone crops due to non-planting. This seems to have failed as non-cultivation brought the economic activities to a standstill. Payments were made to landowners and thus income sources of tenant cultivators and off-farm income to farm families became non-existing. There were also serious threats to household food security as payments were made as a lump sum and many recipients used it for non-food expenses and had no other source of income to buy food. 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.

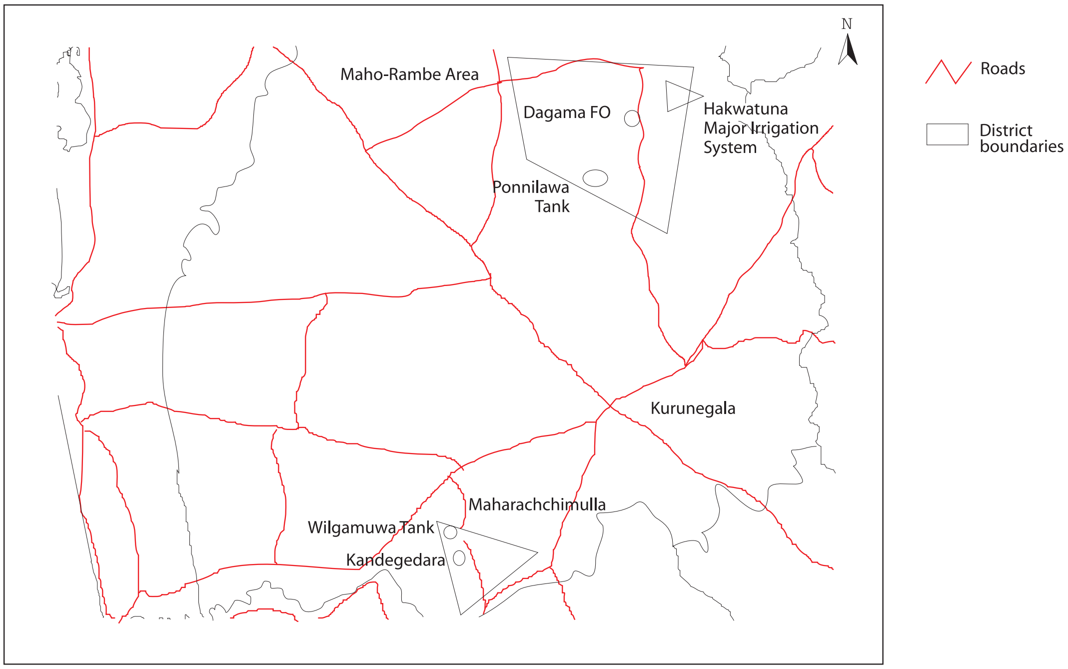
Kurunegala District

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 falls within the dry zone and southern part in the wet zone. Coconut cultivation in plantations as well as in smallholdings 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 accounts for 12,621 ha of major irrigation under 15 irrigation schemes and 33,804 ha under 4,188 minor tanks and 657 minor river diversion schemes. About 29,028 ha of paddy land are rain-fed (figure 3).

Both study locations in Kurunegala, Maharachchimulla and Maho-Rambe, are situated within the intermediate low country. The former is in the ntermediate low country one (IL1) agro-ecological region and the other in the intermediate low country three (IL3) region. IL1 is wetter than IL3 as it receives more rainfall and has more uniformly distributed rainfall than the latter. The landscape in the IL1 region is rolling, undulating and flat while that in IL3 it is undulating. The soil type in IL1 is Red Yellow Podzolic or Regosols on old sands. In the IL3 region, soils are Reddish Brown Earth (RBE) in the highland while the paddy soils are Low Humic Gley (LGH).

Land use patterns in the two locations show some differences. In the Maharachchimulla area, coconut cultivation is the predominant user of land. Paddy is mainly rain-fed. There are eight minor irrigation tanks and five minor river

FIGURE 3.
Location of the Study in the Kurunegala District.



diversions irrigating 160 ha and 50 ha, respectively. Ginger is grown as a cash crop in paddy lands in intermittent years. The area is closer to trunk routes and to urban locations. Paddy under minor tanks and seasonal crops in the highlands is the mainstay of agriculture in the Maho -Rambe area. There are 4,288 ha of paddy area irrigated through 533 minor tanks, and 23 river diversion schemes irrigate 288 ha of paddy. There are also 2,375 ha of irrigated land under major tanks systems. 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 the Kurunegala district mainly due to its proximity to the “Nature Farming Center,” a training and research center on ecological farming and initiatives by one regional farmer federation to produce and distribute hand weeders, an essential tool for practicing SRI.

The Adoption of SRI in Sri Lanka: The Spatial and Temporal Dynamics

Information and Awareness

System of Rice Intensification (SRI) has only a 5-year history in Sri Lanka. Only one farmer is reported to have learned about SRI in 1998. The majority of the SRI sample farmers in Kurunegala have learned about it in 2000. SRI sample farmers from Kalthota lagged behind Kurunegala farmers by about 2 years in terms of awareness. Even though about 11.7 percent of the SRI sample farmers were aware of SRI during 1998/1999, the actual practice commenced first in Kurunegala in year 2000. The temporal dynamics of SRI awareness among adopters and non-adopters are quite similar (figures 4 and 5).

Moreover, there is a marked difference regarding the sources of information (table 1). While extension (Ministry of Agriculture) was the main source of information for SRI sample farmers, for non-SRI farmers, other farmers (i.e., relatives, neighbors) are a major source of information about SRI. Generally, farmer to farmer dissemination of information seems to be the most important diffusion channel for SRI in both locations. About 87.5 percent of the non-SRI farmers reported to have been aware of SRI; however, only 25.4 percent of these farmers have shown an interest to practice SRI in the near future. The non-SRI sample farmers who were aware of SRI, but have not shown an interest to practice it were asked why they do not intend to practice. The response or reasons they gave are summarized in table 2. Consistent with the practicing farmers' observations, the non-SRI farmers reported that the major obstacle to SRI adoption was the high labor demand and the tedious nature of the

FIGURE 4.
Year the farmers first learned about SRI.

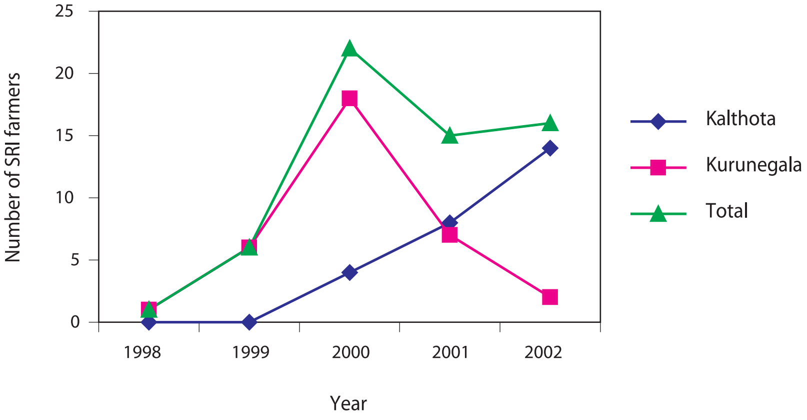


FIGURE 5.
Year of awareness of SRI farmers.

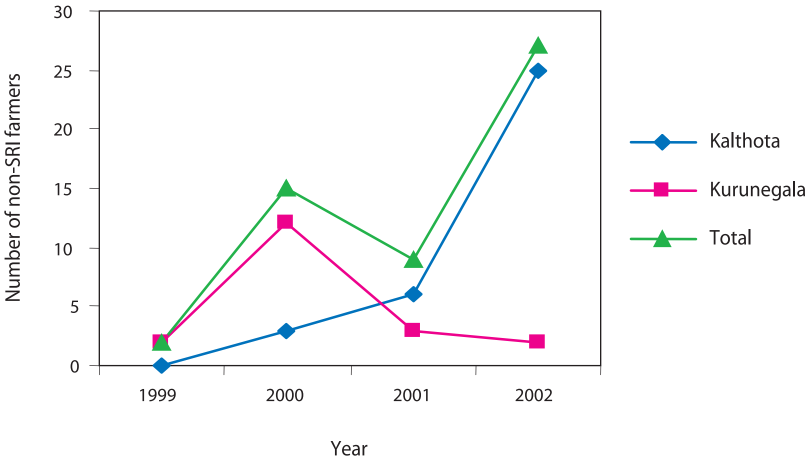


TABLE 1.
Sources of information about SRI.

Sources	SRI Sample		Total	Non-SRI Sample		Total
	Kalthota	Kurunegala		Kalthota	Kurunegala	
Extension	30.8	61.7	43.4	0.0	20.0	7.3
Farmer organization	15.4	8.8	6.7	2.9	15.0	7.3
Other farmers	26.9	14.7	20.0	48.6	45.0	47.3
Ceylon Electricity Board	23.0	0.0	15.0	37.2	0.0	18.9
Newspaper	3.9	8.8	6.7	0.0	0.0	0.0
From SRI adopter	0.0	14.7	8.3	17.1	20.0	18.2
N	26	34	60	35	20	55

Note: The numbers in the first six rows are in percentage.

TABLE 2.
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 a 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

associated management practices such as transplanting and manual weeding. For instance, SRI requires transplanting in a square grid. But preparing a square grid requires an ambient soil moisture level at the time of transplanting. If the soil moisture is too high or too little, transplanting in a square grid is not possible according to some farmers.

The other reasons given were the failure of some of the early adopters of SRI and land tenure issue. Land tenure is important in adopting technologies with long-term benefits such as SRI (Feder et al. 1982). It is argued that the addition of high doses of organic matter and the decrease in the level of inorganic fertilizer may initially reduce yield but in the long run the yield from that particular plot will be higher (Barison 2002).

The non-SRI farmers were also asked about the general attitude of the community towards SRI. About 69 percent of these farmers reported that their community considers SRI to be a good practice, while about 9.1 percent reported that the community does not have a favorable perception of SRI. Moreover, about 22 perecnt of them had no opinion about the attitude of their community members towards SRI adoption.

Practicing 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 3 and 4. The most significant merits of SRI as compared to conventional systems 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. Some farmers reported less labor for transplanting as an advantage of SRI, this was inconsistent with estimated hours of transplanting.

An experimental result in Cuba showed that SRI required less hours of transplanting because of fewer and smaller seedlings (Perez 2002).

The most important demerits of SRI relate to its extremely high demand for labor, problems of weed control, and unavailability of organic

TABLE 3.
Advantages of SRI relative to conventional-farmers' assessment.

No.	Criteria	Percentage 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 4.
Disadvantages of SRI relative to conventional-farmers' assessment.

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

matter. Seventy-seven 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.

Trends in SRI Area

Gross SRI area for the sample farmers increased from about 4.1 ha during year 2000 to about 13.8 ha during year 2002 (table 5). However, the general picture conceals the real situation of the specific study locations. For instance, in Kurunegala, while the SRI area showed an increasing trend from year 2000 to 2001 for both maha and yala seasons, it decreased from year 2001 to 2002, modestly in maha and more drastically in yala. In line with the general rice production pattern in Sri Lanka, the area under SRI during yala season is lower than during maha season. This is consistently so for the two study locations, even though, one may expect the reverse scenario based on the relative water scarcity during yala and the water productivity-improving attribute of SRI. Moreover, the numbers of sample farmers practicing SRI are generally higher during maha season.

The SRI area trend for Kalthota is inconclusive, as the adoption process has just

TABLE 5.
Area of SRI over years or seasons by locations.

Year	Rathnapura				Kurunegala				Total area		Annual area in ha
	Maha		Yala		Maha		Yala				
	Area in ha	N	Area in ha	N	Area in ha	N	Area in ha	N	Maha	Yala	
2000	0	0	0	0	2.3	15	1.8	9	2.3	1.8	4.1
2001	0.2	1	0	0	2.7	19	3.3	16	2.9	3.3	6.2
2002	6.0	20	4.8	20	1.7	13	1.2	11	7.8	6.0	13.8

begun. However, here too SRI area during maha season seems to be higher than during yala season.

Factors Influencing 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. Moreover, they compel the disturbance terms to be homoscedastic because the forms of probability functions depend on the distribution of the difference between the error terms associated with one particular choice and another. Usually a choice has to be made between logit and probit. But Amemiya (1981) states that the statistical similarities between the two models make such a choice difficult. Choice of any one model is, therefore, not dominant and may be evaluated after analysis on statistical grounds, although there will not usually be strong reasons for choosing one model over the other. However, the logit model is selected here.

Following Pindyck and Rubinfeld (1981), the model is written as:

$$P_i = \frac{1}{1 + \ell^{-z_i}} \qquad (1)$$

Where p_i is a probability of being an SRI adopter for the i^{th} farmer and ranges from 0 to 1 regardless of the values of Z. Z_i is the linear combination of *m* explanatory variables (X) and is expressed as:

$$Z = \beta_0 + \sum_i^m \beta_i X_i \qquad (2)$$

Where β_0 is the intercept β_i are the slope parameters in the model and X_i to X_m are the independent variables. In multiple regressions the interpretation of the regression coefficient is straightforward. It tells the amount of change in the dependent variable for a unit change in the independent variable. The parameters in the logistic models are interpreted in terms of odds and log-odds. The odds of SRI adoption are defined as the ratio of the probability of adoption (p_i) to the probability of non-adoption ($1-p_i$) as follows.

$$\frac{p_i}{1-p_i} = \left(\frac{1}{1+\ell^{-Z_i}}\right) \Big/ \left(1 - \frac{1}{1+\ell^{-Z_i}}\right) \qquad (3)$$

$$= \frac{1}{\ell^{-Z_i}}$$

$$= \ell^{(\beta_0 + \beta_i X_i + \ldots + \beta_m X_m)}$$

Then e raised to the power of β_i is the factor by which the odds of adoption change when the i^{th} independent variable increases by one unit. Taking the natural log of the odds ratio specified above will result in what is known as logit model. Here the βs are interpreted as the change in the log-odds associated with a one-unit change in the explanatory variables. If β_i is positive then $e^{\beta i}$ will be greater than one which means that the odds are increased. When β_i is 0 the factor equals one, which leaves the odds unchanged. Specifically the model is:

$$\ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 X_1 + \ldots + \beta_{15} X_{15} \qquad (4)$$

The Xs are the hypothesised explanatory variables as defined in table 6. 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. 1982). Hence, logit analysis which uses a number of independent variables has been used to predict the probability of farmers' SRI adoption.

TABLE 6.
Factors hypothesized to influence the adoption of SRI.

Variable code	Description
DEPRA (X1)	Proportion of children whose age is less than 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 5 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)*
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; [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 severe labor shortage and 13 indicating the abundance of labour in the community)**
CATTL (X15)	Number of cattle owned

Notes: *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 was a member and played a leadership role in all organizations in the past and as well as at present, i.e., 5 x 2 x 2).

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

The logistic regression model fitted to analyze the effect of these variables on the adoption decisions of farmers is presented in table 7. A high proportion of children less than 7 years of age (DEPRA), an older household head (AGEHH) and a greater proportion of annual income from non-farm activities (PRNIN) reduces the likelihood of a farmer being a SRI adopter (see the negative value of the regression coefficients). By contrast, family size (FAMIS), years of schooling (YSCHH) and participation in agricultural training programs (NFTPA) significantly increase the probability of a farmer being a SRI adopter. For instance, as the family size of the farmer increases by a unit, the likelihood of being a 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 that children

TABLE 7.
Determinants of SRI adoption: Results of logistic regression analyses.

Variable Code	ß	SE	Exp(ß)
CONSTANT	- 2.3134	2.9217	-
Dependency Ratio (DEPRA)	- 0.0454*	0.0277	0.9556
Proportion of Children in the Family (PCHIL)	0.0462*	0.0285	1.0473
Family Size (FAMIS)	0.3095*	0.1791	1.3628
Age of the Household Head (AGEHH)	- 0.0509	0.0359	0.9504
Years of Schooling of the Household Head (YSCHH)	0.1645*	0.0861	1.1787
Number of Training Programs Attended (NFTPA)	0.1760*	0.0901	1.1925
Number of Extension Contact (NEXCY)	0.0343	0.5146	1.0349
Proprotion of Income from Rice (PRICE)	0.0048	0.0117	1.0048
Proportion of non-farm Income (PRNIN)	- 0.0039	0.0124	0.9961
Incidence of Yield Loss due to Low Water Stress (FYLWS)	0.0575	0.1509	1.0592
An Index of Social and Political Capital (POSOL)	0.0327	0.0821	1.0333
Poverty Group (Poor)	0.0464	0.6746	1.0475
Poverty Group (Middle)	-1.1770*	0.6857	0.3082
Povert Group (Rich)—reference category			
Location of the Farm or Field (Head)	- 0.2209	0.9935	0.8018
Location of the Farm or Field (Middle)	- 1.5452*	0.9161	0.2133
Location of the Farm or Field (Tail)	- 1.9079**	0.9309	0.1484
Location of the Farm or Field (Rain-fed)—reference category			
An Index of Labour Availability Perception (LABAV)	0.1334	0.1438	1.1427
Number of Cattle Owned (CATTL)	0.5139	0.3380	1.6719

Notes: * significant at 10 percent probability level, ** significant at 5 percent probability level; -2 Log Likelihood = 108.98; Model Chi-square = 46.284 (df = 18, p=0.0003); Cox and Snell R^2=0.385[1]; Nagelkerke R^2=0.513; Percent correctly predicted = 76.79; N=112

were actively participating in the transplanting of SRI fields.[6] Moreover, studies in other countries showed that women and children are particularly suited for handling the transplanting of small and delicate rice seedlings (Perez 2002).

Location of the farm along the irrigation canal and the type of farming system (i.e., irrigated or rain-fed farming system) had a 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 rain-fed farms. This is indicated by the overall significance of the LOCFA variable and the negative sign of the subcategorization of irrigated farms based on their relative positions along the canal. This inference is particularly true for middle and tail farmers because the coefficients associated with these subcategories

---

[6] 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.

are negative and statistically significant. However, there is no significant difference between farmers situated around the head of the irrigation canal and rain-fed farmers regarding the likelihood of SRI adoption.

Why are rain-fed farmers more likely to adopt SRI than irrigated farmers? This is due to (1) the observed production risk differential among the two types of farming systems and (2) the wage difference between rain-fed and irrigated areas. Rain-fed rice farming faces risk and uncertainty regarding the availability and distribution of rainfall. Therefore, rain-fed 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 on *Rice Agronomy and Irrigation Water Management* of this report, SRI involves the addition of huge amounts of organic fertilizer, which improves the water-holding capacity of the soil and hence eases 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 where there is abundant labor relatively at lower rates. The positive sign of labor availability (LABAV) and family size (FAMIS) variables further corroborate this argument.

As already explained above, 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 of rain-fed farmers. At 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 a buffer; in case irrigation water arrives at large intervals. Keeping the field drained is very risky if they have no control over water.

One of the main motives for promoting SRI particularly in the Kalthota irrigation scheme, was to save water for hydropower generation. But the question is: water saving for whom? If the water saved can be used on the farm, this can be a huge incentive for adopting SRI by itself. However, due to the public or community nature of irrigation systems in Sri Lanka, the net water saved on the farm will benefit the community or the society at large. Hence, the on-farm benefit of SRI adoption is less than the societal benefits,[7] heralding the need for supporting such a resource-conserving and environment-friendly production system through appropriate incentive mechanisms.[8]

The significance of rice in the total household income, the incidence of water scarcity as perceived by farmers, and the social capital variables had the expected signs but were not statistically significant. 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

---

[7] This is particularly so if we consider the ecological benefits of SRI due to reductions in the use of inorganic fertilizers, herbicides, pesticides and fungicides.

[8] This may include at minimum improvement in the marketing system through organizing the producers and searching appropriate market outlets (specifically export markets). This is particularly necessary because the quality of SRI rice is superior to that of conventional rice.

no significant difference in SRI adoption between poor and rich farmers.

Intensity of Adoption of SRI

Out of the 60 farmers who are SRI adopters, 40 have continued practicing during yala or maha season of the year 2002. The remaining 20 farmers may be regarded as disadopters because they failed to practice SRI for two consecutive seasons. Of these disadopters one has totally given up cultivating paddy. Moser and Barrett (2002) reported a disadoption rate of 19 percent to 100 percent across five sites in Madagascar. No farmer has allotted more than one field to SRI. But about 20 percent of the farmers had two paddy fields cultivated with conventional methods during yala and 26.6 percent of the farmers had two paddy fields cultivated with conventional methods during the maha season.

The intensity of adoption once the farmer has decided to practice SRI was evaluated using the mean 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 6 and 7. 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 7). The proportion of SRI farmers with 100 percent of their paddy fields allocated to SRI is higher during yala than during maha in Kurunegala. This is in line with the presumption that the yala season is more water-scarce than the maha season, and one of the advantages of SRI is to conserve water as has been elaborated in the previous sections.

In the previous section, determinants of SRI adoption-decision were assessed. However, the extent or intensity of adoption once the adoption decision is made gives important information for

FIGURE 6.
Mean proportion of total rice area allotted to SRI in 2002.

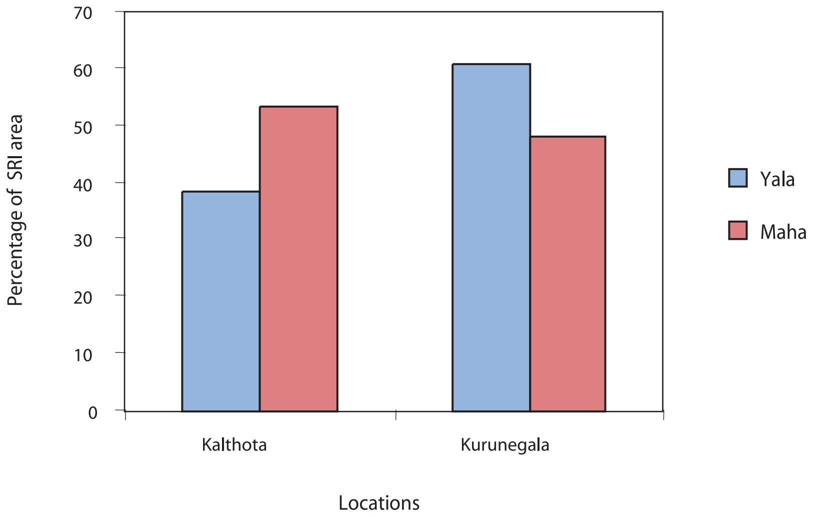
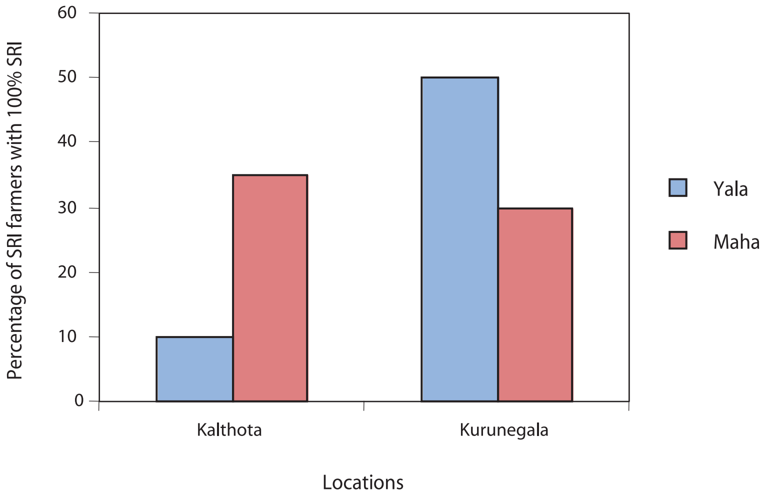


FIGURE 7.
Proportion of SRI farmers who allotted 100 percent of paddy area to SRI in 2002.



research, extension and policy. This issue was evaluated using tobit regression model.[9] The tobit model permits determining not only the probability of adoption but also the intensity of adoption once the adoption decision has been made. The tobit model can be specified as:

$$y_i^* = \beta' x_i + \varepsilon \qquad (5)$$

where y_i^* is a latent variable representing the use of the SRI; X is a vector of independent variables described in table 6, 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:

$$y_i = \begin{cases} y_i^* & if \quad y_i > 0 \\ 0 & if \quad y_i \leq 0 \end{cases} \qquad (6)$$

Using lower tail censoring, 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 8.

In the incidence of adoption model (i.e., logit model) discussed in the previous section, informational variables such as participation in a training program and extension contact, poverty status, location of the farm, the farming system (i.e., irrigated versus rain-fed 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.

---

[9] The tobit model 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.

TABLE 8.

Variables influencing the extent or intensity of adoption of SRI.

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
Proportion 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 and 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

Notes: sigma=0.4439***

log likelihood function=-58.35

N=120

* statistics significant at 10 percent

** statistics significant at 5 percent

*** statistics significant at 1 percent

Table 8 also shows the decomposition of the total elasticity of the variables.[10] 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 increase 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.

Determinants of Disadoption

Disadoption is one important aspect which has 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 policymakers. 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 under *Factors Influencing SRI Adoption* 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 3. 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 4. 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 SRI yield (kg/ha) realized by SRI farmers. 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

---

[10] 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.

5, where 1 indicates severe cash constraint and 5 indicates the absence of a cash constraint. We expect this variable to have a positive relationship with disadoption.

All of the variables included in the disadoption model had the expected signs (table 9). 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 the initial adoption process determines the acceptance and the pace of dissemination of a technology. In the adoption model (table 7), there is no significant difference in the probability of adoption of SRI between poor and rich farmers. Contrarily, the probability of disadoption among poor farmers is significantly lower than 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.

TABLE 9.
Factors explaining the disadoption of SRI: Logistic 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
Poverty Group (Rich)- Reference category			
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

Notes: ** means the coefficient is significant at 5 percent significance level

–2 Log likelihood = 37.43

Cox and Snell R^2 = 0.48

Nagelkerke R^2 = 0.66

Percent correctly predicted = 86.7

N=60

Microeconomics of SRI

Rice agronomy and irrigation water management

Farmers' agronomic practices, level of cash input utilization, and irrigation water management differentiated by system of production and seasons is shown in table 10. The outputs for the statistical analyses showing the significance of the mean differences is presented in appendix 1. Expectedly, there is a substantial difference between the two systems of rice production regarding the planting method, fertility management and weed control practices. For instance, on average a SRI farmer transplants one 8-days-old rice seedling per hill, on a square grid of about 23 x 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. Conventional farmers planted on average four 18-days-old rice seedlings in a clump per hill, on a square grid of 15x15 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.

The weed control method is another important aspect differentiating the two systems of production. SRI farmers rarely use herbicides, 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). Here an attempt was made to have an indirect and general 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.[11] On average, SRI fields received about 24 percent less number of irrigation and 23 percent less hours of irrigation per unit area than the conventional paddy fields. However, the difference between SRI and conventional regarding hours of irrigation is not statistically significant (appendix 1, and table 10). Consistent to our prior 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 (figure 8).

Table 10 also clearly indicates that SRI fields generally demand higher amounts of human labor (about three times more) due mainly to planting (about 37 man-days per ha), weeding (about 31 man-days per ha), bund construction and cleaning (about 4.1man-days per ha), and

---

[11] Farmers were asked about 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 irrigations. 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. For a more conclusive result an exact field-level measurement needs to be done, preferably for a number of farmers.

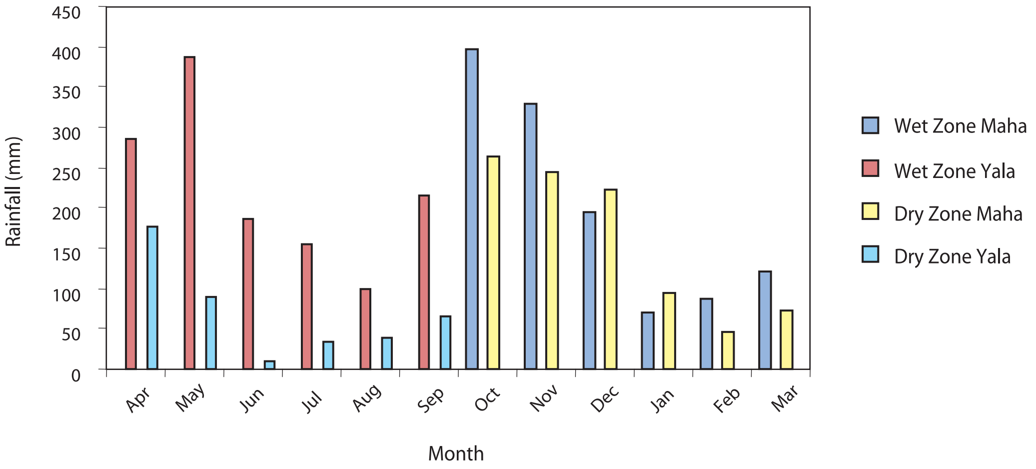
TABLE 10.

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**
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	Urea per ha	77	73.0	32	78	80.4	32	141	86.2	128	133	81.5	147
(Inorganic)	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	Cow dung in kg per ha	2,024	3,066	32	1,422	2,541	32	153	617.8	129	152	594.2	145
(Organic)*	Tree leaves in kg per ha	1,013	1,443	32	733	2,513.3	32	247	1,620.0	129	131	510.2	145
	Straw in kg per ha	951	1,900.4	32	261	799.0	32	170	706.4	129	287	1,022.6	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
	Bund construction and cleaning (hours/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	1,942	2,425	21	1,720	2,116	23	2,589	4,038	97	2,154	2,993	103
Harvesting	Hours of harvesting per ha	328	266.2	31	326	376.7	13	355	254.6	115	265	181.7	84

Notes: *Except for compost and tree leaves, the values reported are dry weight ** N refers to the number of fields. Since most of the farmers had more than one conventional rice field 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 have practiced SRI during 2002.

FIGURE 8.
Monthly rainfall distribution for the Dry and Wet Zones of Sri Lanka (1961-90).



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.

Yield Comparisons

The mean paddy yields obtained during the last 3 years differentiated by the system of production and seasons are listed in the table 11. The results of the statistical analyses showing the significance of the mean yield differences is shown in appendix 1. 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 the 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/ha depending on the type of farming system (i.e., rain-fed or irrigated rice farming) and the type of irrigation scheme (Kikuchi et al. 2002).

However, the yields reported in table 11 conceal the effects of location, season and adoption status.[12] The highest paddy yield (8.1 t/ha) was recorded for SRI in the Kalthota area during maha season for adopter group, while the lowest (2.1 t/ha) was recorded for disadopters during yala season in Kurunegala (table 12). Generally, disadopters experienced the lowest paddy yield during the first year of adoption forcing them to discontinue the SRI practice. The

---

[12] The adoption status here refers to the fact that not all farmers have continued with SRI. Some farmers have stopped practicing after one or two seasons of experimenting with it. In the present case the farmers who have not practiced SRI during yala or maha seasons of the year 2002 are regarded as disadopters. Conversely, those farmers who have practiced SRI in maha or yala are regarded as adopters. Both groups belong to the original SRI sample.

TABLE 11.
Rice yields under SRI and conventional system of management (Kg/ha).

Year	SRI			Conventional			Percentage of yield increase
	Yala	Maha	Mean	Yala	Maha	Mean	
2000	4,097	6,236	5,488	3,635	3,644	3,641	50.7
2001	5,056	5,327	5,215	3,516	3,749	3,633	43.5
2002	5,737	5,977	5,811	4,189	3,832	4,041	43.8
Mean	5,299	5,763	5,524	3,910	3,757	3,836	44.0

disadoption model under *Determinants of Disadoption* 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 12 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 expectations.

TABLE 12.
Paddy yield 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	5,726	7,217	2,102	4,668	3,501	3,063	3,769	4,372
	2001	6,011	5,499	4,100	4,628	4,040	3,628	2,942	3,851
	2002	5,619	5,977	NA	NA	3,071	3,702	3,863	3,911
	Mean	5,785	6,231	3,101	4,648	3,537	3,464	3,524	4,045
Kalthota	2000	NA	NA	NA	NA	NA	NA	NA	NA
	2001	NA	8,154	NA	NA	6,795	NA	NA	NA
	2002	5,806	NA	NA	NA	4,900	NA	NA	NA
	Mean	5,806	8,154	NA	NA	5,848	NA	NA	NA

Note: NA means Not Applicable/Not Available.

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 as shown in table 13. Moreover, the corresponding paddy yields recorded for each stratum are reported. Interestingly, the SRI farmers who did not apply

TABLE 13.
Yield comparison of SRI farmers by level of fertilizer application and season.

Amount of inorganic fertilizer (kg/ha)*	Yield (kg/ha)					
	Yala			Maha		
	Mean	SD	N	Mean	SD	N
0	5,792	2,715	5	4,349	2,460	2
0 to 100	4,851	2,133	9	4,159	3,279	4
100 to 200	5,954	2,350	3	5,362	2,202	2
200 and above	6,481	2,755	13	9,133	1,977	4
Grand mean	5,825	2,506	30	6,049	3,218	12
F value	1.741(P=0.195)			4.985 (P=0.035)		

Note: *The inorganic fertilizers were UREA, TSP, NPK, and MOP.

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 a declining trend) during yala, the yield response to additional levels of fertilizer has not reached an 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 the 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 14). 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 14.
Yield comparison of conventional rice farmers by level of fertilizer application and season.

Inorganic fertilizer (kg/ha)*	Yield (kg/ha)					
	Yala			Maha		
	Mean	SD	N	Mean	SD	N
0	3,970	1,786	9	1,821	1,136	5
0 to100	4,153	1,699	28	3,797	1,615	30
100 to 200	4,384	1,975	68	3,805	1,930	35
200 and above	5,052	2,153	20	4,449	1,522	10
Grand mean	4,409	1,936	125	3,758	1,786	80
F value	1.058 (p = 0.370)			2.625 (P = 0.056)		

Note: *The inorganic fertilizers include UREA, TSP, NPK, and MOP.

Profitability Comparisons

The microeconomics of the two systems of rice production was assessed using the enterprise budgeting technique.[13] Net returns were estimated for each farmer using the following relationships:

$$NR = GR - TC \tag{7}$$

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

$$TC = VC + F$$

$$GR = RY * RP$$

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 various inputs included were seed, human labor, bullock labor, tractor, fertilizers, herbicides, and pesticides. The individual budgets prepared for each and every sample of farmers differentiated by system of production and seasons (i.e., SRI and conventional) were averaged to facilitate easy comparisons (see table 15). 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.[14] Even though SRI reduces or avoids the use of cash inputs such as fertilizer and herbicides, the resulting savings cannot fully compensate for the additional costs born due to greater labor input for weeding, transplanting, and organic matter collection and transporting. However, the cost per unit of paddy output (rupees per kilogram) is lower in SRI than that of the conventional system 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 15 also shows that some farmers experienced losses during both seasons. This shows the advantage of budgeting for each farm than for an average farm. Two inferences may be made. First, the incidence of loss is higher for yala than for maha season. Second, the incidence of loss among SRI farmers is substantially lower than that of conventional farms irrespective of the season.

In Sri Lanka, it is usually claimed that the competitiveness of rice sector has 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 table 15 make us believe this claim.

---

[13] The 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).

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

TABLE 15.
Summary of results of the enterprise budgets in 2002.

Season	At Zero Wage Rate													
	Revenues (Rupees/ha)						Cost of production						Incidence of	
	Gross revenue			Net revenue			Rupees/ha			Rupees/kg			Net Loss	
	Conventional	SRI	Increase	Conventional	SRI	Increase	Conventional	SRI	Decrease	Conventional	SRI	decrease	Conventional	SRI
Yala	27, 017	34,899	29%	16,032	29,371	83%	10,742	6,506	40%	7.6	3.6	53%	9	1
Maha	23,871	36,720	54%	14,373	34,575	141%	9,503	5,291	44%	6.8	2.2	68%	0	0

Season	At Farm Wage Rate													
	Revenues (Rupees/ha)						Cost of production						Incidence of	
	Gross revenue			Net revenue			Rupees/ha			Rupees/kg			Net Loss	
	Conventional	SRI	Increase	Conventional	SRI	Increase	Conventional	SRI	Increase	Conventional	SRI	Decrease	Conventional	SRI
Yala	27,017	34,899	29%	8,417	15,992	90%	18,600	18,907	1.7%	13.3	11.1	17%	27	4
Maha	23,871	36,720	54%	7,490	16,285	117%	16,381	20,435	25%	11.9	8.7	27%	15	1

Season	At non-farm Wage Rate													
	Revenues (Rupees/ha)						Cost of production						Incidence of	
	Gross revenue			Net revenue			Rupees/ha			Rupees/kg			Net Loss	
	Conventional	SRI	Increase	Conventional	SRI	Increase	Conventional	SRI	Increase	Conventional	SRI	Decrease	Conventional	SRI
Yala	27,017	34,899	29%	4,215	10,223	143%	22,248	24,842	12%	15.5	15.0	3%	29	6
Maha	23,871	36,720	54%	4,369	13,374	206%	19,687	26,493	35%	14.0	11.4	19%	22	2

Note: US$1 = Rs 96.75.

Poverty Outreach of SRI Adoption

Because of the skewed impacts of the past development programs, policies, projects and technologies, much emphasis is given to equity issues in designing development interventions these days. Therefore, it is pertinent to evaluate the poverty outreach of SRI adoption in the study locations. The specific question to be answered in this regard is: which type of farmers adopted SRI? To answer this question, it is necessary to assess the poverty status of each farmer and in the process recognize the multidimensional nature of poverty and explicitly consider it in the measurement of poverty. Specifically we apply an indicator-based poverty assessment tool that was developed to assess the poverty outreach of micro-finance projects (Henry et al. 2003).

Construction of a Poverty Index

Developing an objective measure of poverty initially requires identifying the strongest individual indicators that distinguish relative levels of poverty and then their explanatory power has to be pooled into a single index using factor analysis or principal component analyses. Various indicators of poverty were included in the survey instrument a priori, based on our own experience in Sri Lanka and experiences from other countries (table 16).

However, which combinations of indicators prove the most instrumental in measuring relative poverty in a given area will differ. In other words, not all of the indicators enumerated in table 16 are relevant to explaining poverty. Therefore, we have used linear correlation coefficient procedures for filtering poverty indicators that are the strongest in capturing differences in the relative poverty of households (table 17). Testing the level and direction of correlation among a wide range of variables with the benchmark poverty indicator is the primary means of determining the strength of indicators. The best benchmark poverty indicator in Sri Lanka is whether the household is eligible for welfare assistance, commonly known as the Samurdi program.

Investigation of the correlation of ordinal and interval-scaled poverty indicators, enumerated in table 17, with the eligibility for the Samurdi program reveals important patterns. First, unlike some countries in sub-Saharan Africa, the number of livestock owned does not differentiate the poor from the rich. Second, again unlike in sub-Saharan African countries, where food security and vulnerability is an important variable in the rural households (and also among poor urban households), these variables have little discriminatory power between poor and rich households in Sri Lanka. In other words, most Sri Lankan rural households satisfy their basic food needs from their harvests.

However, our main objective here is to identityfy and combine variables that jointly explain poverty and help predict the poverty status of our sample farmers. The poverty indicators that have significant association with the poverty benchmark indicator (participation in the Samurdi program) are combined using principal component analyses (PCA) to measure a household's relative poverty status. The PCA creates a single index of relative poverty that assigns to each sample household a specific value called a "score," representing that household's poverty status in relation to all households' poverty status in the sample. Since the indicators are related in more than one way, more than one underlying component may be created. However, only one component will measure a household's relative poverty. The analysis was first done for non-SRI farmers

TABLE 16.
Prospective indicators of poverty.

Category	Specific indicators
Human Resources	Dependency ratio
	Proportion of children in the family
	Years of schooling
	Political capital
	Social capital
Food security and vulnerability	Frequency of inferior food 1 consumption during the last 7 days
	Frequency of inferior food 2 consumption during the last 7 days
	Frequency of luxury food 1 consumption during the last 7 days
	Frequency of luxury food 2 consumption during the last 7 days
Dwelling	Type of toilet in the main house
	Type of electricity connection
	Type of floor of the main house
	Type of wall of the main house
	Number of rooms in the main house
Household Assets	Number of refrigerators owned
	Number of TVs owned
	Per person clothing expenditure
	Household assets
Farm and other assets	Number of motor bikes owned
	Number of motorized threshers owned
	Number of two-wheel tractors owned
	Number of lined dug wells owned
	Livestock owned
	Own farm area in ha
	Net farm area operated
	Proportion of off-farm income

because this sample represents the general population and, therefore, a more appropriate group to use for building the initial model.

There are certain conditions, which have to be met for successful principal component analyses. These are considerations for sampling adequacy, singularity and multicollinearity. The four initial outputs of the PCA model, i.e., the component matrix, the explained common variance table, the communalities table, and the KMO-Bartlett test are presented in appendix 2, table A2.1 to table A2.6. These outputs are used to interpret the results and refine the model. The value of KMO for the final model encompassing the whole sample (SRI and non-SRI) is 0.738, which is greater than 0.5 indicating the adequacy of the sample. The Bartlett's test, which examines whether the poverty indicators are perfectly independent from one another (all correlations are zero), is also significant indicating that the correlation is not an identity and, therefore, the PCA is appropriate. Another useful statistic is the table of communalities. The closer the reported communalities are to 1.0, the better the factors are at explaining the original data.

TABLE 17.
Correlations of household specific variables with poverty benchmark indicator (eligibility to Samurdhi Program).

Ordinal and interval scaled poverty indicators	Correlation Co-efficient
Eligibility to welfare assistance (Samurdi program)	1.000
Dependency ratio	.199**
Number of refrigerators owned	-.208**
Number of motor bikes owned	-.146*
Number of motorized threshers owned	-.145
Number of two-wheel tractors owned	-.191**
Number of lined dug wells owned	-.216**
Livestock owned	-.047
Type of toilet in the main house	-.332***
Electricity connection	-.109
Type of floor of the main house	-.144
Type of wall of the main house	-.123
Number of rooms in the main house	-.186**
Years of schooling of the household head	-.307***
Number of TVs owned	-.236***
Political capital	-.157*
Social capital	-.098
Proportion of children in the family	.149*
Per person value of total assets	-.271***
Per person clothing expenditure	-.155*
Farm area owned by the household in ha	-.159*
Net farm area in ha	-.137
Percentage of off-farm activities in the total household income	.181**
Household assets	-.171*
Frequency of inferior food 1 consumption during the last 7 days	-.046
Frequency of inferior food 2 consumption during the last 7 days	-.122
Frequency of luxury food 1 consumption during the last 7 days	-.046
Frequency of luxury food 2 consumption during the last 7 days	.026

Notes: *Correlation is significant at the 0.1 level (2-tailed).
**Correlation is significant at the 0.05 level (2-tailed).
*** Correlation is significant at the 0.01 level (2-tailed).

One other decision problem in PCA is that of how many components to retain because the set of variables measured on the sample households may measure different dimensions of the rural life environment. In the present case, four components were identified with varying magnitudes of eigenvalues and percentage of variance explained. The first component had an eigenvalue of 2.383, which is much higher than that of the remaining three components (appendix 2, table A2.7). Eigenvalues associated with a component indicates the substantive importance of that component. It also explains about 60 percent of the total variance, while the other three components combined could only explain the remaining 40 percent of the total variance. It is reasonable to assume that this first component measures principal aspects of poverty because (1) the variables included in the analyses were purposively screened based on their degree of association with the poverty benchmark indicator, and (2) observation of the sign and magnitude of the correlation coefficients of the screened variables with the component (table 17). In general, because the model has been refined to create a measure of relative poverty, it is reasonable to expect the component explaining the most variance to be the poverty indicator. The model's explanatory power was improved by screening out variables that have low component loadings on the poverty component. The iteration was continued or repeated with alterations until the resulting model appears to be the most appropriate for the survey data as in table 18.

TABLE 18.
Component Matrix.

Variables	First component
Per person value of total assets	.852
Household assets	.844
Number of motor bikes owned	.755
Per person clothing expenditure	.612

Note: Extraction Method; Principal Component Analysis.

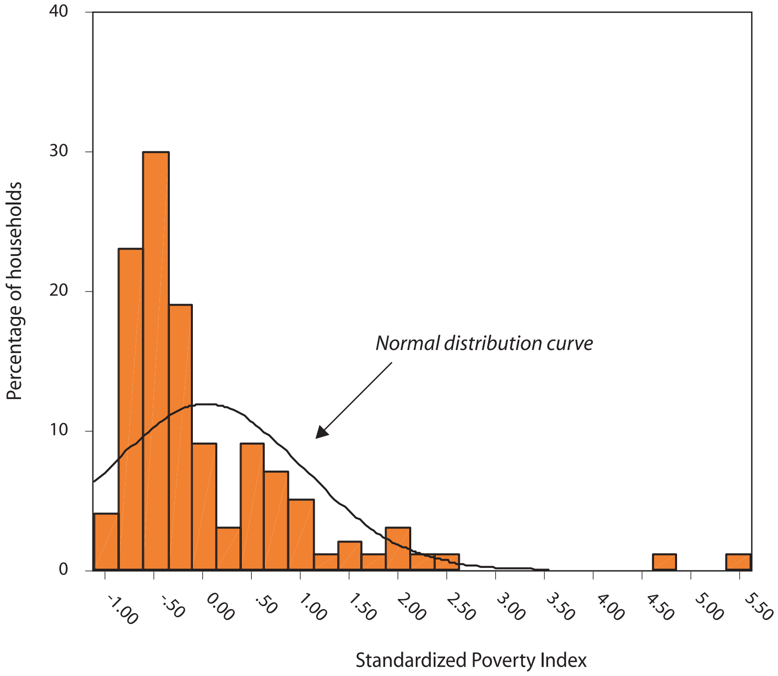
Out of the range of variables considered, only the four enumerated in table 18 were found to be powerful in explaining relative poverty. These variables had a positive sign indicating a direct relation with the relative wealth of the household. As the values of an indicator increase, so does the value of the component, which in this case is the relative wealth of the household.

Negative coefficients indicate an inverse relationship between the indicator and the relative wealth of the household. Once the final model for computing the poverty index was decided, the sample size was increased from 60 to 120. The standardized values of the poverty component were calculated using the final version of the PCA model.

Poverty Outreach of SRI by Groupings

The creation of the poverty index assigns to each household a poverty ranking score. The lower the score, the poorer the household is relative to all others with higher scores. Figure 9 shows the distribution of a poverty index in a standardized form. It is interesting to observe that the histogram is skewed to the left on the relative poverty score. Most households are concentrated around the lower end of the poverty measurement scale with a few individuals conspicuously much better off than the general population. In the graph shown, the poverty score ranges from -0.93 to 5.46. Approximately two-thirds of the households fall in the range between -1 and 1. The scores for SRI and non-SRI farmers can be compared to indicate the extent to which SRI reaches the poor. The average non-SRI score is -0.012 and the average SRI score is 0.0586 suggesting that on average SRI farmers are assessed as richer than non-SRI farmers in the areas studied. But, these average figures hide the correct pattern of distribution in the poverty index. To reveal this, an appropriate definition of the poor has to be

FIGURE 9.
Histogram of standardized relative poverty index.



adopted. If the presumed target is the poorest section of the local population, the sample farmers can be divided into quintiles, and thereby capture the poorest 20 percent of the local population. A broader definition of poor may assume that the lower half of the population can be considered poor. One must bear in mind that this definition of the poor is context-specific.

In the present case, a cutoff of 33 percent was used to define the poorest group within the study areas. This translates into categorizing the sample farmers into poor, middle and high-ranked groups of households by relative poverty. First, the non-SRI households were ranked based on their relative poverty score to create three relative poverty terciles. This is because, as has already been explained, the non-SRI sample farmers represent the unbiased sample of the general population. Then the cutoff values for the non-SRI tercile was used to group the SRI farmers (table 19). The poverty outreach of SRI can be assessed by three closely linked methods. The first method involves dividing the percentage of SRI farmers belonging to the lowest ranked poverty tercile by 33 percent. If this ratio is greater than 1 it implies that the proportion of the poorest households among the SRI farmers is greater than that in the general population. The higher values show more extensive outreach of SRI to the poorest households in the area. The second method involves dividing the percentage of clients belonging to the highest ranked poverty tercile by 33. This ratio reflects the extent to which the less poor households are represented in the client population. A ratio of 1 or less than 1 indicates that, compared to the non-SRI population, a lesser proportion of SRI households falls into a lesser poor group. These figures are computed and presented in table 19.

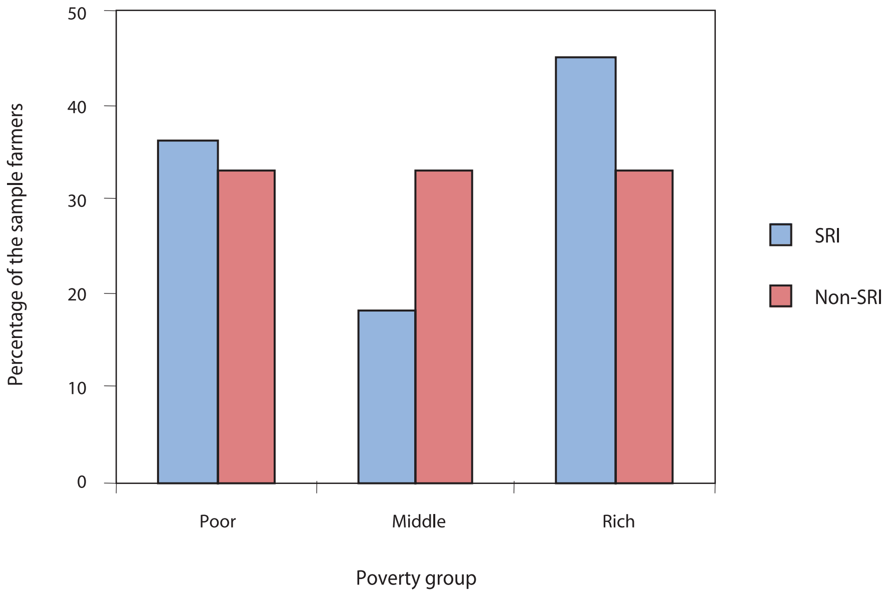
The third method involves drawing bar graphs of the distributions of SRI and non-SRI

TABLE 19.
Poverty outreach of SRI.

Terciles	Poverty group	Non-SRI (%)	SRI (%)
<-0.52474	poor	33.3	36.5
-0.52474 to -0.18043	middle	33.3	18.3
>-0.18043	rich	33.3	45.1
Ratio 1		-	1.096
Ratio 2		-	1.354

farmers by poverty terciles and then visual inspection of the pattern of distribution. By default, the bars for non-SRI farmers are expected to be equal in size across the poverty groups, and if SRI was poverty neutral, the distribution for SRI farmers is expected to follow a similar pattern to that of non-SRI. However, this is not true as depicted in figure 10. The graph shows that the poor and the rich are both represented in the SRI sample more than their proportion in the general population.

FIGURE 10.
Percentage breakdown by poverty tercile of SRI and non-SRI farmers.



Realized Benefits of SRI by Poverty Groupings

In the above sections we have seen poverty by SRI interactions and concluded that SRI was adopted by poorer and richer sections of the rural population in the studied areas. The reason for this lies in the characteristics of SRI itself. That is to say that SRI demands high labor input as has been shown in the preceding sections and poor farmers own this vital resource (labor) for implementing SRI. The prominence of the rich farmers in the SRI sample may be explained by (1) the propensity of the rich and educated section of the rural population to try out new things first, (2) the biased dissemination strategy followed, and (3) the ability of the rich to hire labor provided it results in net cost reductions, which largely depends on the differential cost of labor vis-á-vis the costs of other inputs it substitutes for.

Still one important issue remains to be investigated. That is, how SRI farmers in the different poverty groups (i.e., poor, middle and rich) have actually realized the benefits of SRI. To address this issue, per-hectare paddy yields along with the computed net benefits were calculated and presented in table 20. It can be clearly seen that rich farmers have recorded better paddy yields even though this is not supported by the observed statistical significance. This yield differential might be explained by variations in the access to training opportunities. SRI is a management and knowledge-intensive venture and, therefore, requires adequate support in terms of training and information. The per-hectare net benefits for the middle poverty group is extremely low as compared to that of the other groups. This may be due to the fact that this group of farmers may have used excessive conventional inputs even though they still prefer to be labeled as "SRI" practicing farmers.

TABLE 20.
SRI productivity differential by poverty group.

Poverty group	Rice Yield (kg\ha)	Net Benefit (Rs\ha)
Poor	5,109	30,798
Middle	5,590	14,704
Rich	6,262	49,506
Average	5,746	40,000

Note: US$1 = Rs 96.75.

Conclusions and Implications

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 the initial adoption decision. There was a wide variation in the way farmers practiced SRI, with the majority of the adopters using the system on only a portion of their farms. The main variables influencing the incidence of SRI adoption are (i) location of the farm, (ii) the type of farming system (i.e., irrigated versus 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. 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.

The absence of significant difference in SRI adoption probability between farmers located at the head end of irrigation canals and rain-fed farmers, and the observed lower probability of SRI adoption among those located at the middle and tail ends of irrigation canals underlines the importance of the irrigation water supply risk and uncertainty variable in the SRI adoption decision. Hence, contrary to the ideal SRI methodology, 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. One of the controversies surrounding SRI is whether it is suitable for adoption by poorer households. The study showed that SRI adopters mainly 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 it than the rich farmers. Moreover, low realized yield during the first experiment with SRI is the major factor behind discontinuing the SRI methodology.

The regression results coupled with insights gained from qualitative inquiries suggest that the most appropriate domains (target group) for SRI adoption are those farmers:

a. with limited landholdings;
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 major share of annual income and consumption;
e. with limited alternative employment opportunities;
f. with relative certainty regarding irrigation water supply; and
g. practicing rain-fed paddy cultivation.

The main advantages of SRI include yield increase, reduced number of irrigations or irrigation-hours per irrigation round 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.

The main problems associated with the SRI practice are the demand for skills and high amount of labor for weed control and transplanting, nonavailability of organic manure, and limited availability of rotary weeders. SRI demands higher amounts of labor per unit area (a lot of drudgery is involved) and induces the active participation of children below 14 years of age and women. However, whether this is a significant social disutility is a matter for further scrutiny.

The declining world market price for rice coupled with the modestly increasing off-farm and non-farm employment opportunities in rural Sri Lanka necessitates interventions that enhance labor productivity in paddy production systems. One major strategy would be mechanization of the transplanting and weeding operations.

Appendixes

APPENDIX 1.

Analyses of variance for variables included in table 12.

Variables	Sources of variation and the associated F-Values with significance levels				
	PROSYS+	Location	Season	PROSYS X Season	PROSYS X Location
Tractor hours per ha	1.17	NA	0.26	0.35	NA
Bullock hours per ha	0.19	NA	0.52	0.14	NA
Seed rate kg per ha	369.71***	NA	0.003	0.24	NA
Cow dung (kg/ha)	72.27***	NA	2.66*	2.64*	NA
Amount of poultry manure	0.002	NA	0.006	0.32	NA
Amount of straw	7.13***	NA	4.12**	8.12***	NA
Amount of tree leaves	12.78***	NA	1.07	0.18	NA
Amount of compost	7.23***	NA	1.50	1.5	NA
Amount of rice bran	11.99***	NA	2.92*	2.92*	NA
Amount of urea	26.92***	NA	0.08	0.16	NA
Amount of TDM	7.79***	NA	1.15	0.96	NA
Amount of NPK	22.70***	NA	0.61	0.14	NA
Amount of TSP	0.60	NA	0.19	0.19	NA
Amount of MOP	0.67	NA	0.05	0.05	NA
Transplanting hours	10.80***	NA	17.18***	0.58	NA
Band construction hours	22.73***	NA	0.43	0.02	NA
Hand weeding hours	48.52***	NA	0.00	2.32	NA
Mechanical weeding hours	223.17***	NA	4.72	4.34	NA
Amount of herbicide in l	27.79***	NA	0.08	0.01	NA
Number of irrigation	5.31**	50.39***	0.02	0.02	2.36
Hours of irrigation	1.48	11.22***	0.25	0.001	0.07
Harvesting hours	0.16	NA	1.14	1.01	NA
Paddy yield (kg/ha)	4.74**	5.12**	2.49*	0.91	0.95

Notes: * Statistics significant at 10 percent.

** Statistics significant at 5 percent.

*** Statistics significant at 1 percent.

+ Prosys=Rice production system (SRI and conventional)

NA=Not applicable

APPENDIX 2.

Principal Component Analyses.

TABLE A2.1
KMO and Bartlett's Test—non-SRI farmers.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.725
Bartlett's Test of Sphericity	Approx. Chi-Square	91.803
	df	6
	Sig.	.000

TABLE A2.2.
Communalities—non-SRI farmers' cases.

Indicators	Initial	Extraction
Number of motor bikes owned	1.0	.627
Per person value of total assets	1.0	.802
Per person clothing expenditure	1.0	.512
Household assets	1.0	.656

Notes: Extraction Method; Principal Component Analysis.

TABLE A2.3.
Total variance explained—non-SRI farmers' cases.

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	Percentage of Variance	Cumulative percentage	Total	Percentage of Variance	Cumulative percentage
1	2.598	64.943	64.943	2.598	64.943	64.943
2	.646	16.159	81.102			
3	.523	13.079	94.181			
4	.233	5.819	100.000			

Notes: Extraction Method; Principal Component Analysis.

TABLE A2.4.
Component Matrix—Non-SRI Farmers (Extraction Method: Principal Component Analysis).

Indicators	Component 1
Per person value of total assets	.896
Household assets	.810
Number of motor bikes owned	.792
Per person clothing expenditure	.716

Notes: 1 Components extracted.

TABLE A 2.5.
KMO an Bartlett's Test—whole sample.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.738
Bartlett's Test of Sphericity	Approx. Chi-Square	134.173
	df	6
	Sig.	.000

TABLE A2.6.
Communalities—whole sample.

Indicators	Initial	Extraction
Number of motor bikes owned	1.0	.571
Per person value of total assets	1.0	.726
Per person clothing expenditure	1.0	.374
Household assets	1.0	.712

Note: Extraction Method; Principal Component Analysis.

TABLE A2.7.
Total variance explained—whole sample.

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	Percentage of Variance	Cumulative percentage	Total	Perecentage of Variance	Cumulative perecntage
1	2.383	59.568	59.568	2.383	59.568	59.568
2	.748	18.710	78.278			
3	.547	13.672	91.950			
4	.322	8.050	100.000			

Notes: Extraction Method; Principal Component Analysis.

Literature Cited

Amemiya, T. 1981. Qualitative Response Models: A survey. *Journal of Economic Literature* 19 (4): 1483-1536.

Barison, J. 2002. Evaluation of nutrient up take and nutrient use efficiency of SRI and conventional rice cultivation methods in Madagascar *(http://ciifad.cornell.edu/SRI/proc1/SRI-32.pdf.)* accessed: August 25, 2003.

Barker, R.; R. Loeve.;Y. H. Li.; T. P Tuong (eds.). 2001. *Water Saving Irrigation for Rice.* Proceedings of an International Workshop held in Wuhan, China, 23-25 March 2001. Colombo, Sri Lanka: International Water Management Institute.

Batuwitage, G. P. 2002. Adaptations of the System Rice Intensification in Sri Lanka. In: *Assessment of the system of rice intensification.* Proceedings of an international conference held in Sanya, China, April 1-4, 2002. N. Uphoff ; E. Fernandes; Y. Longping; P. Jining; S. Rafaralahy; J. Rabenandrasana. (eds). 2002. Ithaca,NY: Cornell International Institute for Food and Agriculture Development. pp. 70-74.

Bonlieu, F. 1999. Summary off Findings from Thesis Research on SR*(http://ciifad.cornell.edu/sri/bonlieu.pdf)* accessed: August 25, 2003.

CIMMYT (Centro Internacional de Mejoramiento de Maíz y Trigo).1988. From Agronomic Data to Farmer Recommendations: An Economics Training Manual. Completely Revised Edition. Mexico City D.F.: (CIMMYT).

Doss, C. R. 2003. Understanding Farm Level Technology Adoption: Lessons Learned from CIMMYT's Micro Surveys in Eastern Africa. CIMMYT Economics Working Paper 03-07. Mexico, D.F.: CIMMYT (Centro Internacional de Mejoramiento de Maíz y Trigo).

Feder, G.; Just, R. E.; Zilberman, D. 1982. Adoption of Agricultural Innovation in Developing Countries: A survey. World Bank Staff Working Papers Number 542. Washington D.C.; The World Bank.

Henry, C.; Lapenu, C.; Zeller, M.; Sharma, M.2003. *Microfinance Poverty Assessment Tool*. Washington DC. The World Bank.

Javaya (Newspaper Published by Sri Lanka Ministry of Agriculture). January/February 2000 issue. (in Sinhala)

Kikuchi, M.; Barker, R.; Samad, M.; Weligamage, P. 2002. Comparative advantage of rice production in Sri Lanka with special reference to irrigation costs. In: *Development in the Rice Economy*. Proceedings of the international workshop on medium- and long-term prospects of rice supply and demand in the 21st Century, 3-5 December 2001. M .Sombilla, M. Hossain and B. Hardy (eds) Los Banos, Philippines. International Rice Research Institute. pp 343-368.

McDonald, J. F.; Mofitt R. A. 1980. The use of *tobit* analysis. *Review of economics and statistics*, 62 (2), pp.318-321.

McHugh, O. V.; Steenhuis, T. S.; Barison, J.; Fernandez, E . C. M.; Uphoff, N. T. 2002. Farmer Implementation of alternate wet and dry and non-flooded irrigation practices in the system of rice intensification. In: *Water-Wise rice production*. Proceedings of the International Workshop on Water-Wise Rice Production, 8-11, April, B.M.A. Boum; H. B. Hardy; P. S. Bindraban; T. P. Tuong; J. K. Ladha (eds) Los Banos, Philippines. International Rice Research Institute.pp 89-102.

Moser, C. M.; Barrett, C. B. 2002. The system of rice intensification in practice: Explaining low farmer adoption and high disadoption in Madagascar. In: *Water-Wise rice production.* Proceedings of the International Workshop on Water-Wise Rice Production, 8-11, April. B .M.A. Boum; H. B. Hardy; P.S. Bindraban; T. P. Tuong; J. K. Ladha (eds). Los Banos, Philippines. International Rice Research Institute.pp 103-118.

Moser, C. M.; Barrett, C. B.2003. *The complex dynamics of smallholder technology adoption: The case of SRI in Madagascar.* Working Paper 03-20. Ithaca,NY: Department of Applied Economics and Management. Cornell University.

Panabokke, C.R. 1996. *Soils and agro-ecological envioronments of Sri Lanka*. Colombo, Sri Lanka: Natural Resources Energy and Science Authority.

Perez, R. 2002. Experience in Cuba with the system of rice intensification. In: *Assessment of the system of rice intensification.* Proceedings of an international conference held in Sanya, China, April 1-4, 2002. N. Uphoff; E. Fernandes; Y. Longping; P. Jining; S. Rafaralahy; J. Rabenandrasana. (eds). 2002. Ithaca, NY: Cornell International Institute for Food and Agriculture Development. pp. 53-55.

Pindyck, R. S.; Rubinfeld, D. L. 1981. *Econometric Models and Economic Forecasts*. New York, McGraw-Hill.

Rogers, E. M.1995. Diffusion of Innovations (4 .ed.). New York : The free press.

Stoop, W. A.; Uphoff, N.; Kassam, A. 2002. A review of agricultural research issues raised by the system of rice intensification (SRI) from Madagascar: opportunities for improving farming systems for resource-poor farmers. *Agricultural Systems 71 (2002)* 249-274.

Thyagarajan,T.M.; Velu, V.;Ramasamy,S.;Durgadevi,D.;Govindarajan,K.;Priyadarshini,R.; Sudhalakshmi,C.; Senthilkumar, K.; Nisha, P.T.; Gayathry, G.; Hengsdijk, H.; Bindraban, P.S. 2002. Effects of SRI practices on hybrid rice performance in Tamil Nadu, India. In: *Water-Wise rice production.* Proceedings of the International Workshop on Water-Wise Rice Production, 8-11, April. B.M.A Boum; H. B. Hardy; P. S. Bindraban; T. P.Tuong and J. K. Ladha (eds). Los Banos, Philippines. International Rice Research Institute.

Uphoff, N.; E. Fernandes; Y. Longping; P. Jining; Rafaralahy, S.; Rabenandrasana, J. (eds). 2002. *Assessment of the system of rice intensification.* Proceedings of an international conference held in Sanya, China, April 1-4, 2002. Ithaca, NY: Cornell International Institute for Food and Agriculture Development.

Research Reports

62. *Irrigation Sector in Sri Lanka: Recent Investment Trends and the Development Path Ahead.* M. Kikuchi, R. Barker, P. Weligamage and M. Samad. 2002.

63. *Urban Wastewater: A Valuable Resource for Agriculture.* Wim van der Hoek, Mehmood Ul Hassan, Jeroen H. J. Ensink, Sabiena Feenstra, Liqa Raschid-Sally, Sarfraz Munir, Rizwan Aslam, Nazim Ali, Raheela Hussain and Yutaka Matsuno. 2002.

64. *Use of Untreated Wastewater in Peri-Urban Agriculture in Pakistan: Risks and Opportunities.* Jeroen H. J. Ensink, Wim van der Hoek, Yutaka Matsuno, Safraz Munir and M. Rizwan Aslam. 2002.

65. *Land and Water Productivity of Wheat in the Western Indo-Gangetic Plains of India and Pakistan A Comparative Analysis.* Intizar Hussain,R.Sakthivadivel, Upali Amarasinghe, Muhammad Mudasser and David Molden. 2003.

66. *Agro-Well and Pump Diffusion in the Dry Zone of Sri Lanka: Past Trends, Present Status and Future Prospects.* M. Kikuchi, P. Weligamage, R. Barker, M. Samad, H. Kono and H.M. Somaratne. 2003.

67. *Water Productivity in the Syr-Darya River Basin.* Hammond Murray-Rust , Iskandar Abdullaev, Mehmood ul Hassan, and Vilma Horinkova. 2003.

68. *Malaria and Land Use: A Spatial and Temporal Risk Analysis in Southern Sri Lanka.* Eveline Klinkenberg, Wim van der Hoek, Felix P. Amerasinghe, Gayathri Jayasinghe, Lal Mutuwatte and Dissanayake M. Gunawardena. 2003.

69. *Tubewell Transfer in Gujarat: A Study of the GWRDC Approach.* Aditi Mukherji and Avinash Kishore. 2003.

70. *Energy-Irrigation Nexus in South Asia: Improving Groundwater Conservation and Power Sector Viability.* Tushaar Shah, Christopher Scott, Avinash Kishore and Abhishek Sharma. 2003.

71. *Policies Drain the North China Plain: Agricultural Policy and Groundwater Depletion in Luancheng County, 1949-2000.* Eloise Kendy, David J. Molden, Tammo S. Steenhuis and Changming Liu. 2003.

72. *Development Trajectories of River Basins: A Conceptual Framework.* François Molle. 2003.

73. *A Method to Identify and Evaluate the Legal and Institutional Framework for the Management of Water and Land in Asia: The Outcome of a Study in Southeast Asia and the People's Republic of China.* Ian Hannam. 2003.

74. *A Diagnostic Model Framework for Water Use in Rice-based Irrigation Systems.* Wilfried Hundertmark and Ali Touré Abdourahmane. 2003.

75. *Prospects for Adopting System of Rice Intensification in Sri Lanka: A Socioeconomic Assessment.* Regassa E. Namara, Parakrama Weligamage and Randolph Barker. 2003.

Postal Address:
P O Box 2075
Colombo
Sri Lanka

Location
127, Sunil Mawatha
Pelawatta
Battaramulla
Sri Lanka

Tel:
+94-11 2787404

Fax:
+94-11 2786854

E-mail:
iwmi@cgiar.org

Website:
http://www.iwmi.org

IWMI
International
Water Management
Institute

FUTURE
HARVEST
IWMI is a Future Harvest Center
supported by the CGIAR

COMPREHENSIVE
Assessment
of water management
in agriculture

ISSN 1026-0862
ISBN 92-9090-535-2