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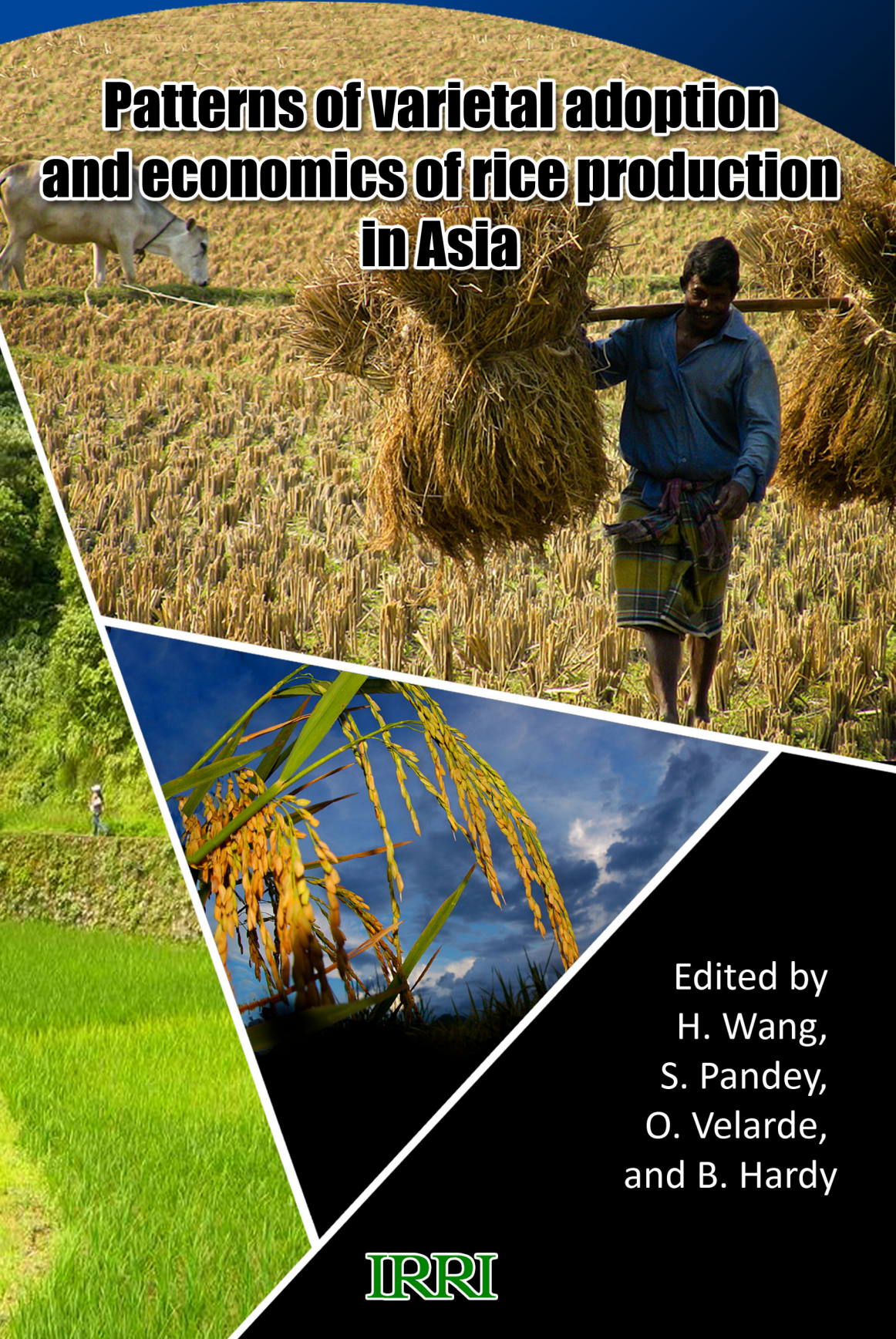
Patterns of varietal adoption and economics of rice production in Asia



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H. Wang,
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O. Velarde,
and B. Hardy

IRRI

Patterns of varietal adoption and economics of rice production in Asia

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2012

IRRI

INTERNATIONAL RICE RESEARCH INSTITUTE

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Contents

Foreword v

Acknowledgments vii

Chapter 1
Synthesis of key results and implications 1

Chapter 2
Methodological framework 15

Chapter 3
Pattern of varietal adoption and economics of rice production in Cambodia 23

Chapter 4
Pattern of varietal adoption and economics of rice production in Pakistan 67

Chapter 5
Pattern of varietal adoption and economics of rice production in Sri Lanka 91

Foreword

Rice research remains an important global undertaking to ensure an adequate food supply for sustainable food security of the poor. Improved technologies for rice productivity growth are critical for achieving food security and reducing poverty in the face of increasing competition for land, labor, and water and the challenges posed by global warming.

Millions of poor small farmers grow rice in Asia and Africa under very diverse conditions. These include areas affected by drought, submergence, salinity, problem soils, insects, diseases, and other pests. Farmers often have to contend with various adverse factors simultaneously. Clearly, a steady stream of improved technologies is needed to tackle these persistent and evolving problems.

With the support of its donors, the International Rice Research Institute in partnership with national programs is leading the development of suitable rice technologies for these diverse conditions through the application of modern scientific approaches and tools. A major focus of IRRI's work continues to be the development of improved rice germplasm that is high-yielding and tolerant of abiotic and biotic stresses. Other major work of IRRI, as described in the Global Rice Science Partnership (GRiSP), involves improving crop management, reducing postharvest losses, and improving the nutrient content of rice grains.

One of the major projects being implemented by IRRI, in partnership with the Chinese Academy of Agricultural Sciences (CAAS), concerns developing "Green Super Rice" (or GSR) for Asia and Africa. These rice varieties are expected to be both high-yielding and environment-friendly as they incorporate several traits for pest and disease resistance. The GSR project, supported by the Bill & Melinda Gates Foundation, is conducting activities in several Asian and African countries.

Improved varieties resulting from these scientific research efforts, however, will not have the desired impact unless the target farmers ultimately adopt these varieties. Hence, it is important to understand the social and economic contexts of rice production in these countries for efficient targeting. This book aims at providing such socioeconomic contexts for rice production in the key countries in Asia (Sri Lanka, Cambodia, and Pakistan) where the GSR project is taking place. The various chapters in this book are based on household-level benchmark data on farmers' resource endowments, their livelihood strategies, rice production practices,

technology adoption patterns, constraints to the adoption of existing improved technologies, gendered division of labor, and household income structures. I am confident that the results, based on a detailed analysis of farm-level data, not only provide important insights for underpinning technology development and dissemination but also serve as a benchmark for future impact assessments.

Robert S. Zeigler
Director General
International Rice Research Institute

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We would like to acknowledge several organizations and individuals that have directly or indirectly contributed to the completion of this research work and publication. The research carried out here is a part of the Bill & Melinda Gates Foundation (BMGF)–supported project on Green Super Rice (GSR) for the Resource-Poor of Africa and Asia. We acknowledge funding support from the Foundation.

The International Rice Research Institute (IRRI) implemented the research in partnership with national research organizations in South and Southeast Asia. The main partner organizations directly involved were SME Development and the Ministry of Agriculture, Forestry, and Fisheries (MAFF) in Cambodia; Socio Economic and Planning Centre (SEPC) and Rice Research and Development Institute (RRDI) of the Department of Agriculture in Sri Lanka; and the University of Agriculture in Faisalabad in Pakistan.

The staff of these organizations who had leadership roles in implementing the research work were Mr. Sam Bona and Dr. Pyseth Meas (Cambodia); Dr. Nimal Dissanayake, Ms. Ranjika Walisinghe, Dr. R.M. Herath, and Mr. Darshana Rajapaksa (Sri Lanka); and Dr. Anjum Abedullah (Pakistan). We would like to express our appreciation to these organizations and individuals for their collaboration.

We thank the staff of IRRI's Social Sciences Division—Ludy Velasco, Lydia Damian, and Gina Zarsadias—who were directly involved in providing support at various stages of the research study, and Dr. Andy Nelson and the staff of IRRI's Geographic Information Systems Laboratory, particularly Cornelia Garcia. We also wish to thank Emmanuel Panisales of IRRI's Communication and Publications Services, who helped with the graphic design, and Priscilla Grace Cañas, who provided editorial assistance. We are also grateful to the GSR project management team, led by Dr. Zhikang Li and Dr. Jauhar Ali. We also acknowledge the help provided by GSR administrative staff members Pauline Jasmin and Judy Lee.

Finally, we are thankful to the 2,100 farmers from Cambodia, Sri Lanka, and Pakistan who provided their time and valuable information on which this work is based.

Chapter 1

Synthesis of key results and implications

Huaiyu Wang, Sushil Pandey, and Orlee Velarde

Rice is the world's most important food staple and 90% of the rice-producing area is located in Asia. It accounts for 70% of the calorie supply in Cambodia, 40% in Sri Lanka, and 37% in Pakistan (FAOSTAT 2012). It is a major source of livelihood for farmers, especially in low-income and lower-middle-income countries (Dawe et al 2010, Pandey et al 2010). Thus, rice is a strategic commodity and sustained growth in its productivity is important for improved food security and income growth of the poor.

Because of increasing water and land scarcities and climate change, a major challenge is to increase rice yield in Asia to meet the growing demand as Asia accounts for 90% of global rice consumption (Hazell 2010). Rice varieties of the future thus need to be tolerant of stresses (such as high temperature, drought, and submergence) and higher yielding to ensure that rice production can keep pace with the rising demand for rice, especially by the poor. Similarly, rice varieties that are genetically resistant to various pests and diseases are needed to reduce the dependence on pesticides for human health and environmental reasons.

The Social Sciences Division at the International Rice Research Institute (IRRI) is implementing socioeconomic research work related to the Green Super Rice for the Resource-Poor of Asia and Africa (GSR) project for South and Southeast Asia. The main objectives of this research are to

- Analyze the patterns of adoption and diffusion of existing improved varieties and identify constraints to adoption;
- Analyze the economics of rice production and farmer livelihood strategies and understand the gender roles in rice production and women's participation in decision making;
- Estimate the potential impact of improved varieties being developed under the project on rice production, farmer income, and poverty reduction; and
- Draw implications for technology development, targeting, and policy reforms.

This report provides the results based on the work accomplished in three countries (Cambodia, Sri Lanka, and Pakistan) and consists of five chapters. The first chapter provides an overall synthesis of key findings and their implications. The second chapter includes the methodological aspects and the survey sampling design. The following chapters provide a detailed analysis of the results from each of the three countries. The household surveys were implemented in collaboration with NARES institutions and NGOs in 14 representative locations (provinces/districts) in Cambodia, Sri Lanka, and Pakistan. The surveys covered 1,200 farm households in key rice-producing areas. The farm-level data were collected for the cropping year 2009-10.

Key findings

Rice production trends

The national picture of rice production in Cambodia in Southeast Asia and Sri Lanka and Pakistan in South Asia is shown in Table 1. Averaged over 2008-10, the three countries together had a total rice area and production of 6.3 million ha and 17.8 million tons, respectively.

In Cambodia, average rice consumption was 143 kg of milled rice (223 kg of rough rice) per capita per year while the average rice production per capita was more than 560 kg of rough rice (MAFF 2011), indicating that Cambodia is a rice-surplus country. The surplus of paddy in Cambodia was estimated to be nearly 4 million tons in 2010 (MAFF 2011). The current situation of the rice sector in Cambodia not only has an impact within the country but also can influence global food security as Cambodia has re-entered the rice export market following a long gap (Pandey and Bhandari 2009). One of the main challenges for rice production in Cambodia is to improve yield, which is still below 3 t/ha.

Sri Lanka is largely self-sufficient in rice, with minimal trading activities. The percentage of rice consumed as food is more than 90% of the domestic supply. Since 2000, implementation of supportive policies coupled with special extension programs and new technologies contributed substantially to production growth. In 2005, a price support system called "guaranteed price scheme" and a new fertilizer subsidy program were implemented. The government policies aim to achieve food security by increasing and stabilizing rice production. Rice consumption is 116 kg of milled rice per person per year (Central Bank of Sri Lanka annual report 2010).

Rice in Pakistan is mainly a cash crop and is one of the main export products. It occupies about 10% of the total cropped area (Shaikh et al 2011) and accounts for 4.4% of the value added in agriculture (Ministry of Food and Agriculture 2010). Basmati and IRRI varieties play dominant roles in rice production in Pakistan, accounting for 57% and 31% of the total rice area in 2008, respectively. The national average yield of IRRI varieties (2.9 t/ha) was 72% higher than that of Basmati varieties (1.7 t/ha) in 2008.

Yield varies significantly across the three countries (Table 1). This difference is largely accounted for by irrigation and the extent of adoption of improved varieties. Irrigated area accounts for 80% and 30% of the agricultural area in Pakistan and Sri Lanka, respectively (Hazell 2010). In the case of Cambodia, only 8% of the area is irrigated and rice production takes place mainly under rainfed conditions (IRRI 2006). Almost all rice area in Sri Lanka is under improved varieties while in Pakistan improved varieties account for over 31% of the area. In contrast, traditional varieties are still quite popular in Cambodia and occupy around 60% of the rice area; they are more popular in the central and northern provinces.

Rice yields have been moving upward, especially in the past decades (Fig. 1). It is highlighted that the yield trends have much variation, such as Sri Lanka and Pakistan having continuous growth at a higher level, but Cambodia at a lower level.

Table 1. Rough rice area, yield, and production, GSR countries in Asia (2008-10).

Area and country	Area (million ha)	Production (million tons)	Yield (t/ha)
Southeast Asia			
Cambodia	2.7	7.7	2.9
South Asia			
Sri Lanka	0.9	3.9	4.4
Pakistan	2.7	6.2	2.3

Data source: FAOSTAT and national statistics.

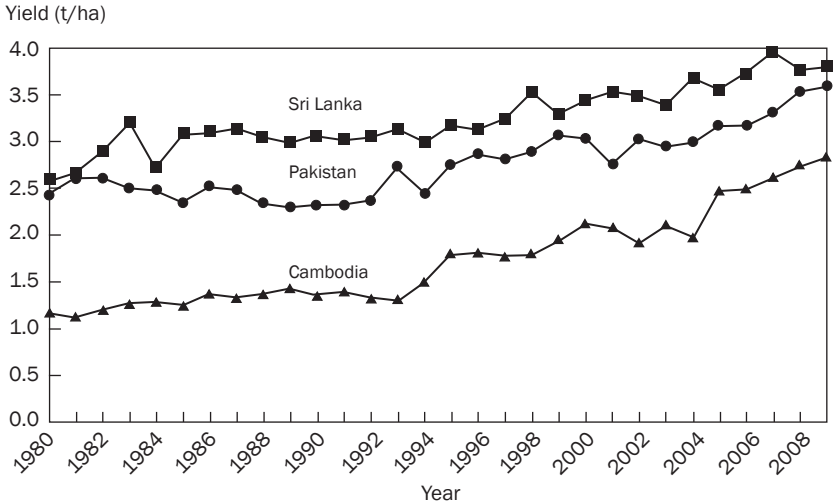

Fig. 1. Rice yield trend in 1980-2009. Data source: FAOSTAT.

Poverty

The incidence of poverty is high in all three countries (Table 2). The rural poverty rate in Pakistan and Cambodia remains significantly high at 27% and 34%, respectively. However, in terms of the absolute number of poor people, Pakistan has the most poor people living in rural areas.

Farm characteristics and cropping intensity

The average farm size per household ranges from 0.8 ha to more than 5 ha per household (Table 3). Of the total sample size, 60% of the farm households have more than

Table 2. Poverty in GSR countries.

Region and country	National poverty (%)	Rural poverty (%)	Number of rural poor people (million)
Southeast Asia			
Cambodia	30.1	34.5	4.0
South Asia			
Sri Lanka	15.2	15.7	2.7
Pakistan	22.3	27.0	29.1

Data source: World Development Indicators (2011).

Table 3. Characteristics of farm households.

Region and country	Farm size (ha/hh)	Irrigation of paddy (%)	Cropping intensity (%)
Southeast Asia			
Cambodia	1.8	23	113
South Asia			
Sri Lanka	1.2	40	150
Pakistan	5.5	90	187

Data source: IRRI GSR project, household survey 2010.

2 ha in farm size, which indicates the importance of small farms in these countries. Rice production in Sri Lanka and Pakistan is mostly irrigated, whereas production takes place mainly under rainfed conditions in Cambodia.

Cropping intensity is used to measure the intensity of rice land use and is influenced by different cropping systems and irrigation in the three countries. Farmers in Cambodia and Sri Lanka mostly practice a rice-rice cropping system. Rice is the main crop, accounting for more than 90% of all cropped area in Cambodia and Sri Lanka in the survey. The cropping intensity in Cambodia is also much lower than in Sri Lanka because of limited access to irrigation and the long duration of rice varieties. The cropping intensity in Pakistan is higher because farmers usually rotate rice (52% of area) with wheat (33% of area).

Adoption of improved rice varieties

Popular varieties. Inbred rice varieties are commonly grown in all the countries, with some hybrid rice being grown in Pakistan. The majority of farmers (87%) grow only one to two varieties and only 13% of the farmers grow three or more varieties (Table 4). The rice varieties grown are not diverse in South Asian countries. Some 87% and 71%

Table 4. Percentage of farmers by number of varieties adopted (%).

Number of varieties	Cambodia	Pakistan	Sri Lanka	Total
1	38	87	71	57
TV[a]	33	0.5	0	16.4
MV[a]	5	76	71	39
Hybrid	0	10	0	2
2	41	11	25	30
TV	21	0	0	10
MV	0.8	9	25	10
MV and TV	18.9	0	0	9
Hybrid and MV	0	2	0	0.3
3	14	2	3	8
4 and above	7.7	0	0.2	4.3

[a]MV refers to inbred MV. Data source: IRRI GSR project, household survey 2010.

of the farmers in Pakistan and Sri Lanka grow only one rice variety. Varietal diversity is higher in Cambodia, with farmers growing both traditional and improved varieties. The adoption of modern inbred varieties in Sri Lanka is almost 100% and very few areas grow traditional varieties. Most farmers prefer varieties with 3–3.5 months' duration primarily because of their short maturity, thus giving farmers more time for a second crop and allowing them to effectively match the cropping calendar with the rainy season. In Cambodia, traditional varieties occupy a substantial area (59% of the total rice area). In Pakistan, hybrids account for about 15% of the total rice area. The adoption of improved varieties is generally high but adoption in stressed environments is characterized by "patchiness." Farmers adopt improved varieties in land types or "patches" with favorable hydrological conditions while traditional varieties are grown mainly in areas with unfavorable hydrological conditions. Farmers cultivate different land types such as upper, middle, and lower fields. These land types differ in field hydrological conditions. In the upper fields, which tend to hold less water, farmers grow traditional and short-duration varieties. Lower and middle fields that retain more water are the main areas for modern varieties (Table 5).

More than 50% of the rice farmers in the survey areas grew only a single rice variety (Table 4). In Cambodia, 38% of the farm households grew a single variety and 55% of the rice farmers interviewed grew 2–3 rice varieties (Table 4). In Pakistan, IRRI-6 and IRRI-9 accounted for 68% of the rice area (Table 6). IRRI-6 is a coarse rice variety that was officially released in 1971 with the name IRRI-6 in Punjab and Mehran-69 in Sindh Province. IRRI-6 and IRRI-9 are mostly grown in Sindh and DG Khan District in Punjab.

Sri Lanka does not have much variation among farmers regarding the extent and types of rice varieties grown. The single popular variety Bg 300 accounted for

Table 5. Percentage of rice area by variety across different land types.

Growing area and type of variety	Cambodia[a]	Sri Lanka	Pakistan	Total
Total				
Hybrid	–	–	15	4
Inbred MV	41	100	85	64
TV	59	–	–	32
Lower field				
Hybrid	–	–	1	1
Inbred MV	49	100	99	73
TV	51	–	–	26
Middle field				
Hybrid	–	–	19	10
Inbred MV	39	100	80	60
TV	61	–	1	30
Upper field				
Hybrid	–	–	–	19
Inbred MV	19	–	–	30
TV	81	–	–	51

[a]Traditional variety includes improved TVs. Data source: IRRI GSR project, household survey 2010.

Table 6. Major varieties grown in GSR countries.

Country released	Variety name	% area	Yield (t/ha)	Year
Cambodia	504 (IR50404-57-2-2-3)	21	4.1	1990
	IR66	13	2.7	1990
	Riang Chey	13	2.1	–
Pakistan	IRRI-6	56	3.5	1971
	IRRI-9	12	3.7	1999
	Pukhraj (hybrid)	11	4.9	–
	Super Basmati	10	1.9	–
Sri Lanka	Bg 300	62	2.6	1987
	Bg 352	13	3.1	1992
	Bg 358	7	2.4	1999

Data source: IRRI GSR project, household survey 2010.

62% of the rice area. It can be harvested in 3 months and is suitable when rainfall is limited in the dry season. The top three varieties in Sri Lanka (Bg 300, Bg 352, and Bg 358) have intermediate bold-type grains and they are recommended for general cultivation. Bg 352 and Bg 358 mature in 3 ½ months. Farmers from rainfed areas prefer to cultivate Bg 352 while farmers with access to irrigation prefer Bg 358.

In Cambodia, market linkage is an important factor for varietal adoption. The coverage of modern varieties is much higher in the southern provinces than in the northern and central provinces due to the influence of the Vietnamese market. For example, 504 and IR66, two popular rice varieties in Vietnam, are grown widely in southern Cambodia bordering Vietnam. The traditional varieties grown in northwest Cambodia that mostly end up in the export market either come directly from Cambodia or indirectly through cross-border trade with Thailand. And, improved traditional varieties such as Riang Chey are popular in the central provinces that supply rice mainly to urban centers in Cambodia. The results of econometric models estimated in this study indicate that the adoption of improved varieties is influenced by the proximity to domestic and international markets.

Despite the high incidence of adoption of improved varieties, average yields have remained low in all three countries. In Pakistan, a hybrid variety such as Pukhraj achieved the highest yield at 5 t/ha. However, most of the average yields of the popular varieties are lower than 4 t/ha and some of them are just 2–2.5 t/ha. This is also the situation in Cambodia and Sri Lanka. Thus, varietal adoption alone is not a very useful indicator of progress in rice farming.

In summary, one or two major varieties accounting for a large area are considered mega-varieties. Second, the adopted varieties are generally old (that is, those released before 1990), with limited adoption of newly-released varieties for the main wet-season cropping.[1]

Varietal traits preferred. Farmers rank rice yield as the most important trait of a variety. But, farmers value other traits also such as grain quality (Table 7).

[1]In Pakistan, rice is grown in the wet season only.

Table 7. Farmers' desirable varietal traits by country (%).

Trait	Cambodia	Pakistan	Sri Lanka	Total
High yield	29	61	38	35
Grain and eating quality	42	27	36	39
High market price	17	11	2	12
Resistant to lodging	7	1	10	7
Resistant to pests and diseases	5	1	14	7

Data source: IRRI GSR project, household survey 2010.

In Pakistan, 61% of the farmers considered yield as the most important trait. Grain and eating quality is an important trait for farmers in Cambodia (42%) and Sri Lanka (36%). Farmers in Cambodia (17%) and Pakistan (11%) are more sensitive to the rice market price, which might be because of their export markets. Only 2% of the farmers in Sri Lanka mentioned the market price as an important factor.

In Sri Lanka, maturity duration is an important factor that affects farmers' adoption. For example, Bg 300 is perceived to have very good characteristics, including higher yield, lodging and disease resistance, and good taste. Although its yield is not the highest, it is popular because of its short duration.

Economics of rice production. In general, yield drives the return to rice farming (Fig. 2). In terms of cost composition, material inputs, particularly chemical fertilizers, account for a large portion of cash cost. In Sri Lanka, fertilizer is heavily subsidized and this contributes to higher returns. In Pakistan, high yield of 3.7 t/ha makes up for the higher input costs and helps farmers gain an attractive profitability, US$500 per ha. Rice farming in Cambodia has the lowest yield (2.31 t/ha) and cash cost ($206 per ha). This performance can be expected in a situation where both the adoption of MVs and investment in inputs are low. Although lower cash cost could result in a higher share of net returns as demonstrated in Cambodia, net cash income remains the lowest among the three countries.

Labor use in rice production. Family labor is the main labor source for rice farming in the three countries. Sri Lanka has the lowest labor use in rice production (69 person-days per ha), the highest daily wage rate (nearly $5 per day per worker), and highest labor cost ($350 per ha). This is probably due to the nonfarm work opportunities in Sri Lanka, which has affected the availability of labor in the farming

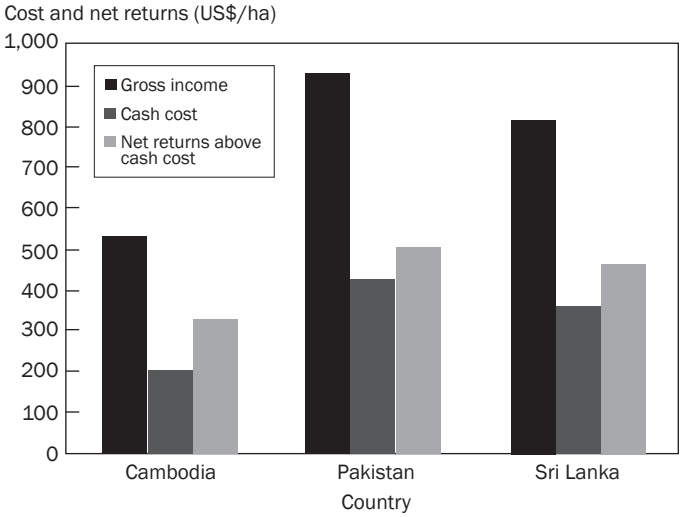

Fig. 2. Costs and net returns of rice production in target countries, 2010.

sector. The extent of farm mechanization varies among countries, with rice farming being more mechanized in Sri Lanka and Pakistan than in Cambodia, where farmers mainly use draft animals for farm power (Table 8).

Structure and sources of household income

Table 9 shows the structure and sources of household income across countries.[2] The results indicate that the nonfarm sector is now quite an important source of income in all three countries. However, the share of rice in total income is also quite important and rice actually ranks first in the case of Cambodia. A higher share of rice income in total household income indicates the potential role of rice productivity improvement in poverty reduction. This role of rice obviously varies across countries.

[2]Rice income is based on the total output value less the total cash cost.

Table 8. Distribution of labor and power use for the wet season.

Labor and power use	Cambodia	Pakistan	Sri Lanka
Total labor (person-days per ha)	80	96	70
Labor cost (in US$)	221	251	350
% hired labor cost	31	37	26
% imputed family cost	69	63	74
Daily wage rate (in $)	2.67	2.09	4.67
Power use (%)			
Animal	80	0	9
Tractor	11	62	56
Harvester, thresher, and winnowing fan	9	38	35

Data source: IRRI GSR project, household survey 2010.

Table 9. Share of income from different sources.

Income share	Cambodia	Pakistan	Sri Lanka
% rice	44	16	11
% nonrice	1	38	10
% animal sale	13	1	17
% off-farm income	2	9	1
% nonfarm income	40	36	61
Total income (in US$)	1,688	3,075	3,475
Per capita income per day (in $)	0.94	1.35	2.44

Data source: IRRI GSR project, household survey 2010.

Rice farmers in Cambodia and Pakistan, two important export countries, are more market-oriented. In Cambodia, 58% of the production is sold. In Pakistan, 50% and 30% of rice production are used as sales and payment to landlords and/or hired laborers, respectively. In Sri Lanka, a large portion of rice production is for home consumption (Fig. 3).

Gender participation and decision making

There were no female respondents in the survey in Pakistan and gender participation and decision making were studied only in Cambodia and Sri Lanka. In all aspects, women in Cambodia have a higher Women's Empowerment Index (WEI) than in Sri Lanka. Women are involved in more diverse rice-farming activities in Cambodia than in Sri Lanka. In Cambodia, women farmers are mostly engaged in crop establishment, harvesting and threshing, and postharvest activity. In Sri Lanka, it is only harvesting and threshing.

In both countries, women's exposure to training has a positive significant effect on women's empowerment and the effect of training on the husband is negatively significant. The number of females in the household and the age of the wife also contribute to women's empowerment.

In Sri Lanka, the education levels of wives and their contribution to nonfarm income increase WEI significantly.

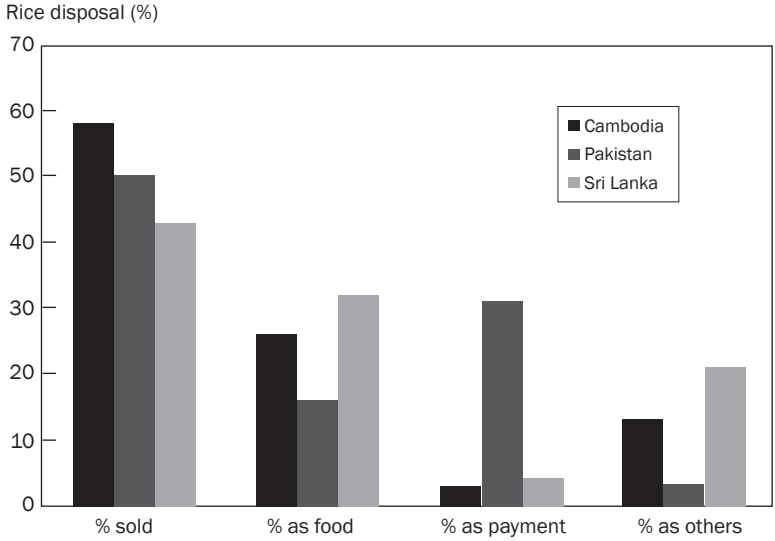

Fig. 3. Disposal of rice production. Data source: IRRI GSR project, household survey 2010.

Ex ante assessment

The ex ante impact assessment was based on two impact indicators: the number of poor rice farmers that can be lifted above the poverty line and the additional number of people that can meet their food requirement from additional production. The anticipated benefit at the farm level was estimated based on the household-level data, which were extrapolated to the country level using secondary data. The two scenarios used pertain to the short term of 3–5 years and medium term of 6–10 years. The adoption rates for the short and medium terms were assumed to be 10% and 20% of the area of the potential domain, respectively. A yield increase at a conservative rate of 10% was also assumed.

Increased rice yield due to the adoption of improved varieties could lift more than 20,000 people out of poverty in the short term and this estimate increases to about 50,000 in the medium term (Fig. 4). This is the total sum for all three countries. Cambodia accounts for the lion's share of this total effect, followed by Pakistan. Similar results apply for the medium term.

For the number of people that can be fed due to additional rice production under the same assumption of technology dissemination, the effect is quite close in the three countries, with nearly 400,000 people that can be fed in the short run in each country (Fig. 5). Pakistan has a slightly larger impact in the short and medium term than the other two countries.

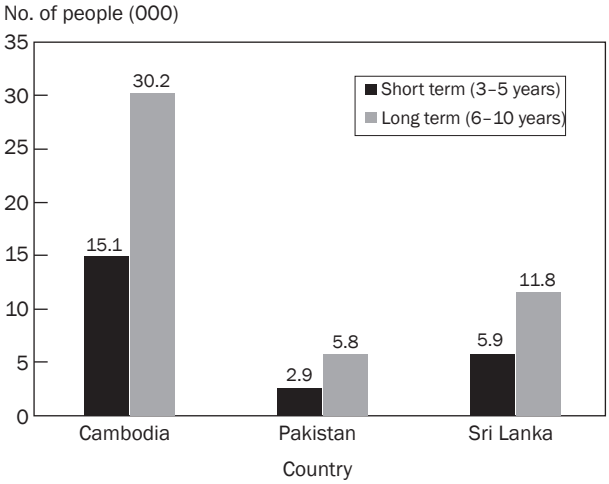

Fig. 4. Number of poor rice farmers lifted out of poverty in the country in the short and medium term.

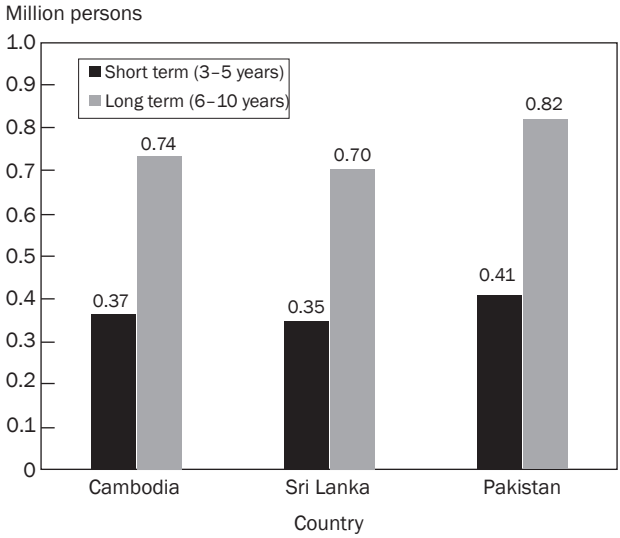

Fig. 5. Additional number of people who can be fed with rice production in the short and medium term.

Implications

The three countries analyzed represent a diversity of rice production environments, technology levels, and institutional setup. The performance of the rice sector is obviously a reflection of these differences that were highlighted above but are described in some detail in individual country chapters. Nevertheless, it is clear that yield in all three countries is low, especially in stress-prone areas. In the context of climate change induced by global warming and likely scenarios of increased frequency of extreme weather events (such as drought and floods), stability and growth in rice productivity will depend critically on interventions (technology and/or policy) that are flexible and better adapted to such extreme events. Efforts to develop improved rice varieties that are tolerant of such stresses are thus very important. In this context, the improved rice varieties being developed under the GSR project could play an important role.

The ex ante impact assessment based on yield gain and adoption rate shows different effects across the three countries. The impact of improved stress-tolerant varieties is likely to be higher in Cambodia, given the lower average yield and the dominance of rainfed production systems. Among the households, the impact will be higher for those that have a higher share of rice income in their total income. This information could help set priorities across countries. Similarly, a higher poverty impact is likely to be generated if the dissemination strategy targets those households that derive most of their income from rice production.

Several implications can be drawn from the key findings in the study. First, the grain quality characteristics that had been emphasized by farmers in the field work will be very important. The new lines and/or varieties to be developed should go through

the proper grain quality test and evaluation or whatever is needed to make sure these are the traits that farmers desire, especially regarding quality for hybrid rice.

Second, the dominance of mega-varieties basically indicates that a breeding strategy can build on existing materials and include some additional desirable traits to facilitate rapid dissemination. Grain quality could be such an additional consideration as farmers ranked grain quality as the second most important trait after yield. Lastly, some of the long-term problems we have observed are the lack of availability of and access to quality seeds caused by a lack of institutional capacity. In poor rainfed areas, limited access to quality seeds of improved varieties remains a problem because of several institutional constraints. Increased investments in extension and participation of local agencies and NGOs will be needed to accelerate the process of technology diffusion.

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Chapter 2

Methodological framework

Orlee Velarde, Huaiyu Wang, and Sushil Pandey

The main objective of this study is to analyze farmers' livelihood strategies, technology adoption patterns, adoption constraints, and the economics of rice production in the key rice production areas of Cambodia, Pakistan, and Sri Lanka. These three countries were involved in the first phase of the Green Super Rice (GSR) project. The analytical results are expected to provide a scientific basis for targeting new improved varieties developed under the GSR project, and for developing strategies for rapid dissemination. In addition, the data generated will serve as a benchmark for assessing the future impact of these improved technologies.

The research approach

The analytical method consists of the use of both published statistical information on the rice sector as well as farm-level surveys conducted in major stress-prone areas of Cambodia, Pakistan, and Sri Lanka. National and regional trends in rice production, area, and yield are analyzed using available time-series data. A detailed farm-level analysis is based on the household survey implemented under the project. The survey used a structured questionnaire with similar format for all three countries. Pretested questionnaires for baseline surveys and focus group discussions were used for the primary data collection.

The farm household survey was implemented in collaboration with national agricultural research and extension system (NARES) partners. In Cambodia, SME Development took the lead in the survey, with consultation from the Ministry of Agriculture, Forestry, and Fisheries (MAFF). In Sri Lanka, the Socioeconomic and Planning Centre (SEPC) and Rice Research and Development Institute (RRDI) of the Department of Agriculture of Sri Lanka implemented the survey. The survey in Pakistan was implemented by the University of Agriculture in Faisalabad. In addition, rice breeders involved in the GSR project were interviewed to identify potential target areas for the breeding program.

Research implementation

Site selection

Survey sites were selected to represent key abiotic stresses. Consultations with extension workers and local community leaders and site visits were conducted together with NARES partners to identify the target sites that will be appropriate for the objectives of the study. The main criteria for selection of a location were (1) the area is prone to

stress (such as drought, submergence, and salinity) and (2) the location represents a major rice production zone in the country. After purposive selection of the geographic locations (village/district/province, etc.), rice-growing farm household respondents from each location were randomly drawn.

Cambodia is a country with good potential for expansion of the rice export market. Six provinces (Battambang, Pursat, Kampong Thom, Kampot, Takeo, and Prey Veng) are the major rice production areas in Cambodia associated with the main abiotic stresses—drought, submergence, and salinity. The sites are located in southern, central, and northern Cambodia bordering Thailand and Vietnam. The southern and northern provinces are well linked with the international market due to their proximity to the major exporting countries, Vietnam and Thailand, respectively. The central province is connected to the major domestic market in Phnom Penh.

In Sri Lanka, three rainfall zones were used as the basis to locate areas affected by submergence and drought: the wet zone (annual rainfall > 2,500 mm), dry zone (rainfall below 1,750 mm), and intermediate zone (rainfall between 1,750 and 2,500 mm). Three districts, Kalutara (wet zone), Kurunegala (intermediate zone), and Puttalam (dry zone), were selected for the household survey as rice production in these districts is known to be affected by both biotic and abiotic stresses. Kurunegala was divided into two categories: minor irrigated (MI) and rainfed (RF).

In Pakistan, Punjab and Sindh are the two main rice-growing provinces. Basmati and IRRI varieties play dominant roles in the nation's rice production. In total, 12 villages from three districts in Sindh and two villages from DG Khan District in Punjab were selected to represent the diversity of production situations in Pakistan, which is an important rice-exporting country. The overall sample size and major locations are summarized in Table 1, with details in Annex 1.

Design of survey instruments and survey procedures

The survey used a standard questionnaire in all three countries to facilitate a comparative analysis and more efficient data processing. The questionnaire was structured and translated into the local language during the pretesting phase and actual survey. The information collected in the interview includes information about the respondent, the members of his/her household, landholdings, farm and nonfarm activities, major crops grown and their production amounts, rice production practices, rice yield and input use, costs and returns, income sources, and gender roles. A subsample of 30% was randomly selected for collecting detailed information on inputs used and the cost of rice production for each season.

The selected respondent for interviews was the person who managed the farm but was not necessarily the head of the household. General information about the farm and the nature of the constraints to rice production, including the frequency/intensity of abiotic stresses, was elicited from the respondent. During the interview, the unit of measurement recorded was based on local standards and it was subsequently converted to the metric system during data entry. For rice, the type and variety name and method of establishment were also collected for each land parcel. Farmers were asked about

Table 1. Sample distribution in the target countries.

Country	Province/district	Stress	Sample size
Cambodia	Takeo	Drought	124
	Prey Veng	Drought	121
	Pursat	Drought	60
	Battambang	Drought/submergence	120
	Kampong Thom	Drought/submergence	122
	Kampot	Submergence/salinity	60
Sri Lanka	Kalutara	Submergence	100
	Kurunegala (MI)	Drought	102
	Kurunegala (RF)	Drought	102
	Puttalam	Salinity	100
Pakistan	Larakana	Drought	60
	Shikarpur	Drought/submergence/salinity	60
	Badin	Salinity	30
	DG Khan	Salinity	60

Data source: IRRI GSR project, household survey 2010.

the desirable and undesirable traits of each variety. The questions were open-ended, which allowed farmers to provide answers based on their own perceptions.

Focus group discussions (FGDs) were conducted to understand the broader aspects of farmer practices and the economic situation in the survey villages. The instruments used for FGDs and the baseline survey aimed to capture both quantitative and qualitative data. The mechanisms deployed by farmers to cope with the effect of abiotic stresses on rice production were also elicited during the FGDs.

Analytical framework

Secondary data. FAOSTAT and IRRI World Rice Statistics were used as the main data sources for aggregate-level analysis. The published information was updated based on the latest statistics provided by NARES partners. In addition, NARES partners provided information about the current rice policy in their countries.

Secondary data were used to estimate the trend of rice production (area, production, and yield) in the last decades. Also, the growth rate and coefficient of variation (CV) of production/yield around the trend line were estimated. The CV around the trend line is defined as the ratio of the standard deviation to the mean of detrended data series and is a commonly used indicator of the variability of production.

Household-level analysis. At the household level, descriptive statistics in tabular form were used mainly to describe and illustrate the socioeconomic characteristics and variations across locations.

- ***Land***

Farmers typically classify their fields as upper, middle, and lower fields based on the relative location along the toposequence in Cambodia and Pakistan. In Sri Lanka, paddy fields are exclusively for rice production and farmers cannot shift rice land to other crops without government permission. Thus, in the chapter on Sri Lanka, the land area is divided into rice fields and nonrice fields. Rice fields are located in lower fields while nonrice fields are in higher fields.

- ***Analysis of costs and returns***

Detailed input and output information at the farm level collected in the household survey was used to analyze the costs and net returns of rice production by variety and season. A general cost summary was used to estimate the net returns on rice production of each household. Two types of production costs were considered in the estimation—cash and noncash costs. Cash costs refer to inputs, power use, and labor use paid in cash or the equivalent value if paid in kind. On the other hand, noncash costs refer to the opportunity cost of resources owned by farmers. These include own seeds from the previous harvest, own animals and machines, and family members who rendered their own labor. The farm-gate price of rough rice was used to estimate gross returns. Net returns are defined as gross returns minus the cash cost.

- ***Varietal adoption***

The analysis on the adoption of modern varieties was done only for Cambodia since the sample farm households in Sri Lanka and Pakistan have already fully adopted modern varieties (MVs). For these two countries, the analysis focused mainly on the economics of rice production using mega-varieties (in Sri Lanka) and the economics of rice production using hybrid and inbred varieties (in Pakistan).

- ***Econometric analysis on determinants of MV adoption in Cambodia***

Adoption is normally measured using two indicators: the incidence of adoption and the intensity of adoption. A farmer is considered to be an adopter if the farmer grows improved varieties even though the area under improved varieties may be very small; otherwise, the farmer is considered to be a nonadopter. On the other hand, the intensity of adoption is measured as the proportion of area under improved varieties. This represents the extent of adoption.

Since the incidence of adoption is a binary variable (i.e., a farmer is either an adopter or a nonadopter), discrete binary choice models such as a probit model (or its variant) are used to model adoption behavior. A probit model is described as

$$Y^* = x'\beta + \delta$$

$$Y = \begin{cases} 1(adopter) \text{ if } Y^* > 0 \\ 0(nonadopter) \text{ if } Y^* \leq 0 \end{cases}$$

where Y^* is unobserved and is referred to as a latent variable and Y is the observed choice. The probit model assumes that adoption is a function of a latent variable, and adoption is observed only when the latent variable exceeds the individual-specific threshold value. The latent variable is assumed to be a function of farm and household characteristics as well as external interventions.

The intensity of adoption is measured as the proportion of rice area of each farm household occupied by modern varieties. Following the literature, the factors determining cross-sectional variations in the intensity of adoption of modern rice varieties among households were analyzed using the standard tobit specification (Wooldridge 2002).

The tobit model, originally developed by Tobin (1958), is specified as

$$Y = X_i\beta + \varepsilon_i > 0 \quad \text{if} \quad X_i\beta + \varepsilon_i > 0$$
$$= 0 \quad \text{if} \quad X_i\beta + \varepsilon_i \leq 0$$
$$\text{and} \quad \varepsilon_i \sim N(0,\sigma^2)$$

where Y_i is the proportion of rice area under modern varieties between 0 and 1, X_i is a vector of variables capturing the farm and household characteristics, β is a vector of unknown coefficients, and ε is an error term that is assumed to be independently distributed with mean zero and a constant variance. The β coefficients measure the marginal effect of each of the exogenous variables on the intensity of adoption.

- ***Income from rice and other sources***

Net income from rice was estimated by deducting the cash cost from gross income. Net income from rice and nonrice together with off-farm and nonfarm income, animal husbandry, and other sources were included in the estimation of household income. Rice income in terms of its share in total household income is an important indicator of the importance of rice in farmers' overall livelihoods.

- ***Ex ante impact assessment***

The varieties being developed under the GSR project are still in a trial stage and have not yet been released for farmers' adoption. Hence, the actual impact of these varieties cannot yet be assessed. Instead, an initial assessment of the potential impact of GSR varieties has been conducted using the farm-level survey data and various assumptions regarding the size of the potential yield gain and the adoption rate. The impact assessment conducted below considers only one aspect of the impact, that is, economic gains resulting from yield increases. Any cost savings that may result from a reduced use of pesticides and environmental/health benefits are not considered at this stage.

Two major parameters are needed to estimate the increase in farm income arising from the adoption of improved varieties: the increases in yield per unit area and the area under improved varieties. Conceptually, estimates of increases in yield per unit area can be derived from varietal trials conducted in farmers' fields but the estimation of the area under improved varieties can be somewhat complicated. Farmers tend to expand the area under new varieties gradually over time as they experiment and learn more about varietal performance. Predicting this process of expansion for ex ante analysis such as this can be tricky and requires much more specific information on the farm characteristics and a greater understanding of farmer decision-making processes and their perceptions. A simpler pragmatic approach based on alternative scenarios is used here to estimate the anticipated benefit. The first scenario pertains to the short term of 3–5 years. This represents the starting period of adoption of a new variety. During this initial period, a farmer is likely to adopt the variety in a small area only. The yield increase as a result of the new variety, if any, will be realized in that area

only. The average proportionate increase in yield for the whole farm can be obtained as the product of the proportionate area under the new variety and the yield increase in the area adopted. This average yield increase in the short term is assumed here to be 10%. The average yield gain tends to increase over time as farmers learn more about the new varieties and manage the crop better. In addition, there may be some expansion of area under the variety. To capture these dynamic effects, we assume an average yield increase of 20% in the medium term (6–10 years).

Taking the poverty line of $1.25 per day per capita as the reference, this income effect of new varieties can be translated into poverty impact by estimating the number of people that can be lifted above the poverty line in the short and medium term. These poverty impact estimates derived from the sample are extrapolated to the national level to estimate the likely total impact on poverty.

- ***Gender analysis and the Women's Empowerment Index***

Women not only provide farm labor but also are increasingly involved in managing farms in Asia. An analysis of women's role and the extent to which they are empowered to make various household/farm decisions is thus important. In this study, a gender analysis in terms of women's participation and decision-making related to rice production and overall household livelihood was carried out. The status of women's empowerment was computed using the Women's Empowerment Index based on 16 farm and household-related indicators.

Following Hossain et al (2004) and Paris et al (2008), the WEI was calculated as follows:

$$WEI = \sum_{i=1}^{n} \frac{X_i}{n}$$

where *WEI* represents the Women's Empowerment Index between values from 1 to 5 and X_i is the rating of indicator i from 1 to 5 where its corresponding definition for each rating is described as follows:

1 = decision is made by the husband only
2 = decision is made by the husband in consultation with the wife
3 = joint decision by husband and wife
4 = decision is made by the wife in consultation with the husband
5 = decision is made by the wife only

and n is the total number of decision variables included in the questionnaire for which either the husband or wife or both is making the decision.

OLS regression was applied to analyze the factors affecting women's empowerment. It is specified as

$$Y_i = X_i\beta + \varepsilon_i \qquad \varepsilon_i \sim N(0, \sigma^2)$$

where Y_i is the average WEI of the *ith* household, X_i is a vector of variables capturing the farm and household characteristics, β is a vector of unknown coefficients, and ε is an error term that is assumed to be independently distributed with mean zero and a constant variance.

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Annex 1

Table 1. Sample distribution in Cambodia.

Stress	Province	Village	Sample size
Drought	Takeo	Sochan	44
	Takeo	Svay Russey	40
	Takeo	Daung	40
	Prey Veng	Thkauv	40
	Prey Veng	Chreav	40
	Prey Veng	Prey Snieth	41
	Pursat	Koh	28
	Pursat	Phar Loeu	32
	Battambang	Balang	40
	Battambang	Chrab Kror Sang	40
	Kampong Thom	Toul Domnakk	44
Submergence	Kampot	Khnach	30
	Battambang	Boung Rang	40
	Kampong Thom	Chey Moung Koul	43
	Kampong Thom	Doung	35
Salinity	Kampot	Prey Tonle	30
	Total		607

Data source: IRRI GSR project, household survey 2010.

Table 2. Sample distribution in Sri Lanka.

Stress/district	Village	No. of households
Submergence (Kalutara)	Thudugala	33
	Thebuwana	37
	Thebuwana West	30
Drought (Kurunegala, MI)	Dalupothagama	32
	Kurakkanahnegedara	34
	Thoranegedara	36
Drought (Kurunegala, RF)	Siwallawa	26
	Mirihanpitiya	16
	Thanawatte	60
Salinity (Puttalum)	Wadaththa	31
	Viharagama	8
	Kottukachchiya	61

Data source: IRRI GSR project, household survey 2010.

Table 3. Sample distribution in Pakistan.

Stress	Province	District	Village	Sample size
Drought	Sindh	Larakana	Ali Hassan Junejo	11
	Sindh	Larakana	Mehrab Khan Gachal	6
	Sindh	Larakana	Rato Kot	16
	Sindh	Larakana	Rohal Khan Bhugti	15
	Sindh	Larakana	Ghari Khuda Bux	12
	Sindh	Shikarpur	Jhali Kalwari	14
	Sindh	Shikarpur	Muhammad Hayat Junejo	7
Submergence	Sindh	Shikarpur	Haji Bero	8
Salinity	Sindh	Shikarpur	Khuda Bux Mastoi	16
	Sindh	Shikarpur	Theenda	15
	Sindh	Badin	Malhan	15
	Sindh	Badin	Noor Muhammad Dars	15
	Punjab	DG Khan	Moza Charhatta Sindh Shumali	32
	Punjab	DG Khan	Peer Adil	28

Data source: IRRI GSR project, household survey 2010.

Pattern of varietal adoption and economics of rice production in Cambodia

Huaiyu Wang, Orlee Velarde, Sam Bona, and Pyseth Meas

Introduction

Country background

Cambodia is a small country located in the Mekong region between Thailand and Vietnam. The poverty ratio[1] of this agriculturally oriented country with a population of 14.8 million is quite high at 28.3%. The major economic characteristics of the country are summarized in Table 1. Overall, agriculture accounts for 29% of the gross domestic product and 75% of the total employment (The World Factbook 2009, cited by Pandey and Bhandari 2010). Rice is an important crop as it occupies more than 90% of the total cultivated area. It is the staple food that accounts for around 70% of the total calorie supply. In 2010, rice consumption was 143 kg of milled rice (223 kg of rough rice) per capita per year, while rice production per capita was more than 560 kg of rough rice (MAFF 2011), indicating that Cambodia is a rice-surplus country. As a result, Cambodia has re-entered the export market and has a good potential for expanding rice exports (Pandey and Bhandari 2010). The surplus of paddy in Cambodia was estimated to be nearly 4 million tons in 2010 (MAFF 2011). The main challenge for rice production is to increase yield as it is still below 3 t/ha. Rice production in Cambodia occurs mainly under rainfed conditions, and the adoption of improved technology is low. A number of technological and policy constraints have resulted in a low adoption of improved technologies and low yield of rice.

[1]The poverty line is US$1.25 per day per capita.

Table 1. General characteristics of Cambodia.

Characteristics	Number
Land area in 2008 (km^2)[a]	181,035
Share of arable land (%)[a]	22.1
Share of agricultural area in total land (%)[a]	31
Population in 2009 (million persons)[a]	14.8
Rural population (%)[a]	78
Average annual population growth (1990-2009, %)[a]	2.2
Poverty rate in 2007 (%)[a]	28.3
Share of agriculture in GDP in 2010 (%)[b]	29
Gross value added for agriculture in 2010 (billion US$)[b]	2.08
Rice consumption per capita in 2010 (kg/person/year)	143

Data source: [a]World Development Indicators 2011. [b]Annual report of Agriculture, Forestry, and Fisheries (2010-11), Ministry of Agriculture, Forestry, and Fisheries. Cambodia.

Objective

This report is an outcome of the baseline socioeconomic survey under Objective 9 (Targeting and Impact Assessment) of the GSR project. The main objective of the study is to analyze farmers' livelihood strategies, technology adoption patterns, adoption constraints, and the economics of rice production in key rice production areas of Cambodia. The specific objectives of the study are

- To describe the general picture of rice production in Cambodia.
- To analyze the patterns of varietal adoption and investigate the factors that determine the adoption of modern rice varieties.
- To analyze the economics of rice production in key production areas.
- To analyze farmer livelihood strategies and gender roles in rice production.
- To generate guidelines for rice technology design, targeting, and policy reforms for increasing rice production through increased adoption of improved technologies.

Organization of the report

This chapter is organized as follows. The first section provides background information on Cambodia. The next section briefly describes the rice production trends in Cambodia in the last decades as well as related policies. The third section analyzes the economics of rice production based on the household survey. The fourth section focuses on the pattern of varietal adoption and the factors that affect the adoption of modern rice varieties. Based on the potential yield gain and technology adoption rate, an ex ante impact assessment of improved varieties being developed under the GSR project is conducted in the fifth section. The final section provides a summary of the main findings and implications.

Rice production trends in Cambodia

The average rice area in Cambodia during 2008-10 was 2.7 million ha, with average yield of 2.85 t/ha. Rice yield and production have been on an upward trend, especially in recent years (Fig. 1).

Pandey and Bhandari (2010) describe four identifiable trends in rice production in Cambodia. Between 1961 and 1970, rice production had an increasing trend, resulting mainly from increasing yield, while area remained almost constant. Rice production decreased sharply during the 1970s as much of the rice land was left uncultivated during the Khmer Rouge regime. Rice production picked up slowly after the fall of the Khmer Rouge regime and continued to increase at a moderate rate during 1981-94. The increase in production was mainly brought about by the increase in rice area while yield remained below 1.5 t/ha. The major break in this trend took place in 1995 when area, yield, and production started to increase sharply, with production growth averaging 6.3% per annum during 1995-2010 (Table 2).

The spread of improved technologies is the major factor contributing to this impressive growth. Increased adoption of both photoperiod-insensitive improved varieties and higher-yielding traditional varieties developed through pure-line selection

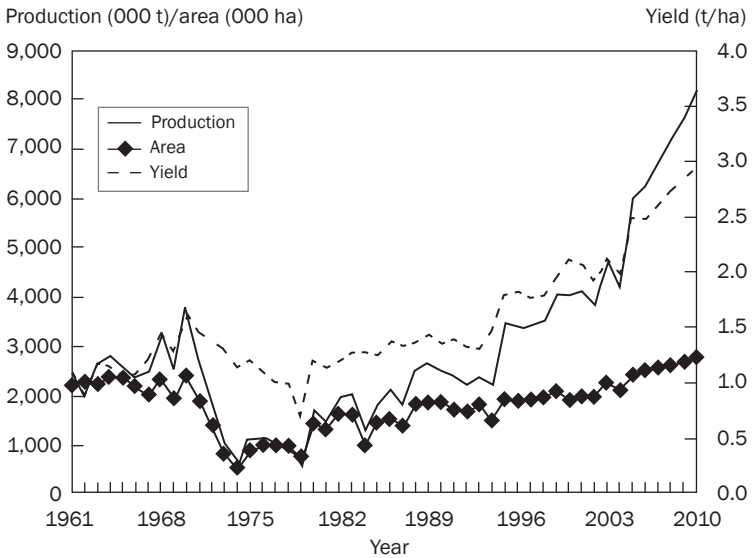

Fig. 1. Production, area, and yield of rice in Cambodia (1961-2010). Data source: FAOSTAT (http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor). 2010 data from MAFF, Cambodia.

Table 2. Growth rates of rice production, area, and yield (% per annum).

Period	Production	Area	Yield
1961-69	3.84	−0.39	4.23
1971-80	−7.26	−2.20	-5.06
1981-94	3.38	2.08	1.30
1995-2010	6.30	2.75	3.55

Data source: calculations based on data from FAOSTAT and MAFF.

occurred during this period. The use of quality seeds, expansion of dry-season rice area, and increased extension efforts were some of the other major reasons for this rapid increase in production (Young et al 2001, cited by Pandey and Bhandari 2010).

Rice is grown in both the wet and dry seasons in Cambodia. In the wet season, rice is planted in May-June and harvested in December-January. The wet season is the main season for rice production. It accounts for 80% of the total rice production and 85% of the total rice area. The wet season is subdivided into the early wet season (April-May to August-September) and the normal wet season (July-December). With the spread of modern photoperiod-insensitive rice varieties, there is now some expansion of area under the early wet season. In 2010, the early-wet-season rice area was approximately 575,000 ha or approximately 21% of the total rice area. The wet-season rice consists of rainfed lowland rice as well as upland and floating rice (Table 3).

Rice is grown in the dry season under irrigated conditions during January-Febuary to May-June. In 2010-11, rice area in the dry season was approximately

405,000 ha, and it accounted for over 14% of the total rice area. Dry-season rice accounted for 21% of the total annual rice production. Dry-season rice in 2010 yielded 4.2 t/ha, 52% more than the yield of wet-season rice (2.76 t/ha).

Although rice is grown in all 24 provinces of Cambodia, the main rice-growing areas are in the northwestern and southern parts (Appendix I). Two northwestern provinces (Battambang and Pursat), three southern provinces (Prey Veng, Takeo, and Kampot), and one central province (Kampong Thom) contributed 63% of the rice surplus in 2010. Four provinces in southeastern Cambodia (Takeo, Prey Veng, Kandal, and Kampong Cham) accounted for nearly 70% of the total dry-season rice area in 2010 (Table 3).

Rice policy in Cambodia

The Cambodian National Agricultural Strategy (Ministry of Agriculture 2010) has identified several major constraints to yield increases of rice: weak agricultural research

Table 3. Rice area distribution by province and type in Cambodia (2010-11).

Province-town	Wet-season cultivated area (000 ha)					Total wet-season area	Dry-season area
	Early	Medium	Late	Upland	Floating	(000 ha)	(000 ha)
Prey Veng	70	161	41	–	0	273	81
Battambang	59	95	88	3	25	270	10
Takeo	83	92	9	–	0	184	81
Banteay Meanchey	53	102	59	–	18	232	3
Kampong Cham	29	63	71	1	1	166	52
Kampong Thom	27	74	54	5	23	183	31
Siem Reap	43	86	35	6	9	179	16
Svay Rieng	47	99	21	–	–	167	16
Kampot	10	101	16	0	0	128	4
Kampong Chhnang	15	73	15	0	4	107	24
Pursat	41	28	20	2	15	105	8
Kampong Speu	30	72	8	1	–	111	0
Kandal	9	20	15	1	0	45	62
Preah Vihear	7	22	13	3	–	46	0
Kratie	12	11	7	0	–	30	14
Others	40	76	23	30	0	165	1
Total	575	1,175	495	52	95	2,391	403

Data source: Annual Report for Agriculture, Forestry, and Fisheries 2010-11. Ministry of Agriculture, Forestry, and Fisheries, Cambodia.

and extension, poor infrastructure, lack of irrigation, and low use of fertilizers. In its Rectangular Strategy Phase II (2008), the government committed to an integrated approach to overcome these constraints.

In addition, the Cambodian government is making efforts to transform the country into a major global rice supplier. A new policy framework is geared to promoting paddy production and boosting rice exports. Under this framework, the target is to raise paddy output to 9.1 million tons by 2015, a level that is expected to result in an estimated 4.5 million tons of paddy surplus for export. Strategies to increase rice production have been identified in a policy paper. These include promoting the use of high-yielding varieties and modern farming techniques and expanding irrigation facilities. This is expected to raise the current low productivity and permit more crops to be planted per year. Rural transport and electrical infrastructure are also to be expanded and agricultural microcredits are to be promoted (Policy paper on the promotion of paddy production and rice export 2010, Council of Ministers, Cambodia).

Farm household-level analysis

Survey sites and sampling design

The survey sites cover northwestern, central, and southern provinces. Battambang and Pursat are located in northwestern Cambodia, which is near the border with Thailand. The central province Kampong Thom is located at the center of Cambodia. Kampot, Prey Veng, and Takeo are located in southern Cambodia near the border with Vietnam. These selected provinces account for 48% of the rice area of the country and they cover a wide range of production environments (see Appendix II). Rice is grown in both the wet and dry seasons in these provinces (Table 4). The locations are also linked to domestic and international markets as a good proportion of rice produced in these areas is marketed both locally and across the borders.

Table 4. Rice production in sampled provinces (triennium average, 2007-09).

Province	Harvested area (000 ha)		Production (000 tons)		Rice yield (t/ha)	
	WS	DS	WS	DS	WS	DS
Battambang	247	5	627	21	2.53	4.10
Kampong Thom	163	23	359	91	2.21	3.98
Pursat	97	3	250	10	2.58	3.21
Kampot	126	2	349	8	2.76	3.29
Prey Veng	255	73	687	305	2.69	4.20
Takeo	180	74	542	327	3.01	4.42

Data source: Annual Report for Agriculture, Forestry, and Fisheries, MAFF, Kingdom of Cambodia.

A total of 607 households from 16 villages of 6 provinces were included in the survey (Fig. 2). The villages were selected on the basis of major abiotic stresses (drought/submergence). In each village, at least 30 households were interviewed. In the detailed inputs of rice production, only the largest parcel on the farm was selected as a basis for the costs and returns analysis. In total, 180 households (30% of the sample) were interviewed to get detailed input and output information. Farmers grow rice 1–3 times on the parcels and all the detailed information was collected from the respondents. The data collected pertain to the 2009 wet season and 2009-10 dry season. Drought and flood are the main abiotic stresses affecting rice production in the main wet season (Table 5).

Stresses affecting rice production[2]

In 2010, the six provinces included in the survey accounted for 72% and 25% of national drought- and flood-affected area (MAFF 2011). Takeo and Prey Veng provinces are the main drought-prone provinces. About 90% of the villages included in the survey suffered from frequent stress occurrences and the yield losses during stress years estimated subjectively by farmers exceed 50% (Table 5).

[2]Results reported in this section are based mainly on focus group discussions conducted prior to household surveys.

Fig. 2. Survey sites.

Table 5. Percentage of area affected and yield loss during stress[a] years.

Stress	Province	Village	% of rice area affected by stress	% of households affected by stress	% yield loss
Drought	Takeo	Sochan	44	45	54
	Takeo	Svay Russey	50	50	24
	Takeo	Daung	20	30	20
	Prey Veng	Thkauv	27	100	83
	Prey Veng	Chreav	90	100	86
	Prey Veng	Prey Snieth	77	80	40
	Pursat	Koh	50	100	40
	Pursat	Phar Loeu	n.a.	43	44
	Battambang	Balang	n.a.	70	64
	Battambang	Chrab Kror Sang	80	90	54
	Kampong Thom	Toul Domnakk	50	80	54
Submergence	Kampot	Khnach	60	80	96
	Battambang	Boung Rang	50	80	65
	Kampong Thom	Chey Moung Koul	10	5	14
	Kampong Thom	Doung	40	100	48
Salinity	Kampot	Prey Tonle	10	30	–

[a]Stress in the table refers only to abiotic stress (drought and submergence). n.a. = not available.
Data source: IRRI GSR project, household survey 2010.

Demographic characteristics

Household members who manage the farm were interviewed during the survey. A majority of the respondents in this household survey were women (Table 6). Obviously, women are prominent in rice production in Cambodia, not only as farm laborers but, more importantly, as farm managers.

In terms of average years of education, the difference between male and female respondents is 1–2 years. The average household size is about 5 and its variation across provinces is minimal. More than 70% of the members of the household are 16 to 65 years old—the age group that can be considered as part of the labor force. The number of laborers per household is also similar across provinces. Farming is the main occupation (Table 7).

Farming conditions

Farm size varies across regions. The average farm size is 1.8 ha, from 1.2 ha in Kampong Thom to 2.3 ha in Prey Veng. Most farmers own the land they cultivate, with less than 4% being rented land. There are some regional variations in the proportion of rented land with Battambang and Kampong Thom farmers operating 22% and

Table 6. General household characteristics.

Characteristic	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Sample size	120	60	122	60	121	124	607
Respondent info							
Female respondents (%)	56	85	66	47	57	55	60
Average age (years)							
Males	48	44	49	45	49	47	48
Females	44	46	46	38	43	42	44
Average education (years)							
Males	6	4	5	5	6	6	6
Females	5	5	3	4	5	5	4
Average household size	4.8	4.5	5.0	5.0	4.6	5.3	4.9
Average number of household members in labor force	2.6	2.9	3.0	3.0	2.5	3.0	2.8
Age group (%)							
Less than 16 years	26	26	21	35	20	30	26
16 to 65 years	69	67	76	63	77	68	71
More than 65 years old	5	7	3	2	3	2	3

Data source: IRRI GSR project, household survey 2010.

Table 7. Primary occupation of household members (%)

Occupation	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Agriculture	90	93	87	87	77	75	83
Regular jobs[a] (private and government)	4	7	8	8	14	23	11
Seasonal/temporary jobs[b]	5	0	1	1	5	2	3
Business[c]	2	0	4	1	1	0	2
Others[d]	0	0	0	3	4	0	1

[a]Regular jobs refer to a regular job in a private organization or government service. [b]Seasonal/temporary jobs refer to contract labor and services rendered on a short-term basis. [c]Business in the survey mainly refers to family-operated retail businesses. [d]Others include livestock production, overseas workers, etc.
Data source: IRRI GSR project, household survey 2010.

10% rented land, respectively. Overall, 77% of the land is rainfed and the share of irrigated area in the southern provinces is higher than in other provinces (Table 8). Rice production is mainly rainfed.

Land use

The degree of crop diversity is small since rice is the main crop accounting for more than 90% of all cropped area in all provinces while less than 10% of the area is used for fruits, vegetables, legumes, and other crops (Table 9).

Farmers classify their fields as upper, middle, and lower fields based on the relative location along the toposequence. Rice production is limited to the wet season only in upper fields. Rice is grown in the dry season also in some parts of the middle and lower fields that have access to irrigation. The cropping intensity is similar across land types (100–120%) in all provinces except Kampot (Table 10). In Kampot, the overall cropping intensity is 162%, with cropping intensity in lower and middle fields of 156% and 183%, respectively. Differential access to irrigation is a major determinant of cropping intensity.

Rice production

Rice area. In the northwestern and central provinces, farmers usually grow rice in the main wet season only. But, in the southern provinces, rice is mostly grown in both the main wet and dry seasons, with several cases in which rice is grown in another season called the early wet season. Rice is grown primarily in lower fields while nonrice crops are grown in upper fields (Table 11).

Rice varieties in Cambodia can be categorized into three types: modern (MV), traditional (TV), and improved traditional varieties (iTV). Improved traditional varieties were developed through pure-line selection from traditional varieties (Javier 1997).

Table 8. Landholding characteristics.

Item	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Average farm size (ha)	1.9	1.9	1.2	1.9	2.3	1.6	1.8
By land type (% of area)							
Lower field	38	59	77	28	60	50	52
Middle field	48	21	9	69	28	31	34
Upper field	14	20	14	3	12	19	14
By tenure (% of area)							
Owned	78	96	90	95	96	97	91
Rented-in	22	4	10	4	4	3	9
By irrigation (% of area)[a]							
Rainfed	84	97	91	57	70	78	77
Irrigated							
Canal	14	1	8	42	4	11	12
Well	1	0	0	0	15	0	5
Lake	0	0	0	0	9	7	4
Others	0	2	1	1	3	4	2

[a]This is the percentage of the gross cultivable area combining WS, DS, and early WS.
Data source: IRRI GSR project, household survey 2010.

Table 9. Percentage of gross cropped area.

Crops	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Rice	93	100	95	99	100	94	97
Fruits	2	0	0	0	0	1	0.7
Vegetables	2	0	1	0	0	5	1
Other crops and legumes	3	0	4	1	0	0	1

Data source: IRRI GSR project, household survey 2010.

Table 10. Cropping intensity.[a]

Type of field	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Upper	99	100	100	104	125	109	108
Middle	104	96	100	156	128	107	120
Lower	111	100	100	183	112	102	110
Total	106	99	100	162	118	105	113

[a]Operational holding area includes own, rented-in, shared crop, and government land. Gross cropped area is the total area cultivated for one cropping year.
Data source: IRRI GSR project, household survey 2010.

Modern varieties account for 41% of the total rice area, with the southern provinces accounting for a large share of this area. Traditional varieties and improved traditional varieties, more popular in northwest and central Cambodia, account for 27% and 19% of the total rice area, respectively.

Modern varieties are grown mainly in lower fields. Traditional varieties and improved traditional varieties are mainly grown in middle and upper fields. Lower fields generally have favorable hydrological conditions for rice growth and, as a result, farmers tend to grow MVs in lower fields. In the southern provinces near the Vietnamese border, more than 85% of the lower fields are planted to MVs (Table 12).

Although modern varieties are popular in the southern provinces, there are some seasonal differences in the adoption levels of MVs. Modern varieties in these provinces account for a large share of area in the early wet and dry seasons only. In the main wet season, traditional varieties cover a majority of the rice area in the southern and northwestern provinces (Table 13). In Battambang, MVs account for nearly 80% of the rice area in the dry season.

Yield effects by variety. The yields of modern and improved traditional varieties are almost double those of traditional ones in the early wet and dry seasons. In the main wet season, yield across different types of varieties ranges from 2.2 to 2.8 t/ha (Table 14). The dry-season rice yield is about 4 t/ha.

Table 11. Share (%) of rice in total cropped area in different seasons and by land types.

Season and land type	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
By season							
Early WS	–	–	–	38	17	3	11
Main WS	91	100	100	26	38	47	61
DS	9	0	0	36	45	49	28
By land type							
Lower field	42	59	79	32	57	50	52
Middle field	47	21	9	66	30	32	36
Upper field	12	20	12	2	13	18	12

Data source: IRRI GSR project, household survey 2010.

Table 12. Percentage rice area by variety across different land types.

Land and variety type	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Total							
MV	10	0	0	76	67	55	41
TV	54	39	23	20	25	39	33
iTV	37	61	77	4	7	5	25
Lower							
MV	6	0	0	89	85	83	49
TV	61	34	23	9	11	15	24
iTV	33	66	77	1	4	2	28
Middle							
MV	14	0	0	72	45	28	39
TV	48	46	17	24	43	62	41
iTV	38	54	83	4	12	10	20
Upper							
MV	4	0	0	4	41	26	19
TV	52	45	26	74	48	67	51
iTV	44	55	74	22	11	6	30

Data source: IRRI GSR project, household survey 2010.

Table 13. Percentage rice area by variety in different seasons.

Item	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Overall							
MV	10	0	0	76	67	55	41
TV	54	39	23	20	25	39	33
iTV	37	61	77	4	7	5	25
Early WS							
MV	–	–	–	100	98	92	99
TV	–	–	–	0.36	1	8	1
iTV	–	–	–	–	1	–	0.3
Main WS							
MV	3	–	0.1	9	17	6	5
TV	57	39	23	77	66	82	54
iTV	40	61	77	15	17	12	41
DS							
MV	79	–	–	100	99	100	98
TV	18	–	–	–	–	–	1
iTV	3	–	–	–	1	–	1

Data source: IRRI GSR project, household survey 2010.

Many parts of the southern provinces are flooded and farmers mainly grow traditional varieties in the main wet season. As a result, rice yield in the southern provinces is lower than in the northwestern provinces. However, the pattern is opposite in the dry season, wherein the southern provinces have a yield advantage over the northwestern provinces. Modern varieties are widely grown in the dry season in the southern provinces and yields are also high.

Crop establishment method. Rice is established by both direct seeding and transplanting methods in the main wet season but mostly by direct seeding in the dry and early wet seasons (Table 15). Despite this general pattern, direct seeding is generally more popular in Battambang and Prey Veng even in the main wet season.

Traditional and improved traditional varieties are mostly established by transplanting (Table 16). There are some exceptions, such as in Battambang, where direct seeding is common. For modern varieties, there is considerable variation in the crop establishment method practiced, with transplanting being dominant in some locations (e.g., Kampong Thom) while direct seeding is the dominant method in others (Prey Veng).

Rice production. Modern varieties account for more than 70% of the total rice production in the southern provinces and they play a dominant role, especially in the dry season and in the early wet season. In the northwestern provinces near the Thai

Table 14. Yield (t/ha) of rice production by season.

Item	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Yield[a]	2.80	1.68	2.70	2.71	2.23	3.17	2.63
Early WS							
MV	–	–	–	3.02	2.67	1.18	2.55
TV	–	–	–	1.44	1.67	1.00	1.44
iTV	–	–	–	–	2.50	–	2.50
Main WS							
MV	3.39	–	0.96	1.92	2.66	2.94	2.76
TV	2.54	2.28	1.67	2.09	2.59	2.46	2.39
iTV	2.83	2.19	1.68	2.24	2.62	2.37	2.22
DS							
MV	3.93	–	–	4.04	3.03	5.49	4.09
TV	2.38	–	–	–	–	–	2.38
iTV	4.00	–	–	–	4.00	–	4.00

[a]Average yield is the plotwise mean value.
Data source: IRRI GSR project, household survey 2010.

Table 15. Percentage rice area by method of crop establishment in different seasons.

Season and establishment method	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Early WS							
Direct seeding	–	–	–	90	96	87	93
Transplanting	–	–	–	10	4	13	7
Main WS							
Direct seeding	50	0	18	15	43	5	27
Transplanting	50	100	82	85	57	95	73
DS							
Direct seeding	83	–	–	95	100	100	98
Transplanting	17	–	–	5	0	0	2

Data source: IRRI GSR project, household survey 2010.

Table 16. Percentage of area planted by variety type and crop establishment, main wet season.

Variety type and establishment method	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
MV							
Direct seeding	42	–	0	48	94	66	76
Transplanting	58	–	100	52	6	34	24
TV							
Direct seeding	62	0	23	14	30	1	29
Transplanting	38	100	77	86	70	99	71
iTV							
Direct seeding	33	0	16	4	40	0	18
Transplanting	67	100	84	96	60	100	82

Data source: IRRI GSR project, household survey 2010.

border, both traditional varieties and improved traditional varieties are widely grown. In Kampong Thom, located in central Cambodia, improved traditional varieties occupy three-quarters of the rice area (Table 17).

Rice is the major source of both food and cash income at the survey sites. Rice is produced more for commercial purposes in the northwestern and southern provinces. These provinces have a higher production per household than the central provinces and the majority of this production is sold for cash income (Table 18). The share of rice sold in the southern provinces near the Vietnamese border is higher than in the northwestern provinces near the Thai border.

Rice input use

Seed input. On average, the seeding rate is about 113 kg per ha. The amount of seed input for direct seeding at 180 kg per ha is twice as much as for transplanting (Table 19).

Fertilizer input. Fertilizer use averaged 50 kg/ha of NPK, which is similar between direct seeding and transplanting. Fertilizer application is much lower in Kampong Thom than in other locations. More than 50% of the farmers applied less than 40 kg/ha of N while only about 10% of the farmers applied more than 80 kg/ha (Fig. 3). The average ratio of N:P:K is approximately 10:2:1. This ratio may indicate a slight imbalance in nutrient application as the recommended ratio in rainfed lowlands of Cambodia is 6:1:1, on average (personal communication, S. Haefele). The optimal ratio will, of course, vary across locations depending on local soil nutrients.

Chemical fertilizers account for about 82% of the total input cash cost and they are the major cash input (Table 20). Taking rice farming in the main wet season as an example, the total cash cost varies from US$74/ha to $131/ha across provinces. The total cash costs of rice production in the northwestern and southern provinces

Table 17. Percentage of rice production by variety and by season.

Variety and season	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Total							
MV	12	0	0	85	71	74	54
TV	51	42	25	13	22	23	27
iTV	37	58	75	2	7	3	19
Early WS							
MV	0	0	0	100	98	93	99
TV	0	0	0	0	1	7	1
iTV	0	0	0	0	1	0	0
Main WS							
MV	4	0	0	7	17	6	6
TV	55	42	25	80	66	82	56
iTV	41	58	75	14	17	12	39
DS							
MV	82	100	0	100	98	0	99
TV	14	0	0	0	0	0	1
iTV	3	0	0	0	2	0	1

Data source: IRRI GSR project, household survey 2010.

Table 18. Alternative uses of rice production (%) by location.

Use	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Rice production (tons per HH)	4.84	3.89	1.85	9.56	7.65	5.79	5.37
% sold	43	57	27	69	68	59	58
% as food	40	36	59	15	18	20	26
% as seeds	5	4	7	8	7	4	6
% as feed	0	1	2	3	1	3	2
% as payment	7	2	3	1	0	3	3
% for future use	4	0	1	4	7	12	6

Data source: IRRI GSR project, household survey 2010.

Table 19. Input use (main wet season).

Use	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Seed (kg per ha)							
Direct seeding	174	–	276	177	131	200	180
Transplanting	116	70	99	83	98	79	91
Total	140	70	138	108	112	86	113
Fertilizer (kg per ha)							
N	26	63	8	44	57	43	37
P	12	12	5	12	7	10	9
K	10	1	4	0	4	0	4
Total	48	76	17	56	68	53	50

Data source: IRRI GSR project, household survey 2010.

are higher than in the central province. The total cash costs for direct seeding and transplanting are similar at $100/ha and $97/ha, respectively.

The positive yield response to N (Fig. 4) clearly indicates that application of additional N would result in further yield gains. Obviously, the economically optimal application rate will depend on both grain and fertilizer prices.

Animal and machinery input. Data indicate that some mechanization of rice farming has also taken place. In Battambang Province, the use of mechanical devices (tractors, harvesters, and threshers) is more than in other provinces perhaps due to a higher yield and the largely commercial mode of production (Table 21). Farm tractors are mostly hired although a significant percentage of farmers also own tractors in Battambang, Kampong Thom, Prey Veng, and Takeo (Table 22). Draft animals are mostly owned.

Labor use and cost. Hired labor accounts for around 30% of the total labor use in rice production. The labor use per ha in rice farming at the survey sites of southern Cambodia near the Vietnamese border is much higher than in the northwestern and central provinces. The person-days per hectare range from 86 to 116 days in the southern provinces while in the northwestern provinces they range from 43 to 74 (Table 23).

The higher labor use in the southern provinces may be attributed primarily to less mechanization, as depicted in Table 21. Unlike in the northwestern provinces, particularly in Battambang, a high percentage of power cost (36%) is accounted for by the use of harvesters and threshers. Labor use in transplanting is 53% higher than in direct seeding (Table 24).

Costs and returns of rice production. Net returns above cash costs (i.e., gross value of rice minus the cash costs) provide an estimate of cash income not to mention the economic returns to family-owned resources, such as family labor. The overall average net returns per ha are $329 (Table 25). Cash costs account for only about a

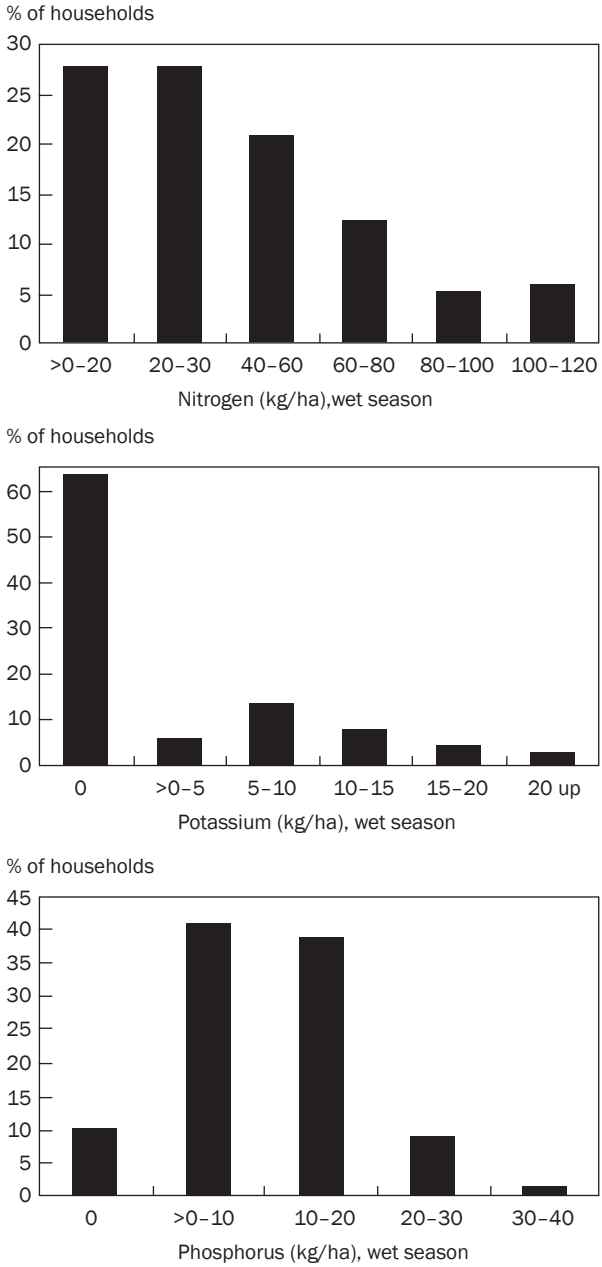

Fig. 3. Distribution of the amount of fertilizer (NPK) applied, main wet season. Data source: IRRI GSR project, household survey 2010.

Table 20. Percentage distribution of input cash cost (main wet season).

Item	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Total cost per ha (in $)	128	122	74	74	114	72	98
Input cash cost (%)							
Seed	1	2	7	2	2	1	2
Fertilizer	70	96	86	88	75	92	82
Herbicide and insecticide	3	0	3	7	3	5	3
Irrigation and fuel cost	10	2	0	3	19	2	8
Land rent	16	0	3	0	1	0	5

Data source: IRRI GSR project, household survey 2010.

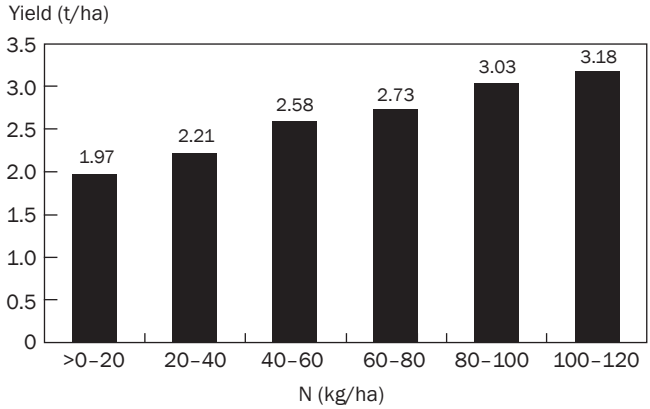

Fig. 4. Distribution of the amount of nitrogen and average yield, main wet season. Data source: IRRI GSR project, household survey 2010.

quarter of the gross value of the output. The differences in net returns across provinces are thus mainly driven by differences in yield. On average, returns to rice production are higher in the northwestern and southern provinces than in the central provinces.

Income

Rice is the main source of income and it accounts for 44% of the total household income (Table 26). Nonfarm income accounts, in most cases, for less than 40% of the total household income. The importance of rice income is greater in the northwestern and southern provinces than in the central province. A high share of rice income in total household income indicates the potential role of increases in rice production for poverty reduction.

Table 21. Share of animals and machinery in total cost from hired and own (imputed) power inputs.

Item	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Total cost ($ per ha)	71	267	281	618	205	230	240
Share of cost (%)							
Animal	4	82	82	97	77	86	80
Tractor	60	11	11	1	8	8	11
Harvester and thresher[a]	36	7	8	2	16	6	9

[a]Includes combined harvester-thresher.
Data source: IRRI GSR project, household survey 2010.

Table 22. Distribution between hired and own (imputed) cost.

Power source	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Animal							
Total cost ($ per ha)	3	218	229	597	157	198	192
% hired	0	0	1	0	4	1	1
% own	100	100	99	100	96	99	99
Tractor							
Total cost ($ per ha)	43	29	30	8	16	18	26
% hired	52	100	61	100	60	79	66
% own + fuel	48	0	39	0	40	21	34
Harvester and thresher[a]							
Total cost ($ per ha)	26	20	22	13	32	14	22
% hired	99	99	99	94	100	96	98
% own + fuel	1	1	1	6	0	4	2

[a]Includes combined harvester-thresher.
Data source: IRRI GSR project, household survey 2010.

Table 23. Labor use in rice farming, wet season.

Item	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Total labor (person-days per ha)	74	42	69	116	86	98	80
Share of labor use (%)							
Land preparation	9	7	9	14	8	7	9
Crop establishment	24	45	52	20	20	26	30
Crop care management	22	16	9	11	21	18	17
Harvesting and threshing	40	31	28	43	38	36	36
Postharvest activity	4	2	2	11	13	13	8
Labor cost (in $)	196	138	211	254	223	288	221
% cash cost for hired labor	39	50	35	9	26	28	31
% imputed cost for family labor	61	50	65	91	74	72	69

Data source: IRRI GSR project, household survey 2010.

Table 24. Labor use for each activity by crop establishment method, wet season.

Labor use	Person-days per ha			Percentage		
	Direct seeding	Transplanting	All	Direct seeding	Transplanting	All
Total labor	57	87	80	100	100	100
Land preparation	6	7	7	11	8	9
Crop establishment	7	29	24	12	33	30
Crop care management	11	14	13	19	16	17
Harvesting and threshing	27	30	29	47	34	36
Postharvest activity	6	7	7	11	8	8

Data source: IRRI GSR project, household survey 2010.

Table 25. Costs and returns from rice production, wet season.

Item	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Yield (t/ha)	2.48	2.26	1.66	1.95	2.64	2.70	2.31
Average price (in $ per ton)	212	245	240	243	224	236	231
Gross income (in $ per ha)	527	554	398	473	592	637	535
Input cost (in $ per ha)	128	122	74	74	114	72	98
Power cost (in $ per ha)	48	49	41	20	48	29	40
Hired labor cost (in $ per ha)	76	69	74	23	58	80	68
Cash costs (in $ per ha)	252	239	189	118	220	181	206
Net returns above cash costs (in $ per ha)	275	314	208	355	372	456	329
Returns to cash costs (%)	52	57	52	75	63	72	62

Data source: IRRI GSR project, household survey 2010.

Gender analysis

Women in Cambodia are involved in most household decision making, especially the selling decision in farming activities as well as allocation of income. In Cambodia, women's share of labor inputs during the main wet-season and dry-season rice production is 46% and 25%, respectively. In terms of activities, women farmers are mostly engaged in crop establishment, harvesting and threshing, and postharvest activities. And, women and men have almost the same wage rate in rice farming (Table 27).

The average Women's Empowerment Index (WEI) is 3.2 in Cambodia, which is composed of farming decisions, income and expenditure, child care, and other family activities. Women are empowered in most activities, especially in selling the harvest, and income and expenditure allocation, for which their WEI is higher than 3.0 (Table 28).

The result of the OLS regression model indicates that women are more empowered in farm households with a smaller farm size. Also, women's exposure to training had a positive significant effect on women's empowerment and the effect of training on the husband was negatively significant. The number of females in the household and the age of the wife also contributed to women's empowerment in family decisions (Table 29).

Table 26. Share of income from different sources.

Income share	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Total income (in $)[a]	1,279	1,231	1,148	1,951	2,008	2,398	1,688
Share (%)							
Rice	55	51	17	61	54	36	44
Nonrice	2	0	2	0	0	3	1
Animal sale	6	14	8	20	12	15	13
Off-farm income	2	2	2	2	3	1	2
Nonfarm income							
Salary from regular jobs	9	11	7	10	13	32	16
Seasonal jobs	4	5	4	4	7	3	4
Business	19	15	41	2	5	8	13
Remittances and pension	2	0	15	0	6	1	4
Transport operations	2	1	4	0	1	1	2
Others	0	1	1	0	0	1	1

[a]Annual estimate.
Data source: IRRI GSR project, household survey 2010.

Table 27. Gender differences in labor use and wage rate.

Item	Labor use in main wet season		Labor use in dry season		Wage rate (US$/day/person)	
	Females	Males	Females	Males	Females	Males
Total labor (person-days per ha)	37	43	10	30	–	–
By type of labor (%)						
Land preparation	14	86	5	95	2.80	3.00
Crop establishment	61	39	37	63	2.40	2.50
Crop care management	24	76	9	91	2.60	2.80
Harvesting and threshing	53	47	39	61	2.50	2.60
Postharvest activity	40	60	35	65	2.60	3.20
Total labor	46	54	25	75	2.60	2.80

Data source: IRRI GSR project, household survey 2010.

Table 28. Women's Empowerment Index (WEI).

Type of decision	Value
Farming decisions	
1. What rice variety(ies) to grow	3.0
2. Adoption of technology in rice production	2.8
3. What farm implements to purchase	2.8
4. Who and number of farm laborers to hire	3.2
5. Whether to sell or consume the harvested crop	3.4
6. Quantity of output to sell and consume	3.4
7. When and where to sell the harvested crop	3.4
8. At what price to sell the output	3.4
Income and expenditure	
9. Allocation of farm income	3.4
10. Allocation of household income	3.5
11. What types of food to consume in times of crisis	3.6
12. Where to borrow	3.2
Child care	
13. Children's education	3.2
14. Number of children to raise	3.2
Others	
15. Participation in voting/politics	3.1
16. Whether to sell or slaughter animals	2.9

Data source: IRRI GSR project, household survey 2010.

Adoption patterns of rice varieties and determinants

Adoption patterns of rice varieties

The majority of the farmers grow more than one type of rice variety and the extent of varietal diversification varies across provinces (Table 30). Overall, a small percentage of farmers grow modern varieties, indicating that most farmers are only partial adopters of MVs. About a quarter of the farmers grow traditional varieties only, with another quarter growing both modern and traditional varieties simultaneously.[3] There are some variations across provinces, with the proportion of farmers growing both modern and traditional varieties being much higher in the southern provinces than in the northern and central provinces.

In terms of area coverage of different varieties, modern varieties account for 41% of the total rice area overall. Again, the coverage of MVs is much higher in the southern provinces than in the northern and central provinces. This pattern may be influenced

[3]When a farmer grows two or more types of varieties, each type is mostly grown in separate fields.

Table 29. OLS regression model of the factors contributing to women's empowerment.

Dependent variable in WEI	Coefficient[a]	T-value
Distance to market (km)	0.0435***	4.90
Years of education of wife	0.0143	1.62
Age of wife	0.00746***	3.47
Dummy for wife with nonfarm primary occupation	0.0309	0.31
Percentage of females in the household	0.00273*	1.75
Farm size (ha)	–0.0542***	–3.13
Percentage contribution to nonfarm income of female	0.00008	0.10
Percentage contribution to nonfarm income of male	–0.00197***	–3.24
Dummy for husband who attended a training	–0.195***	–3.71
Dummy for wife who attended a training	0.154***	2.76
Constant	2.713***	16.91
N	593	

[a] * $P < 0.1$, ** $P < 0.05$, *** $P < 0.01$. Province dummies were omitted.

Table 30. Percentage of farmers growing rice by variety and percentage of rice area by variety.

Variety	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Percentage of farmers							
MV only	6	0	0	28	7	5	6
iTV only	43	42	66	2	1	2	27
TV only	31	23	16	18	7	22	19
MV & TV	7	0	1	33	55	52	26
MV & iTV	0	0	0	3	8	2	2
iTV & TV	10	35	17	7	4	5	11
MV & iTV & TV	3	0	0	8	18	12	8
Percentage of area							
MV	10	0	0	76	67	55	41
TV	54	39	23	20	25	39	33
iTV	37	61	77	4	7	5	25
Total rice area (ha)	229	111	138	182	328	191	1,178

Data source: IRRI GSR project, household survey 2010.

by the Vietnamese market, where improved varieties of rice grown in Cambodia find a ready market. For instance, Variety 504 is a popular rice variety in Vietnam. It was released in 1990 and became popular for nearly two decades (1990-2010).[4] Similarly, Variety 85 and IR66 are also popular varieties in Vietnam.[5] The opposite holds true for the northwest provinces, where traditional varieties grown in Cambodia can be sold easily across the border in Thailand. Improved traditional varieties that supply rice mainly to urban centers in Cambodia are popular in the central province. Thus, geographic location may be an important factor for farmers' adoption, which is influenced by demand and marketing considerations as mentioned above.

In each of the villages surveyed, farmers grow about 20 different types of rice varieties. Among them, popular varieties are Riang Chey in Battambang and Kampong Thom, 504 in Kampot and Takeo, IR66 in Prey Veng, and Phka Rumduol in Pursat. These varieties cover more than 30% of the gross rice area in these provinces, not to mention the popularity of 504, which covers 71% of the gross rice area (Table 31).

Good eating and grain quality in addition to high yield were the top reasons why farmers chose to grow a specific variety (70% of the responses). Farmers grow modern varieties such as 504 and IR66 mainly because of their high yield, whereas the preference for improved traditional varieties such as Riang Chey and Phka Rumduol is driven by their good agronomic characteristics, resistance to pests and diseases, and better market value. In general, farmers in the provinces near the Vietnamese border gave more emphasis to yield than to other traits.

Almost half of the responses (45%) indicate that farmers consider susceptibility to pests and diseases as undesirable characteristics (Table 32). In addition to these considerations, farmers prefer varieties that are of short duration, that mature uniformly, and that are drought tolerant and submergence tolerant.

Determinants of the adoption of modern varieties

There are two commonly used measures of adoption: the incidence and the intensity of adoption. The incidence of adoption is an indicator of whether or not a farmer is an adopter. A farmer is considered to be an adopter if the farmer grows improved varieties even in a small area of the farm. The intensity of adoption is measured by the proportionate area under improved varieties. These two measures are good indicators of adoption.

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[4]www.rice-festival.com/newsdetail-224-Hau-Giang--the-cradle-of-the-rice-strain-504.html.

[5]Variety 85 is not the full name of the variety but farmers could not tell its origin. By checking the variety information, 85 might be TH 85, also another variety from Vietnam. http://irri.org/partnerships/country-relations/asia-oceania/vietnam/rice-varieties-released-in-vietnam. IR66 is the modern variety released by CARDI in 1990 with the cooperation of IRRI. The variety was released for rainfed and irrigation-receding conditions with short maturity, less than 120 days, and photoperiod insensitivity. IR66 was also introduced to Vietnam.

Table 31. Popular varieties in terms of percentage of total cropped area.

Variety name	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
504	2	0	0	71	15	34	21
IR66	0	0	0	3	45	1	13
Riang Chey	34	1	49	1	0	1	13
Phka Rumduol	2	32	21	0	4	3	7
Phka Khnei	17	4	0	0	0	1	4
Phka Malis	6	18	1	0	0	2	3
85	0	0	0	0	0	20	3
Neang Khon	14	1	0	0	0	0	3
Srouv Krorhorm	0	0	0	2	0	15	3
Kondeung	0	0	0	0	8	0	2
Ot Chmous	0	0	0	0	0	12	2
Koun Srouv	0	0	0	0	7	0	2
Sen Kro Ob	6	0	0	0	3	0	2
CAR 9	0	15	0	2	0	0	2
Sen Pi Dao	2	0	0	0	5	0	2
Total	83	71	71	79	87	89	82

Data source: IRRI GSR project, household survey 2010.

It is shown that there is no significant difference between modern variety adopters and nonadopters in terms of demographic characteristics of the respondents (Table 33). Modern variety adopters are located closer to the market and their lower field area for rice production is larger. Also, the irrigated area of modern variety adopters (1.80 ha/household) is three times higher than that of nonadopters, which is only around one-half hectare per household. The share of irrigated area in the farm size of modern variety adopters is more than twice that of nonadopters.

On average, the rice area of modern variety adopters is nearly twice that of nonadopters. The rice yield of adopters is 1.3 t/ha, that is, 60% higher than that of nonadopters. Modern variety adopters can sell more than half of the total rice production, around 5 tons per household, but nonadopters sell only less than one-fourth of their rice production.

The decision problem for a farmer involves the choice of two possible varietal categories, modern varieties (MVs) and traditional varieties (TVs and iTVs). In this categorization, a farmer is either an adopter or a nonadopter. A probit model is the standard tool for analyzing such a decision problem. A farmer who decides to adopt will also have to make a decision on how much area to cultivate under improved varieties. This latter decision is best analyzed using a tobit model. Variations in the adoption patterns of improved varieties among households could result from differences

Table 32. Farmers' perceptions on the desirable and undesirable traits of the varieties they grow.

Trait	Northwest		Central	South			All
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Desirable (%)							
High yield	7	23	21	42	36	41	29
Resistant to lodging	21	3	13	3	2	4	7
Resistant to pests and diseases	11	3	4	3	5	1	5
Good eating quality	16	23	23	21	29	21	23
Good grain quality	32	26	26	13	10	14	19
High market price	13	22	12	18	18	20	17
Undesirable (%)							
Low yield	2	9	15	10	15	9	10
Not resistant to lodging	27	16	6	3	2	5	8
Not resistant to pests and diseases	44	53	35	47	43	49	45
Poor eating quality	6	7	13	33	32	34	24
Poor grain quality	15	11	8	8	5	3	7
Low market price	5	4	23	0	3	1	5

Data source: IRRI GSR project, household survey 2010.

in demographic characteristics, landholdings, access to market and variety, cropping pattern, and location. The major variables used in the econometric model and their expected directional effects on adoption are summarized in Table 34.

The result of the probit model indicates that farm size, share of lowland, share of midland, and share of irrigated area are positively significant factors in encouraging MV adoption (Table 35). Compared with the farmers located near the Vietnamese border, those near the Thai border and in the central province are less likely to adopt modern varieties. The demand for improved varieties in the Vietnamese market bordering Cambodia must be a factor contributing to the extent of adoption of improved varieties in southeastern Cambodia. Among farmers in a location, market distance has a negative influence, that is, farmers who are closer to a market are more likely to be MV adopters.

A tobit model was used to analyze technology adoption intensity and the share of rice area under modern rice varieties was used to measure the intensity of adoption. Similar to the result in the probit model, the shares of midland and lowland have a positive significant effect on the intensity of adoption relative to the share of upland. Farmers with a border with Vietnam have a bigger share of MV adoption. This effect can indicate the influence of international rice markets to some extent.

Table 33. Comparison of characteristics of nonadopters and adopters of different varieties.

Explanatory variables	Nonadopter (TV & iTV)		MV adopter		All	
	Mean	SD	Mean	SD	Mean	SD
Household size (persons)	4.84	1.45	4.98	1.58	4.90	1.51
Labor (persons)	2.78	1.28	2.91	1.35	2.83	1.31
Respondent dummy (1 = female, 0 = male)	0.67	0.47	0.50	0.50	0.60	0.49
Age (years)	45.81	13.31	44.55	11.57	45.28	12.60
Average education (years)	5.56	2.11	5.36	1.88	5.47	2.02
Market distance (km)	4.04	2.78	3.78	3.27	3.93	3.00
Farm size (ha/hh)	1.45	1.14	2.19	1.39	1.77	1.30
Lower field area (ha/hh)	0.76	0.97	1.16	1.22	0.93	1.10
Middle field area (ha/hh)	1.29	1.12	1.07	1.11	1.15	1.12
Area irrigated (ha/hh)	0.56	1.05	1.80	1.42	1.09	1.37
Rice area (ha/hh)	1.39	1.09	2.69	1.91	1.94	1.63
MV rice area (ha/hh)	0.00	0.00	1.88	1.85	0.80	1.52
Rice production (t/hh)	2.84	2.50	8.75	7.03	5.37	5.76
Rice yield (t/ha)	2.09	0.89	3.36	1.33	2.63	1.26
% of rice production sold	24.71	26.50	55.45	26.52	37.83	30.54

Data source: IRRI GSR project, household survey 2010.

Impact assessment

The varieties being developed under the GSR project are still in a trial stage and have not yet been released for farmers' adoption. Hence, the actual impact of these varieties cannot yet be assessed. Instead, an initial assessment of the potential impact of GSR varieties has been conducted using the farm-level survey data and various assumptions regarding the size of the potential yield gain and the adoption rate.

In the short term, the average increase in household income is estimated to be $122, holding all other incomes constant. This absolute increase in income translates into a total income gain of 7%. In the medium term, the corresponding increase in household income will be 14%. There are considerable variations across provinces in these figures depending on the initial level of yield and the share of rice in total household income (Table 36).

This income effect of new varieties can be translated into poverty impact by estimating the number of people that can be lifted above the poverty line. Taking the poverty line of $1.25 per day per capita as the reference, results indicate that 5–8% of poor people could be lifted out of poverty in the short and medium terms (Table 37). The impact of increased rice yield varies across regions, with the impact being

Table 34. Description of covariates.

Variables	Description of variables	Incidence of adoption	Intensity of adoption
Dependent variables			
Adopt	Farmer grew modern varieties. 0 = no, 1 = yes		
PMVarea	Share of modern variety area in total rice area (%)		
Explanatory variables			
Age	Age of respondent (years)	+	+
Dfemale	Dummy variable of the gender of respondent, 0 = male, 1 = female	?	?
Hhsize	Household size (persons)	+	+
Farm size	Farm size (ha/hh)	+	+
Plowarea	Percentage of lower fields in the farm size (%)	+	+
Pmidarea	Percentage of middle fields in the farm size (%)	+	+
Pirrigarea	Percentage of area irrigated (%)	+	+
Tborder	Dummy of location. 1 = border with Thailand, 0 = border with Vietnam	–	–
Cborder	Dummy of location. 1 = central Cambodia, 0 = border with Vietnam	–	–
Market	Distance from nearest market (km)	–	–

Table 35. Factors affecting the incidence and intensity of modern variety adoption by farmers.[a]

Factor	Incidence of adoption	Intensity of adoption
	Probit	Tobit
Household size	0.0132	1.108
	(0.26)	(0.70)
Age of respondent	−0.0061	−0.255
	(−0.99)	(−1.26)
Respondent gender (1 = female, otherwise 0)	−0.1900	−3.655
	(−1.18)	(−0.73)
Farm size	0.2120***	5.280***
	(3.33)	(2.88)
Share of lowland	0.0096***	0.435***
	(3.26)	(4.25)
Share of midland	0.0045*	0.254***
	(1.66)	(2.60)
Share of irrigated area	0.0108***	0.595***
	(5.52)	(8.15)
Region dummy (Thailand border)	−2.1900***	−83.76***
	(−11.94)	(−12.35)
Region dummy (central province)	−3.3900***	−150.9***
	(−8.61)	(−8.93)
Market distance	−0.0470*	−1.270
	(−1.71)	(−1.60)
N	607	607

[a]t statistics in parentheses. * $P < 0.1$, ** $P < 0.05$, *** $P < 0.01$.

Table 36. Effects of gain in yield of rice on average household income.

Item	Northwest		Central	South			Total
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Average rice yield (t/ha)	2.80	1.68	2.70	2.71	2.23	3.17	2.63
% of rice income in total income	55	51	17	61	54	36	44
Scenario 1: Short term							
Additional household income ($ per hh)	101	91	45	223	169	134	122
% of income increase	8	7	4	11	8	6	7
Scenario 2: Medium term							
Additional household income ($ per hh)	202	183	89	446	337	268	244
% of income increase	16	15	8	23	17	11	14

Table 37. Estimated effect of yield gain in the short (3–5 years) and medium term (6–10 years) on poverty incidence.

Effect[a]	Northwest		Central	South			Total
	Battambang	Pursat	Kampong Thom	Kampot	Prey Veng	Takeo	
Depth of poverty (poverty gap index)	0.48	0.45	0.57	0.31	0.26	0.32	0.40
Short term							
Additional income per capita ($)	24	21	10	44	38	28	26
Poverty ratio (%)	84	84	87	65	57	62	73
% poor lifted above the poverty line	4	2	1	3	12	8	5
Medium term							
Additional income per capita ($)	48	42	19	88	76	56	53
Poverty ratio (%)	82	81	85	57	55	60	70
% poor lifted above the poverty line	7	6	3	15	15	11	8

[a]The poverty line is $1.25 per day per capita. % poor lifted is the share of the number of poor lifted in the number of poor people before GSR.

highest in southern Cambodia. This variation is related to the share of rice in total income and the depth of poverty. The impact is more in situations where farmers earn a larger proportion of their total income from rice and/or where they are not too far below the poverty line.

These poverty impact estimates derived from the sample are extrapolated to the national level to estimate the likely total impact on poverty. The technology is assumed to spread to 10% of the area in the short run and to 20% of the area in the medium run. Under these assumptions, a total of 15,000–48,000 poor people could be lifted above the poverty line in the short and medium runs, respectively, as a result of the adoption of these improved varieties in Cambodia (Table 38). Thus, the potential impact on poverty reduction is considerable.

Summary of the main findings

- The early wet season, main wet season, and dry season are the three seasons during which rice is grown in Cambodia. The main wet season is the main season for rice production and it accounts for more than 80% of the total rice area. Dry-season rice production is mainly concentrated in the southeastern region of Cambodia.
- Rice production in recent years has increased rapidly and Cambodia is now a rice-exporting country. Despite this growth in production, the average rice yield is still low at below 3 t/ha.
- The average farm size is small at 1.8 ha. Rice is the major crop, accounting for more than 90% of the gross cropped area. The cropping intensity is higher in the southern provinces, where rice is grown in both the wet and dry seasons.
- Women play an important role in rice farming and household decision making in Cambodia. Education and access to nonfarm income as well as training opportunities are the key factors that improve women's empowerment. More efforts should be made by national agricultural research and extension programs to provide women with education, income opportunities, and training on improved farming practices so that they could become more empowered to be better farm managers and key agents of technological change.
- Rice varieties in Cambodia can be categorized into modern, traditional, and

Table 38. Number of poor people that could be lifted out of poverty

Term	Adoption rate[a] (%)	% of poor lifted above the poverty line[b]	Total number of poor people lifted above the poverty line (persons)
Short	10	5	15,113
Medium	20	8	48,363

[a]Adoption rate is assumed for short and medium run.
Source: [b]The percentage of poor lifted out in the survey is 5–8% for the 10–20% yield increase in Table 37.

improved traditional varieties. Modern varieties are mainly grown in the dry season while traditional varieties and improved traditional varieties are dominant in the main wet season.

- Modern varieties, mainly grown in lower fields in the northwestern and southern provinces, account for 41% of the total rice area. Traditional varieties and improved traditional varieties, mainly grown in middle and upper fields, account for 33% and 25% of the total rice area, respectively.
- Farmers' varietal adoption patterns differ across seasons and land types. The popular varieties are Riang Chey in Battambang and Kampong Thom, 504 in Kampot and Takeo, IR66 in Prey Veng, and Phka Rumduol in Pursat.
- The econometric analysis indicated that farm size, landholdings, irrigation, and location are significant factors in determining the incidence and intensity of MV adoption.
- Rice farmers are poor and the average income per capita per day is less than a dollar. Rice accounts for 44% of the total household income. Given this large contribution of rice to total household income, increasing the productivity of rice could be an important strategy for raising farmers' incomes and reducing poverty.
- Improved GSR technologies that increase rice yield by 10–20% could increase average household income by $122–244. This amount of income gain can be translated into a 5–8% reduction in the incidence of poverty. This results in 15,000 to 48,000 poor rice farmers being lifted above the poverty line. These impacts are expected to be more in the northwestern and southern province, where the shares of rice in total income are higher than in the central province.
- Given the dominance of rainfed environments in Cambodia, breeding programs for developing stress-tolerant varieties for such environments are likely to have higher poverty impacts relative to those for irrigated environments and, hence, the GSR breeding program should be targeted to such environments.
- To generate a faster impact, dissemination of improved varieties should be targeted to provinces where rice accounts for a larger share of income.
- Adoption rates of existing MVs are much lower in the northwestern and central parts than in the southeastern parts, indicating that an effort to develop and extend improved varieties to the northwestern/central region is likely to generate a greater impact.

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Appendix I

Rice balance by provinces in Cambodia (2010-11).

Province-town	Production (000 tons)	Remaining paddy for consumption (000 tons)	Converted into milled rice (64%) (000 tons)	Food requirement per year (000 tons)	Rice balance (surplus/deficit) (000 tons)	% food requirement	% rice balance
Banteay Meanchey	630	548	351	107	244	5	10
Battambang	800	696	445	161	284	8	11
Kampong Cham	769	669	428	250	179	12	7
Kampong Chhnang	387	336	215	73	142	4	6
Kampong Speu	300	261	167	110	57	5	2
Kampong Thom	541	470	301	96	205	5	8
Kampot	401	349	224	88	136	4	5
Kandal	388	337	216	195	21	9	1
Koh Kong	24	21	13	19	−6	1	0
Kratie	131	114	73	50	23	2	1
Mondulkiri	37	32	21	10	11	0	0
Phnom Penh City	14	12	8	225	−217	11	−9
Preah Vihear	117	102	65	27	39	1	2
Prey Veng	1,098	956	612	140	471	7	19
Pursat	312	271	174	61	113	3	4
Rotanakiri	66	57	37	24	13	1	1
Siem Reap	520	453	290	143	147	7	6
Preah Sihanouk	37	32	21	35	−15	2	−1
Stueng Treng	63	54	35	18	17	1	1
Svay Rieng	469	408	261	72	190	3	8
Takeo	968	842	539	126	413	6	16
Otdar Mean Chey	145	126	81	31	50	2	2
Kep	10	8	5	6	0	0	0
Pailin	24	21	13	13	1	1	0
Total	8,251	7,175	4,595	2,080	2,517	100	100

Data source: MAFF (2011).

Appendix II

Battambang, located near the Thai border, is one of the major northwestern provinces, which accounts for nearly 10% of the total rice area in the country. Three major dams and other water sources ensure that 20% of the province's land area is served by irrigation systems. A combination of good rainfall, annual flooding, and investment in irrigation systems provides a good environment for rice production. The province accounted for more than 11% of Cambodia's wet-season rice crop production in 2010.

Pursat Province, which is next to Battambang, also has a strong agricultural sector because of its good soil and water supply. The province accounts for over 4% of Cambodia's rice crop. Wet-season yields average above 2.5 t/ha, but many farms achieve yields well above this. In the dry season, two large dams irrigate more than 7,000 hectares in addition to 17 other smaller irrigation systems.

Kampong Thom Province is located in the central part of Cambodia. It is one of the main rice provinces, accounting for more than 6.5% of Cambodia's wet-season crop. The province also has a high dry-season yield, averaging over 4 t/ha across 80,000 hectares. Yields and total production have increased in recent years and are expected to continue to increase with the new Kuwaiti investment in irrigation in five districts.

In the southern areas near the Vietnamese border, the major rice-growing provinces are Prey Veng, Kampot, and Takeo, which account for 27% of the total rice area and 49% of the total dry-season rice area. Pursat, Battambang, and Kampong Thom are located near Tonle Sap Lake.

Two major rivers, the Mekong and Tonle Bassac, traverse Prey Veng Province. It has the largest area planted to rice, nearly 13% of the total rice area of the country. The total rice area in Takeo is 264,708 hectares, with rice grown in both the wet and dry seasons. The rice area in Kampot is about 120,500 hectares, with the average farm size being bigger than the national average. But, the yield of rice in Kampot is lower

Appendix III

Policy measures for promotion of paddy production and rice exports.

Policy	Types of measures	Issues to be examined	Policy measures	Responsible Institutions	Remarks
Rice production	Quick-win measures		Facilitate import clearance for rice seeds, fertilizers, agricultural inputs, and machinery. Continue providing tax incentives to encourage imports of materials and equipment.	MEF. MAFF	Action plan by MAFF: 1. Rice intensification 2. Diversification 3. Agricultural cooperatives 4. Contract farming 5. MAFF determined 10 prioritized rice varieties[a]
		Increase productivity by using high-yield seed and modern farming techniques	Provide incentives to local seed producers and distributors. 1. Determine the number of prioritized rice varieties to be promoted and disseminated by the end of 2010. 2. Prepare legal framework and mechanism to promote seed production and distribution by the end of 2010. 3. Strengthen and expand further the capacity of CARDI, the Agricultural Experiment Station, the Agricultural Development Centre, and the Centre for Seed Production. Research, and Technical Training. 4. Review the framework for agricultural extension.	MAFF	
		Continue to expand irrigation	— Make full use of existing water resources. — Select economically viable investment projects. — Invest in small-scale irrigation system to get water from existing dams and major canals to farms.	MOWRAM	
			Encourage NGOs and charitable persons to build small-scale irrigation canals.	MOWRAM. Relevant ministries and institutions	
			Strengthen institutional capacity for maintenance and management of water user community.	MOWRAM	
		Continue to build and maintain rural roads	Focus further on the construction and maintenance and management of water user community.	Ministry of Rural Development (MRD). Relevant ministries and institutions	
		Promote micro-credit for agriculture	Review measures to facilitate and encourage commercial banks and other financial institutions to provide more credit to farmers.	MEF. NBC	

[a]The MAFF already determined 10 prioritized rice seed varieties, which included 3 nonseasonal early rice varieties, Sen Pidor, Chol Sa, and IR66; 4 medium seasonal rice varieties, Pkar Romdoul, Pkar Romdeng, Pkar Romeat, and Chan Senpidor; and 3 late seasonal rice varieties, Riang Chey, CAR-4, and CAR-6. MAFF annual report 2010-2011.

Policy measures for promotion of paddy production and rice exports (cont.)

Policy	Types of measures	Issues to be examined	Policy measures	Responsible Institutions	Remarks
Rice production	Medium to longer term measures	Improve productivity and crop intensification	Prepare a long-term plan for water resource management (10–20 years) with concrete measures. Determine government priority investments in irrigation and water management systems.	MOWRAM, MAFF	
			Increase investment in the rehabilitation of agricultural development stations and centers; agricultural farms to support research and development; and the transfer of technology to support agricultural production.	MOWRAM	
			Expand agricultural extension services at commune level.	MAFF, relevant ministries and institutions	
		Promote implementation of the National Policy on Rural Electrification	Implement the National Policy on Rural Electrification. Design a new project as soon as possible to facilitate electricity transmission and distribution to rural areas for pumping water to irrigate agricultural crops.	MIME, relevant ministries and institutions	Electricity represents 25% of total processing costs.
		Promote and establish farmer organizations	Prepare plan to support the establishment of farmer organizations. Strengthen ownership of farmer organizations in coordination, production, and needs and issues identification.	MAFF, relevant ministries and institutions	
			Strengthen capacity of farmers and agricultural communities to secure and use effectively loans from financial institutions	MAFF, relevant ministries and institutions	
		Promote and encourage the implementation of policy on sustainable use of agricultural land	Give high priority to delivering land titles in potential rice production areas.	MLMUPC	The challenges include: Lands are underused. Crops do not suit the soil conditions. Only around 10% of farmers have land titles.
			Prepare land-use zoning and widely disseminate information to farmers.	MLMUPC, MAFF, relevant ministries and institutions	
			Draft a Law on Agricultural Land Use and Management to ensure sustainable and efficient use of agricultural land.	MAFF, MLMUPC	
			Conduct national agricultural census every 10 years as a basis to develop a land-use map.	MoP/NIS, MAFF, relevant ministries and institutions	
			Draft a Law on Agricultural Community and a Subdecree on Contract Farming.	MAFF	

Policy measures for promotion of paddy production and rice exports (cont.)

Policy	Types of measures	Issues to be examined	Policy measures	Responsible Institutions	Remarks
Paddy rice collection and processing	Quick-win measures	Encourage participation of the private sector in paddy processing and rice exports	Continue the implementation of the Investment Law, the Law on Amendment to the Law on Financial Management 2009, and related regulations. Improve the legal framework for investment and other related regulations, if necessary.	CDC, MEF, relevant ministries and institutions	
		Continue financing paddy collection	Recapitalize RDB with an additional $7 million by end of 2010 or, at the latest, in early 2011.	MEF.	
			Double the capital of ADSF from $18 million to $36 million, at the latest, in 2011.	MEF.	
			Develop a Credit Guarantee Scheme to guarantee loan from commercial banks to companies and paddy collectors, at the latest in 2011.	MEF. NBC	
			Set up Risk Sharing Facility to encourage commercial banks to extend loans to agricultural processing activities and small and medium enterprises (SMEs) in general, at the latest in 2011.	MEF	
		Provide support and strengthen the Rice Miller Association	Provide special treatment to the Rice Miller Association similar to the treatment provided to GMAC.	Government	
	Medium to longer term measures	Create new financial instruments and leverage mechanism for financing	Develop new financing instruments. Strengthen the implementation of the Law on Secured Transactions and the Law on Financial Leasing. Establish centralized credit information to reduce fear and risks for commercial banks and microfinance institutions.	MEF, MoC, NBC	
			Consider the establishment of the Agricultural Development Bank (ADB) to support and promote agricultural production and processing.	MEF, NBC	
		Develop "open paddy market"	Develop the "open paddy market" and related activities such as contract farming, weighing, drying, paddy-based collateralized loans for members, and provision of high-quality seeds and fertilizers for market-driven rice production.	MAFF, relevant ministries and institutions	

Policy measures for promotion of paddy production and rice exports (cont.)

Policy	Types of measures	Issues to be examined	Policy measures	Responsible Institutions	Remarks
		Reduce electricity price and extend area coverage	Accelerate the diversification of rural energy sources to secure lower energy costs and expand rural area coverage.	MIME	
			Take measures to ensure effective and rigorous enforcement of existing laws and regulations to ensure efficient energy supply, best practices, and an appropriate tariff.	Electricity Authority of Cambodia (EAC)	
			Improve further EDC management.	MIME/EDC	
Logistic systems	Quick-win measures	Enhance trade facilitation, reduce informal fees, and eliminate illegal checkpoints	Develop a specific strategy to identify and streamline export-processing procedures, including inspection, documentation requirements, fees, and time required to process export applications. Define clear and publicly transparent division of responsibilities among export-regulating ministries/agencies. Consider rice export as a top priority in order to reduce to a minimum informal payments and time required to export by extending "special treatment" similar to the garment sector.	MEF/General department of Customs and Excise (GDCE) MAFF. MoC/General Department of Cam control (Camcontrol). Relevant ministries, institutions, and authorities.	MAFF Action Plan: develop and disseminate procedures on import-export of agricultural products.
		Implement single-stop service for export processing	Set up a single Stop Service for export processing and issuing certificates for SPS, fumigation, grading and quality-quantity and weight, and customs declaration.	MEF/GDCE. MoC/Camcontrol, MIME, relevant ministries and insitutions	
		Address grading and quality standards in compliance with internationally recognized standards	Create an independent certifying body or encourage well-known international independent certifying institutions to issue grading and quality certificates as required by importing countries.	MIME, MAFF, MoC	
			Define grading and standards of Cambodian rice and collaborate with the private sector to enforce them. Build technical capacity to achieve the required standards.	MIME, MAFF, MoC, private sector	

Policy measures for promotion of paddy production and rice exports (cont.)

Policy	Types of measures	Issues to be examined	Policy measures	Responsible Institutions	Remarks
		Encourage the construction of Phnom Penh Port bonded warehouse	Strengthen the capacity and promote the use of Phnom Penh Port as an exit point. Encourage the construction of bonded warehouses in Cambodia to facilitate transport and distribution.	MPWT, MEF	
Logistic systems	Medium to longer term measures	Formulate strategic and legal framework with a special focus on sanitary and phytosanitary (SPS) standards	Develop new needed legislation and regulations and amend the existing legal and regulatory framework.	Farmers' Products Export Promotion Committee, relevant ministries and institutions	
			Draft a Law on SPS and related subdecrees and *parkas* (regulations), and strengthen a sound SPS certification system. Strengthen the enforcement of laws and regulations. Develop a common SPS strategy with clear division of responsibilities. Strengthen human resource capacity and technical capability of existing laboratories to conduct tests and inspections, and enforce SPS measures.	MAFF, MoC, Ministry of Health (MoH), MIME	MAFF action plan: to develop and disseminate technical notes on milled rice pests. To identify nonpest areas.
			Strengthen the capacity and infrastructure for SPS inspection.	MAFF, relevant ministries and institutions	
		Invest in necessary infrastructure to reduce export costs	Prepare plan of action to reduce infrastructure-related costs for export. Engage bilateral and multilateral partners and/or the private sector to mobilize resources for investment projects.	MPWT, relevant ministries and institutions	
			Accelerate the rehabilitation and operationalization of the railway system (Project Phnom Penh and Phnom Penh-Sihanouk Ville). Accelerate the rehabilitation and development work and earliest operation of the railways in collaboration with the concessionaire.	MPWT, license-holder companies	

Policy measures for promotion of paddy production and rice exports (cont.)

Policy	Types of measures	Issues to be examined	Policy measures	Responsible Institutions	Remarks
		Facilitate financing for export	Consider the establishment of the Export-Import Bank (Exim Bank) to support the export of rice and other agricultural products.	MEF, NBC	
		Facilitate financing for infrastructure development	Consider the establishment of the Cambodia Development Bank (CDB) to support the development of other physical infrastructure necessary for economic growth and competitiveness of the Cambodian economy.	MEF, NBC	
Marketing measures	Quick-win measures	Explore export opportunities in regional and global markets	Comprehensive study on Cambodia's potential markets for rice. Disseminate widely the results to stakeholders. Lead trade delegations consisting of representatives of relevant ministries and rice-exporting companies to negotiate the sale of rice to the Philippines.	MoC, MFAIC, relevant entities	MAFF: rice price information via radio, television, SMS, bulletins, and Web site. Conduct surveys on domestic paddy-rice trade flows and border trade, etc.
		Establish a Rice Market Intelligence Unit	Consider options for establishing a Rice Market Intelligence Unit to provide information and analysis on regional and global rice markets.	MoC, MAFF, private sector	
		Develop arrangements for information sharing with stakeholders in domestic market	Disseminate market information. Use the information to prepare a monitoring toolkit covering the process of production, processing, export, and trade.	MoC, MAFF, MOWRAM, Ministry of Rural Development (MRD)	
	Medium to longer term measures	Prepare a Strategic Penetration Plan and Cambodia's position to compete in regional and global markets	Define strategic objectives to position Cambodia in international markets. Lead this task by exploring new markets and disseminating market information to rice producers and exporters. Negotiate bilateral agreements with potential rice-importing countries. Realize the initiative of establishing the Association of Rice Exporting Countries (AREC).	MoC, MFAIC, relevant ministries and institutions	

Pattern of varietal adoption and economics of rice production in Pakistan

Huaiyu Wang, Orlee Velarde, and Anjum Abedullah

Introduction

Country background

Pakistan is located in South Asia, along the border of the Arabian Sea, between India on the east and Iran and Afghanistan on the west and China on the north. The country has an area of 770,875 km^2 and a population of 177.1 million. In 2008, the irrigated land area was 198,700 km^2 accounting for more than 25% of the total land area (World Factbook 2011). The poverty ratio in urban and rural areas is 15% and 28%, respectively, with a national average of 22.3% (Wahid et al 2011). Agriculture is the largest sector, accounting for more than 21% of GDP, and it remains the largest source of employment, absorbing about half of the country's total labor force and being the largest source of foreign exchange earnings (Table 1).

Rice is the second-largest staple food crop after wheat in Pakistan in terms of area. It is also a cash crop as it is one of the main export products. Rice occupies about 10% of the total cropped area (Wahid et al 2011), and accounts for 4.4% of the gross value added in agriculture and 0.9% of GDP (Nazeer et al 2012).

Table 1. General characteristics of Pakistan.

Characteristics	Values
Total land area (000 km^2)[a]	770,875
Population in 2010 (million)	177.1
Rural population (million)	111.8
Agricultural employment share (including agriculture, forestry, hunting, and fishing) (%)	45
Per capita income 2010-11 (US$)	1,254
Share of agriculture in GDP (%)	21
Share of rice in GDP (%)	0.9
Poverty ratio in 2005-06 (%)[b]	22.3
Average production of paddy (000 tons), 2008-09–2010-11[c]	6,219
Average harvested rice area (000 ha), 2008-09–2010-11[c]	2,737
Average yield of paddy (t/ha), 2008-09–2010-11[c]	2.27

[a]World Factbook (2011). [b]Shakeel Ahmed Khan (2010), Nazeer et al (2012). [c]Federal Bureau of Statistics 2011. www.statpak.gov.pk/fbs/content/agriculture-statistics. Data source: Faroog (2011).

Objective

This report is an outcome of the baseline socioeconomic survey under Objective 9 (Targeting and Impact Assessment) of the GSR project. The main objective of the study is to analyze farmers' livelihood strategies, technology adoption patterns, adoption constraints, and the economics of rice production in key rice production areas of Pakistan. The specific objectives of the study are

- To describe the general picture of rice production in Pakistan.
- To analyze the patterns of varietal adoption.
- To analyze the economics of rice production in key production areas.
- To analyze farmer livelihood strategies in rice production.
- To generate guidelines for rice technology design, targeting, and policy reforms for increasing rice production through increased adoption of improved technologies.

Organization of the report

This chapter is organized as follows. The first section provides background information on Pakistan. The next section briefly describes the rice production trends in Pakistan in the last decades as well as related policies. The third section analyzes the economics of rice production based on the household survey. The fourth section focuses on the patterns of varietal adoption. Based on the potential yield gain and technology adoption rate, an ex ante impact assessment of improved varieties being developed under the GSR project is conducted in the fifth section. The final section provides a summary of the main findings and implications.

Rice production in Pakistan

Rice production trends in Pakistan

Pakistan has two main cropping seasons per year, kharif (rainy) and rabi (postrainy). Rice is grown in the kharif season (June-October) only whereas nonrice crops such as wheat, gram, and lentils are grown in the rabi season (December-April). Rice is normally sown in June and July and harvested in October and November.

In 2010, rice area harvested was 2.4 million ha and production was 4.8 million tons. These figures are 18% and 30% lower than the respective area and production in 2009 because of the devastating floods of July 2010 (Pakistan Economic Survey 2010-11).

Rice production has been on an upward trend for the past several decades, which can be attributed to yield growth as the main source of production growth (Fig. 1). Between 1961 and 1980, rice area, yield, and production growth were increasing, with annual growth rates of area and yield of 3.68% and 5.24%, respectively. This resulted in an annual average growth rate in rice production of 8.91%, mainly attributed to the spread of technologies during the Green Revolution period. From 1981 to 1995, the growth rate of rice production was modest as both area and yield growth rates were close to zero. A second spike in growth was observed during 1996-2009, as hybrid

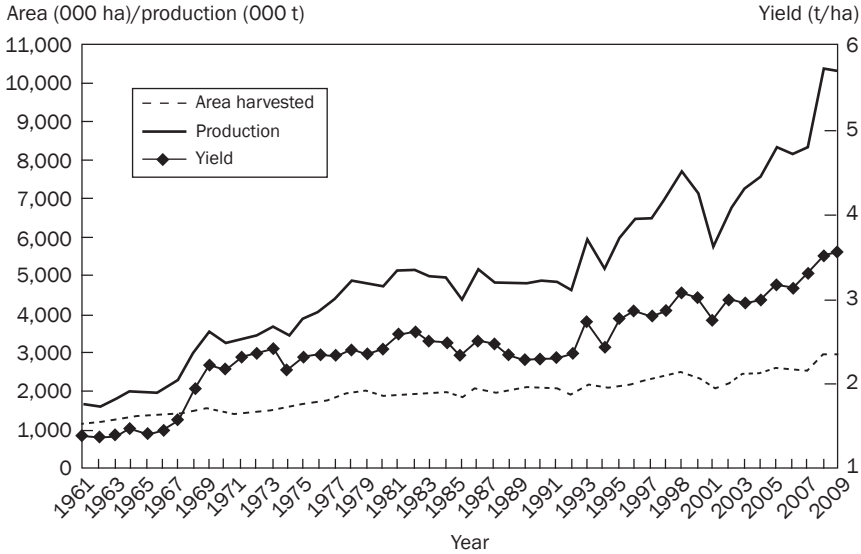

Fig. 1. Production, area, and yield of rice in Pakistan (1961-2009). Data source: FAOSTAT.

Table 2. Growth rates of rice production (%/year).

Years	Production	Area	Yield
1961-80	8.91	3.68	5.24
1981-95	0.66	0.69	–0.03
1996-2009	3.26	1.60	1.60

Source: Calculations based on data from FAOSTAT.

varieties spread and intensification of input use took place. Production grew at 3.3% per annum during this period (Table 2).

Pakistan has four rice-growing provinces. Punjab and Sindh are the two main provinces for rice production, accounting for 67% and 24% of the total rice area during the triennium of 2006-08, respectively (Fig. 2).

The area under rice in Punjab increased by 2.5% per year during 1961-2008. The share of rice area in Sindh has decreased over time. The respective production shares during the triennium of 2006-08 are 56% and 34% in Punjab and Sindh. The rice yield in Punjab, 2.0 t/ha, is much lower than that of Sindh, 3.2 t/ha (Table 3), which may be due to the varietal difference, that is, Basmati in Punjab and IRRI varieties in Sindh.

Basmati and IRRI varieties play dominant roles in the rice production of Pakistan, accounting for 57% and 31% of total rice area in 2008, respectively. And their respective shares in production in 2008 were 43% and 40% (Agriculture Statistics of Pakistan 2008-09). The national average yield of IRRI varieties (2.9 t/ha) was 72% higher than that of Basmati (1.7 t/ha) in 2008 (Table 4).

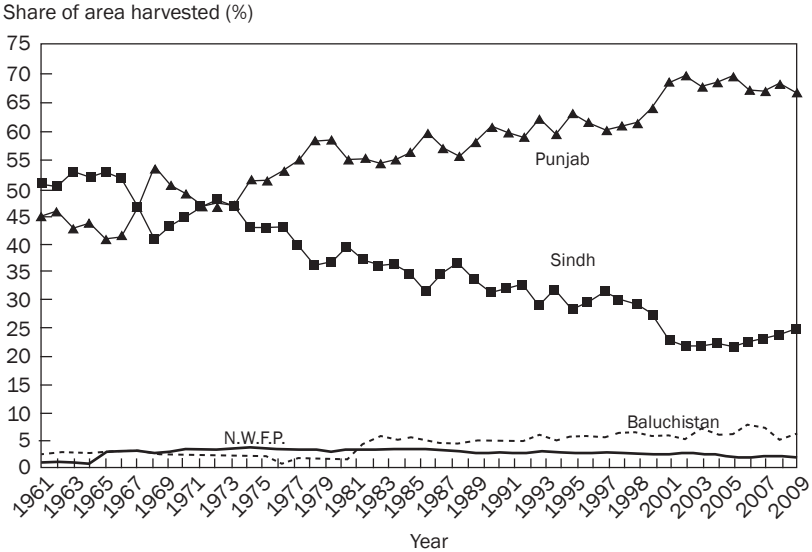

Fig. 2. Rice area distribution by province (1961-2008). Data source: IRRI World Rice Statistics.

Table 3. Average rice area, yield, and production in Pakistan (2006-08).

Item	Baluchistan	N.W.F.P.	Punjab	Sindh	Total
Area (million ha)	0.17	0.06	1.81	0.64	2.69
Production (million tons)	0.48	0.13	3.33	2.04	5.98
Yield (t/ha)	2.82	2.17	1.84	3.19	2.22

Data source: IRRI World Rice Statistics.

Table 4. Rice yield and the share of rice area by variety in 2008.

Province	Share of rice area (%)			Rice yield (t/ha)		
	Basmati	IRRI	Others	Basmati	IRRI	Others
Punjab	91.3	22.1	64.7	1.0	1.0	1.0
Sindh	5.2	61.2	24.0	2.1	1.2	2.3
Baluchistan	2.7	15.7	0.3	1.7	2.6	2.3
N.W.F.P.	0.8	1.0	11.0	1.5	3.5	5.4
Total	100.0	100.0	100.0	1.7	2.9	3.0

Data source: Agriculture Statistics of Pakistan 2008-09.

Basmati rice is the main variety in Pakistan grown traditionally, especially in the Punjab region. It has long and fine grains, with good quality and aroma. It is famous for good cooking quality and kernel elongation after cooking.

Improved rice germplasm in Pakistan was received from IRRI starting in 1964. Two major varieties, IRRI-6 and IRRI-9, are now grown in Pakistan. IRRI-6 is a coarse rice variety that was officially released in 1971 with the name IRRI-6 in the Punjab and Mehran-69 in Sindh.[1] IRRI-9, which was developed through cross-breeding, was released in 1999. It is characterized by long and bold grain. IRRI-6 and IRRI-9 are mostly grown in the province of Sindh and DG Khan District in Punjab. Although Basmati is the most popular variety in Punjab, DG Khan is the only district/division in Punjab where IRRI varieties are predominantly grown.

Rice policy

There is no export tax on rice, but imports are subject to a 10% customs duty (Salam 2009). Following the very high international and domestic prices experienced in 2007-08, the government fixed minimum export prices (MEP) for various varieties of rice: $1,500/ton for Super Basmati, $1,300/ton for Basmati, $1,000/ton for IRRI-9, and $750/ton for IRRI-6 (The World Trade Review 2008).

To achieve the national target of 7.5 million tons of milled rice production in 2015, fallow land was brought back under cultivation together with the distribution of fertilizer and seeds. In addition, packing and grading plants were set up in key growing areas in 2009. Meanwhile, the Pakistan Agricultural Storage and Supply Corporation (PASSCO) was established under the new rice procurement mechanism to procure supplies from producers when market prices fall below a set of reference prices (FAO 2009).

In 2010, the government approved the importation of 400,000 tons of urea to support the procurement campaign (FAO 2010a). In 2010, the government initiated a crop loan insurance program to complement the public support schemes, including the setting of intervention prices and the provision of seeds, fertilizers, agricultural machinery, and tractors at subsidized prices (FAO 2010b). Moreover, despite widespread increases in the prices of basic inputs, official assessments attest to the growing adoption of hybrid rice varieties, which may promote further yield gains (FAO 2011).

Farm household-level analysis

Survey sites and sampling design

The data collected were based on the kharif 2010 and rabi 2010-11 seasons. Four districts were selected for the survey: Dera Ghazi Khan (DG Khan in the following text), Badin, Larkana, and Shikarpur.[2] DG Khan is part of Punjab Province while

[1]IRRI-6 and Mehran-69 are the same variety but with a different name in Punjab and Sindh.

[2]Although area allocated to IRRI rice varieties was higher in Jaccobabad and Thatta districts than in Badin in Sindh, these two districts were badly affected by flood in 2010 and therefore only Badin was included in the survey.

the others are in Sindh Province. Rice production in this area ranges from 60,000 to 255,000 tons. In Sindh, Badin has the same range of rice production as DG Khan while Shikarpur and Larkana have a rice production range of 255,000 to 1.56 million tons.

In each district, 1–2 tashils were selected and one village was selected randomly from the tashil. Thirty farmers from each village were randomly selected. For those small villages with less than 30 farm households, another nearby village with similar rice production characteristics was selected.

Drought and salinity are the main stresses affecting rice production in the area. A total of 210 respondents participated in the survey. Figure 3 shows the location of the survey sites.

Demographic characteristics

All respondents in the sampled survey are males, with an average age of 42 years (Table 5). The respondents attained only 4 years of education, on average, except in Badin, where it was 6 years. The average household size in the sampled survey is 6 members. About 70% of the households belong to the working age population (16–65 years age group).

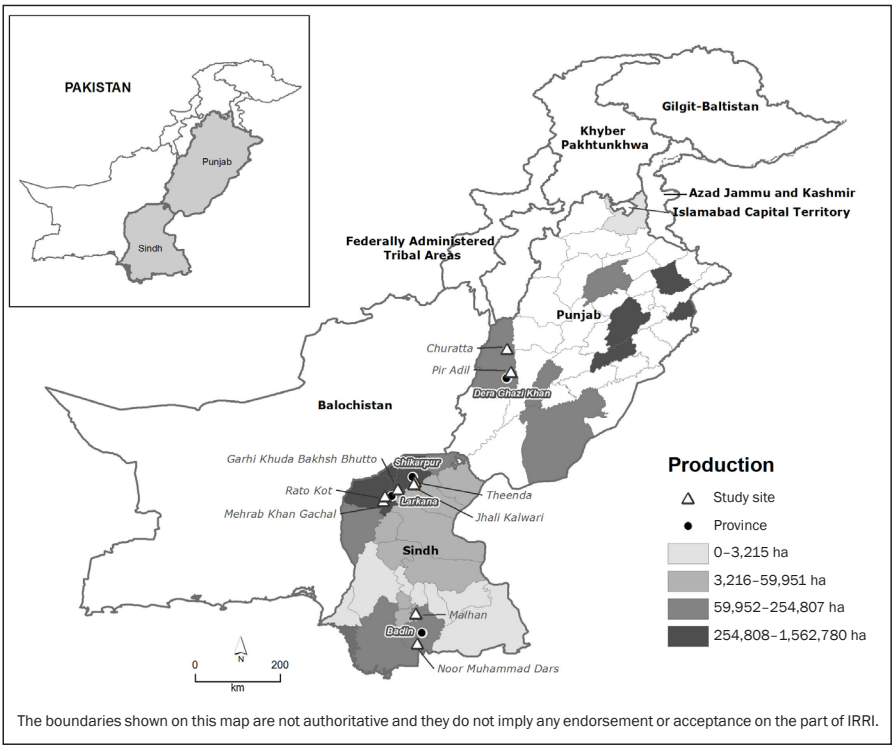

Fig. 3. Survey sites.

Table 5. Household characteristics.

Characteristic	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Sample size	60	30	60	60	210
Respondent information					
Average age	37	38	44	46	42
Average education years	4	6	3	4	4
Av household size (no. of members)	5	6	7	7	6
Age group (%)					
Less than 16	34	27	35	29	32
16 to 65	63	71	63	69	66
More than 65 years old	3	2	2	2	2

Source: IRRI GSR project, household survey 2010.

The primary occupation of the surveyed households involves agriculture, employment, temporary/seasonal jobs, and business. A majority of the respondents (73%) are involved in farming while only 6% are employed in the government and private sector although seasonal jobs or those who were hired on a short-term basis are also quite important (13%). Business and other entrepreneurial activities are not practiced much by the households included in the sample (Table 6).

Farming conditions

The farm size of the sampled households varies from 0.2 ha to 20 ha with an average of 3.0 ha. In terms of farm size group (Fig. 4), about 40% own less than 2 ha of land while another 40% own 2 to 4 ha. So, over 75% of the farms are less than 4 ha.

The land near the river and in the lower part of the toposequence is considered as "lowland" by farmers. The other land type is medium land. Most farm land in the survey is mid-level land type or medium land. Farmers owned more than half of the farm area while about a third is operated on a sharecrop basis (Table 7). Sharecropping is a common practice in Pakistan. The share of the landlord of the total output is based partly on the landlord's input share.

Rice production in Pakistan is mainly irrigated. And, Punjab has a proportionately higher share of irrigated area in cultivated area than Sindh (Table 8).[3]

The fields in the kharif season are 90% irrigated, for which 81% of the irrigation water comes from rivers while the rest comes from tube wells. During the rabi season, farmers have limited access to irrigation, wherein about 29% of the farm land depends on rainfall. About 23% of the area in Punjab is rainfed while 16–47% of the area is rainfed in Sindh. In the rabi season, 60% of irrigation comes from rivers while tube wells supply 11% of irrigation (Table 9).

[3]The national irrigation data are not consistent with the survey data.

Table 6. Occupation of the household members (%).

Occupation[a]	Punjab		Sindh		All
	DG Khan	Badin	Larkana	Shikarpur	
Agriculture	60	75	82	75	73
Regular jobs (private and government)	2	12	4	10	6
Seasonal/temporary jobs	19	5	13	10	13
Engaged in business	3	0	0	1	1
Others	16	8	1	4	7

[a]Regular jobs refer to a regular job in a private organization or government service.
Seasonal/temporary jobs refer to contract labor and services rendered on a short-term basis.
Others are professional, religious, and transport services but in DG Khan, half of which are overseas.
Data source: IRRI GSR project, household survey 2010.

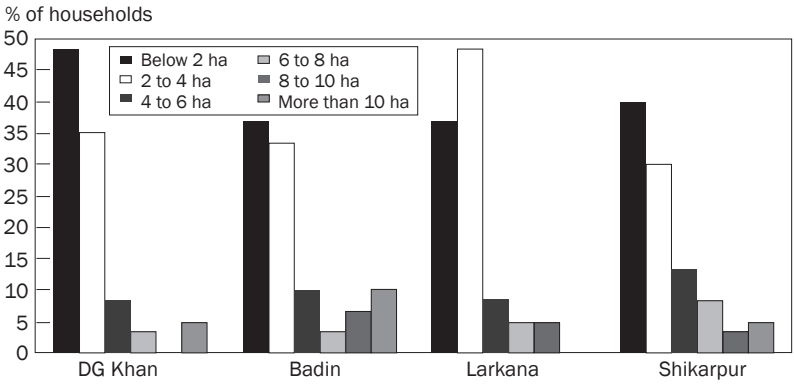

Fig. 4. Percentage of farmers by farm size group. Data source: IRRI GSR project, household survey 2010.

Table 7. Farm landholdings.

Item	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Farm size (ha)	2.6	3.9	2.4	3.4	3.0
By land type (%)					
Lowland	3	2	25	46	22
Medium	97	98	75	54	78
By tenure (%)					
Owned	83	51	28	61	57
Sharecrop	0	37	72	39	36
Rented-in	17	12	0	0	7

Data source: IRRI GSR project, household survey 2010.

Table 8. Irrigated area and cultivated area in Punjab and Sindh.

Province and district	Irrigated area[a] (000 ha)	Cultivated area (000 ha)	% of irrigated area
Punjab	10,326	12,348[b]	84
DG Khan	413	446[b]	92
Sindh	2,515	5,797[c]	43
Badin	200	464[c]	43
Larkana	174	385[c]	45
Shikarpur	102	200[c]	51

Data source: [a]www.fao.org/nr/water/aquastat/irrigationmap/pk/index.stm. [b]Data in 2002-03. Punjab Development Statistics (2005). [c]Data in 2000-01. Sindh Development Statistics (2005).

Table 9. Percentage of irrigated area by source and by season.

Item	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Kharif					
Rainfed	23	3	9	2	10
Irrigated					
River	58	92	91	87	81
Tube wells	19	2	0	10	8
Mixed	0	2	0	0	0
Rabi					
Rainfed	23	38	16	47	29
Irrigated					
River	55	54	84	45	60
Tube wells	23	5	0	8	11
Mixed	0	3	0	0	0

Data source: IRRI GSR project, household survey 2010.

Land use

In the survey area, food crops play a dominant role in the farming system, in which rice and wheat are the major crops. Rice occupies 52% of the gross cropped area. Wheat is planted to 33% of the area, followed by mustard, green peas, sunflower, and other crops that comprise 15% of the area (Table 10).

In the kharif season, farmers grow only rice, whereas, in the rabi season, a majority of the farms grow wheat along with other crops (Table 11).

Farmers usually rotate rice with wheat, that is, they grow rice (in kharif season) and wheat (in rabi season) on the same land. The cropping pattern in lowland and medium land is also similar (Table 12). Land use in the sampled area has an intensity of almost 2.0, which means that land is being used or grown to crops twice in a cropping year.

Table 10. Percentage of gross cropped area by season.

Crop	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Rice	49	60	54	51	52
Wheat	50	22	17	36	33
Mustard	0	0	20	0	5
Green peas	0	0	1	7	3
Sunflower	0	9	0	0	1
Other legumes and vegetables	1	9	8	6	6

Data source: IRRI GSR project, household survey 2010.

Table 11. Percentage of total cropped area by season.

Season and crop	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Kharif					
Rice	100	100	100	100	100
Rabi					
Wheat	98	58	37	72	70
Mustard	0	0	43	0	10
Green peas	0	0	2	15	6
Sunflower	0	24	0	0	3
Other crops[a]	2	19	18	13	11

[a]Other crops in the rabi season include cotton and fodder (DG Khan), oat, rapeseed, barseem, and okra (Badin), coriander, oat, canola, lusan, jawan, and linseed (Larkana), coriander, oat, tomato, gram, alfalfa, spinach, and oat (Shikarpur). In Badin, farmers grow sugarcane as a perennial crop, which occupies 2.8 ha of land.
Data source: IRRI GSR project, household survey 2010.

Rice production

Rice varieties grown and their yields. On average, rice area per household in the survey is nearly 3 hectares, ranging from 2.5 ha per household in DG Khan to 3.8 ha per household in Badin. The varieties grown in the survey are inbred and hybrid rice varieties. Most farmers in the survey grow an inbred variety except in Badin, where 53% of the farmers grow hybrid rice and 33% an inbred variety (Table 13). Basically, each household grows only one type of variety and the diversification of rice varieties is low in the surveyed locations.

Inbred rice varieties are commonly grown at the survey sites except in Badin, where only 38% of the area has inbreds and the rest has hybrid rice. Hybrid rice is also present in Larkana and Shikarpur but it is grown on only 6% of the area for each

Table 12. Percentage of total cropped area by land type.

Item	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Lowland					
Rice	52	50	50	50	50
Wheat	48	50	23	38	35
Mustard	0	0	21	0	6
Other crops	0	0	5	12	10
Cropping intensity index	1.92	2.00	2.00	1.95	1.97
Medium land					
Rice	49	61	55	53	54
Wheat	50	21	15	33	32
Mustard	0	0	19	0	4
Other crops	1	18	11	14	10
Cropping intensity index	1.87	1.60	1.84	1.94	1.83

Data source: IRRI GSR project, household survey 2010.

Table 13. Pattern of rice varieties grown by farmers.

Type of variety	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Hybrid only (%)	0	53	10	0	10
Hybrid and Inbred (%)	0	14	0	5	4
Inbred only (%)	98	33	90	95	86
TV only (%)	2	0	0	0	0
Sample size	60	30	60	60	210

Data source: IRRI GSR project, household survey 2010.

district. Traditional varieties are grown on only 3% of the rice area in DG Khan although this is for only one farmer in the sample. The produce is used purely for home consumption by the farm household. Overall, 85% of the area grows inbred varieties at the survey sites and 15% grows a hybrid variety (Table 14).

The average yield in the survey is 3.5 t/ha, with significant yield differences across locations and among varieties. However, the average yield is not much different between land types (Table 15). On average, yield is highest in Badin (5.16 t/ha), attributed mainly to the high adoption of hybrid rice, while yield is the lowest in Shikarpur (2.67 t/ha). The average yield of hybrid rice is 50% higher than that of inbred varieties (3.3 t/ha).

Table 14. Percentage of rice cultivated area by variety.[a]

Item	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Rice area (ha/household)	2.5	3.8	2.4	3.4	2.9
Hybrid MV (%)	0	62	6	6	15
Inbred MV (%)	100	38	94	94	85

[a]Only one farmer in DG Khan grows a TV, which is purely for home consumption, which was not included in the table. Data source: IRRI GSR project, household survey 2010.

Table 15. Plot-level average yield of rice production (t/ha).

Item	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Overall	3.69	5.16	3.48	2.67	3.46
By variety type					
Hybrid	–	5.72	3.27	4.26	5.08
Inbred	3.70	4.48	3.50	2.61	3.25

Data source: IRRI GSR project, household survey 2010.

Popular varieties. Basmati is the most popular variety in Pakistan for both home consumption and export. Consumers prefer Basmati for its long grain, aroma, and fluffiness. Basmati is primarily grown in Punjab and accounts for 73% of the rice area in the whole province. A majority of the rice area in each division of Punjab grows Basmati except in DG Khan, which accounts for only 20% of the rice area (Table 16). In Sindh, data from the Agriculture Department of the government of Sindh show that only 10% of the rice area grows Basmati while 73% grows IR varieties.

The sampled area has 11 rice varieties. The most popular is IRRI-6, accounting for 56% of the rice area, followed by IRRI-9, Basmati, and Pukhraj, grown on more than 10% of the rice area, respectively (Table 17).

The popular varieties across survey sites are different. IRRI-6 is the dominant variety in DG Khan and Larkana, and was the first variety released by IRRI in Pakistan. Pukhraj, a hybrid variety, is mainly grown in Badin and accounts for 50% of the rice area in the district. Basmati is mainly grown in Shikarpur District and accounts for nearly one-third of the rice area.

Varietal traits preferred. High yield and good eating quality are the two most important characteristics of the varieties that farmers prefer (Table 18). In DG Khan, farmers mostly focus on the yield advantage of the varieties being adopted. This might be related to their high share of marketed surplus. In DG Khan, 83% of the rice area has IRRI-6, which is mostly sold for export. In general, farmers in Sindh grow rice for domestic consumption and grain quality is an important consideration. In Badin, Larkana, and Shikarpur, about 50% of the farmers selected yield, followed by good

Table 16. Percentage of rice area by variety in Punjab, 2009.

Variety type	Punjab Province[a]	DG Khan only
IRRI	11	78
Basmati	74	20
Others	15	2

[a]Including DG Khan. Data source: Agriculture Department, government of Punjab.

Table 17. Percentage of popular rice varieties by area (%).

Variety	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
IRRI-6	84	15	83	40	56
IRRI-9	14	–	5	24	12
Basmati	–	–	5	30	11
Pukhraj	–	50	3	2	11
KS-282	–	21	–	–	4
China guard	–	12	1	4	4
Sohrab	2	–	–	–	1
Shandar	–	2	–	–	0.5
DR-83	–	–	1.4	–	0.3
Royal hybrid	–	–	1.0	–	0.2
Royal China	–	–	0.3	–	0.1

Data source: IRRI GSR project, household survey 2010.

eating quality, which is about 25%. The most undesirable traits as mentioned by farmers are lack of resistance to pests/diseases (Table 18).

Crop disposal

The average rice production per farm household was 10 tons during the survey year. Half of the harvest was sold in the market (Table 19). About 30% was given as payment to landlords and/or hired laborers. Farmers set aside 16% of the harvest for home consumption. In DG Khan, only 8% was left for food while other districts were left with 15% to 23% of the harvest. Overall, the proportion of production kept for consumption is relatively small because of market-oriented production.

Besides rice, wheat is an important staple food and a source of income among farm households. Farmers produced about 4 tons of wheat on average although production across districts varied from 1.1 to 7.9 tons. About 40% of the harvest was sold in the market and 17% was used as a crop share payment to landlords. According to the survey, 33% of production was used for home consumption, which is higher than for rice consumption.

Table 18. Farmers' preferences for varietal traits.

Traits	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Desirable					
High yield (%)	90	67	59	45	61
Good eating quality (%)	6	20	33	27	24
High market price (%)	0	13	3	22	11
Good grain quality (%)	0	0	5	3	3
Resistant to lodging (%)	4	0	0	0	1
Resistant to pests and diseases (%)	0	0	0	3	1
Total responses	52	40	75	100	267
Undesirable					
Not resistant to pests and diseases (%)	67	86	94	70	83
Low yield (%)	0	9	6	26	13
Not resistant to lodging (%)	0	0	0	0	0
Poor eating quality (%)	0	0	0	0	0
Poor grain quality (%)	33	5	0	0	3
Low market price (%)	0	0	0	4	1
Total responses	6	22	34	27	89

Data source: IRRI GSR project, household survey 2010.

Rice input use

Seeds and fertilizer input. The amount of seeds used per hectare varies across variety types. On average, farmers use 76 kg/ha of seeds although seeding rates are much lower in areas such as Badin, where hybrid varieties are popular.

Farmers use both organic and chemical fertilizers. The amount of organic fertilizer varies greatly across survey sites. In DG Khan, the use of organic fertilizers is twice as much as in other districts primarily because of the presence of a livestock industry in the district (Table 20).

Most farmers applied less than 150 kg/ha of nitrogen and 20–30 kg/ha of phosphorus and a few of them apply potassium. In Badin, which is part of Punjab, about 67% of the farmers applied nitrogen within the recommended range (75–160 kg/ha) and 23% applied more than the recommended amount. In other districts, which are part of Sindh, 48% of the farmers applied less than the recommended amount of nitrogen and 18% applied more than the recommended amount. For phosphorus application, almost all farmers applied less than the recommended amount (29 kg/ha).

Labor use. In the survey, labor used in rice production is about 100 person-days. Farmers in DG Khan used 20 person-days less than in other districts and spent most of the labor on harvesting and threshing. However, farmers in Sindh spent most of their time on crop care management (Table 21).

Table 19. Distribution of rice and wheat production.

Crop and uses	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Rice					
Production per HH (tons)	10	18	8	10	10
% sold	69	41	36	50	50
% as payment	21	40	37	27	30
% as food	8	15	23	20	16
% as seeds	2	1	2	2	2
% for future use	0	2	1	0	1
% for other use	0	1	1	1	1
Wheat					
Production per HH (tons)	7.9	3.5	1.1	2.9	3.9
% sold	46	47	38	37	43
% as payment	10	28	34	20	17
% as food	34	25	21	37	33
% as seeds	4	0	4	5	4
% as feed	1	0	0	0	0
% for future use	5	0	3	1	3
% for other use	0	0	0	0	0

Data source: IRRI GSR project, household survey 2010.

Table 20. Fertilizer application per ha.[a]

Item	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Seeds (kg)	71	37	85	93	76
Fertilizer					
Organic fertilizer (tons)	17	9	5	6	9
Chemical fertilizer (kg)					
Total	150	210	140	130	150
N	140	190	110	110	130
P	16	20	24	23	21
K	0	1	0	0	0
Zinc sulfate	173	169	130	131	143

[a]See Table in Appendix I for the recommended amount of fertilizer. Data source: IRRI GSR project, household survey 2010.

Table 21. Distribution of labor use.

Labor use	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Land preparation (%)	5	6	6	6	6
Crop establishment (%)	29	13	22	20	22
Crop care management (%)	22	46	38	39	36
Harvesting and threshing (%)	39	24	25	25	28
Postharvest activity (%)	5	11	9	10	8
Total labor (person-days/ha)	76	111	100	105	96
Family (%)	44	75	68	66	63
Hired (%)	56	25	32	34	37
Daily wage rate (US$)	2.93	2.08	1.77	1.59	2.09

Data source: IRRI GSR project, household survey 2010.

Family labor is the main source of labor for rice farming in the survey districts except in DG Khan, where more than half of the labor for rice farming is hired. This might be because of the smaller household size and a strong competition for labor from the well-established nonfarm sector. The wage rate paid to farmers in DG Khan is higher by about $1 a day than in other districts.

Noncash cost component. Noncash cost refers to the farmers' own inputs and labor for rice production and includes seeds, family labor, and power source owned by the family. Noncash inputs were valued at the respective market prices to represent the market value of inputs and opportunity cost of machines and labor.

Overall, farmers' own material inputs were equivalent to 2% of the total material input cost (Table 22). Most of these represent the use of organic fertilizer, which is commonly available for free. In Badin and DG Khan, only farm tractors comprised noncash cost while in Shikarpur noncash cost also included threshers. In Larkana, no farmers own any type of farm machinery. Few farmers own farm machinery while others opt to rent these machines for rice production. Farmers saved as much as 52% of the total labor cost by using family labor. Most of the labor requirement that the household members provided is for crop care management, harvesting, and threshing.

In Sindh, 65% of the labor use came from family labor, whereas, in DG Khan, this was only 31%. As mentioned earlier, the availability of nonfarm income activities among family members probably affects their willingness to work on the farm.

Costs and returns of rice production. In general, almost half of the total cash cost of production was spent to buy material inputs, particularly chemical fertilizers (Table 23). In DG Khan, farmers also spent a large amount on labor due to limited use of family labor and the higher wage rate of farm laborers. Farmers in Badin have high costs per ha but also have a higher yield because of the adoption of hybrid rice. As a result, the net returns of $744 per ha are the highest in the survey. In DG Khan, the cost of rice production was also high like in Badin. The high cost was due mainly to hiring more laborers than in other districts.

Table 22. Share of noncash cost.

Input	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Material inputs					
Noncash (%)	6	1	2	1	2
Cash (%)	94	99	98	99	98
Total cost (US$ per ha)	227	307	213	225	234
Power use					
Noncash (%)	11	3	0	1	3
Cash (%)	89	97	100	99	97
Total cost ($ per ha)	54	126	80	85	81
Labor use					
Noncash (%)	31	65	65	65	52
Cash (%)	69	35	35	35	48
Total cost ($ per ha)	346	253	214	191	251

Data source: IRRI GSR project, household survey 2010.

Table 23. Costs and returns of rice production.

Item	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Gross income ($ per ha)	871	1,258	943	796	932
Yield (t/ha)	3.70	5.13	3.68	2.90	3.67
Average price ($ per ton)	235	245	256	274	254
Cash cost ($ per ha)	499	515	365	375	427
Input cash cost (%)	43	59	57	60	53
Power cash cost (%)	10	24	22	22	18
Labor cash cost (%)	47	17	21	18	29
Net returns ($ per ha)	372	744	578	421	504

Data source: IRRI GSR project, household survey 2010.

Farmers spent more on material inputs and power use for hybrid rice, particularly for seeds and the use of a thresher. In total, material inputs of a hybrid variety cost about $124 per ha more than for an inbred variety. On the contrary, the hybrid variety had the lowest cost for hired labor, $93 per ha. Farmers who grow hybrid rice spent $113 per ha on power use, which is $40 per ha higher than for inbred rice farmers and the difference is mainly because of thresher use (Table 24).

In terms of yield and net returns, hybrid varieties performed better than inbred varieties. Their average yield was 5.03 t/ha and they provided a net return of $700 per ha, which is $223 per ha more than for inbreds. Although the cost of production

Table 24. Percentage distribution of cash cost.

Item	Hybrids	Inbreds	All
Material inputs			
Seed (%)	29	10	13
Organic fertilizer (%)	5	2	2
Chemical fertilizer (%)	56	77	73
Herbicide and insecticide (%)	8	11	12
Others (%)	2	0	0
Total cash cost ($ per ha)	291	167	182
Power use			
Animal (%)	0	0.2	0
Tractor (%)	54	64	62
Thresher (%)	45	26	29
Power tiller (%)	1	10	9
Cash cost ($ per ha)	113	73	78
Hired labor use			
Land preparation (%)	1	2	2
Crop establishment (%)	31	28	28
Crop care management (%)	3	3	3
Harvesting and threshing (%)	55	60	60
Postharvest activity (%)	10	7	7
Cash cost ($ per ha)	93	123	120
Irrigation ($ per ha)	8	21	20
Land rent ($ per ha)	31	27	27

Data source: IRRI GSR project, household survey 2010.

of hybrid rice was $124 per ha higher than for inbred varieties, its gross cash income was $346 per ha more primarily due to its 43% higher yield (Table 25).

Income sources

The major income source varies across districts. In Larkana, rice is the primary income source and it accounts for one-third of household income. In DG Khan of Punjab, wheat is the main source of income as its share surpasses 50%. On average, 16% of total household income comes from rice production while 31% comes from wheat. These two crops are important sources of both income and food for the farm households (Table 26).

Nonfarm activities are important sources of income, which contribute about 36% of the total income, which basically comes from salary. In DG Khan, the income from transport operations (12%) contributes the most among nonfarm activities. DG Khan has a lower share of income from employment. The selected villages for the survey

Table 25. Costs and returns of rice production by variety type.

Item	Hybrid	Inbred	All
Input cash cost (%)	61	52	54
Power cash cost (%)	21	18	18
Labor cash cost (%)	18	30	28
Cash cost ($ per ha)	535	411	426
Yield (t/ha)	5.03	3.49	3.67
Average price ($ per ton)	246	255	254
Gross income ($ per ha)	1,236	890	933
Net returns ($ per ha)	701	478	507
No. of plots	25	184	209[a]

[a]One plot, planted to a traditional variety, is not included. Data source: IRRI GSR Project, household survey 2010.

Table 26. Distribution of household income from different sources.

Item	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Rice production (%)	10	16	33	14	16
Wheat production (%)	51	19	15	24	31
Nonrice/wheat (%)	0	16	5	11	7
Off-farm income (%)	8	8	12	9	9
Sale from animals/products (%)	0	0	2	1	1
Nonfarm income (%)	31	41	33	41	36
Salary from employment (%)	8	33	24	34	23
Seasonal jobs (%)	4	4	4	2	3
Business (%)	7	1	2	1	3
Remittances and pension (%)	0	3	2	1	1
Transport operations[a] (%)	12	0	1	2	5
Others (%)	0	0	0	1	1
Total household income (in $)	3,719	4,573	1,777	2,980	3,075
Per capita income					
Annual	741	742	262	433	494
Per day	2.03	2.03	0.72	1.19	1.35

[a]Working as a driver or helper to assist the driver in collecting money from passengers and doing other minor things. Data source: IRRI GSR project, household survey 2010.

do not have easy access to the central part of the city. In addition, the industrial sector in DG Khan is very small compared with that of other districts in Punjab.

The sampled households in the survey earned an average of $1.35 per capita per day, which is slightly higher than the international poverty line of $1.25. Badin

is nearer to Karachi City, which is highly industrialized, and people can easily travel for a job on a daily basis. Per capita daily income is slightly more in Badin than in other locations.

Impact assessment

The varieties being developed under the GSR project are still in a trial stage and have not yet been released for farmers' adoption. Hence, the actual impact of these varieties cannot yet be assessed. Instead, an initial assessment of their potential impact has been conducted using the farm-level survey data and various assumptions regarding the size of the potential yield gain and the adoption rate.

In the short term, the average increase in household income is estimated to be $92, holding all other incomes constant. This absolute increase in income translates into a total income gain of 3%. In the medium term, the corresponding increase in household income will be 6%. There are considerable variations across provinces in these figures depending on the initial level of yield and the share of rice in total household income (Table 27).

This income effect of new varieties can be translated into a poverty impact by estimating the number of people that can be lifted above the poverty line. Taking the poverty line of $1.25 per day per capita as the reference, results indicate that 4–7% of poor people could be lifted out of poverty in the short and medium term, respectively (Table 28). The impact of increased rice yield varies across regions, with the impact being highest in Badin District. This variation is related to the share of rice in total income and the depth of poverty. The impact is more in situations where farmers earn a larger proportion of their total income from rice and/or where they are not too far below the poverty line.

These poverty impact estimates derived from the sample are extrapolated to the national level to estimate the likely total impact on poverty. In total, 6,000–12,000 poor people could be lifted above the poverty line in the short term and 31,000–41,000

Table 27. Effects of a gain in yield of rice on average household income.

Item	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Average rice yield (t/ha)	3.70	5.13	3.68	2.90	3.67
% of rice income in total income	10	16	33	14	16
Scenario 1: Short term (10% yield gain)					
Additional household income ($)	87	125	95	79	92
% income increase	2	3	5	3	3
Scenario 2: Medium term (20% yield gain)					
Additional household income ($)	174	251	190	158	185
% change in household income	5	5	11	5	6

Table 28. Estimated effect of a yield gain in the short and medium term on poverty incidence.

Item	Punjab	Sindh			All
	DG Khan	Badin	Larkana	Shikarpur	
Poverty ratio in the survey (%)	42	36	86	63	62
Depth of poverty (poverty gap index)	0.18	0.15	0.49	0.35	0.31
Short term					
Additional income per capita ($)	20	23	18	14	18
Poverty ratio (%)	38	31	85	62	59
% poor lifted above the poverty line	9	14	2	2	4
Medium term					
Additional income per capita ($)	40	47	35	29	36
Poverty ratio (%)	38	26	82	61	57
% poor lifted above the poverty line	9	26	5	3	7

Data source: IRRI GSR project, household survey 2010.

Table 29. Number of poor people that could be lifted out of poverty in Pakistan.

Time period	Adoption rate[a] (%)	% of poor lifted out in the survey[a]	Number of poor lifted out in the country (persons)
Short term	10	4	5,888
	20	4	11,776
Medium term	30	7	30,912
	40	7	41,217

[a]The adoption rate is assumed for short-term and long-term adoption. Data source: The percentage of poor lifted out of poverty in the survey is 8–16% for a 20–40% yield increase in Table 27.

people in the medium term as a result of the adoption of these improved varieties in Pakistan (Table 29).

Thus, the potential impact on poverty reduction is considerable. In addition, the increased production can be sufficient to feed an additional 0.41–0.83 million people in the short run and 2.5–3.3 million people in the medium run (Table 30).

Summary of main findings

- There were two spikes in rice production in the last decades attributed to the Green Revolution in the 1970s and the adoption of hybrid rice in the 1990s.
- Punjab and Sindh are the two main rice-producing areas. Basmati and IRRI varieties are popular varieties.
- The average farm size is 3 ha per household. Farm size varies greatly from 0.2 ha to 20 ha per household in the survey and more than 80% of the households have less than 4 ha.

Table 30. Additional people in Pakistan that can be fed with increased production.

Time period	Adoption rate (%)	Target area (000 ha)[a]	Increase in yield (t/ha)[b]	Increase in production (million tons)	Value of increased production at farm-gate price[c] (million US$)	Expected consumption per capita (kg milled rice)	Additional number of people who can be fed with increased production (million)
Short term	10	237	0.23	0.05	11	87	0.41
(3–5 years)	20	473	0.23	0.05	22	87	0.83
Long term	30	710	0.46	0.22	65	87	2.48
(10–20 years)	40	946	0.46	0.32	87	87	3.30

[a]Target area is the rice area in 2010 multiplied by the adoption rate, which is 10–20% for the short term and 30–40% for medium term. [b]Increase in yield is 10% and 20% in 2010 for short term and medium term, respectively. [c]Farm-gate price of rice is $200 per ton.

- Over one-third of the land is sharecropped in Pakistan. Around 10% of the rice area is rainfed, which indicates good irrigation in the sampled area.
- Hybrid rice is adopted widely in Badin District and accounts for 62% of the rice area. Rice yield in Badin (5.16 t/ha) is much higher than in other districts.
- The nature of popular varieties varies across the survey sites. On average, IRRI-6 and IRRI-9 account for 56% and 12%, respectively. The hybrid rice Pukhraj is popular in Badin and occupies half of the rice area.
- High yield and good eating quality are preferred by 61% and 24% of the households, respectively. Those with a higher share of marketed rice surplus focus more on rice varieties with higher yield.
- Both farm and nonfarm activities are important for livelihood strategy. Some 80% of rice production is sold and used as payment. Rice and wheat are important for food security and household income.
- Improved GSR technologies that increase rice yield could increase average household income by $92–185 depending on the amount of yield increase. This income gain can be translated into a 4–7% reduction in the incidence of poverty.
- The potential impact on poverty reduction is considerable. In total, 6,000–12,000 poor people could be lifted above the poverty line in the short term and 31,000–41,000 people in the medium term.

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Appendix I

Recommended amount of fertilizer for rice (kg/ha).

Province	Nitrogen	Phosphorus[a]	Potassium[a]
Punjab II	75–160	29	50
Sindh II	134–180	29–44	42
NWFP I	120–150	29	50
Balochistan III	120	29	42

[a]Derived from phosphate (43.6% P) and potash (83% K). Data source: FAO (2004). Fertilizer use by crop in Pakistan.

Pattern of varietal adoption and economics of rice production in Sri Lanka

Huaiyu Wang, Orlee Velarde, Ranjika Walisinghe, R.M. Herath, and Darshana Rajapaksa

Introduction

Country background

Sri Lanka is part of the South Asian region, located next to the southern tip of India. The country has an area of 65,610 km^2 and the population in 2010 was 20.65 million. GDP per capita for 2010 was reported to be US$2,399, with a poverty ratio of 8.9%. Agriculture accounts for 12% of GDP and 33% of employment. Rice contributed 1.8% to the GDP of Sri Lanka in 2010 (Table 1).

The country has three agro-climatic zones: the wet zone in the southwest, the dry zone in the north and east, and the intermediate zone in between. This Zoning is based on the amount of rainfall (Fig.1). Two monsoons, the northeast (December to February) and southwest (May to September), and two intermonsoons bring rains to the country (Weerakoon et al 2011). Rice is the second-largest crop after tea. Rice consumption per capita for 2010 was estimated to be 116 kg (Table 1).

Objective

Table 1. General characteristics of Sri Lanka.

Characteristic	Number
Total land area (000 km^2)	65.61
Population in 2010	20,653,000
Employment in 2010	7,707,000
Agriculture (%)	32.7
GDP in 2010 (US$ billion)	49.58
Agricultural GDP (%)	11.9
Rice GDP (%)	1.8
GDP per capita in 2010 ($)	2,399
Rice consumption per capita (kg/person/year)	116
Poverty ratio in 2010b (%)	8.9
Average production of paddy (t), 2008-10	3,944,000
Average Maha paddy production (t), 2008-10	2,630,000
Average harvested rice area (ha), 2008-10	906,000
Average yield of paddy (t/ha), 2008-10	4.35

[a]Paddy statistics of Sri Lanka (2009).
[b]Poverty indicators. Department of Census and Statistics, Sri Lanka. May 2011. www.statistics.gov.lk/poverty/PovertyIndicators2009_10.pdf
Data source: Central Bank of Sri Lanka annual report (2010).

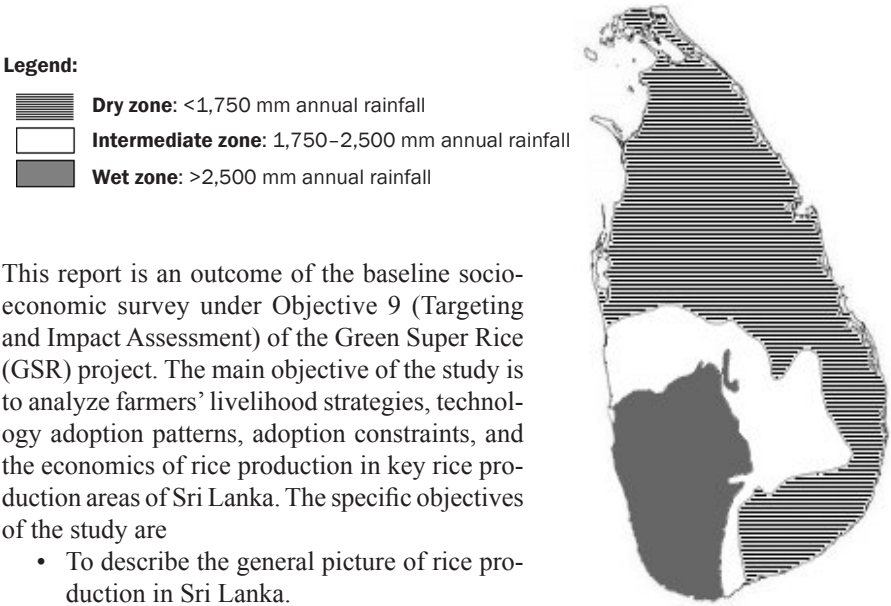

Fig. 1. Agro-climatic zones in Sri Lanka.

This report is an outcome of the baseline socio-economic survey under Objective 9 (Targeting and Impact Assessment) of the Green Super Rice (GSR) project. The main objective of the study is to analyze farmers' livelihood strategies, technology adoption patterns, adoption constraints, and the economics of rice production in key rice production areas of Sri Lanka. The specific objectives of the study are

- To describe the general picture of rice production in Sri Lanka.
- To analyze the patterns of varietal adoption.
- To analyze the economics of rice production in key production areas.
- To analyze farmer livelihood strategies and gender roles in rice production,
- To generate guidelines for rice technology design, targeting, and policy reforms for increasing rice production through increased adoption of improved technologies.

Organization of the report

This chapter is organized as follows. The first section provides background information on Sri Lanka. The next section briefly describes the rice production trends in Sri Lanka in the last decades as well as related policies. The third section analyzes the economics of rice production based on the household survey. The fourth section focuses on the pattern of varietal adoption. Based on the potential yield gain and technology adoption rate, an ex ante impact assessment of improved varieties being developed under the GSR project is conducted in the fifth section. The final section provides a summary of the main findings and implications.

Rice production in Sri Lanka

Rice is the most important staple crop of Sri Lanka as it accounts for more than 40% of the daily calorie intake. Sri Lanka is largely self-sufficient in rice with minimal trading activities. More than 90% of the domestic supply of rice is consumed as food. Government policies aim to achieve food security by increasing and stabilizing rice production.

Rice production in Sri Lanka has continued to increase over time (Fig. 2) because of technological improvements, increased fertilizer use, land expansion, and

various policy support by the government (Walisinghe et al 2010). It is possible to discern three distinct trends in rice production during 1961-2009. Between 1961 and 1984, rice area, yield, and production were increasing, with the annual growth rates of yield and area being 2.55% and 1.64%, respectively. This led to a 4.19% annual growth rate in rice production during this period. By the 1980s, rice area had reached 750,000 ha.

During 1985-2000, the growth rate in rice production slowed down considerably, with the annual growth rate being only 0.66% (Fig. 2). The area of rice even decreased slightly. After 2000, the growth in rice production picked up once again, with both rice area and yield increasing rapidly. The annual growth rate of rice area and yield was 2.6% and 1.41%, respectively, and the rice production growth rate reached 4% (Table 2). Favorable weather, a better policy environment, and the rapid spread of improved technology contributed to this increase in production growth. Cropping intensity also increased from around 119% to 147%. The implementation of supportive policies coupled with special extension programs and new technologies contributed substantially to the production growth. In 2005, a price support system called "guaranteed price scheme" and a new fertilizer subsidy program were also implemented.

The trend in the coefficient of variation (CV) of production indicates that, overall, Sri Lanka has been able to achieve both production growth and stability simultaneously (Fig. 3). In more recent years, there has been some tendency toward increased production variability, which is driven mainly by increased area variability as yield variability has continued to decrease over time and has remained quite low in recent years.

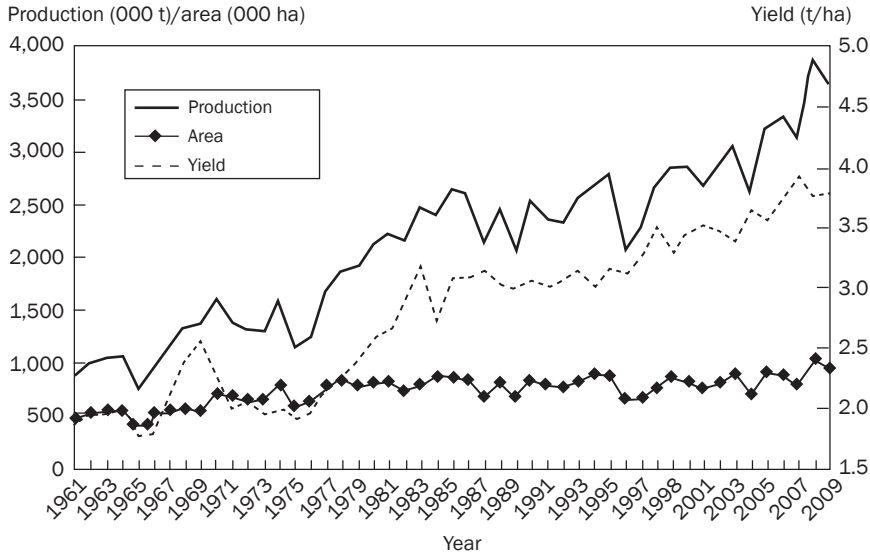

Fig. 2. Production, area, and yield of rice in Sri Lanka. Data source: FAOSTAT.

Table 2. Moving growth rates of rice production (%).

Years	Production	Area	Yield
1961-84	4.19	2.55	1.64
1985-2000	0.66	−0.19	0.86
2001-09	4.01	2.60	1.41

Data source: calculation based on data from FAOSTAT.

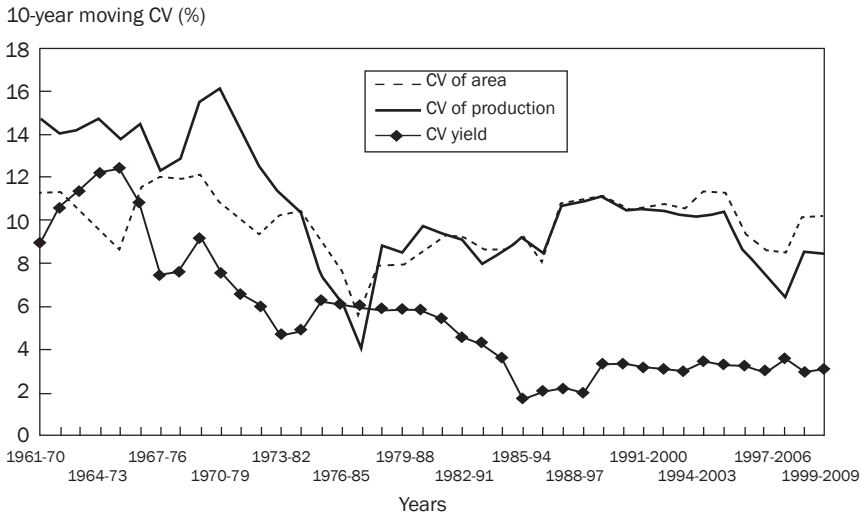

Fig. 3. Coefficient of variation of rice yield in Sri Lanka. Data source: calculation based on data from FAOSTAT.

The rice calendar in Sri Lanka

Sri Lanka has two rice-growing seasons per year. The maha season is the main season for rice production and accounts for around two-thirds of rice production (Table 1). The maha season receives the intermonsoon rain and the northwest monsoon, which is well distributed all over the island. In the yala season, rainfall occurs mostly in the southwest region of the country. The rice area in the yala season is less than in the maha season (Weerakoon et al 2011).

The maha season covers the period from late September to February while the yala season spans the period from early April to early September. The cropping calendar varies slightly across different regions of Sri Lanka based on local factors. At the survey sites, farmers mostly grow maha rice from October to February and yala rice from April to August (Table 3).

Sri Lanka has two types of irrigation schemes, major and minor irrigation. As of 2007, major irrigation covered 53% while minor irrigation covered 21% of the total rice land. Agro-wells are large wells that are used as alternative water sources

Table 3. The rice calendar in a normal year in Sri Lanka. ■ = maha, □ = yala.

Stress	Province	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Drought	Kurunegala (MI)		■	■	■	■	■	□	□	□	□	□	□
Drought	Kurunegala (RF)		■	■	■	■	■	□	□	□	□	□	□
Submer-gence	Kalutara		□	■	■	■	■	■	□	□	□	□	□
Salinity	Puttalam		■	■	■	■	■	■	□	□	□	□	□

Data source: FGD survey in GSR project 2010.

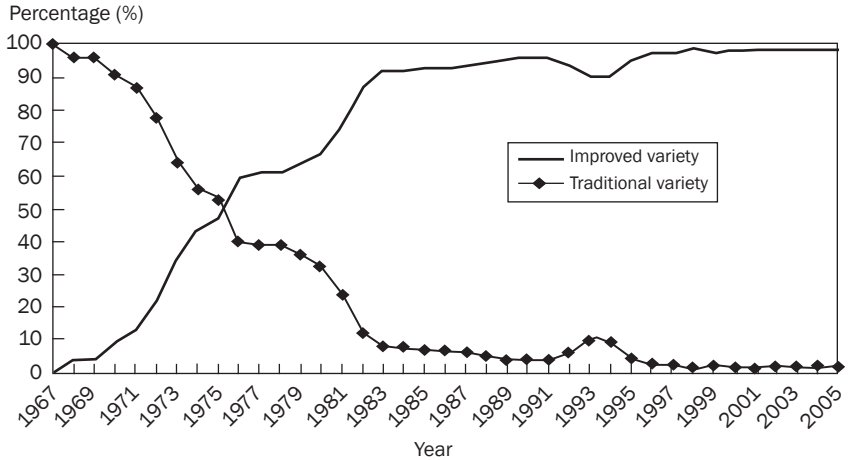

Fig. 4. Percentage area covered by rice varieties in Sri Lanka. Data source: Rice Research and Development Institute (RRDI), 2011.

to irrigate rice land. In 2010, rice sown area in Sri Lanka was estimated to surpass 1 million hectares with 21% of the area being rainfed.

Variety adoption in Sri Lanka

Farmers in Sri Lanka generally choose varieties based on the maturity period; thus, the maturity period is used as an indicator to identify the dominant varieties. This information is also used in the household-level analysis.

Before 1958, the rice varieties in Sri Lanka were all traditional varieties, 1.5–2.0 meters tall. From 1958 to 1970, a substantial part of Sri Lanka's rice area was planted to the "H" series of improved traditional rice varieties, which are intermediate in height. These varieties are considered traditional as they do not contain the dwarfing gene.

In 1968, Sri Lanka imported IR8 seeds for production and for breeding. Taking IR8-246 as the female parent, variety Bg 34-8 with 3 months' maturity and Bg 34-6 with 3 ½ months' maturity were officially released in 1971. Newer varieties with the dwarfing gene and with short duration were developed subsequently. These are commonly known as improved varieties (Fig. 4).

Up until 2010, a total of 69 improved varieties had been released in Sri Lanka (RRDI 2011). The varieties released were divided into groups in terms of their maturity duration. By 2009, the shorter maturity varieties (85–105 days) became the dominant varieties that accounted for 91% of the rice area in both the maha and yala seasons (Table 4).

The Rice Research and Development Institute (RRDI) of the Department of Agriculture is the main public institute responsible for rice breeding in Sri Lanka. The rice variety names starting with "Bg" are bred in Batalagoda, with "At" in Ambalanthota, with "Ld" in Labuduwa, and with "Bw" in Bombuwela. The top 15 popular varieties, each covering at least 1% of the total rice area, have a maturity period of 3 ½ months (Jayawardena et al 2010). Eleven of them belong to Bg varieties and they are followed by three At varieties and one Ld variety.

These popular varieties are grown widely across districts that represent different environmental conditions, indicating their wide adaptability. The top three varieties, Bg 300, Bg 352, and Bg 358, are grown in 23 out of 25 districts and together they account for around half of the total rice area in the country. High yield, short maturity, good adaptability, and good grain quality are the main reasons for their popularity (Table 5).

Considering only those varieties that each occupy at least 5% of the total rice area, the trends in the area shares of popular varieties are shown in Figure 5. The area shares of the popular varieties Bg 300, Bg 352, and Bg 358 seem to have stabilized during 2000-10. The share of At 362, which is the only variety released after 2002, has increased. The share of Bg 359 (released in 1999) has similarly increased over time.

The rice varieties are released by the Seed and Planting Material Development Center (SPMDC) in Sri Lanka. Figure 6 shows the rice seed chain. The improved

Table 4. Rice varieties cultivated based on maturity period in 2009.

Maturity period	Number of varieties released	Area (000 ha)			% of the total		
		Maha	Yala	Total	Maha	Yala	Total
5–6 months (150–180 days)	5	1.1	0.1	1.2	0.2	0.0	0.1
4–4 ½ months (120–135 days)	24	57.7	23.5	81.2	9.1	7.4	8.5
3 ½ months (99–105 days)	24	424.9	223.6	648.5	67.3	70.0	68.2
3 months (85–90 days)	14	146.0	71.1	217.2	23.1	22.3	22.8
2 ½ months (70–80 days)	2	1.3	1.2	2.6	0.2	0.4	0.3
Total	69	631.1	319.6	950.7	100	100	100

Data source: RRDI (2011).

Table 5. Popular rice varieties in Sri Lanka.

Duration (in months)	Variety	Year of release	No. of districts	Area in 2009 (000 ha)			% of area			Reasons
				Maha	Yala	Annual	Maha	Yala	Annual	
3	Bg 300	1987	23	120	53	173	18.9	16.7	18.2	Higher yield, earliness, adaptability
3	Bg 305	1999	13	9	4	14	1.5	1.4	1.5	Higher yield, good eating quality, earliness
3	At 307	2005	14	6	4	10	0.9	1.2	1.0	Higher yield, good grain quality
3 1/2	Bg 350	1986	17	8	5	13	1.2	1.6	1.3	Red pericarp, good eating quality
3 1/2	Bg 352	1992	23	113	50	163	17.8	15.6	17.1	Higher yield, earliness, wider adaptability
3 1/2	Bg 357	1997	18	12	15	27	1.9	4.6	2.8	Higher yield
3 1/2	Bg 358	1999	23	102	41	143	16.1	13.0	15.0	Higher yielding samba, high price
3 1/2	Bg 359	1999	18	30	21	51	4.8	6.5	5.4	Higher yield, good plant growth on less favorable lands
3 1/2	Bg 360	1999	24	17	9	26	2.6	2.9	2.7	Good taste, high price
3 1/2	Bg 94-1	1975	15	54	28	82	8.5	8.9	8.6	Higher yield, good as parboiled rice
3 1/2	At 362	2002	14	37	15	52	5.8	4.8	5.5	Red pericarp, good eating quality
3 1/2	At 353	1992	23	22	10	32	3.4	3.1	3.3	High yield, good as parboiled red rice
3 1/2	Ld 356	1994	18	12	11	23	1.9	3.5	2.4	Red pericarp, good eating quality
4–4 1/2	Bg 379-2	1980	20	14	8	23	2.3	2.7	2.4	Good for boggy and Fe-toxic soils, better taste
4–4 1/2	Bg 403	1993	17	10	2	12	1.6	0.6	1.3	Blast and BLB resistant, higher yield
	Others			68	41	109	10.7	12.9	11.4	
	Traditional			1	0	1	0.2	0.1	0.1	
	Total			632	320	952	100	100	100	

Data source: RRDI (2011), Jayawardena et al (2011).

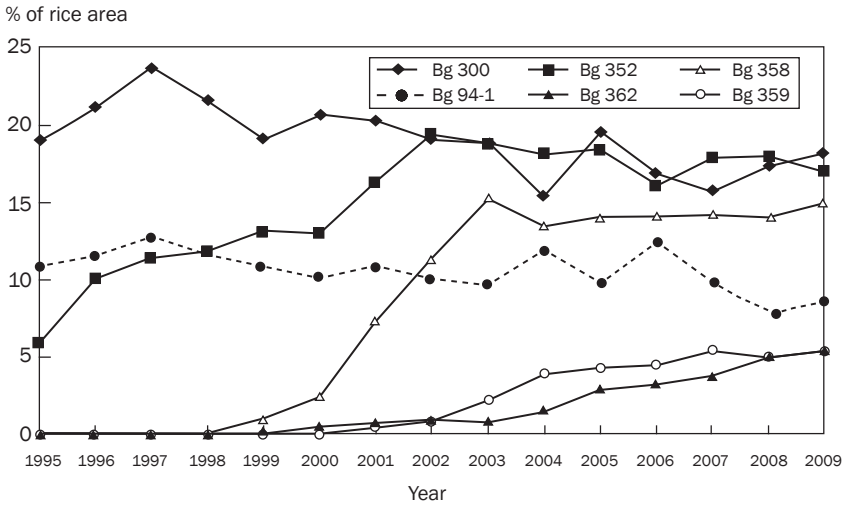

Fig. 5. Trends of popular varieties in Sri Lanka. Data source: 1995-2007 data from Paddy Statistics of Sri Lanka (2009). 2008-09 data from AgStat Vol. VI & VII, pocket book of agricultural statistics. Socioeconomic and Planning Center.

varieties released in Sri Lanka generally come from RRDI. Private companies collect farmers' seed requests and feed back the requirements to breeders through the SPMDC. Basically, rice breeding in Sri Lanka is carried out by the public sector, with the private sector being involved mainly in seed multiplication and distribution.

Rice policy in Sri Lanka

A number of policies are designed to encourage rice production in Sri Lanka. These policies cover input subsidies and price support for outputs. The details are summarized in Annex I.

The government of Sri Lanka has used trade and marketing policies to benefit both consumers and producers. The government specifies a ceiling price in the market to protect consumers and a floor price to support rice farmers. The Paddy Marketing Board (PMB) is a key agency implementing these policies. Another important policy is input subsidy. The government subsidized fertilizer for rice production at a fiscal cost of Rs 27 billion (around US$24.5 million) in 2009. The market price of fertilizer without the subsidy is Rs 120/kg and the subsidy accounts for nearly 95% of the price. Irrigation is similarly subsidized, with farmers receiving irrigation free of cost. At the beginning of 2011, Sri Lanka began a specific 3-year project with Rs 700 million (about $6.4 million) to develop the seed sector. The government also implemented a land policy that restricts any shift of rice land to other crops without government permission to maintain rice area.

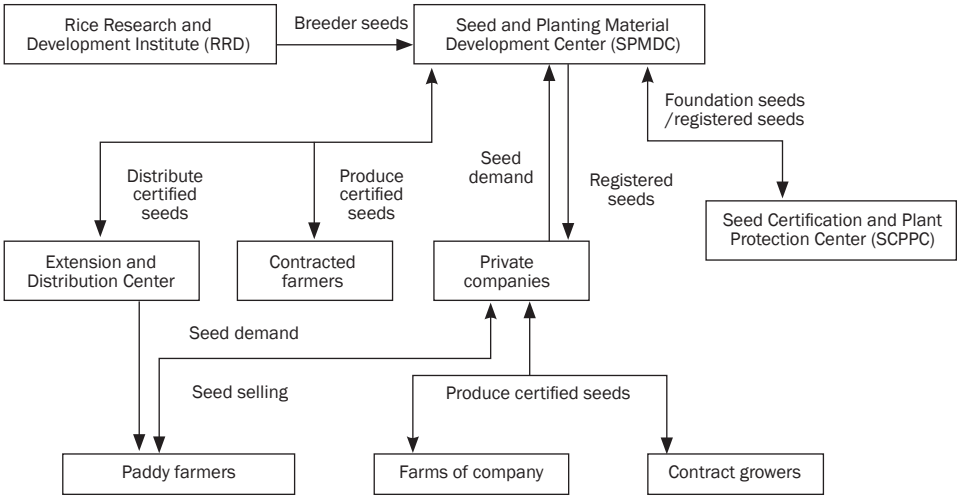

Fig. 6. The rice seed distribution system in Sri Lanka.

The farm household

Survey sites and sampling design

The farm-level data collected were based on 2009 Yala and 2009-10 Maha seasons. The Socioeconomic and Planning Center (SEPC) of the Department of Agriculture of Sri Lanka implemented the survey. Three districts, Kalutara, Kurunegala, and Puttalam, were selected for the household survey as rice production in these districts is known to be affected by both biotic and abiotic stresses. Of these, Kurunegala is divided into two categories in the survey, minor irrigated (MI) and rainfed (RF). A total of 404 respondents participated in the survey, which was implemented in 2010. The survey included information on farmers' resource endowment, rice varieties grown, rice yield, rice production, income structure, and other related information. In addition, detailed information on inputs, power, and labor use and costs of rice production was collected from a subsample of 121 households or 30% of the total sampled farmers. Figure 7 shows the location of the survey sites.

Kalutara District is located in the Western Province of Sri Lanka. It is situated in the wet zone, where the average annual rainfall surpasses 2,500 mm. It represents the submergence-prone area and farm households at the survey sites suffer from submergence almost every year. Flooding usually occurs in May and October. According to information obtained from focus group discussions, flooding duration is 7–21 days, with a water depth of 3–5 meters. Rice area in the district in 2010 was 25,000 ha, with an average yield of 3 t/ha.

Kurunegala District is located in the Northwestern Province of Sri Lanka and represents the intermediate zone, in which average annual rainfall is 1,750–2,500

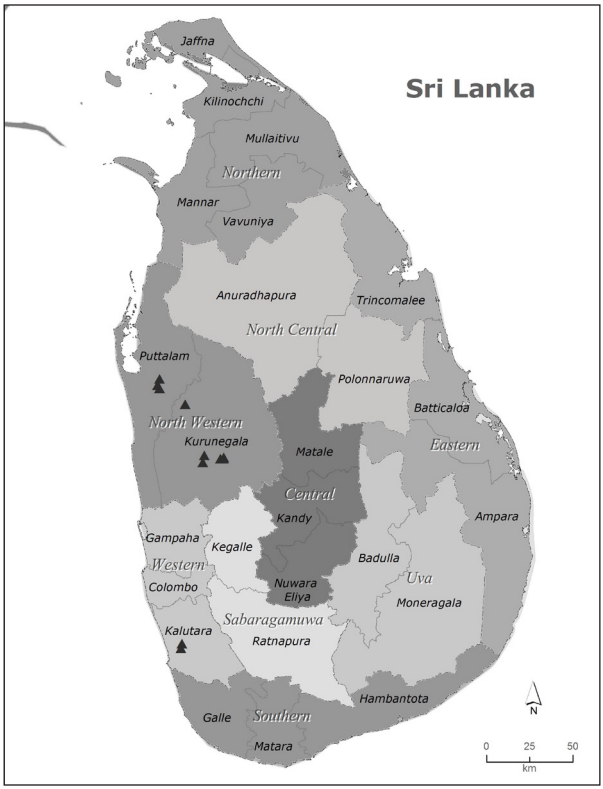

Fig. 7. Location of survey sites.

mm. Kurunegala is divided into two categories: minor irrigated and rainfed. It is one of the major paddy-producing districts and it accounts for 12% of national paddy production. In 2010, rice cultivated area surpassed 124,000 ha, with an average yield of 4 t/ha. Drought is a frequently occurring stress that adversely affects rice production, especially in rainfed areas. According to information obtained during the focus group discussions, drought was reported 2–4 times during the past 10 years. June, July, and August are the months with drought occurrence. Yield loss due to drought was subjectively estimated by local farmers at 50%.

Puttalam District is located in the Northwestern Province of Sri Lanka. This district belongs to the dry zone, in which annual rainfall is below 1,750 mm. In 2010, rice cultivated area in the district was 20,100 ha, with an average yield of 3.8 t/ha. The survey sites have access to minor and major irrigation but suffer from inland salinity. Tables 6 and 7 show a summary of the main characteristics of the selected districts and stress occurrence.

Table 6. Summary of the investigated districts

District	Agricultural zone[a]	Mode of Irrigation[a]	Harvested area[b] (000 ha)		Production ('000 tons)[b]		Yield (t/ha)[b]		Stress[a]
			Maha	Yala	Maha	Yala	Maha	Yala	
Kalutara	Wet zone	Rainfed	11	9	34	25	3.06	2.88	Submergence
Kurunegala (MI)	Intermediate	Minor irrigation	33	18	132	59	4.01	3.19	Drought
Kurunegala (RF)	Intermediate	Rainfed	27	18	96	56	3.52	3.19	Drought
Puttalam	Dry zone	Irrigation	7	5	27	18	3.71	3.55	Salinity

[a]From FGD survey of GSR project in 2010.
[b]Three-year average (2008-10), From Paddy Statistics of Sri Lanka (2010), Department of Census and Statistics.

Table 7. Characteristics of sampled villages.

Stress/district	Village	Severity of latest stress	Duration (days)	Depth (m)	Years	Months	No. of households
Submergence (Kalutara)	Thudugala	Severe	14	3	Every year	May, Oct	33
	Thebuwana	Severe	14–21	3–4	Every year	Apr, May, Oct	37
	Thebuwana West	Severe	7	5	Every year	May, Oct, Nov	30
Drought (Kurunegala, MI)	Dalupothagama	Moderate	60		2000, 2003, 2009	Aug, Apr	32
	Kurakkanahnegedara	Severe	45		2006, 2007	Jun, Jul	34
	Thoranegedara	Severe	45		2007, 2008, 2009	Jul, Aug	36
Drought (Kurunegala, RF)	Siwallawa	Moderate	60		2005, 2009	Feb, Mar, Aug	26
	Mirihanpitiya	Low	30		2000, 2001, 2005, 2006	Jun, Jul	16
	Thanawatte	Moderate	30		2005, 2009	May, Jul	60
Salinity (Puttalam)							
	Wadaththa	Severe	–	–	Every year	–	31
	Viharagama	Moderate	–	–	Every year	–	8
	Kottukachchiya	Severe	–	–	Every year	–	61

Data source: FGD survey of GSR project in 2010.

Stresses affecting rice production

The majority of the surveyed farmers mentioned that various stresses affect rice production (Table 8). The reported yield losses, estimated by farmers subjectively, were substantial and ranged between 23% and 56%.

Demographic characteristics

The average household size in the sample areas is about 4 members (Table 9). This result is comparable to the national average of the country based on the 2009-10 Household Income and Expenditure Survey conducted by the Department of Census and Statistics of Sri Lanka.

A majority of the surveyed respondents or those who manage the farm are males, with only about 8% being females. The average number of years of schooling is 9, which is relatively high compared with that of other South Asian countries. The government of Sri Lanka provides free basic education up to the secondary level, which usually requires 9–10 years of schooling.

The primary occupation of the surveyed farmers is agriculture, employment in private and government institutions, seasonal jobs, and business. A majority of the respondents (74%) are engaged in farming as their primary occupation (Table 10). In Kalutara, the proportion of respondents who considered farming as the primary occupation is lower than in other districts as Kalutara is more urbanized and developed.

Table 8. Percentage of area and households affected by stresses and yield loss estimated by farmers.[a]

Stress/district	Villages	% of rice area affected by stress	% of households affected by stress	% yield loss	
				Maha	Yala
Drought (Kurunegala)	Dalupothagama	50	100	48	56
	Kurakkanahnegedara	80	95	50	53
	Thoranegedara	80	90	41	41
	Siwallawa	100	85	51	50
	Mirihanpitiya	83	70	44	48
	IThanawatte	50	70	52	55
Submergence (Kalutara)	Thudugala	100	80	37	23
	Thebuwana/Ihalagama	84	80	59	–
	Thebuwana/Alegoda	99	99	33	42
Salinity (Puttalam)	Wadaththa	75	100	40	35
	Viharagama/ Halmillawewayaya	90	64	58	58
	Kottukachchiya	100	90	51	46

[a]Information collected from focus group discussions.
Data source: FGD survey of GSR project in 2010.

Table 9. General household characteristics.

Item	Kalutara	Kurunegala (MI)[a]	Kurunegala (RF)[a]	Puttalam	All
Sample size	100	102	102	100	404
Household size	4.0	4.0	3.8	3.9	3.9
Respondent info					
No. of female respondents	6%	9%	7%	10%	8%
Average age (years)	55	51	53	50	52
Average years of schooling	8.6	9.1	9.0	8.2	8.7

[a]MI refers to minor irrigated area and RF to rainfed area.
Data source: IRRI GSR project, household survey 2010.

Table 10. Primary occupation (%) of the respondents.

Item	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
Agriculture	53	76	83	78	74
Regular jobs (private and government)[a]	27	8	8	12	13
Seasonal/temporary jobs	9	7	6	7	7
Business[b]	11	8	3	4	6

[a]Permanently employed in both private and government institutions. [b]Self-employed activities.
Data source: IRRI GSR project, household survey 2010.

Rice is the main crop in Kurunegala and Puttalam and, in addition to rice, farmers grow coconut and field crops such as groundnut and cowpea.

Farming conditions

Farm size in the sampled districts ranges from 0.98 to 1.86 ha (Table 11). In Puttalam, farm size is larger than in Kalutara and Kurunegala. In terms of elevation, all farms are in lowland areas. Land that has been prepared or developed by constructing bunds or dikes for rice cultivation is known as "rice land." Rice lands are situated on fields lower than nonrice lands to facilitate water retention during cultivation. In terms of Sri Lanka land-use policy, farmers are not allowed to shift paddy land to other crops without government permission.

Most of the land is owner-cultivated with only a small proportion being rented. Renting of land may be on a fixed-payment basis or on a share-cropping basis. If the owner provides inputs such as fertilizer, pesticides, and machinery, the harvest is shared, with the most common sharing being on a 50% basis. If the owner doesn't supply inputs, the owner receives only a 25% share of the harvest.

Table 11. Landholding characteristics.

Item	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
Average farm size (ha)	1.03	1.01	0.98	1.86	1.22
By land type (%)					
Rice land	65	46	61	54	56
Nonrice land	35	54	39	46	44
By tenure (%)					
Owned/shared crop[a]	95	98	99	96	97
Rented-in	0	1	1	2	1
Rented-out	0.3	0	0	0	0.1
Government	4	1	0	2	2
Source of irrigation for rice land only[b] (%)					
Rainfed	100	19	100	28	60
Minor irrigated	0	81	0	66	38
Major Irrigated	0	0	0	6	2

[a]Landowner owns shared crop land. [b]It is the percentage of the gross cultivable area combining Maha and Yala cropping seasons.
Data source: IRRI GSR project, household survey 2010.

Table 12. Percentage of cropped area for nonrice crops.

Crops grown	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
Coconut	9	65	72	46	50
Mixed crops	24	32	22	37	31
Rubber	56	0	0	0	10
Others	11	3	5	17	10

Data source: IRRI GSR project, household survey 2010.

Some farmers use government lands for crop cultivation, particularly in reserved forest areas and reservations. During the yala season, farmers who are short of irrigation tend to clear nearby forest areas for *chena* (slash-and-burn) cultivation. This can be observed only in the dry part of the district but not in the wet part.

Land use

Rice is cultivated exclusively in the lower fields while nonrice crops such as coconut, rubber, and vegetables are grown in the higher fields. The land use for nonrice crops at the survey sites is shown in Table 12.

Coconut cultivation in Kurunegala District is prominent and thrives well in the wet part of the district. Other crops such as vegetables, betel leaves, and banana are grown mainly for home consumption. In Kalutara, rubber is a major perennial crop.

Table 13. Cropping intensity.

Land type	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
Rice land	1.2	1.9	1.9	1.4	1.5
Nonrice land	0.9	0.9	1.0	0.8	0.9

Data source: IRRI GSR project, household survey 2010.

Table 14. Percentage of cultivated rice area and yield by season.

Item	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
% cultivated to total rice area					
Maha	97	96	97	79	90
Yala	19	98	97	56	63
Yield (t/ha)					
Maha	1.9	3.0	2.4	3.6	2.7
Yala	1.3	2.5	2.2	3.2	2.5

Data source: IRRI GSR project, household survey 2010.

In general, the rice-rice cropping system is practiced on rice land. Two cropping seasons are possible in all districts even in rainfed areas since the rain is pronounced throughout the year (Table 13). The cropping intensity index of nonrice land is close to unity as nonrice crops are mostly perennial. For the rice land, cropping intensity in Kalutara is lower than in other districts because of the unfavorable climatic conditions and a high risk of crop failure due to flooding. The areas in Kalutara are flooded every year and farmers leave the land fallow, especially in the yala season.

Rice production

The availability of water from an irrigation system allows farmers to increase the area cultivated during the yala season such as in Kurunegala (MI) and Puttalam, where minor irrigation is available.

As shown in Table 14, yield in the yala season is lower than in the maha season. The low solar radiation limits rice yield during the yala season because of the high cloud cover.[1] In Kurunegala (MI) and Kurunegala (RF), the average rice yields of the surveyed farmers are 3 t/ha and 2.4 t/ha, respectively, in the maha season and 2.5 t/ha and 2.2 t/ha, respectively, in the yala season. The yields are below the district[2] and national averages (4.2 t/ha). In Kalutara and Puttalam, the average yield of the surveyed farmers is below the district average mainly because of submergence and salinity stresses, respectively.

[1]Sri Lanka Rice Knowledge Bank (2007). Accessed on 1 June 2011. www.knowledgebank.irri.org/sriLanka/agro_ecol_zone.html.

[2]It is 4 t/ha for minor irrigated rice and 3.7 t/ha for rainfed rice, Paddy Statistics of Sri Lanka (2009).

Puttalam has access to both major and minor irrigation, but only 79% of the rice land during the maha season is cultivated. This is mainly because farmers decide the rice area in terms of the amount of water stored for irrigation in tanks. If there is not enough water, farmers decrease the rice area.

Adoption of modern varieties

Most farmers prefer to cultivate varieties that have 3 to 3.5 months' maturity duration (Table 15). This is primarily because of short maturity and less demand for water. Farmers can effectively match the cropping calendar with the rainy season if they cultivate varieties with 3–3 ½ months' duration. Consumer preference for cooked rice of this specific group is also quite favorable.

Popular varieties and their yields. There is not much variation among farmers regarding the extent and types of rice varieties grown. The variety Bg 300 dominates in the sample. The majority of the farmers grow Bg 300, followed by Bg 352 and Bg 358, except in Kalutara (Table 16). In Kurunegala and Puttalam, more than 60% of the area cultivated is grown to Bg 300 while it is only 41–47% in Kalutara. A number of varieties other than Bg 300 jointly account for 40–60% of the area. About 20% of the area is occupied by either Bg 358 or Bg 352 in Kurunegala and Puttalam. In Kalutara, Ld 356 is popular and it is in second place after Bg 300.[3]

[3]More information on varieties is in Appendix II.

Table 15. Percentage area cultivated by maturity (age).

Months	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
2.5	0	4	2	5	3
3	47	71	72	66	65
3.5	53	25	25	29	32
4–4.5	0	0	1	0	0

Data source: IRRI GSR project, household survey 2010.

Table 16. Percentage of farmers who grow Bg 300, Bg 352, Bg 358, and Ld 356 and rice area.

Location	Percentage of farmers (%)					Percentage of area (%)				
	Bg 300	Bg 352	Bg 358	Ld 356	Others	Bg 300	Bg 352	Bg 358	Ld 356	Others
Kalutara	66	0	8	27	23	46	0	6	26	22
Kurunegala (MI)	79	15	17	–	15	69	9	10	–	12
Kurunegala (RF)	76	22	12	–	27	64	13	8	–	15
Puttalam	78	35	7	–	17	64	23	4	–	9
All	75	18	11	7	21	62	13	7	5	14

Data source: IRRI GSR project, household survey 2010.

Bg 300 is the most popular variety in all districts because of its short maturity time, good traits, and availability of seeds as well as good market price. It matures in 3 months and is suitable for the dry season in which rainfall is limited. This variety is an intermediate bold-grain type and farmers prefer its hardy texture when cooked. This variety was released in 1987 and is recommended for general cultivation.

The varieties Bg 352 and Bg 358 have intermediate bold-type grains and are also recommended for general cultivation. These varieties mature in 3 ½ months. Bg 352 is less popular than Bg 300 because of its susceptibility to lodging. Farmers from rainfed areas prefer to cultivate Bg 352 while farmers with access to irrigation prefer Bg 358. Variety Ld 356 is recommended for the low-country wet zone, which is represented by Kalutara District. Its red pericarp and good eating quality are special reasons for the cultivation of Ld 356 (Jayawardena et al 2010).

The yields of popular varieties in the maha season are generally higher than in the yala season. And, the yields vary across varieties and locations. Bg 352 has the highest yield in both maha (3.3 t/ha) and yala seasons (3 t/ha). The yield of the most popular variety, Bg 300, is slightly higher than the average but lower than that of Bg 352. The yield gap between Bg 300 and Bg 358 is not significant. The yields of popular varieties in Puttalam are all higher than 3 t/ha, which are higher than in other locations as well. Kalutara is also the location with the lowest yield in two seasons (Table 17).

Varietal traits preferred. Farmers were requested to provide a list of traits they prefer to see in a new variety. Thirty-eight percent of the farmers considered higher yield as the most important trait (Table 18). Other important traits desired by farmers are good grain quality and good taste. They also indicated a preference for varieties that are of short duration, semidwarf type with good tillering, and tolerant of abiotic stresses. On the other hand, farmers considered susceptibility to pests/diseases as the most common undesirable trait.

Farmers perceived that Bg 300 is the best variety based on its varietal traits (Table 19). Compared with two other popular varieties, Bg 300 was perceived to have very good characteristics, including higher yield, lodging and disease resistance, and good taste. Although not the highest yielding (Appendix III and Table 17), Bg 300 is popular because of its short duration. Other short-duration varieties are also popular in areas that are affected by drought. These varieties escape drought because the crop can be harvested before the rains cease. The earliness and good adaptability for general cultivation could be the key factors for the wide adoption of Bg 300.

Rice input use

Seed input. Information on costs and returns was collected from a subsample of 30 farmers from each district for both the maha and yala seasons as applicable. The results show that farmers use 128 kg of seed per ha on average, which is more than the government recommendation (Table 20). Seed usage did not vary much between maha and yala but it varied across rice ecosystems. In areas with access to irrigation such as in Kurunegala (MI) and Puttalam, farmers applied 30 kg/ha more seeds than in the rainfed areas in Kalutara and Kurunegala (RF). Seed prices vary with grain

Table 17. Yield of Bg 300, Bg 352, Bg 358, Ld 356, and other varieties by season (t/ha).

Varieties	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
Maha					
Bg 352	–	3.41	2.54	3.83	3.34
Bg 358	2.53	2.83	2.39	3.11	2.71
Bg 300	1.78	2.83	2.29	3.53	2.64
Ld 356	2.22	–	–	–	2.22
Other varieties	1.87	2.82	2.57	3.22	2.49
Yala					
Bg 352	–	2.76	2.25	3.53	2.98
Bg 358	2.10	2.62	1.76	3.75	2.54
Bg 300	1.40	2.31	2.21	3.05	2.42
Ld 356	1.24	–	–	–	1.24
Other varieties	0.92	2.27	2.23	3.39	2.48

Data source: IRRI GSR project, household survey 2010.

Table 18. Desirable and undesirable traits of the varieties that farmers grow.

Traits	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
Desirable traits (%)					
High yield	37	42	34	40	38
Resistant to lodging	10	10	14	7	10
Resistant to pests and diseases	18	14	13	11	14
Good eating quality	20	19	18	24	20
Good grain quality	14	14	21	15	16
High market price	1	2	1	3	2
Total responses (no.)	217	172	191	178	758
Undesirable traits (%)					
Low yield	18	14	26	13	17
Susceptible to lodging	6	11	11	18	12
Susceptible to pests and diseases	53	67	59	43	56
Poor eating quality	12	2	1	8	6
Poor grain quality	8	5	1	16	7
Low market price	3	1	1	1	2
Total responses (no.)	66	87	74	76	303

Data source: IRRI GSR project, household survey 2010.

Table 19. Reasons (%) for growing varieties based on farmers' perceptions.

Districts	Yield	Lodging resistance	Pest resistance	Taste	Grain quality	Price
Kurunegala and Puttalam						
Bg 300	66	61	59	58	65	18
Bg 352	16	21	22	13	16	27
Bg 358	9	4	7	9	9	27
Other varieties	10	14	12	19	10	27
Total responses (no.)	207	56	68	108	91	11
Kalutara						
Bg 300	63	52	49	30	43	0
Ld 356	19	19	21	37	27	33
Bg 358	6	0	8	14	10	33
Other varieties	12	29	23	19	20	33
Total responses (no.)	81	21	39	43	30	3

Data source: IRRI GSR project, household survey 2010.

Table 20. Seed input[a] by season (in kg/ha).

Season	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
Maha	109	132	128	142	128
Yala	92	133	124	139	128

[a]The government recommendation is 105 kg/ha.
Data source: IRRI GSR project, household survey 2010.

type. Short-grain (samba) seeds cost $0.43 per kg[4] while long-grain (nadu) seeds cost $0.39 per kg.

Fertilizer input. The average rate of fertilizer application (total NPK) is similar for both seasons (Table 21). Usually, the rate of fertilizer application is low in rainfed rice. According to the 2008-09 cost of cultivation survey conducted by the Department of Agriculture, the average usage of total fertilizer (NPK) is 125 kg per ha for rainfed areas and 180 kg per ha for irrigated areas.

All farm households apply nitrogen, with 60% of the farmers applying 100–150 kg/ha (Fig. 8). In terms of phosphorus application, 95% of the farmers applied up to 25 kg per ha of phosphorus. About 77% of the farmers also applied potassium from 30 to 60 kg per ha.

The Department of Agriculture in Sri Lanka provides recommendations on the optimal quantity of fertilizer for each agro-climatic zone and the growth duration of

[4]Short-grain (samba) varieties cost Rs 1,000/bu while long-grain (nadu) varieties cost Rs 900/bu. 1 bu = 21 kg.

Table 21. Fertilizer input by season (in kg/ha).

Season	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
Maha					
Total	129	152	153	177	153
N	63	101	101	118	96
P	14	16	16	20	16
K	52	35	35	39	40
Yala					
Total	101	148	150	165	148
N	50	96	98	109	95
P	13	16	15	19	16
K	37	36	37	37	37

Data source: IRRI GSR project, household survey 2010.

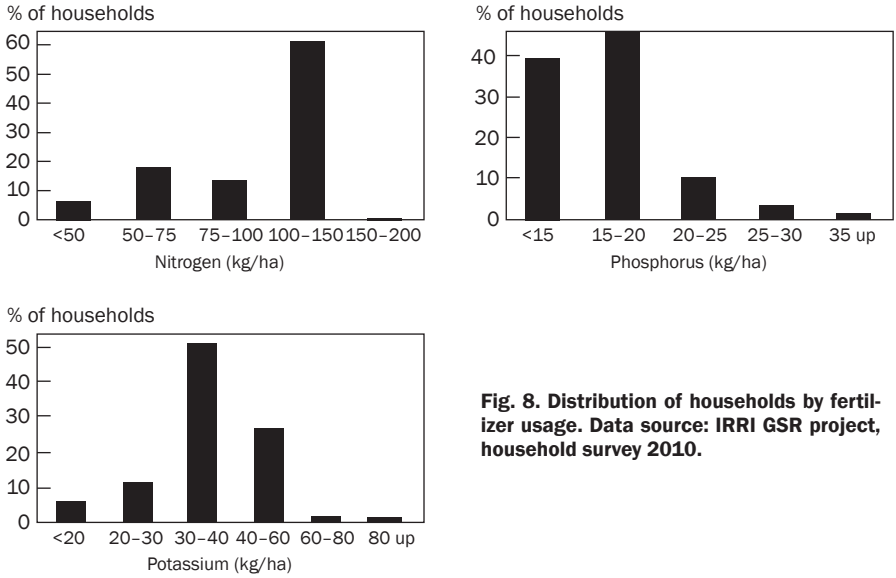

Fig. 8. Distribution of households by fertilizer usage. Data source: IRRI GSR project, household survey 2010.

the variety. The amount of fertilizer recommended also depends on the targeted yield. Since only two of the households reached a yield of 6 t/ha and most of them were below 5 t/ha, we took the recommended amount of fertilizer for 5 t/ha as a reference value to further analyze fertilizer inputs (Appendix IV).

In the survey area, only 17% of the farmers adhered to the recommended amount of N. A high percentage of farmers in Kalutara (73%) and Puttalam (100%) applied more than the recommended amount of nitrogen. For P usage and K usage, only 7% and 5% of the farm households interviewed followed the recommended amount,

respectively. Most farmers (90%) in all districts apply less than the recommended quantities of P. In contrast, many farmers (78%) applied more than the recommended amount of K. In general, there is a positive yield response to fertilizer within the application range observed, indicating that there may be some opportunity to raise yield by applying more fertilizer, especially to those fields where the current application rates are very low (Fig. 9).

Cash cost and its components. Because of the heavy subsidy, fertilizer cost accounts for only a small proportion of the cash cost. Unlike for fertilizers, there is no government subsidy for pesticides in Sri Lanka. Farmers shoulder the full cost of pesticides, which accounts for 46% of the total cash cost (Table 22). Most farmers apply herbicides to control harmful weeds in paddy instead of doing manual weeding.

The government of Sri Lanka does not collect irrigation fees from farmers. However, some farmers incur irrigation costs in terms of investments in irrigation pumps in areas where the water supply through surface irrigation schemes is limited.

Land preparation, threshing, and harvesting are mostly mechanized, especially in areas with higher yield. In the case of Kalutara, which has a lower yield, investment in machinery is less, and 44% of the farmers (Table 22) still continue to use draft animals for tillage. Some farmers own tractors but others hire on agreed rates that vary across locations. For land preparation, the charge is based on the area prepared and, for threshing, it is based on the number of hours/minutes operated.

Labor use and cost. The national average of total labor use for paddy cultivation ranges from 70 to 80 person-days/ha/season. The total labor use based on the survey data is close to the national level. Of the total labor requirement shown in Table 23, about 40% of the labor is used for harvesting and threshing. Operations such as crop care management also use more labor in irrigated conditions since the crop is grown more intensively than in rainfed conditions. Land preparation is basically done using a two-wheel tractor (2–3 plowings) and draft animals are barely used except in Kalutara. After plowing, leveling is done before seeding and leveling can take 2–4 weeks depending on the availability of water.

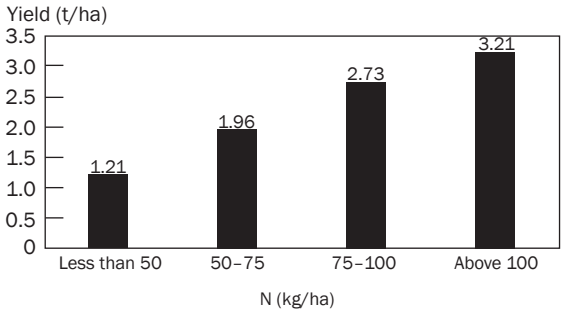

Fig. 9. Yield of farmers' plots by N fertilizer application. Data source: IRRI GSR project, household survey 2010.

Table 22. Distribution (%) of input and power cash cost.

Item	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
Material inputs					
Seed	50	24	22	24	28
Fertilizer	17	27	17	28	22
Herbicide and insecticide	33	49	46	48	45
Fuel cost for pump irrigation	0	1	0	0	0
Land rent	0	0	14	0	5
Total input cost (US$/ha)	111	87	136	96	107
Power use					
Animal	44	0	0	0	9
Tractor	29	66	59	64	56
Harvester, thresher, and winnowing fan	28	34	41	36	35
Total power cost ($/ha)	149	115	128	151	134

Data source: IRRI GSR project, household survey 2010.

Table 23. Distribution of labor use.

Item	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
Total labor use (%)					
Land preparation	22	20	24	20	21
Crop establishment	18	12	14	13	14
Crop care management	13	30	17	32	24
Harvesting and threshing	40	35	42	34	37
Postharvest activity	6	3	2	1	3
Total labor (person-days per ha)	63	68	67	77	69
Share of family labor in total labor (%)					
Land preparation	15	16	20	12	16
Crop establishment	8	10	13	7	10
Crop care management	12	30	16	30	23
Harvesting and threshing	14	28	32	20	25
Postharvest activity	4	3	2	1	2
Total family labor share	52	87	83	69	75

Data source: IRRI GSR project, household survey 2010.

Table 24. Distribution (%) of hired labor cost.

Item	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
Land preparation	16	30	28	26	23
Crop establishment	22	13	9	21	18
Crop care management	6	4	4	9	6
Harvesting and threshing	50	47	57	42	48
Postharvest activity	6	6	2	1	4
Total hired labor cost ($ per ha)	186	44	53	122	92
Total cost (in $ per ha)	376	328	312	399	350
Hired labor cost (%)	49	13	17	31	26
Imputed family cost (%)	51	87	83	69	74

Data source: IRRI GSR project, household survey 2010.

Most farmers use their own family labor for paddy cultivation except in Kalutara. Table 24 shows that, in Kurunegala (83–87%), the share of family labor imputed cost is relatively higher than for farmers in Kalutara (52%) and Puttalam (69%). In Kurunegala, the family labor contribution is high because their primary income source is farming and other employment opportunities are fairly low within the district. On the other hand, family members in Kalutara and Puttalam have largely shifted to nonfarming activities.

Most labor activities are also done by males, whose labor share is about 80%. Males mostly carry out power-intensive work such as tractor operation, bund clearing, and pesticide application, while females are mainly involved in crop establishment, harvesting, and threshing operations. Males receive $5–6 per day while females are paid $3–4 per day.

Costs and returns of rice production. Farmers in Kurunegala (MI) and Puttalam had relatively higher net returns primarily because of favorable conditions in irrigated areas. Returns are lower in Kurunegala (RF) and Kalutara, which are drought-prone and submergence-prone.[5] Except for Kalutara, the net cash income from rice production ranges from $408 to $608 per ha. Farmers in Kurunegala (MI) and Puattalam benefit more from rice production because of their good access to irrigation (Table 26). Production costs in both seasons are similar as well as net returns except in the case of Kalutara (Appendix V).

It is shown that the difference in labor cost is mainly reflected in the estimated net returns above cash costs. Although the total labor input in terms of person-days employed is similar across locations, the cash cost of labor input varies across locations depending on the proportion of hired labor used. Based on the 2008-09 Cost of Cultivation Survey of the Department of Agriculture, the average cash cost of paddy cultivation in Sri Lanka is $350–450 per ha during yala and $450–520 per ha during maha.

[5]Since the sample sites are located in stress-prone areas, it is expected that the net returns will be lower than the national average.

Table 26. Costs and returns of rice production.

Item	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
Yield (t/ha)	1.88	2.97	2.48	3.60	2.79
Average price (in $ per ton)	273	288	293	260	280
Gross income (in $ per ha)	513	853	724	937	780
Cash cost (in $ per ha)	446	246	317	368	332
Input cost (in $ per ha)	111	87	136	96	107
Power cost (in $ per ha)	149	115	128	151	134
Hired labor cost (in $ per ha)	186	44	53	121	91
Net cash income (in $ per ha)	67[a]	608	408	569	447

[a]Net cash income is low because of the high hired labor cost in Kalutara.
Data source: IRRI GSR project, household survey 2010.

Table 27. Crop disposal.

Item	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
% sold	19	35	40	56	43
% as food	50	36	34	24	32
% for future use	17	16	7	12	12
% for other use	6	4	9	2	5
% as payment	7	6	6	2	4
% as seeds	1	3	3	4	3

Data source: IRRI GSR project, household survey 2010.

Crop disposal

Most of the rice production is for home consumption in Kalutara whereas a large proportion is sold in Puttalam (Table 27). The price is similar across regions in Sri Lanka because of the guaranteed rice price system.

Income

Rice production accounts for less than 20% of the total household income (Table 28). The importance of rice income is much smaller in Kalutara than in other locations. Nonfarm income accounts, in most cases, for more than 50% of the total household income. This income structure indicates that rice is not as important as other sources of income for farmers' livelihoods. At the household level, the livelihood strategy is oriented more toward nonfarm income although rice production continues to remain important for food security.

Gender analysis

In rice farming in Sri Lanka, women's share of labor inputs during both maha and yala season rice production is less than one-fourth of total labor use. Women are mostly

Table 28. Income summary.

Item	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
% rice	1	15	12	16	11
% nonrice	12	19	6	7	10
% animal sales	28	5	32	3	17
% off-farm income	1	2	1	1	1
% nonfarm income	58	60	49	73	61
Regular jobs (private and government)	41	33	19	40	34
Seasonal/temporary jobs	1	6	7	4	5
Business	7	11	7	7	8
Others[a]	8	11	15	22	14
Total income (in $)	3,540	2,620	3,580	4,170	3,480
Household size	4.0	4.0	3.8	3.9	3.9
Per capita income (in $)	890	660	930	1080	890
Per capita income (in $) per day	2.44	1.81	2.56	2.95	2.44

[a]Other sources of nonfarm income include remittances, pension, transport operations, and selling of forest products.
Data source: IRRI GSR project, household survey 2010.

Table 29. Gender difference in labor use and wage rate.

Item	Labor use in Maha season		Labor use in Yala season		Wage rate ($/day/person)	
	Females	Males	Females	Males	Females	Males
Total labor (person-days per ha)	15	55	10	30	–	–
By type of labor (%)						
Land preparation	8	92	8	92	3.8	5.2
Crop establishment	14	86	19	81	4.1	5.3
Crop care management	8	92	6	94	4.0	5.7
Harvesting and threshing	39	61	42	58	3.9	5.3
Postharvest activity	33	67	30	70	4.1	4.8
Total labor	21	79	23	77	4.0	5.4

Data source: IRRI GSR project, household survey 2010.

involved in harvest activities. The wage rate of women farmers is much lower than that of men, around only 73% of men farmers' wage rate on average (Table 29).

Women in Sri Lanka are less empowered in most household decision making as the Women's Empowerment Index (WEI) is usually equivalent to or lower than 2.5, especially for selling decisions in farming activities. The WEI is relatively higher in income and expenditure allocation decisions than for other activities. On average, the WEI is 2.5 (Table 30).

Table 30. Women's Empowerment Index (WEI).

Type of decision	Value
Rice-farming decisions	
1. What rice variety(ies) to grow	2.1
2. Adoption of technology in rice production	2.2
3. What farm implements to purchase	2.2
4. Who and number of farm laborers to hire	2.2
5. Whether to sell or consume the harvested crop	2.4
6. Quantity of output to sell and consume	2.5
7. When and where to sell the harvested crop	2.3
8. At what price to sell the output	2.3
Income and expenditure	
9. Allocation of farm income	2.5
10. Allocation of household income	2.7
11. What types of food to consume in times of crisis	2.8
12. From where to borrow	2.7
Child care	
13. Children's education	3.0
Others	
14. Participation in voting/politics	2.5

Data source: IRRI GSR project, household survey 2010.

The result of the OLS regression model indicates that farm size has an insignificant effect on women's empowerment in Sri Lanka. Women's exposure to training had a positive significant effect on women's empowerment and the effect of training on the husband was negatively significant. The education of the wife and her contribution to nonfarm income increased WEI significantly. Similarly with Cambodia, the number of females in the household and the age of the wife also contributed to women's empowerment in family decisions (Table 31).

Impact assessment

GSR varieties are still in the trial stage and have not yet been released for farmers' adoption. Hence, the actual impact of these varieties cannot yet be assessed. Instead, an initial assessment of the potential impact of GSR varieties was conducted using the farm-level survey data and various assumptions on the size of the yield gain.

If the improved varieties developed under the GSR project lead to a 20% gain in yield at the farm level, this will translate into an income gain of $147 per household, other things remaining constant (Table 32), and a 20% gain in yield will translate into a 4% increase in household income, on average. A 40% gain in yield will result in a

8% gain in household income. Although these average figures on income growth are useful, it is important to estimate the income gains for each household for assessing the impact of such yield improvement on poverty reduction. The impact on poverty reduction can be assessed by comparing the new higher per capita income with the poverty line. This exercise was done under the assumption of 20% and 40% yield increases and adoption in 10% of the area in the short term (3–5 years after varietal release) and in 30% of the area ultimately (10–20 years). The results indicate that the adoption of GSR varieties with higher yields could potentially reduce poverty from

Table 31. OLS regression model of the factors contributing to women's empowerment.

Dependent variable is WEI	Coefficient[a]	t-value
Distance to market (km)	0.00178	0.18
Years of education of wife	0.0373**	2.14
Age of wife	0.0112***	2.73
Dummy for wife with nonfarm primary occupation	–0.123	–0.94
Percentage of females in the household	0.00619**	2.36
Farm size (ha)	–0.00755	–0.13
Percentage contribution to nonfarm income of female	0.00318*	1.88
Percentage contribution to nonfarm income of male	0.00105	1.02
Dummy for husband who attended a training	–0.196*	–1.76
Dummy for wife who attended a training	0.435***	3.17
Constant	1.088***	2.82
N	378	

[a]* P <0.1, ** P <0.05, *** P <0.01: province dummies were omitted.

Table 32. Effect of additional yield on household income.

Item	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
Current situation					
Household income ($ per HH)	3,537	2,622	3,582	4,173	3,475
Scenario 1: Rice yield increased by 20%					
New household income ($ per HH)	3,606	2,757	3,733	4,403	3,622
Scenario 1: Rice yield increased by 40%					
New household income ($ per HH)	3,674	2,893	3,885	4,634	3,769

Data source: IRRI GSR project, household survey 2010.

the current 4–8% (Table 33). Applying this factor to the rural poverty estimate for Sri Lanka, the total potential impact is estimated to be 3,000 to 24,000 poor people lifted above the poverty line in the short and long term, respectively (Table 34).

These figures are aggregate estimates of impact for the whole country. The impact varies across locations within a country depending on the relative importance of rice income in the household income of poor farmers. The potential income and poverty impact will be higher in locations where rice accounts for a larger share of household income. This implies that targeting of improved rice varieties to those areas that are more dependent on rice income will have a higher poverty impact.

Summary of findings

- Rice production in Sri Lanka has increased over time and production stability has also increased. Increased rice yield stability is the main factor contributing to production stability.
- Improved varieties with the semidrawf gene released since the 1970s, especially the Bg series, play a dominant role in rice production in Sri Lanka.
- Two cropping seasons are possible in all districts even in rainfed areas since rain is pronounced throughout the year. Some 90% of the rice land is cultivated in the maha season (the main season) and only 63% in the yala season.
- Bg 300 is the predominant variety at the study site. It is adopted by 75% of the farm households and it accounts for 62% of the rice area. Its earliness and

Table 33. Estimated effect of yield gain on poverty incidence.

Item	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam	All
Additional income per capita ($)					
20% increase in yield	20	38	45	72	43
40% increase in yield	40	75	89	144	87
Current poverty ratio (%)	49	49	50	28	44
Scenario 1: Rice yield increased by 20%					
Poverty ratio (%)	48	47	42	25	41
% poor people lifted above the poverty linea	4	3	16	11	8
Scenario 1: Rice yield increased by 40%					
Poverty ratio (%)	46	44	35	22	37
% poor people lifted above the poverty line[a]	7	9	29	21	16

[a]It is the share of the number of poor people lifted out in number of total poor people before a yield increase. The poverty line is $1.25 per day per capita.

Table 34. Additional people in Sri Lanka can be lifted out of poverty.

Item	Rice sown area in 2010[a] (000 ha)	Adoption rate (%)	Rice area per HH[b] (ha/hh)	Number of people in rice farming (000 persons)	Poverty ratio (%)	No. of poor people in rice farming (000 persons)	% of poor lifted out of poverty in the survey[c] (%)	Number of poor people lifted out of poverty in the country (persons)
	(a)	(b)[d]	(c)	(d) = a × b × 4/c	(e)	(f) = d × e	(g)	(h) = f × g
Short term (3–5 years)	1,065	10	1.05	406	8.9	31	8	2,889
		20	1.05	812	8.9	62	8	5,779
Long term (10–20 years)		30	1.05	1,522	8.9	116	16	17,337
		40	1.05	2,435	8.9	209	16	23,116

Data source: [a]Paddy statistics of Sri Lanka 2011. [b]IRRI GSR project, household survey 2010. [c]The percentage of poor lifted out of poverty in the survey is 4–8% for a 10–20% yield increase in Table 33. [d](b) Adoption rate is assumed for short-term and long-term adoption, (d) average household size is 4 persons.

good adaptability for general cultivation are the main reasons for its widespread adoption.

- Rice varieties with 3–3.5 months' duration account for the majority of rice area.
- The use of improved varieties is widespread, with traditional varieties accounting for less than 1% of the total rice area nationally.
- The average rice yields in the maha and yala seasons in the surveyed stress-prone villages are 2.7 t/ha and 2.5 t/ha, respectively. These are lower than the national averages of 4.6 t/ha and 4.4 t/ha for the maha and yala seasons, respectively. This indicates that varieties tolerant of biotic and abiotic stresses could be important in raising rice yield in these stress-prone environments.
- The livelihood strategy of farmers is oriented more toward nonfarm income as rice accounts for less than 20% of household income. Nevertheless, rice production continues to remain important for food security.
- Women's empowerment in rice farming and household decision making in Sri Lanka is not high. Education, nonfarm income, as well as training opportunities are the key factors that improve women's empowerment. More efforts should be made by national agricultural research and extension programs to provide women with education, income opportunities, and training on improved farming practices so that they can be more empowered to be better farm managers and key agents of technological change.
- Improved technologies that increase rice yield could increase average household

income by $147–294, depending on the amount of yield increase. This amount of income gain can be translated into a reduction in the incidence of poverty by 4–8%.

- Improved GSR technologies can potentially lift 3,000–24,000 poor rice farmers above the poverty line. This estimate includes the direct impact on poor farmers, and additional indirect impact will be generated through lower prices that benefit poor consumers.
- Given the dominance of some of the Bg varieties that are locally adopted and have desired grain quality, a strategy to develop farmer-acceptable higher yielding varieties rapidly is to incorporate the new traits from GSR materials into the Bg parent varieties. This approach can be effective in generating farm-level impact rapidly.

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Appendix I

Policy summary for rice production in Sri Lanka.

Policy		Details
Trade	Current policy	• The budget is different from year to year. • Specific duty is only for specific types such as basmati rice. The amount changes from time to time and was Rs 20/kg in 2009.
	Operation mechanism	• Department of Commerce gives import permission. • Import decision is based on the crop forecasting by Socioeconomic and Planning Center (SEPC). • The government uses rice imports to adjust the local rice price. It will remove the duty to encourage the private sector to import if need be.
	Cost	• 2008, imported 84,000 tons of rice. • 2009, imported 52,000 tons of rice. • 2010, around 50,000 tons of rice. • Budget speech 2009: $800 million to import food items, including rice.
	Issues/constraints	• No company specializes in rice imports. • Millers/collectors can create a shortage of rice by stopping selling to increase the rice price. And, the millers have an organization that can talk to the government. • Too many ministers; responsibilities not so clear.

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Policy		Details
Domestic marketing	Current policy	• Budget speech 2010: As an urgent priority, paddy procurement arrangement by the Paddy Marketing Board, cooperative societies, and the private sector will be further strengthened to stabilize farm-gate prices. • Ceiling price: In 2008, the government established a ceiling price to control the paddy price. It is Rs 70/kg for samba and Rs 65/kg for nadu rice. • Guaranteed price system: in 2010, Rs 30/kg for samba rice, Rs 28/kg for nadu rice.
	Operation mechanism	• Paddy Marketing Board (PMB) is to facilitate/control domestic marketing. PMB buys farmers' product at guaranteed price in terms of the quality requirement such as moisture and so on. • Government uses the paddy stock to adjust the market price when a rice shortage happens in the market.
	Cost	• Budget speech 2010: Rs 35,000 million is provided to meet expenditure for fertilizer subsidies, subsidized credit, and procurement of paddy at the guaranteed price.
	Issues/constraints	• Only 5–10% of production purchased by the government due to limited budget and storage capacity. Most places for paddy storage by government are used temporarily. • 70–80% of rice sales are controlled by a few big companies, so the middlemen benefit a lot by using the gap between the guaranteed price and ceiling price.

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Policy		Details
Fertilizer	Current policy	• Budget speech 2009: A system that provides fertilizer for paddy on an advance basis to reduce difficulties that farmers face when having to purchase fertilizer on a cash basis. This is to provide it during the forthcoming Maha season to all farmers who use organic fertilizer and materials such as hay, and 3 bags of fertilizer per acre under a guarantee issued by farmer societies.
		• Rs 7/kg subsidized price only for rice for three major fertilizers: urea, TSP (triple superphosphate), and MOP (muriate of potash).
		• It started in Dec 2005 and no changes till now.
	Operation mechanism	• Agricultural Research and Production Assistance (ARPA) working at village level is responsible for area registration.
		• Budget speech 2009: After harvesting, a program through such farmers' societies, agrarian service officers, and irrigation officers to give over paddy to government agents, on account of fertilizer obtained. It is implemented under the direct oversight of the government agents and will be monitored by the Ministry of Agriculture.
		• Farmers have to sell a specific amount of paddy to the government agency, Paddy Marketing Board (PMB), under a guaranteed price scheme (GPS) to get the subsidy for the next season.
		• If the registered area for paddy is not planted, the government will take it back.
	Cost	• Rs 27 billion for fertilizer only for paddy in 2009.
	Issues/constraints	• No official system is used to check the area.
		• Sometimes, farmers get fertilizer late and have to buy it from market.
	Remarks	• Budget speech 2009: Fertilizer price in the market is Rs 120/kg.

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Policy		Details
Pesticides /chemicals	Current policy	• There is a Pesticide Act for all crops. And no subsidy for pesticide.
		• Farmers are allowed to use only registered pesticides.
		• Now, the government is promoting organic formulas such as herb usage to control pesticide. Not possible on a large scale.
		• IPM is being promoted in Sri Lanka.
	Operation mechanism	• Registered pesticides are imported.
		• Private company imported and distributed to retail shops.
		• Government lists and bans some chemicals.
	Issues/constraints	• Chemicals are overused due to labor shortage. IPM is not popular because of more work required.
	Remarks	• Farmers just follow the instruction on the label of the package.
		• Rainfed farmers use less pesticide than irrigated farmers.
		• Sri Lanka does not produce any chemicals, including fertilizer, pesticide, herbicide, etc.
Seed	Current policy	• National Seed Policy approved in 1996.
		• National Seed Act and regulations.
		• 2011-14, a specific project with 700 million rupees for 3 years to develop the seed sector funded by government and implemented by Seed Planting Material Development Center (SPMDC).
	Operation mechanism	• Government produces foundation seeds and registered seeds, sometimes also produces certified seeds.
		• Department of Agriculture has its own farm, which is managed by officers.
		• Extension and training center is responsible for extension work and seed distribution. Seed extension mainly depends on the provincial extension office.
	Cost	• 2011-14, a specific 3-year project with 700 million rupees to develop the seed sector.
	Issues/constraints	• Private sector produces only profitable seeds of crops. There is high demand for DOA seeds from farmers, but limited resources to produce them.
	Remarks	• On average, it takes 22 seasons to produce a new variety until release.

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Policy		Details
Irrigation	Current policy	• Budget speech 2011: To rehabilitate all minor irrigation schemes in the country. Special focus will be given to rehabilitate all minor irrigation systems in the Western Province to be able to use over 50,000 hectares of abandoned lands. • Irrigation water is free for farmers.
	Operation mechanism	• Irrigation maintenance is done by the Irrigation Department and Department of Agrarian Services. • Farmer organization will decide the date to use irrigation based on information from Irrigation Department. • Water controller (farmers) was selected from the same community to turn on/shut off the irrigation.
	Cost	• Budget speech 2011: Rs 900 million for a 3-year partnership initiative between the Provincial Councils and the Department of Agrarian Services to rehabilitate all minor irrigation schemes.
	Remarks	• Budget speech 2011: There are 25,000 minor irrigation schemes in the country.
Land	Current policy	• Registration of Title Act 1998 to provide unencumbered and clear title to every parcel of land. • Budget speech 2002: Restrictions on the sale, lease, and transfer of land to be removed. • Agrarian Services Development Act No. 46 2000: allows cultivation of paddy land with other crops subject to approval of Commissioner of Agrarian Services. • Rs 60/year for land tax.
	Operation mechanism	• The Land Commissioner General's Department manages state lands at a well-coordinated level with all relevant agencies, ensuring optimum use to gain sustainable development while maintaining environmental equilibrium.
	Cost	• In 2005, 105 wells in total were constructed by the regional offices at a cost of Rs 2,800,000.
	Issues/constraints	• No paddy land can be abandoned; however, this is not always implemented.
	Remarks	• Two land development programs in Sri Lanka: Northern Spring and Eastern Revival.
Others	Current policy	• Budget speech 2009: To increase import duty on wheat grain from 6% to 10% to discourage the consumption of wheat flour and to promote the production of paddy and other grains. • Budget speech 2009: A 5% tax rate will be imposed on wheat flour to promote the production of locally made flour such as rice flour and kurakkan flour.

Appendix II

Top varieties grown by farmers based on percentage of area cultivated.

Kalutara		Kurunegala (MI)		Kurunegala (RF)		Puttalam	
Variety name	% area	Variety name	% area	Variety name	% area	Variety name	% area
Maha season							
Bg 300	47	Bg 300	68	Bg 300	64	Bg 300	66
Ld 356	27	Bg 358	11	Bg 352	16	Bg 352	22
Bg 358	6	Bg 352	10	Bg 358	7	Bg 358	4.8
Bg 360	6	Bg 250	4.0	At 308	2.9	Bg 250	3.9
Bg 359	5	Bg 94-2	2.4	Bg 250	2.7	Bg 34-6	1.3
Bw 351	4.2	Bg 34-8	2.2	Bg 359	1.5	Bg 359	1.1
Bw 267-3	2.5	Bg 357	1.1	At 307	1.5	At 354	1.0
Bw 272-6b	1.0	Bg 350	0.9	Bg 357	1.2	Bg 350	0.5
Bg 350	0.9	At 307	0.7	Bg 11-11	1.2		
Bw 363	0.9			Bg 360	0.7		
Yala season							
Bg 300	41	Bg 300	69	Bg 300	64	Bg 300	62
Ld 356	26	Bg 358	10	Bg 352	10	Bg 352	24
Bw 351	19	Bg 352	8	Bg 358	9	Bg 250	5
Bw 267-3	7.8	Bg 250	3.7	At 308	6	Bg 358	1.8
Bg 358	4.7	Bg 94-2	2.8	Bg 305	2.2	At 308	1.8
Bw 272-6b	1.6	Bg 34-8	2.2	Bg 359	2.0	At 307	1.4
		Bg 360	2.2	Bg 250	1.7	Bg 359	1.1
		Bg 357	1.1	Bg 360	1.7	Bg 350	1.1
		Bg 350	0.9	At 307	1.3	Bg 34-8	1.1
				Bg 357	1.2		

Appendix III

New improved rice varieties recommended by the Department of Agriculture, Sri Lanka.

Variety by maturity duration	Year released	Parents	Area recommended[a]	Maturity duration (days)	Highest yield recorded (t/ha)	Attributes[b]
3 months						
Bg 300	1987	Bg 367-7//IR841/Bg 276-5	GC	90	7.0	Resistant to GM-1, BPH, BL, and BB
3 1/2 months						
Bg 352	1992	Bg 380/Bg 367-4	GC	105	6.0	Resistant to Bl and BPH, white pericarp, intermediate bold-type grains
Bg 358	1999	Bg 12-1/Bg 1492	GC	105	9.5	Samba, resistant to BPH, BL, and BLB, moderately tolerant of Iron toxicity

[a]GC = general cultivation.
[b]BB = bacterial blight; BL = blast; BPH = brown planthopper; GM-I = gall midge (Biotype I).

Appendix IV

Recommended amount of fertilizer[a] (kg/ha) by age of maturity of rice variety for 5 t/ha yield.

Maturity	Kalutara	Kurunegala (MI)	Kurunegala (RF)	Puttalam
2.5 months				
Nitrogen (N)	50	100	100	100
Phosphorus (P)	25	25	25	25
Potassium (K)	29	15	15	15
3 months				
N	50	100	100	100
P	25	25	25	25
K	29	15	15	15
3.5 months				
N	55	100	100	100
P	25	25	25	25
K	29	44	44	44
4–4.5 months				
N	55	100	100	100
P	25	25	25	25
K	29	15	15	15

[a]Converted to active NPK ingredients.
Data source: Department of Agriculture
(www.agridept.gov.lk/pagelinks.php?pagelink=Fertilizer%20Recommendations%20&heading=Rice).

Appendix V

Costs and returns of rice production by season.

Item	Kalutara		Kurunegala (MI)		Kurunegala (RF)		Puttalam		All	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
Yield (t/ha)	2.08	1.22	3.27	2.66	2.65	2.30	3.72	3.44	2.94	2.60
Average price (in $ per ton)	273	273	288	287	296	289	261	259	280	280
Gross income (in $ per ha)	568	333	942	764	785	667	973	891	821	726
Cash cost (in $ per ha)	460	400	251	241	331	302	387	344	357	301
Net cash income (in $ per ha)	108[a]	−67[a]	692	524	454	364	586	547	464	425

[a]Net cash income is low because of high hired labor cost in Kalutara.
Source: IRRI GSR project, household survey 2010.

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