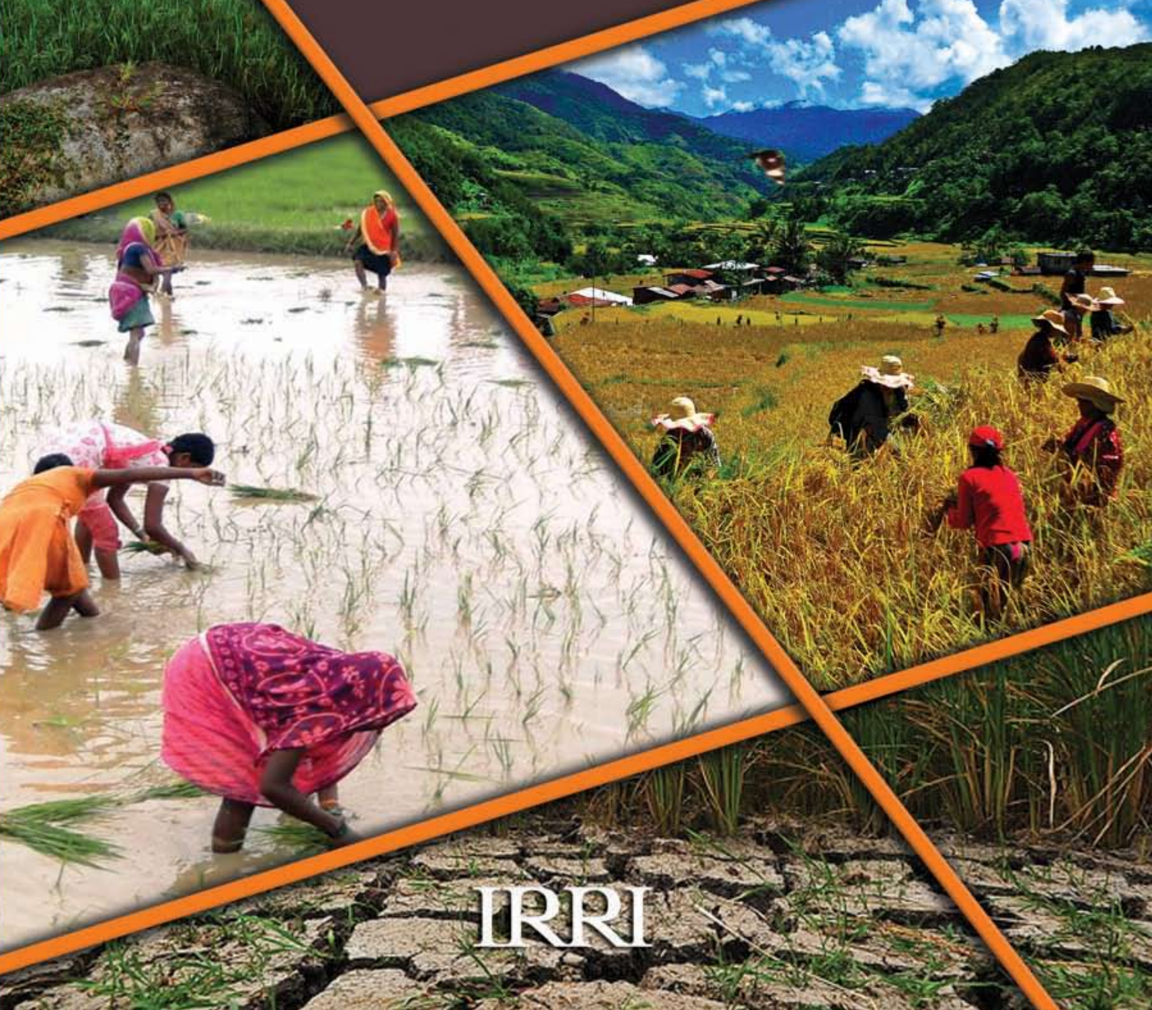
Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas in South Asia

Edited by S. Pandey, D. Gauchan, M. Malabayabas, M. Bool-Emerick, and B. Hardy



IRRI

Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas in South Asia

Edited by
S. Pandey, D. Gauchan, M. Malabayabas,
M. Bool-Emerick, and B. Hardy

2012

IRRI
INTERNATIONAL RICE RESEARCH INSTITUTE

The International Rice Research Institute (IRRI) was established in 1960 by the Ford and Rockefeller Foundations with the help and approval of the Government of the Philippines. Today, IRRI is one of the 15 nonprofit international research centers supported in part by more than 40 donors: members of the Consultative Group on International Agricultural Research (CGIAR – www.cgiar.org), other government funding agencies, foundations, the private sector, and nongovernment organizations.

The responsibility for this publication rests with the International Rice Research Institute.

Mailing address: IRRI, DAPO Box 7777, Metro Manila, Philippines
Phone: +63 (2) 580-5600
Fax: +63 (2) 580-5699
Email: irri@cgiar.org
Web: www.irri.org.
Rice Knowledge Bank: www.knowledgebank.irri.org
Courier address: Suite 1009, Security Bank Center
6776 Ayala Avenue, Makati City, Philippines
Tel. +63 (2) 891-1236, 891-1174, 891-1258, 891-1303

Suggested citation: Pandey S, Gauchan D, Malabayabas M, Bool-Emerick M, Hardy B, editors. 2012. Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas in South Asia. Los Baños (Philippines): International Rice Research Institute. 318 p.

Cover design: Juan Lazaro IV
Page makeup and composition: Emmanuel Panisales
Figures and illustrations: Emmanuel Panisales

ISBN 978-971-22-0287-2

Contents

Foreword

Widespread and persistent poverty in Asia is a longstanding problem, particularly in rainfed ecosystems. Rice is dominant in these areas because it is the only crop that can be grown in the wet season. As a result, it is the principal source of the rural population's food, employment, and income.

Rice yields in these rainfed ecosystems—home to 100 million farm households that plant a total of 60 million hectares—remain low (1.5–2.5 tons/ha) and unstable—unstable because of two perennial wraths of nature, drought and flooding, which with looming climate change will only become worse. Compounding this problem are poor soils that pervade many rice-growing environments.

The incidence of poverty in these rainfed areas is high. Many of these poor people belong to minority ethnic groups, lower castes, and tribes that are economically and socially marginalized. These people are truly the poorest of the poor. And they will stay that way unless the farm families among them can obtain higher incomes through higher and more stable rice yields in the rainfed environments where rice productivity is constrained by difficult growing conditions.

Raising the productivity and stability of rice in this region is a key to reducing poverty. Higher rice productivity will directly increase the quantity of food available to poor households. This will also raise the income of poor landless households as family members are employed as hired labor for rice production. Increased production will benefit the poor households that buy rice by keeping its price low. In addition, higher rice productivity will promote diversification into income-generating activities as family food needs can be met from using less land and labor. The cumulative effect of these factors can provide a strong foundation for reducing poverty.

With this vision, IRRI is investing substantially in developing rice varieties and production practices that are suited to rainfed environments where rice production suffers from drought, submergence, and salinity. Support from many donors has led to the development of several improved rice varieties that are tolerant of submergence, drought, and salinity. These varieties are now being widely distributed in rainfed rice areas in Asia and Africa under the project "Stress-Tolerant Rice for Africa and South Asia (STRASA)" with major support from the Bill & Melinda Gates Foundation.

It is important to understand the social and economic context of rice production in these areas for efficient targeting of such varieties and for assessing their impacts. The various chapters in this book are based on household-level benchmark data on farmers' livelihood strategies, technology adoption patterns, constraints to adoption, and the impact of drought, submergence, and salinity in rainfed rice-growing areas of Bangladesh, India, and Nepal. I am confident that the results, based on a detailed analysis of farm-level data from these three countries, provide important insights for underpinning technology development and dissemination in stress-prone rainfed areas.

Robert S. Zeigler
Director General
IRRI

Acknowledgments

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 Foundations (BMGF)–supported project on Stress-Tolerant Rice for Poor Farmers in Africa and South Asia (STRASA). We acknowledge funding support from the Foundation.

The research was implemented by IRRI in partnership with many national research organizations in South Asia. The main partner organizations directly involved were the Indian Council of Agricultural Research (ICAR), Orissa Univeristy of Agricultural Technology (OUAT), Central Rice Research Institute (CRRI), Indira Gandhi Agricultural University (IGAU), Assam Agricultural University (AAU), Nadia Zilla Farmers' Development Organization (NZFDO), Bangladesh Rice Research Institute (BRRI), Bangladesh Agricultural University (BAU), Institute of Agricultural and Animal Sciences (IAAS), and Nepal Agricultural Research Council (NARC). The following staff of these organizations took on leadership roles in implementing the research work: Dr. Shahe Alam (BRRI), Mr. Eusuf Harun (BRRI), Dr. M. Rafiqul Islam (BRRI), Mr. M. Ariful Islam (BRRI), Mr. Abdus Salam (BRRI), Mr. M. Saidur Rahman (BAU), Dr. Bhanudeb Bagchi (NZFDO), Dr. Parshuram Samal (CRRI), Dr. Dibakar Naik (OUAT), Dr. Debdutt Behura (OUAT), Dr. Nivedita Deka (AAU), Dr. Ajay Kumar Koshta (IGAU), Mr. Megh B. Nepali (NARC), Mr. Sudeep Gautam (NARC), and Mr. Hari Panta (IAAS). We would like to express our appreciation to those organizations and individuals for their collaboration.

We thank the staff of the Social Sciences Division—Ludy Velasco, Orlee Velarde, Lydia Damian, and Gina Zarsadias—who were directly involved in providing support at various stages of the research study. Dr. Andy Nelson and the staff of IRRI's Geographic Information Systems (GIS) Laboratory, particularly Cornelia Garcia, provided the maps. Other SSD staff who provided logistical and other support were Dr. Thelma Paris, Josie Narciso, and Mirla Domingo. We also wish to thank the staff of IRRI's Communication and Publications Services, who helped with the graphic design and gave editorial assistance: Emmanuel Panisales, Juan Lazaro, and Grace Cañas.

We are also grateful to the STRASA management team, initially led by Dr. David Mackill and subsequently by Dr. Abdelbagi Ismail. We also acknowledge the help provided by Dr. Umesh Singh, the South Asia coordinator for STRASA.

Finally, we are thankful to the 1,900 farmers from Bangladesh, India, and Nepal who provided their time and valuable information on which this work is based.

Editors

Chapter 1

Synthesis of key results and implications

Synthesis of key results and implications

D. Gauchan and S. Pandey

Rice is the main staple food and a major source of livelihood for more than 400 million people in South Asia (IRRI 2010). It accounts for 73% of the calorie intake in Bangladesh, 40% in Nepal, and 30% in India (FAOSTAT 2010). South Asia has about 37% of the world's total rice area and approximately 50% of the rice-growing area in South Asia is rainfed (Dawe et al 2010). Rice is the only crop that grows well in large areas of wetlands in monsoon Asia. Most of these rainfed rice areas regularly suffer from various abiotic stresses such as droughts, floods, and salinity. The productivity of rice in these stress-prone rainfed environments is less than 3.0 t/ha (Pandey et al 2010). Historical rice productivity trends in three countries of South Asia (India, Bangladesh, and Nepal) show that growth in yield has been sluggish and unstable in rainfed areas due to the regular occurrence of abiotic and biotic stresses. Therefore, improving the productivity of rice through stress-tolerant technologies is a key entry point to enhance the income and livelihood of resource-poor farmers in these stress-prone environments.

The Social Sciences Division (SSD) at the International Rice Research Institute (IRRI) is implementing research work related to the "Impact Assessment and Targeting" component of the Stress-Tolerant Rice for Africa and South Asia (STRASA) project for South Asia. The main objectives of this component of research are to

1. Analyze patterns of varietal adoption and the factors that influence the adoption of improved varieties.
2. Analyze the economics of rice production and returns to varietal change.
3. Assess farmers' livelihood strategies in stress-prone rainfed environments.
4. Understand the gender roles in rice production and women's participation in decision making.
5. Derive implications for technology design, targeting, and policy reforms for enhancing the impact of improved technologies in stress-prone areas.

This report consists of seven chapters. The first chapter provides an overall synthesis of key findings and their implications. The subsequent chapters provide a detailed analysis of the results from the three countries included, namely, Bangladesh, India, and Nepal. The baseline socioeconomic survey was implemented in partnership with NARES institutions in 19 representative locations (districts) in Bangladesh, India, and Nepal. The survey covered 1,900 farm households growing rice in areas subject to drought, submergence, and salinity. The farm-level data were collected for the cropping year 2008. The methodological aspects and the survey sampling design are described in detail in Chapter 2.

Major findings

The incidence and severity of abiotic stresses

The incidence and severity of abiotic stresses vary by sites in South Asia (Table 1). The findings, based on farmer perceptions elicited during focus group discussions (FGD) and key informant surveys (KIS), indicated that drought and submergence occur very frequently in the study areas, with the annual frequency varying from 20% to 50%. Salinity is a permanent phenomenon but it tends to be more severe during the dry season than in the wet season. Both early-season and end-of-the-season (or terminal) drought are common in these areas of South Asia. Flooding occurs mainly during the vegetative growth stage (tillering and crop growing stage). Coastal salinity is a problem at crop maturity during the dry season (March-May) and seedling and tillering stages in the wet season (June-July). About 20–90% of the rice area in the surveyed locations is affected by these stresses, resulting in a 30–80% yield loss depending on the type of stress and sites.

Farm characteristics and cropping intensity

Rice farmers in South Asia are smallholders, with average farm size of less than 1 hectare in densely populated areas of Bangladesh, Nepal, and West Bengal of India (Table 2). Over two-thirds of the sample farmers in Bangladesh, Nepal, and West Bengal have less than 1 hectare average farm size, indicating the dominance of small farms. Rice is a dominant crop in all parts of South Asia, with its share in gross cropped area being very high in Chhattisgarh (100%) and Bangladesh (95%). The intensity of land use as measured by cropping intensity is low in Assam and Orissa but fairly high in Bangladesh. These estimates obtained from the sample survey are consistent with official statistics at the national/subnational level.

Table 1. Characterization of stress situations at the selected sites, 2008.

Item	Drought	Submergence	Salinity (coastal)
Frequency	Once in 2–3 years	Once in 2–5 years	Regular
Duration	20–45 days	3–30 days (3–7 days, short flood, and 7–30 days, long flood)	Dry season and early wet season
Timing	June-July (early), Sept.-Oct. (terminal)	July-September	March-June
Stage of crop growth	Planting, tillering, maturity	Vegetative stage Early reproductive stage	Panicle stage (dry season) and seedling stage (wet season)
% Yield loss	20–70	30–80	20–40

Table 2. Farm characteristics and cropping intensity in South Asia.

Country	Average farm size (ha)	% Marginal farms (<1 ha)	% Gross rice area to gross cropped area	Cropping intensity (%)
Bangladesh	0.80 (0.60)[a]	76	97	168 (176)
Nepal	0.89 (0.79)	83	50	165 (155)
India				
West Bengal	0.70 (0.82)	75	82	142 (182)
Assam	1.47 (1.20)	41	85	99 (129)
Orissa	1.50 (1.25)	41	73	117 (151)
Chhattisgarh	2.80 (1.60)	11	79	140 (121)

[a]Numbers in parentheses pertain to the national-level averages and are derived from national statistics. Farm size data derived from Census for 2001 in India, 2002 for Nepal and Bangladesh. The cropping intensity data in parentheses are obtained from sources such as www.indiastat.com, BBS (2005), CBS (2008), and FAOSTAT (2010).

Patterns of adoption of improved rice varieties

The incidence and intensity of adoption are two widely used indicators of adoption. The incidence of adoption is measured as the percentage of farmers growing modern varieties (MVs) at a specific point in time. The intensity of adoption, on the other hand, is defined as the percentage of area planted to MVs. Adoption at the farm level reflects the farmers' decision to incorporate MVs into their existing production system by replacing traditional varieties (TVs) or by replacing improved varieties of older vintage that were adopted earlier. The extent and patterns of adoption of modern rice varieties vary among farmers and locations.

Farmers may be full or partial adopters of improved varieties. Those who grow improved varieties on all their rice area are full adopters. Partial adopters are those who adopt MVs in a part of their area only. Figure 1 shows the pattern of adoption of rice varieties across 19 locations in South Asia. A large proportion of farmers growing MVs only (or full adopters) were found in four of the five locations in Bangladesh (Habiganj, Jamalpur, Rajshahi, Satkhira), and in all three locations in West Bengal (Nadia, Purulia, 24-North Paraganas. However, farmers in Assam (Sibsagar, Golaghat) and some locations in Orissa (Jajpur, Dhenkenal), Kurigram in Bangladesh, and Siraha District in Nepal were only partial adopters of MVs. A large number of farmers in coastal salinity locations of Orissa such as Kendrapara (92%) and Bhadrak (68%) grow TVs only due to limited access to improved varieties that are tolerant of the salinity in those locations.

In rainfed ecosystems, farmers generally have their land spread over different parcels and plots along the toposequence. Differences in rice varieties across the "land types" are mostly driven by the differences in hydrological and soil characteristics that vary along the toposequence. Upper fields tend to have lighter soils that drain relatively faster while fields in lower parts of the toposequence generally drain poorly.

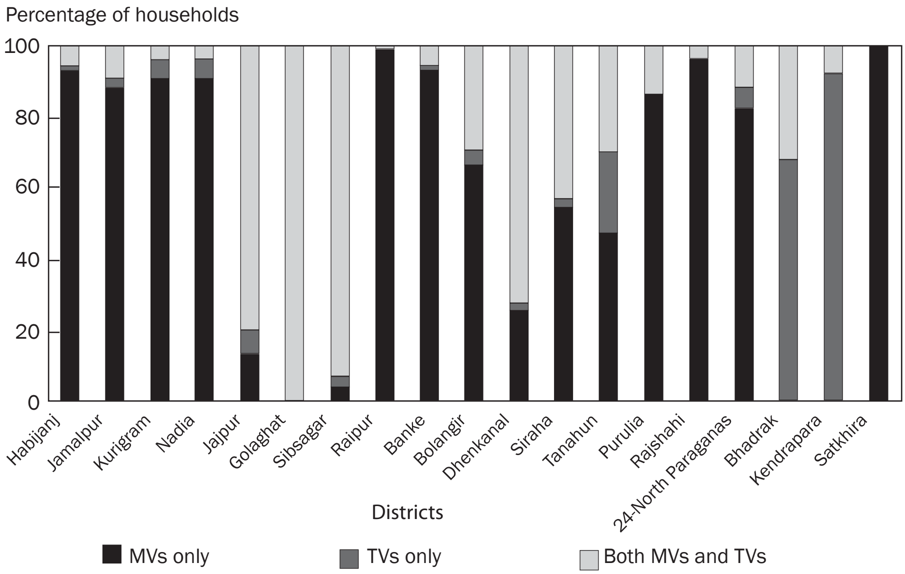


Fig. 1. Pattern of varietal adoption by farmers (%) across South Asia, 2008.

Farmers attempt to "match" varietal duration with this field hydrology. The survey results show that farmers tend to grow shorter duration varieties that mature early in upper fields, medium-duration varieties in medium fields, and longer duration varieties in lower fields (lowland) that have drainage problems. Survey results also show that modern varieties are grown in all land types, upland (upper fields), medium land, and lowland, but the proportion of MVs adopted in these land types varies across locations/countries (Table 3).

Overall, high rates of adoption intensity and incidence were observed in most of the surveyed locations in South Asia (Table 4 and Fig. 2). Most of the locations fall in the northeastern quadrant, indicating a high intensity and high incidence of MV adoption in the majority of the locations included in the survey. However, the lowest adoption rate in terms of very low incidence and intensity was observed mainly in the coastal saline-prone areas of Orissa (left, lower quadrant) such as Kendrapara and Bhadrak, where farmers' land endowment is highly saline prone. A higher proportion of farmers in the other two locations of Orissa (right, lower quadrant III) such as Dhenkenal (drought-prone) and Jajpur (submergence-prone) have a higher incidence of adoption of MVs but at a lower intensity (lower proportion of area), indicating that farmers there are mostly partial adopters of MVs.

The observed partial adoption of MVs may be the result of several factors, including the nature of land endowment that is less suited to the existing MVs and/or farmers' specific preferences for the quality traits of TVs. In low-lying submergence-prone lands such as in Kurigram (Bangladesh), farmers grow TVs that are well adapted to water-stagnant situations of lowlands. In Nepal, farmers grow traditional upland rice

Table 3. MV adoption by land types (% area) across countries/states, wet season.

Countries/states	Upland (upper fields)		Medium land		Lowland	
	MVs	TVs	MVs	TVs	MVs	TVs
Nepal	77	23	87	13	92	8
Bangladesh	97	3	98	2	82	18
India						
Orissa	77	23	77	23	25	75
Chhattisgarh	100	0	99	1	98	2
Assam	–	–	37	63	76	24
West Bengal	92	8	97	3	86	14

Table 4. Adoption intensity (% area) and incidence (% farmers) of MVs.

Location	Intensity (% area)	Incidence (% farmers)
Bangladesh	93	97
Nepal	86	91
India		
Orissa	47	79
Chhattisgarh	99	100
Assam	61	99
West Bengal	93	99

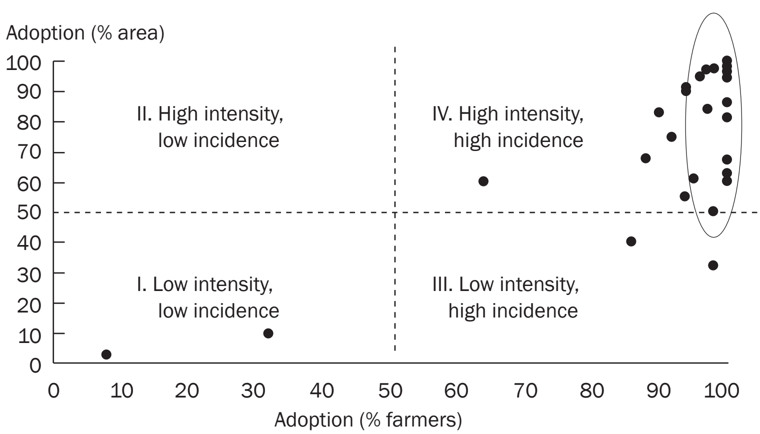


Fig. 2. Intensity and incidence of MV adoption across locations in South Asia.

varieties (e.g., Ghaiya) at the Tanahun hill site due to their tolerance of the moisture stress situation that characterizes the upper fields. At the Siraha site of Nepal, partial adoption is also observed due to farmers' specific preferences for the quality traits of TVs such as Basmati varieties.

In terms of the adoption of improved rice varieties of different vintage (grouped as pre-1990 releases or post-1990 releases), pre-1990s (or "older" MVs) account for a large share of area under MVs. The adoption of "newer" MVs (or post-1990 releases) is much lower, especially in saline areas. Even in locations with high overall adoption rates, the adoption rate of improved varieties of "newer" vintage is much lower than that of the "older" vintage varieties (Fig. 3, Table 5).

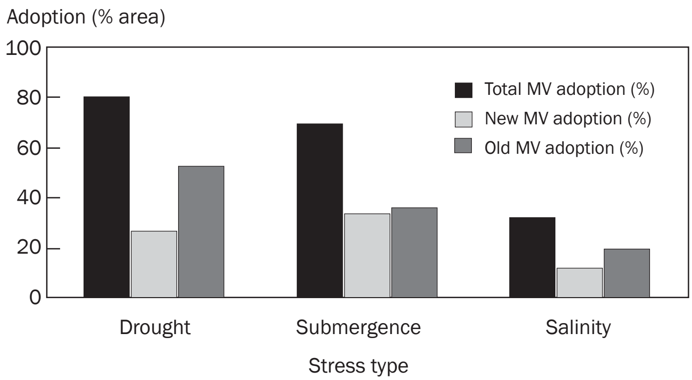


Fig. 3. Adoption (% area) for all MVs, new MVs, and old MVs across locations.

Table 5. Adoption (% area) of new- and old-generation MVs by seasons.

Location	Wet season (% area)		Dry season (% area)	
	New MVs	Old MVs	New MVs	Old MVs
Bangladesh	6	94	93	7
Nepal	40	60		
India				
Orissa	32	68		
Chhattisgarh	39	61		
Assam	55	45		
West Bengal	25	75	99	1

Table 6. Major rice varieties in fields by stress location in the wet season.[a]

Country	Drought	Submergence	Salinity
India	Swarna (39%) Lalat (20%) TVs (28%)	Ranjit (18%) Mahsuri (11%) Swarna (9%)	Swarna (11%) TVs (65%)
Bangladesh	Guti Swarna/ Swarna (93%) TVs (2%)	BR-11 (63%) TVs (10%)	BR-10 (87%) Other MVs (13%)
Nepal	Masuli (13%), Janaki (12%), Radha-11 (11%), Radha-4 (10%); TVs (14%)	n/a	n/a

[a]n/a= not applicable. Numbers in parentheses are estimates of percentage area under each variety.

A handful of "older" vintage improved rice varieties dominates at all sites in South Asia (Table 6). In India, these include Swarna in all environments, Lalat in drought-prone areas (mainly in Orissa), and Mahsuri in submergence-prone environments (mainly in Assam). Ranjit, a variety released in 1992 (new generation), is prominent in submergence-prone environments in Assam and West Bengal.

In Bangladesh, the dominant rice varieties were all of an older generation (released before 1990), such as BR-11 in submergence-prone environments, Swarna/Guti Swarna in drought-prone environments, and BR-10 in saline-prone environments. Traditional varieties occupied a very small area in all types of stress-prone environments in Bangladesh. In Nepal, the older generation varieties such as Janaki and Masuli and the new-generation varieties such as Radha-4 and Radha-11 were grown in a relatively larger proportion of area, even though many other old and new varieties, including TVs, were also found grown widely.

The dominance of a few old varieties such as Swarna (released in 1982), Lalat (released in 1988), and Mahsuri (released in 1973) in India and BR-11 and BR-10 in Bangladesh (both released in 1982) and Masuli (released in 1973) and Janaki (released in 1977) in Nepal indicates that the variety replacement rate is very low. Even the popular new-generation varieties such as Ranjit (released in 1992) in India and Radha-4 and Radha-11 in Nepal (both released in 1994) are already more than 15 years old. The average varietal age was found to be in excess of 19 years in all locations.

Econometric analyses[1] of the farm survey data to identify the factors that determine the incidence and intensity of adoption indicated that the household endowment of suitable land type is a key determinant. In addition, farmer education, their awareness about the availability of stress-tolerant varieties, and participation in extension programs were also found to be significant determinants of adoption. The implications of these findings for technology targeting are obvious.

[1]This analysis was based on the use of limited dependent variable models (probit and tobit).

Economics of MV adoption

Farmers adopt new modern varieties only if they perceive that they will benefit by switching from their current varieties to newer ones. The economic effects of this change in variety can be measured in terms of the incremental gain in yield and net returns (profitability).

The effect of the adoption of MVs on rice yields varies by location and across farms due to differences in the production environments and farmers' crop management practices (Fig. 4). Data show that there is a clear yield gain when farmers switch from traditional to modern varieties. The average yield advantage of MVs over TVs in the surveyed locations is about 1.0 t/ha. However, there are no significant yield gains in most of the locations when farmers switch from older to new-generation MVs. Only in West Bengal, Orissa, and Nepal have new-generation MVs shown some yield advantage (on average, 0.5 t/ha).

The cultivation of MV rice is found to be profitable at all sites when returns above cash costs are considered. The level of profitability, however, varies across locations because of the differences in rice yield and the unit cost of production. The findings show a clear profitability effect of MVs over TVs in most of the locations (Fig. 5). The economic gain (expressed in terms of rice equivalent) from MV adoption is about 500 kg/ha. However, the level of economic gain arising from a switch from old-generation to new-generation MVs is small except in West Bengal, Orissa, and Nepal. This result is similar to the yield effect across locations, indicating that the yield difference is the major driver of the profitability difference.

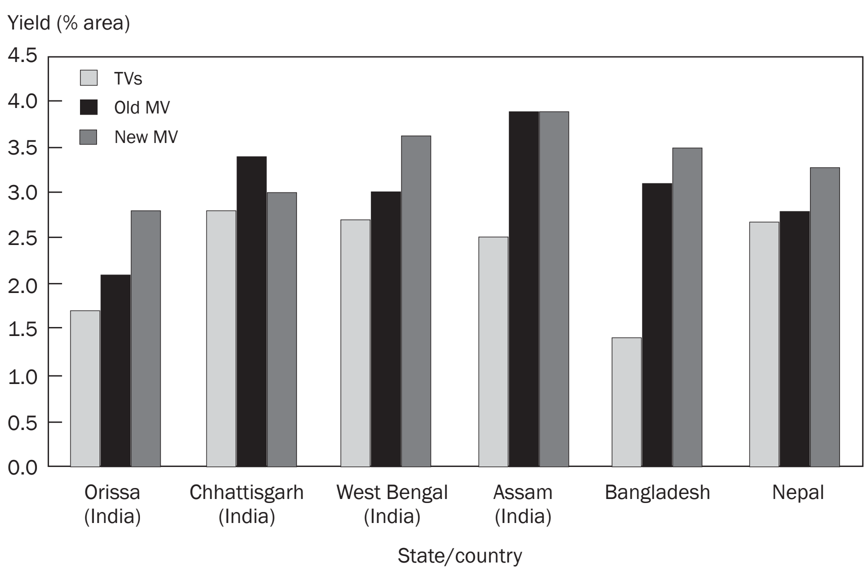


Fig. 4. Yield effects of MV adoption in South Asia, wet season, 2008.

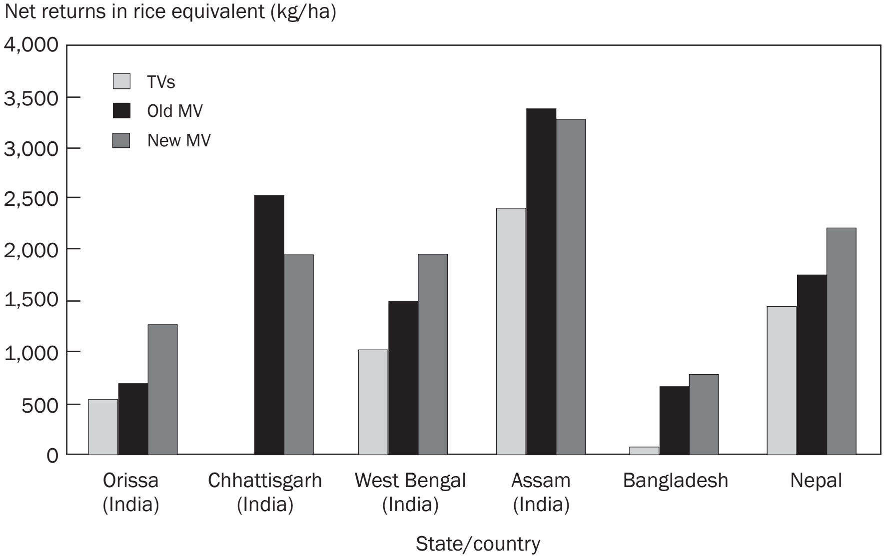


Fig. 5. Profitability of MV adoption in South Asia, wet season, 2008.

These findings imply that the low adoption rate of "newer" generation MVs across stress-prone rainfed locations in South Asia is due to the lack of clear yield and profitability advantages over older ones. The old mega-varieties such as Swarna and BR-11 have remained dominant due to their wide adaptability and superiority over the new-generation MVs under rainfed conditions.

Structure and sources of household income

Rice is a major component of household income in the study locations. Aside from their involvement in rice production, farmers are also engaged in multiple sets of farm, off-farm, and nonfarm activities to meet their diverse livelihood needs. The income structure of the farmers therefore differs across locations depending on their involvement in different activities and the household's endowment of land, labor, and capital, including human capital, and the broader economic environment under which farming is undertaken.

Rice accounts for a fairly large share of total household income in Chhattisgarh (67%) and Bangladesh (62%) as compared with other locations in South Asia (Table 7). Farmers in Nepal have the lowest share of rice income in total household income due to the small size of the rice farm and their dependence on other crops and nonfarm activities. Rice contributes about one-third of total household income in the Indian states of Orissa, Assam, and West Bengal. Thus, livelihood strategies are oriented more toward rice production in Bangladesh and Chhattisgarh than in Nepal and in other states of India. Stress-tolerant rice varieties could generate more impact at the household level if such varieties were targeted to locations where rice production is a major source of livelihood.

Table 7. Percentage shares of different sources[a] in total household income.

Country/state	Rice	Nonrice crop	Nonfarm	Other sources
Bangladesh	62	3	25	10
Nepal	13	27	52	8
India				
Orissa	29	10	49	12
Chhattisgarh	67	5	26	2
Assam	33	6	55	6
West Bengal	29	9	43	19

[a]Nonrice crop includes a crop other than rice, nonfarm also includes remittance, and other sources include income obtained from off-farm labor, fruits and forest products, livestock, aquaculture, etc.

Rice food sufficiency during normal and stress years

Data show that a fairly large proportion of the households in many locations produce rice sufficient for domestic consumption for at least 6 months during normal years (Fig. 6). Many such farmers, however, become rice deficient in years with production shocks. For instance, farmers in two stress-prone areas of the same state of West Bengal (India) such as drought-prone locations in Purulia and submergence-prone locations in Nadia face different situations in stress years (Fig. 6). The drop in rice sufficiency of farmers during the stress year is very high in Purulia, where farmers' rice supply depends on the wet-season rice crop only whereas rice production in the dry season is constrained by a lack of irrigation. However, in Nadia District, the drop in rice sufficiency is small as farmers are able to grow rice in the dry season also. This implies that stress-tolerant technologies can generate more impact by stabilizing rice yields and reducing farmers' vulnerability to shocks and stresses where single wet-season rice is the main source of food security and livelihood (e.g., Purulia).

Gender participation and decision making

Gender roles and gender relations within the households shape the differential roles of men and women in production, marketing, and various livelihood activities. Gender analyses based on the data collected in farm surveys were conducted to examine women's time allocation in rice production and in household decision making.

The results indicate that the share of women's labor in rice farming varies across the locations (Fig. 7). Women's labor inputs account for more than half of the total labor used in rice farming in Chhattisgarh, Assam, and Nepal. However, the share of women's labor in rice production is relatively low in Orissa, West Bengal, and Bangladesh. Within different rice production activities, women are mainly involved in pulling seedlings from the nursery bed, transplanting, weeding, harvesting, and postharvest activities such as winnowing and processing. This implies that technologies such as for direct seeding, transplanting, weeding (herbicide use), harvesting, and postharvest activities will reduce the drudgery of women.

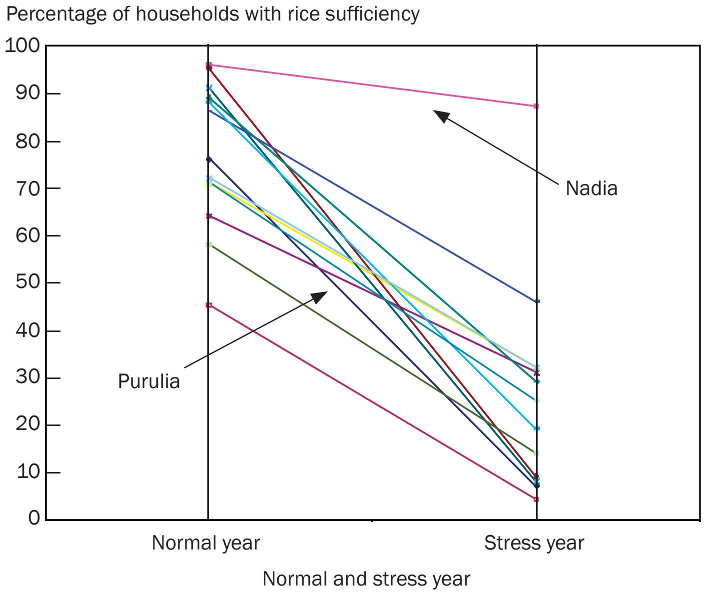


Fig. 6. Rice sufficiency during normal and stress years.

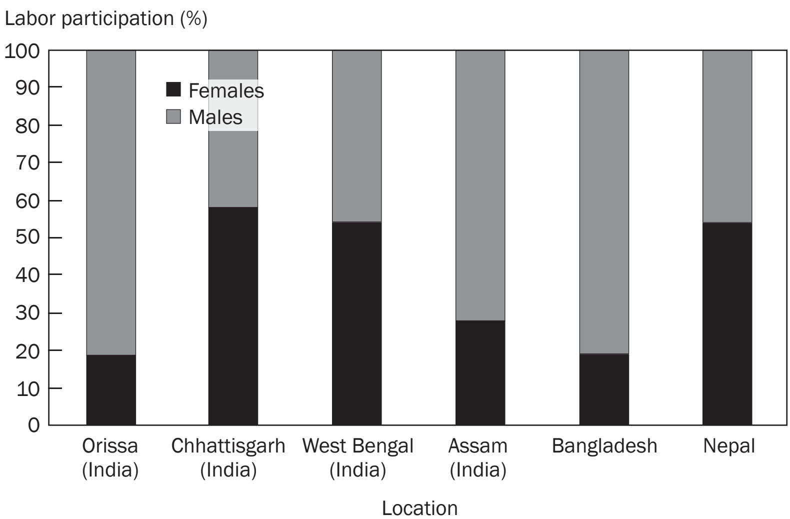


Fig. 7. Labor participation by gender in rice production.

Women's role in decision making in rice farming and broader livelihood activities was analyzed using the Women's Empowerment Index (WEI, see Chapter 2 for details). The index was computed for 16 gender-related indicators of decision making, with a higher value of the index indicating a greater role of women in making that decision. The results indicate that gender roles, responsibilities, and decision-making patterns in rice farming across sites in South Asia are similar, with men making major decisions solely or in consultation with women members in matters related to variety choices, farming, income, marketing, and other household livelihood activities. Women's participation and decision-making roles are found to be limited and confined to decisions mostly related to food consumption and some household management.

Potential farm-level impact of the adoption of improved stress-tolerant rice varieties

Stress-tolerant improved varieties that reduce losses in rice production under stress conditions will generate a farm and aggregate-level impact as adoption spreads. Several varieties that have tolerance of submergence have been developed through the introgression of the *SUB1* gene in popular mega-varieties in South Asia. Similarly, improved varieties with some degree of drought tolerance and tolerance of salinity have also been developed. The seeds of these improved varieties are now being multiplied and distributed widely to rice farmers in South Asia. The dissemination program is described in detail elsewhere.

The potential impact of these varieties in terms of income of farm households is assessed here. This is based on the data regarding the seed quantities being made available to farmers and the likely adoption patterns up to 2014. This initial ex ante impact assessment covering 2011-14 is conducted by considering the impact on farmers' income only.[2] The variety considered is Swarna-Sub1, a submergence-tolerant variety similar in all aspects to the currently popular and widely grown Swarna in South Asia. The beneficial effects considered in this ex ante impact assessment are the reduced production losses in years with submergence and the additional cost of re-transplanting avoided when farmers have no choice but to re-transplant rice because of submergence.

The cumulative undiscounted benefit over the period 2011-14 relative to the counterfactual in which no Swarna-Sub1 varieties are available is estimated to be US$380 million or $95 million per year on average. This is the total value of economic gain considering all submergence-prone areas in the three countries of South Asia. The benefit is the sum of the yield loss prevented due to submergence assuming the submergence probability of 0.3 and considering the avoided cost of re-transplanting when the established crop is damaged by submergence. The latter component, however, accounts for about 5% of the total benefit only. The estimated benefit of $380 million is the average value considering both submergence and nonsubmergence years. The value of production loss avoided in submergence years will be considerably higher

[2]For brevity, the potential impact on consumers through lower rice prices that might result from increased and more stable production has not been considered in this initial analysis.

than this average value, suggesting that the potential impact of submergence-tolerant varieties on farm income can indeed be very large.

Conclusions and implications

- Improved varieties have generally spread in stress-prone areas but most of these improved varieties are of "older" vintage (defined here as varieties released before 1990). Some of these older vintage varieties occupy substantial area and are often known as mega-varieties. These mega-varieties generally have wide adaptability, desirable grain quality characteristics, and well-established marketing/processing channels.
- Field hydrology (as indicated by different "land types" such as upland, medium land, and lowland) is a key determinant of the adoption of improved varieties (irrespective of vintage) across sites and stress situations. Differences in the endowment of land types across households are the key determinants of cross-sectional variations in adoption.
- Yield and profitability effects of MV adoption are greater when farmers switch from TVs to MVs but such effects are not apparent when they switch from older to "newer" generation MV**s** (defined here as those improved rice varieties that were released after 1990). This indicates that available new-generation rice varieties are not distinctly superior in yield and profitability across most stress-prone environments where older generation mega-varieties such as Swarna and BR-11 are widely grown.
- The dominance of the mega-variety Swarna in eastern India and BR-11 in Bangladesh in stress-prone rainfed environments provides a good justification for the strategy followed by STRASA of incorporating *SUB1* and other stress-tolerance genes in these mega-varieties. This strategy is likely to increase the impact domain and the magnitude of impact by accelerating adoption.
- Even in rainfed areas of Asia, rice production is not always the most important source of income of farm households, indicating that other livelihood strategies have evolved over time. Other livelihood options such as the production of a nonrice crop and employment in a nonfarm sector are becoming increasingly important. This indicates that future assessments of rice technologies must take into account not just yield per hectare but the overall contribution to farmer income.
- Increasing farmers' awareness of new stress-tolerant rice varieties can be expected to increase the adoption rate. This requires strengthening of extension and demonstration programs to promote and popularize the new generation of rice varieties suited to rainfed conditions. Similarly, farmers' training and capacity-building programs are needed to further enhance rapid varietal spread.
- The household-level consequences of a loss in rice production due to abiotic stresses are substantial, with poor farmers being pushed back into high food insecurity and vulnerability, particularly in locations where alternative options for livelihood are limited. Rice varieties and technologies that provide protec-

tion from such key stresses need to be targeted for these locations to reduce food insecurity and vulnerability.

- Overall, women's empowerment across all sites in South Asia is limited. There is a need to empower women, who supply farm labor for rice production, to enable them to have faster access to information and new technologies. Women's empowerment for enhancing participation in decision making is equally important for promoting rapid technology adoption.
- Technological development and dissemination strategies in stress-prone environments need to consider the heterogeneity and complexity of the stress situations in South Asia. Farmers own and cultivate heterogeneous land types that are prone to different types and intensity of stresses. As it may be difficult to incorporate multiple abiotic stress tolerance in a single variety, a logical approach would be to develop multiple varietal options to enable farmers to choose those varieties that best meet their livelihood requirements given the nature of their resource endowments.
- Development and dissemination of stress-tolerant technologies should be targeted to those farmers in stress-prone rainfed locations where farmers' food security and livelihood depend on single-season rice cropping as such households are more vulnerable to crop failures during stress years.

References

BBS (Bangladesh Bureau of Statistics). 2005. Report of Household Income and Expenditure Survey (HIES). Dhaka (Bangladesh): BBS. www.bbs.gov.bd.

CBS (Central Bureau of Statistics). 2008. Statistical year book of Nepal. Kathmandu (Nepal): National Planning Commission.

Dawe D, Pandey S, Nelson A. 2010. Emerging trends and spatial patterns of rice production. In: Pandey S, Byerlee D, Dawe D, Dobermann A, Mohanty S, Rozelle S, Hardy B, editors. Rice in the global economy: strategic research and policy issues for food security. Los Baños (Philippines): International Rice Research Institute. p 15-35.

FAOSTAT. 2010. FAO STAT on-line database on different commodities. FAO (http://faostat.fao.org/site/339/default.aspx).

IRRI (International Rice Research Institute). 2010. A Global Rice Science Partnership (GRiSP). Proposal for a Consortium Research Program, revised draft: 25 June 2010. CGIAR Thematic Area 3: Sustainable crop productivity increase for global food security. Los Baños (Philippines): IRRI.

Pandey S, Paris T, Bhandari H. 2010. Household income dynamics and changes in gender roles in rice farming. In: Pandey S, Byerlee D, Dawe D, Dobermann A, Mohanty S, Rozelle S, Hardy B, editors. Rice in the global economy: strategic research and policy issues for food security. Los Baños (Philippines): International Rice Research Institute. p 93-111.

Notes

Authors' addresses: D. Gauchan, Socioeconomics & Agricultural Research Policy Division, Nepal Agricultural Research Council (NARC), P.O. Box 5459, Kathmandu Khumaltar, Lalitpur, Nepal; S. Pandey, Social Sciences Division, International Rice Research Institute, Los Baños, Philippines, respectively.

Chapter 2

Methodological framework

Methodological framework

D. Gauchan and S. Pandey

The framework of this study involves a cross-site comparative analysis of technology adoption and livelihood of rice farmers in rainfed areas affected by submergence, drought, and salinity in South Asia. Three countries are involved in the report: Bangladesh, India, and Nepal. Synthesis reports for Bangladesh and Nepal and for selected states of eastern India were prepared separately. Key syntheses of the overall findings were prepared broadly across sites and stresses together.

Research approach

This study employed a standardized data collection framework across sites to collect reliable, high-quality, and comparable data. A combination of household survey and rural appraisal (focus group discussion, key informant survey) methods was used to collect, complement, and triangulate field data across the sites.

The research was implemented in collaboration with 10 NARES (national agricultural research and extension system) partners at 19 sites (districts) in South Asia (India, Bangladesh, and Nepal) covering 60 villages representing drought, submergence, and salinity stresses in rainfed areas (Table 1). Both primary and secondary data were used to characterize the rice production systems and analyze livelihood situations and the pattern and economics of modern variety adoption (Fig. 1). The collection of primary data was based on the use of detailed household surveys and rapid rural appraisal methods. Secondary aggregate-level data were obtained from government statistical offices for national and subnational levels. They were analyzed to understand broad agricultural and rice production situations nationally and subnationally (state and districts), trends in rice production growth, and historical trends of stress incidence and intensity. The details of the methods and approaches employed for the study are briefly outlined in the following sections.

Research implementation through partnerships with NARES social scientists

The research was implemented in close collaboration and partnership with NARES social scientists in South Asia. The objectives were twofold: to collect reliable and quality benchmark information in a cost-effective manner and, at the same time, enhance the capacity of NARES social scientists. Research activities were implemented by developing new collaboration and expanding partnership with diverse NARES social scientists and their affiliated institutions representing government research institutes, universities, and NGOs. The list of the lead NARES institutions involved in the collaborative research activities in South Asia with the key abiotic stresses, survey districts, and sample villages is presented in Table 1.

Table 1. Lead NARES institutions, states, survey districts, and villages in South Asia.

Country and state	Institution[a]	Key stresses	Surveyed districts	Sample villages
Bangladesh	BRRI	Submergence	Kurigram	Hardanga and Fulbari
		Submergence	Habibganj	Suraboi, Nurpur, Purasanda
		Salinity	Satkhira	Atulia, Beajua, Biralaxmi, Hogla, Joypotrokati, Sreedharkati
		Drought	Rajshahi	Agolpur, Balia Dung, Biroil, Borgitola, Dolia para, Edulpur, Gi-olmari, Gohomabona, Jaoipara, Kamlapur, Lalmatia, Malompara, Norsingor Adorsho, Shahana para, Shreerampur
	BAU	Submergence	Jamalpur	Titpala, Sonkatta
Nepal	NARC	Drought	Siraha	Baluwa
		Drought	Banke	Puraina, Parbatipur
	IAAS	Drought	Tanahun	Bhansar, Purkot
India				
Chhattisgarh	IGAU	Drought	Raipur	Khairkunt, Saguni, Sankara, Tarpongi
Orissa	OUAT	Drought	Dhenkanal	Kankadapala, Kalanga
		Drought	Balangir	Solbandha, Telenpalli
	CRRI Samrudhi	Submergence Salinity	Jajpur Kendrapara	Nuagaon, Sakuntalapur Tilachi, Sikhar
		Salinity	Bhadrak	Khamasi, Bahu
West Bengal	NZFDO	Submergence Drought Salinity	Nadia Purulia 24 North Parganas	Byaspur, Ekperepara, Shibpur Dhuliapara, Ghastoria, Kumardih Darirjungal, Kumarjole
Assam	AAU	Submergence Submergence	Sibsagar Golaghat	Gorkasoria, Mogorhat Kendugiri, Mithamchapori
Total	10 NARES	3 stresses	19 districts	60 villages

[a]BRRI = Bangladesh Rice Research Institute; BAU = Bangladesh Agricultural University;
NARC = Nepal Agricultural Research Council; IAAS = Institute of Agriculture & Animal Sciences;
IGAU = Indira Gandhi Agricultural University; AAU = Assam Agricultural University;
OUAT = Orissa University of Agriculture & Technology; CRRI = Central Rice Research Institute; NZFDO = Nadia Zilla Farmers Development Cooperative Organization.

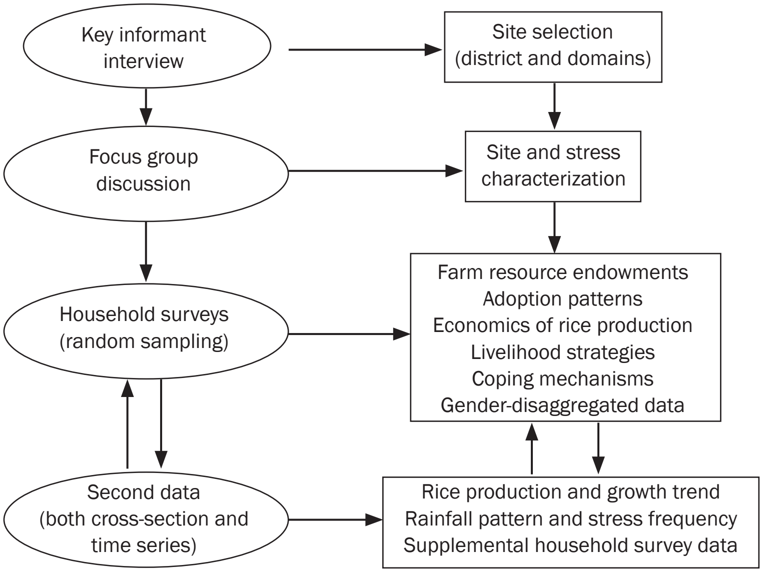


Fig. 1. Survey design and data collection framework.

From Bangladesh, the main institutions involved in social science research activities are the Bangladesh Rice Research Institute (BRRI) and Bangaldesh Agricultural University. In Nepal, the main institutions involved are the Nepal Agricultural Research Council, Kathmandu, and Institute of Agriculture and Animal Sciences (IAAS), Lamjung Campus, Lamjung. From eastern India, the main institutions involved in social science research activities are the Central Rice Research Institute (CRRI), Cuttack (Orissa), and state agricultural universities from Orissa, Chhattisgarh, and Assam. The state universities are Orissa University of Agriculture and Technology (OUAT), Orissa; Indira Gandhi Agricultural University (IGAU), Raipur, Chhattisgarh; and Assam Agricultural University (AAU), Assam. Among local NGOs, NZFDO (Nadia Zilla Farmers Development Cooperative Organization), Nadia, West Bengal, and SAMRUDHI, Bhubaneswar, Orissa, are involved in the implementation of socioeconomic research activities.

Site selection and site characterization

The identification and listing of rainfed districts with key abiotic stresses in each country/state of South Asia were the first step in site selection. Key informant surveys (KIS) were used to identify and select target representative rainfed districts and domains in each state/country. Knowledgeable researchers, extension officials, and local community leaders were consulted and they served as the key informants to identify and select target sites, subdistricts (blocks), and villages. Focus group discussions (FGD) with detailed checklists were used to characterize target sites and key abiotic stresses

(Fig. 1). A target site (location) representing a specific stress domain was selected from each district covering more than one village or a cluster of villages that represent rainfed stress-prone environments. The proportion of rainfed rice area and severity of the abiotic stress were the main criteria used for selecting target districts and sites (locations). During the site selection phase, emphasis was given to identifying and selecting representative sites covering the broader spatial variability and diversity of stress-prone domains. As much as possible, the villages with participatory varietal selection (PVS) trials were included to enable linking with the varietal testing work as well as capturing the diversity of socioeconomic domains in the districts.

In Bangladesh, five districts from different regions with different stress types (submergence, drought, salinity) covering the northern, eastern, and southern coastal belts were selected for the study. However, special emphasis was given to submergence stress by selecting three submergence-prone districts. Similarly, for Nepal, three districts representing the eastern and western Terai and Hill ecological regions were selected to capture the spatial and socioeconomic diversity of the rainfed drought-prone environments. In India, four states of eastern India with the highest proportion of rainfed stress-prone environments were selected and the sites characterized in partnership with NARES. These included five districts of Orissa, one district of Chhattisgarh, three districts of West Bengal, and two districts of Assam. In Orissa and West Bengal, all three types of abiotic stresses were considered when selecting the sites. Table 2 lists the districts selected with the key abiotic stresses and sample sizes.

Design of survey instruments

A standard framework with a different set of questionnaires and checklists was used for each stress, drought, submergence, and salinity, while capturing the differential nature, influences, and effects of each stress on rice production and livelihood of farmers. We designed a structured household survey method to collect detailed data on farmers' socioeconomic information, resource endowment, livelihood situation, land use, rice production practices, technology use and choices, input-output data, income sources, awareness of stress-tolerant rice varieties, coping strategies, and gender participation. The focus of the household survey was to generate baseline

Table 2. Key stress, sites (districts), and sample size by country in South Asia.

Key stress	No. of sites	Country			Sample size (no. of households)
		India[a]	Bangladesh	Nepal	
Drought	8	4	1	3	800
Submergence	7	4	3	0	700
Salinity	4	3	1	0	408
Total sites	19	11	5	3	1,908

[a]The sample survey was implemented in four states of eastern India: Orissa, Chhattisgarh, West Bengal, and Assam.

information on patterns of technology adoption, economics of rice production, and productivity situations, including the nature of their coping mechanisms to deal with abiotic stresses. In addition, emphasis was given to collecting detailed information on costs-returns, sources and components of farm and nonfarm income, and farmers' livelihoods. Special consideration was given to collecting gender-disaggregated data to capture differential roles, livelihood opportunities, and needs and priorities of men and women farmers.

In addition to detailed household questionnaires, a short checklist was also prepared separately for key informant surveys and focus group discussions to document information related to key biophysical and socioeconomic features of the sites, farmers' livelihood situations, rice production systems, technology use and nature, and the magnitude and frequency of the key abiotic stresses that affect rice production at the target sites. After the development of draft survey instruments for the household survey and rapid rural appraisals, a training workshop was organized at the Central Rice Research Institute (CRRI), Orissa, on 16-18 October 2008 to orient NARES partners on data collection and survey implementation and get feedback on the revision of the draft survey instruments. During the training workshop, questionnaires and checklists for each stress were thoroughly reviewed, checked, and revised with the lead NARES partners. Each NARES lead partner, after returning to the respective institution, further revised and pretested the questionnaire to suit the local context and improve the consistency and completeness before actual implementation of the survey.

Household survey implementation

A sampling framework was developed to select sample farmers at each site and in villages. Secondary information on specific districts, target domains, subdistricts, and villages was reviewed thoroughly for developing a sampling framework. FGD and KIS methods as mentioned above were also used to develop a sampling framework for the detailed household survey. A random sampling framework was used to select households from purposefully selected villages from the target stress-prone environments (Fig. 1). A total of 100 sample farmers were interviewed from selected villages for each site in drought- and submergence-prone environments. Unlike the probabilistic occurrence of drought/submergence, salinity is prevalent year-round and regular in a specific area. Therefore, in order to measure the effect of salinity, two villages were selected purposefully: one village representing a saline-prone area and the other village representing a nonsaline area (or "control" village). The nonsaline area (control village) was selected from nearby places with similar agroecological, socioeconomic, and rice production situations but not affected by salinity. From each of these villages, 50 households were randomly selected for the survey.

The respondents interviewed are the household head or household principal male or female members who directly manage the farm. The survey was implemented starting in November 2008 and completed in March-April 2009. Multiple visits were made to collect missing information and to cross-check and remove inconsistencies and ambiguity. The data were collected for the cropping year 2008.

Data management, processing, and analysis

Survey data were compiled, managed, cleaned, and validated by developing a standard database management system in MS Access. The database management system was developed, tested, and refined to make it user-friendly for data entry, cleaning, validation, and management in a standard framework across the sites and countries. A training workshop on data compilation, processing, and management was held in Orissa (OUAT) on 12-14 April 2009 to improve documentation and validation of the data collected by the partners.

Data cleaning and validation involved several rounds of review from IRRI resource persons and subsequent updates of the data sets by the lead NARES partners. A data analysis framework was developed and validated data sets were analyzed by linking MS Access with Excel using Access queries and Pivot tables. Key summary tables were prepared for each section for summarizing the findings of the survey for each site. The STATA statistical package was used for econometric analyses of the factors determining the adoption of modern varieties at the study sites.

Analytical framework

Analysis of growth rate and trend

The annual growth rate for rice area, production, and yield for the STRASA countries in South Asia was estimated using a semi-log trend equation from the time-series data obtained from national statistics. The compound growth rate was estimated for each decade from 1970 to 2008. Before fitting the trend equation for each period and the overall growth rate, estimation data were smoothed using a five-year moving-average process.

Analysis of MV adoption pattern by type and generation

The adoption of improved varieties was measured by two indicators: the proportion of farmers growing modern varieties (incidence) and the proportion of area under modern varieties at a given time (intensity). The adoption of modern varieties (MVs) in terms of percent area and percent farmers growing them was estimated and compared across sites, stress situations (drought vs. submergence), and countries/states. Varietal adoption patterns were also analyzed in terms of farmers growing MVs only, TVs (traditional varieties) only, and a combination of both MVs and TVs for each location.

Two sets of analysis were prepared based on the nature of the data sets and findings of the descriptive analysis. For some locations (e.g., Orissa), where MV adoption is relatively low (where many farmers still grow TVs), the usual analysis of adoption was carried out where the choice set is MV vs. TV. However, for several other locations, where MV adoption has already approached a ceiling value, the problem analyzed was the replacement of old MVs by new MVs. The choice set was a new generation of MVs over an older generation of rice varieties. The objective here was to understand more about the type and generation of MVs (new or old) that farmers

are adopting. For analyzing the specific adoption pattern of new MVs, we classified existing MVs adopted by farmers into two groups, those that were released before 1990 were considered as "old generation" and those that were released after 1990 were considered as "new generation." The adoption percentage in terms of area and farmers growing both new- and old-generation MVs was also estimated and compared across sites.

Yield effects of MV adoption

Yield gains of MVs over TVs as well as new MVs over older MVs were estimated and compared across locations by both land type and season. The comparisons were also made across stress situations, countries, and states in India to identify the effect of MV adoption on the rate of yield gains in different stages of adoption.

Cost-return analysis and profitability effect

Yield and detailed input-use data from intensive data plots obtained from household surveys were used to analyze the costs and returns of rice production by variety type (e.g., MV vs. TV, new vs. old MVs) for different seasons. Both grain and straw yields were used for the estimation of value of output. Costs were estimated from the material inputs (seeds, chemical and organic fertilizers, irrigation, and pesticide use), labor use, and power use (animal and mechanical, e.g., tractors). Farm-gate prices of outputs and inputs obtained from household surveys were used in the revenue and cost estimation. Estimation of both cash and noncash costs (imputed value of family-owned resources, e.g., family labor, farm-produced seeds, farmyard manure, etc.) was made and used in the cost-return analysis. Profitability in terms of both returns above cash costs and total costs was analyzed for each site and compared across sites and countries.

Econometric analysis: determinants of MV adoption

Econometric analyses were carried out to study the various factors influencing the adoption of MVs using household survey data. Censored regression (tobit and probit) models were considered suitable for adoption studies in our context because of the censored nature of the data as there were a number of farmers with zero adoption at the limit.

Two sets of analyses were prepared. In the first analysis, the focus was the factors that determine the differential adoption of modern varieties across fields and households. The focus of the second analysis was to investigate the factors determining farmers' decisions to adopt new-generation rice varieties given the situation that farmers have already adopted an older generation of MVs. We hypothesized that various household-, farm-, and field-specific and institutional variables determine the adoption of new-generation MVs. Analyses of adoption were conducted at both the plot level and farm level. For the first set of analysis, the dependent variable for the tobit model (for farm-level analysis) was the share of rice area allocated to MVs where many farmers are growing both MVs and TVs (e.g., some locations in Orissa).

For the probit model (plot-level analysis), the dependent variable was a dichotomous variable, which was specified as whether MVs are grown or not at the plot level. For the second set of analysis covering locations where MV adoption has reached a ceiling, the dependent variable for the tobit model was the share of MV area allocated to new-generation MVs, whereas, for the probit model, the choice set was the adoption of new-generation MVs at the plot level. Probit and tobit models are described below.

The probit model

A probit analysis was used to explain the adoption and nonadoption of MVs at the plot level. The dependent variable in the probit model is the dichotomous adoption variable that takes value 1 for MV adopters and 0 for nonadopters at the plot level. The model was specified as

$$\mathbf{Y^* = X\,\beta + u}$$

$$Y = \begin{cases} 1 & \text{if } Y^* > 0 \\ 0 & \text{otherwise} \end{cases}$$

where Y* is the unobserved underlying stimulus index of the adoption of new modern varieties and Y is the (n × 1) observable dependent variable, which is equal to 1 if the plot is planted to a new-generation modern variety and 0 otherwise, β is the (k × 1) vector of unknown parameters, X is the (n × k) vector of exogenous or predetermined variables, and u is the residual where $u \sim N\ (0,\sigma^2)$.

Tobit model

A censored regression model (tobit) was used to study the extent of adoption of modern varieties as the data sets are continuous and censored at zero (lower limit). A censored regression model is suitable here as it uses all observations, both those at the limit, usually zero (e.g., nonadopters), and those above the limit (e.g., adopters), to estimate a regression line.

The model is defined as

$$\begin{aligned} Y &= X\,\beta + u, \text{ if } \beta' X + u > 0; \\ &= 0, \text{ otherwise} \end{aligned}$$

where Y_i is the (n × 1) vector of the dependent variable, which is expressed as the share of total rice area of a household under modern varieties or the share of MV area under new-generation rice varieties depending on the type of analysis, β is the (k × 1) vector of unknown parameters, X_i is the (n × k) vector of exogenous and predetermined variables, and u is the residual where $u \sim N\ (0,\sigma^2)$.

Table 3 presents the definitions of variables and hypothesized effects on adoption of MVs. Several variables are hypothesized to determine a farmer's decision to adopt a new technology. A survey of empirical studies of technology adoption indicates that a range of field, farm, farmer characteristics, and institutional variables, including

farmers' perceptions of technology attributes, influences the probability and rate of adoption (Feder et al 1985, Adesina and Zinnah 1993, Bellon and Taylor 1993, Traxler and Byerlee 1993, Adesina and Seidi 1995, Kshirsagar et al 2002, Sall et al 2000, Doss 2006, Langyintuo and Mungoma 2008). These factors include household demographic characteristics (age, education, and household size), gender of the decision makers, land type, farm size, and access to information, awareness level, and participation in training and local farmers' organizations, which are briefly described below.

Household demographic characteristics. Household-specific variables such as age, education, and household size affect adoption decisions through preferences, experiences, knowledge, and family labor available for the adoption of a new technology. Younger farmers may be more receptive to new technology and hence more likely to experiment with new rice varieties. On the other hand**,** an older farmer may have greater experience with farming, and thus may have more ability to make the right decisions on the adoption of new technology (Bellon and Taylor 1993, Langyintuo and Mungoma 2008). Household size is a proxy for labor stock available, which will enhance the adoption of a new technology that may need more care and may be more labor intensive (Doss 2006).

Education helps with the ability to understand and manage new and unfamiliar technology, which may increase willingness to try out new ideas and experiment with

Table 3. Definitions of variables and hypothesized effects of adoption for new MVs.

Type of variable	Variable definition	
Dependent variables		
Grow NMV	Grow new-generation MVs from total MVs at the plot level (yes = 1; otherwise = 0)	Probit model
NMV share	Share of new-generation MVs in total MV rice area	Tobit model
Explanatory variables		**Hypothesized effect**
Farm size	Cultivated area of the farm (ha)	(+, –)
Adult household size	Household members >15 years old	(+)
Age	Age of the household head in years	(+, –)
Education	Education of the household head in years	(+, –)
Gender decisions	Gender of the decision maker who chooses rice varieties to grow (male only = 1; otherwise = 0)	(+)
Land type	Lowland (yes = 1; otherwise = 0)	(+)
Lowlandpct	Percent area under lowland	(+)
Market distance	Distance to nearest market (km)	(–)
Training and organization	Participation in training and farmers' organization (yes = 1; otherwise = 0)	(+)
Awareness	Awareness of new stress-tolerant varieties (yes = 1; otherwise = 0)	(+)

new rice varieties. However, more education may also have a negative effect on adoption since highly educated farmers are more expected to work off the farm, *ceteris paribus*, as human capital accumulated through longer years of formal education becomes an advantage for finding more lucrative off-farm employment opportunities, which makes farming relatively less attractive (Umatsu and Mishra 2010).

Farm size and farm land characteristics. Farm size may have both positive and negative effects on the adoption of new MVs. Larger farmers may adopt new technologies faster since they have more ability to experiment with new varieties due to their higher risk-bearing ability, better financial resources, and larger size of landholdings (Doss 2006, Langyintuo and Mungoma 2008). On the other hand, it may have a negative effect since smaller farmers are likely to be more motivated in searching for new technology due to their subsistence pressure and they may be willing to accept newer varieties in changing circumstances.

In the rainfed heterogeneous environments, farmers grow different rice varieties to match different land types or toposequences of fields based on field hydrology and soil quality (Bellon and Taylor 1993). Therefore, an endowment of favorable-quality land is important in the adoption of modern varieties. Farmers are likely to grow new-generation MVs on preferred land types (lowland, medium land, or upland) that provide more favorable hydrological conditions for crop growth.

Gender participation in the choice of rice varieties. A dummy variable for gender is used to capture women's participation in decision making about a rice variety to grow. We hypothesize that decisions related to choice of new rice technology are made solely by the principal male member, who is normally the household head. In the South Asian context, many such decisions are made by male members who are the main decision makers in farming and they have more control over household resources due to the patriarchal nature of the society and prevailing male-dominated culture.

Market distance. Market distance is considered a proxy for farmers' access to input and output markets. Households that are far from the market are less likely to adopt MVs because of their poor access to new seeds, high search costs, and high transaction cost for selling surplus product from the adoption of new technologies. In Andean potato agriculture, Brush et al (1992) found proximity to markets to be positively associated with the adoption of modern varieties.

Awareness of stress-tolerant rice varieties. Farmers' level of awareness of new rice varieties reduces the fixed cost of adoption and uncertainty of the expected output of the new technology. Since some of the new-generation stress-tolerant rice varieties (e.g., Swarna-Sub1 and Sahabhagi dhan) are already being promoted at the sites, awareness of these rice varieties will help to determine the probability and intensity of adoption.

Participation in training and membership in local farmers' organizations. Participation of farmers in agricultural and rural income-generating training programs and participation in local farmers' organizations increase the likelihood of adopting new-generation MVs. The literature indicates that training provides more knowledge, information, and skills to adopt new technologies (Doss 2006). Similarly, participa-

tion in local farmer organizations such as cooperatives and community and farmers' groups is directly related to adoption behavior because cooperatives provide information and access to credit and new technologies. A dummy variable is used to test the probability and intensity of adopting new-generation MVs by combining training and organizational variables.

Estimation of household income structure

Total household income is estimated by combining gross income obtained from rice, nonrice crops, and other various farm and nonfarm activities that the households derived earnings from during the study period (2008). Gross income for rice and nonrice crops was estimated from the value of total produce on the farm and then it was combined by summing the value of all goods (e.g., livestock income) and services (labor income) produced on the farm, off-farm, and in nonfarm activities to estimate total household income. The major components of total household income are farm, off-farm, and nonfarm income. Farm income constitutes the gross income obtained from rice, nonrice crops, and livestock. Off-farm income constitutes the income earned by the household as farm labor. Nonfarm income is the income arising from nonagricultural labor and nonfarm employment activities, including remittances.

Gender analysis and the Women's Empowerment Index

Gender analyses in terms of women's participation and decision making related to rice production and overall livelihood activities were carried out using gender-disaggregated data collected from the household surveys. The Women's Empowerment Index (WEI) was computed using 16 gender-related indicators to document the status of women's empowerment at the study sites. The index was computed using the approach described by Hossain et al (2004) and Paris et al (2008).

Report preparation and finalization

Separate reports were first drafted by each NARES center based on the analyzed summary tables provided from the IRRI STRASA team. These reports were reviewed and revised by organizing a "writeshop" program at IRRI-Los Baños in May 2010. In addition, this activity was used for sharing initial results of the survey and for receiving feedback on the draft reports and data sets from the partner lead scientists and IRRI resource persons. Based on the feedback and comments, individual draft reports of the NARES centers were revised at IRRI. The revised individual reports were integrated at the country level (e.g., Bangladesh and Nepal) and at the state level for India for the cross-site comparison and synthesis. Finally, a short synthesis report for South Asia was prepared by integrating relevant information from individual country/state reports to draw key conclusions and derive implications for future research.

Organization of the report

This report presents a synthesis of the findings of 19 locations (districts) covering 1,900 households representing 11 sites from India, 5 sites from Bangladesh, and 3 sites from Nepal. The report is organized into three major sections representing three countries of South Asia, Bangladesh, Nepal, and India. For India, the report is further subgrouped by state (Assam, West Bengal, and Orissa + Chhattisgarh). Each country and state report includes a synthesis of different sites and stresses of the country, with details of farm-level analysis, including a broader overview of the rice production situation at the national and state level. Individual country reports have subsections with country/state background, site and stress characterization, details of farm-level analyses focusing on the socioeconomics of rice production and livelihoods, modern variety adoption, farm-level yield effects of MV adoption, economics of rice production, household income analyses, farmers coping strategies, including gender roles and participation in decision making, and women's empowerment situation.

References

Adesina AA, Zinnah MM. 1993. Technology characteristics, farmers' perceptions and adoption decisions: a Tobit model application in Sierra Leone. Agric. Econ. 9:297-311.

Adesina A, Seidi S. 1995. Farmers' perceptions and adoption of new agricultural technology: analysis of modern Mangrove rice varieties in Guinea-Bissau. Quart. J. Int. Agric. 34:358-385.

Bellon M, Taylor JE. 1993. "Folk" soil taxonomy and the partial adoption of new seed varieties. Econ. Dev. Cultural Change 41:763-786.

Brush SB, Taylor JE, Bellon MR. 1992. Biological diversity and technology adoption in Andean potato agriculture. J. Dev. Econ. 39:365-387.

Doss CR. 2006. Analyzing technology adoption using micro-studies: limitations, challenges, and opportunities for improvement. Agric. Econ. 34:207-219.

Feder G, Just RE, Zilberman D. 1985. Adoption of agricultural innovations in developing countries: a survey. Econ. Dev. Cultural Change 33:255-298.

Hossain M, Bose ML, Ahmad A. 2004. Nature and impact of women's participation in economic activities in rural Bangladesh: insights from household surveys. CPD-IRRI, Policy Brief 7. Dhaka (Bangladesh): International Rice Research Institute.

Herdt RW, Capule C. 1983. Adoption, spread and production impact of modern rice varieties in Asia. Los Baños (Philippines): International Rice Research Institute.

Kshirsagar KG, Pandey S, Bellon MR. 2002. Farmer perceptions, varietal characteristics and technology adoption: the case of a rainfed rice village in Orissa. Econ. Polit. Weekly 37(13):1239-1246.

Langyintuo A, Mungoma C. 2008. The effect of household wealth on the adoption of improved maize varieties in Zambia. Food Policy 33:550-559.

Paris T, Singh A, Cueno A, Singh VN. 2008. Assessing the impact of participatory research in rice breeding on women farmers: a case study in eastern Uttar Pradesh, India. Exp. Agric. 44:97-112.

Sall S, Norman D, Featherstone AM. 2000. Quantitative assessment of improved rice variety adoption: the farmer's perspective. Agric. Syst. 66:129-144.

Traxler G, Byerlee D. 1993. A joint-product analysis of the adoption of modern cereal varieties in developing countries. Am. J. Agric. Econ. 75:981-989.
Umatsu H, Mishra AK. 2010. Net effect of education on technology adoption by U.S. farmers. Selected paper prepared for presentation at the Southern Agricultural Economics Association Annual Meeting, Orlando, FL, 6-9 February 2010, USA.

Notes

Authors' addresses: D. Gauchan, Socioeconomics & Agricultural Research Policy Division, Nepal Agricultural Research Council (NARC), P.O. Box 5459, Kathmandu Khumaltar, Lalitpur, Nepal; S. Pandey, Social Sciences Division, International Rice Research Institute, Los Baños, Philippines, respectively.

Chapter 3

Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas of Nepal

Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas of Nepal

D. Gauchan, H.K. Panta, S. Gautam, and M.B. Nepali

Introduction

Country background

Nepal is a small landlocked mountainous country with diverse agroecologies, culture, and agriculture. Agriculture is the mainstay of the economy, providing livelihood to more than two-thirds of the population and accounting for one-third of the GDP (MoAC 2009). The population growth rate is high (2.0%), with about 28 million people in a land area of 147,181 km^2. Its unique topography lies between the southern lap of the Himalayas, bordering with India in the south and the People's Republic of China in the north. The altitudes in the country vary dramatically, from a minimum of 60 m in the lowlands (e.g., Kechana, Jhapa District) to a maximum of 8,848 m (Mount Everest) in the Himalayas, including seven of the ten highest mountain peaks in the world. Geographically, the country is divided into three ecological regions: Mountain, Hill, and Terai, accommodating 7.3%, 44.3%, and 48.4% of the population (CBS 2001). Annual rainfall varies from about 250 mm in rain-shadow areas such as the Mustang valley to over 5,200 mm in the Pokhara valley. Over 80% of the annual rainfall occurs during the four months of the monsoon season, which lasts from June to September.

Rice is the most important food crop in the country in terms of area, production, and livelihood of the people. It is currently grown on about half of the total cropped area and it provides livelihood for more than two-thirds of the farm households in the country. Rice also supplies about 40% of the food calorie intake for the people of Nepal. However, despite its importance in national food security and the economy, currently, a majority of the farmers in Nepal produce their rice crop mainly under rainfed and risk-prone marginal conditions, in which drought is a major constraint to increasing production and improving rural livelihoods.

This report is the outcome of a baseline socioeconomic survey carried out under the Objective 7 (Impact assessment and targeting) component of the STRASA project. The specific objectives of the study follow.

Objectives

- To assess farmers' livelihood systems in the selected drought-prone environments.
- To analyze the patterns of varietal adoption and the factors influencing the adoption of modern rice varieties.
- To analyze the economics of rice production by the type of variety.
- To document strategies of farmers to cope with drought stress.
- To understand gender roles in rice production and women's participation in decision making.
- To serve as a baseline for rice technology design, targeting, and policy reforms in stress-prone areas.

Organization of the report

This report is organized into six major sections. The first section gives a general background on the country and the objectives of the study. This is followed by a short description of research design and data generation. The third section gives a brief description of the broader trends in rice production in Nepal using national-level time-series data. The fourth section provides a general description of the survey sites and stress situations using information gathered from focus group discussions and key informant surveys. Section five provides a farm-level analysis of the socioeconomic survey describing the livelihoods of farmers, adoption patterns, economics of rice production, consumption patterns, coping strategies, and gender analysis. The final section provides a summary of the findings and implications.

Research design and data generation

This research was implemented in close collaboration and partnership with the Socioeconomics and Agricultural Research Policy Division (SARPOD) of the Nepal Agricultural Research Council (NARC), Kathmandu, and Institute of Agriculture and Animal Sciences (IAAS), Lamjung Campus, Lamjung. Data for this study were collected by combining rapid rural appraisals methods, secondary sources, and specifically designed household surveys from three representative rainfed rice-producing locations of Nepal. The selected survey locations represent three developmental regions (east, west, and far/mid-west) and two ecological belts (Hills and Terai[1]) where rice is produced mainly under rainfed and drought-prone conditions (Fig. 1).

The survey was carried out for the 2008 rice-cropping season under the STRASA project in South Asia. The prevalence of drought stress and proportion of rainfed rice area were two major criteria for the selection of districts and study villages. Household surveys were conducted in 300 randomly selected households (100 households in each district) covering representative rainfed districts of the eastern and western Terai and

[1]Terai refers to the southern flat low-lying region of the country bordering India, which is a part of the Indo-Gangetic fertile plains. This region stretches parallel from east to west in the country, covering more than 1,000 km in length.

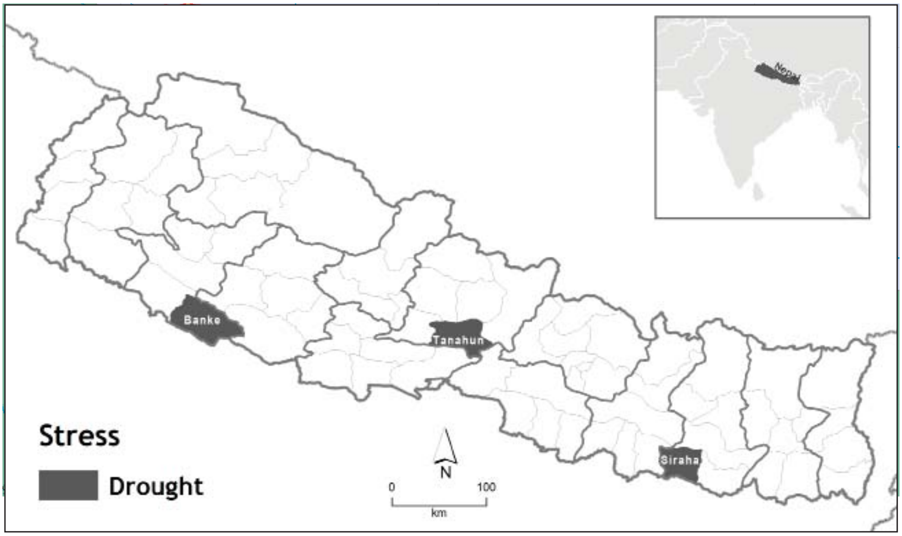


Fig. 1. Map of Nepal showing the STRASA survey sites.

the Hills of Nepal. These districts were Banke, Siraha, and Tanahun, representing eastern and mid-western Terai and the mid-Hills, respectively. Within each district, two villages were selected for the detailed household survey covering 50 households from each village. These selected surveyed villages were also the on-farm participatory varietal selection (PVS) sites for the STRASA project. The survey sites and stress situations were characterized by using focus group discussions (FGD) and key informant surveys (KIS).

Detailed information on farmers' livelihoods, socioeconomic features, rice production systems, variety adoption patterns, input use, costs-returns, income structure, farmers' coping strategies, and gender-disaggregated data on rice farming was collected from the specifically designed household surveys. Survey data were compiled, managed, cleaned, and validated by developing a standard database management system in the MS Access program. The STATA statistical package was used for econometric and statistical analyses.

The annual growth rate for rice area, production, and yield was estimated using a semi-log trend equation. Before fitting a trend equation for each period and the overall growth rate estimation (1961-2008), data were smoothed using a five-year moving-average process. The adoption percentage of modern varieties (MVs) in terms of area and farmers growing them was estimated and compared across sites. For analyzing specific adoption patterns of new MVs, we classified the existing MVs adopted by farmers into two groups: those that were released before 1990 were considered as "old generation" and those that were released after 1990 were considered as "new generation." The area-weighted age of rice varieties was computed for each site using the proportion of rice area covered by each variety with the age of that specific variety

measured from the year of release. The yield effects of MV adoption were analyzed by the variety and field types (land types) across the locations. Econometric analysis was carried out using censored regression (tobit) and probit models to identify the major factors determining the probability and the rate of adoption of new-generation MVs. Yield and detailed input-use data from intensive data plots obtained from household surveys were used to analyze the costs and returns of rice production by variety types (MV and TV) and the generation of modern varieties (new and old MVs). The sources and structure of household income and farmers' coping strategies were assessed and documented. Gender analyses in terms of women's participation and decision making related to rice production and overall livelihood activities were carried out using gender-disaggregated data collected from the household surveys. The Women's Empowerment Index was computed using 16 gender-related indicators to document the status of women's empowerment at the study sites.

Agriculture and trends in rice production

Agriculture and the economy

Nepal is an agrarian country where agriculture is still the single largest sector in the economy, accounting for 32% of GDP (MOF 2009). The country's main agricultural production involves paddy rice, maize, wheat, sugar cane, vegetables, potatoes, pulses, and tea, milk, meat, and other livestock products. The country also produces cash crops such as tea, ginger, citrus, and nontimber forest products in the Hill region for both domestic consumption and export. The cropping pattern is dominated by three crops, rice, maize, and wheat, accounting for over 90% of the area and food grain production. Growth in agriculture has a direct impact on the national economy and livelihood of the poor as more than two-thirds of the labor force is currently employed in agriculture. This high labor force employment from agriculture in Nepal is higher than in other South Asian neighbors such as India (58%), Bangladesh (55%), and Pakistan (47%) (World Bank 2008). Within agriculture, self-employment predominates. Despite the important role of agriculture in the national economy, growth in agriculture is slow and its share has been declining over the years. For 1984-2007, an estimate shows that nonagriculture gross domestic product (at constant 2001 prices) grew at 6% per year. However, agriculture domestic product grew at only 2% per year during the same period (MOF 2009). This is a cause for concern since the growth of the Nepalese economy is determined largely by the growth of its agricultural sector.

Farmland ownership and distribution

Agrarian structures in Nepal are characterized by very small landholdings scattered among different plots, where irrigation is either not available or seasonal. The average size of land owned by the household currently in Nepal is about 0.8 ha, which is frequently fragmented, averaging 3.3 parcels. Currently, 3.3 million farm households cultivate 2.6 million hectares of land, where a wide disparity exists in the distribution of land, with inequality of 0.544 as measured by the Gini coefficient (NLSS 2004).

National statistics show that about 26% of the larger farmers (>1 ha) occupy more than 60% of the farm land, resulting in a concentration of agricultural area among a few large farmers (Table 1). A large number of farm households (74%) have less than 1 hectare of land, with a very high labor to land ratio, low farm labor productivity, and low intensification. Furthermore, the average size of holdings decreased from 1.11 ha in 1961-62 to 0.80 ha in 2001-02.

With the continuing increase in population pressure in agriculture, the proportion of smallholders is expected to increase further over time. The small landholdings pose difficulties for many agriculture-based livelihoods in producing adequate food and generating an adequate income and livelihood.

Food grain production and productivity

Food crops are the major component of agriculture in Nepal. Currently, food grain (cereal) crops cover over three-fourths of the gross cultivated area in Nepal, followed by cash crops, pulses, and horticultural crops. In 2008-09, the country produced about 8.1 million tons of food grains on 3.4 million hectares of area (Table 2). Rice is the most important cereal crop, in terms of both cultivated area and production, followed by maize and wheat. Rice accounted for about 46% of total cereal cultivated area and 55% of the production share, contributing to a significant role in national food security and livelihood of the Nepalese people. Among the cereal crops, rice has the highest productivity (2.9 t/ha), followed by maize and wheat.

Table 1. Average holdings with percentage of households and area owned, Nepal.

Holdings	Percent holdings	Percent area (ha)
<0.5 ha	46.9	14.7
<0.5–1.0 ha	27.2	24.2
>1 ha	25.9	61.1

Source: CBS (Agricultural Census), 2001.

Table 2. Area, production, and productivity of key cereal crops (2008-09), Nepal.

Food crops	Area (000 ha)	Area share (%)	Production (000 tons)	Production share (%)	Productivity (kg/ha)
Rice	1,559	45.6	4,524	55.8	2,907
Maize	875	25.6	1,931	23.8	2,205
Wheat	694	20.3	1,344	16.6	1,934
Finger millet	265	7.8	292	3.6	1,101
Barley	25	0.7	23	0.3	900
Total crops	3,418	100.0	8,114	100.0	2,374

Source: MOAC (2009).

Growth in rice area, yield, and production

Rice is the principal crop grown on 1.5 million hectares. This area has remained almost constant for the past decade (Fig. 2). The trend of area, yield, and production was positive during the early 1980s and 1990s. However, during other periods, before 1980 and after 2000, no significant growth occurred in production and yield. The estimated compound growth rate for rice area, yield, and production for different periods (decades) is presented in Table 3. From 1961 to 2008, rice production for the longer term grew at 1.7% per annum, which was even less than the population growth rate of 2.2%. Yield growth was only 20 kg per year from 1961 to 2008. In recent years, particularly from 2001 to 2008, growth was only marginal in yield and production.

An important characteristic of rice production systems in Nepal is the high temporal variability (Fig. 2). This is mainly due to rainfall variability since about two-thirds of the rice is produced in rainfed conditions. Rice production increased during the favorable monsoon season (e.g., 2003), whereas, during unfavorable years (dry spells, e.g., 2006), area, yield, and production dropped sharply.

Rice production systems and agroecological environments

Rice, the number-one food crop of Nepal, is grown extensively under a wide range of agroecological conditions from lowland in the Terai (50 m) to high mountain valleys and mountain slopes (2,830 m) in Jumla—the highest altitude of rice-growing locations in the world. The crop is cultivated in all agroecological regions (Mountains, Hills, and Terai), covering mountain slopes, hill terraces, intermountain basins, river valleys, and flat lowland plains bordering India (Gauchan et al 2008). About two-thirds (74%) of the paddy is produced in the flat lowland of the Terai and the rest (26%) in the Hills and Mountains. Rice is mainly cultivated during the wet monsoon season (June-November) in major parts of the country. However, in some parts of the lowland plains and valley floors, it is also grown during the spring season (*Chaite* rice) as an irrigated crop. Transplanting is the major method of rice establishment in both irrigated and rainfed lowland conditions. Direct seeding (broadcasting) is mainly practiced for upland rice (*Ghaiya*) in upland fields.

Table 3. Growth rates (% per year) of rice area, yield, and production by period.

Period	Area[a]	Yield	Production
1961-70	0.55***	–0.39***	0.28***
1971-80	1.09***	–0.28	0.68**
1981-90	1.37***	2.08***	3.46***
1991-2000	0.94***	1.06***	1.99***
2001-08	–0.09	0.75**	0.66*
All (1961-2008)	0.85***	0.86***	1.71***

[a]***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively. The growth rate is estimated using a semi-log trend equation. Before fitting the trend equation for growth rate estimation, data were smoothed using a five-year moving average centered at end points.

Fig. 2. Trend in rice area, yield, and production in Nepal. Data source: FAOSTAT (2007), MoAC (2009).

Table 4. Rice area (ha) and percent share by ecosystem.

Rice ecosystem	% of area	Area (000 ha)
Irrigated	21.0	325.5
Rainfed	79.0	1,224.5
Lowland	66.0	1,023.0
Upland	5.0	77.5
Deepwater	8.0	124.0
Total	100.0	1,550.0

Source: IRRI (2009).

Rainfed lowland is the dominant ecosystem, accounting for 79% of the rice area in the country (Table 4). The irrigated ecosystem constitutes one-fifth of the rice area. Upland and deepwater ecosystems account for 5% and 8% of the total rice area, respectively.

A large spatial variation exists in the amount of rainfall from east to west in the country, which can be attributed to the onset and cessation of the southwest monsoon. The eastern part receives more rainfall since the monsoon begins earlier and terminates later there. The country also receives some dry-season rainfall during winter through the west monsoon originating from the Mediterranean Sea.

Rice variety development and release

Efforts started to increase the productivity of rice with the establishment of agricultural farms in Parwanipur and Khumaltar in the 1950s and the introduction of modern varieties (MVs) in the mid-1960s in Nepal (Mallick 1981). In the last 50 years, several rice varieties have been promoted and adopted in different parts of the country. Until 2010, the government of Nepal had developed and released 60 rice varieties for different ecosystems and agroecological conditions (NARC 2010). Most of these varieties came from the International Rice Research Institute (IRRI) through the International Network for Genetic Evaluation of Rice (INGER) and were released directly or used as parents for developing new varieties. A few of them were selections from popular local landraces of Nepal.

CH-45, obtained through IRRI (originated in China), was the first officially released modern variety in 1966 for general cultivation in Nepal, followed by the Taiwanese varieties (Taichung-176, Chainung-242, Chainan-2, and Tainan-1) in 1967 and IR8 from IRRI in 1968 (NARC 2009). These MVs were first planted on a significant area in Nepal in 1968-69, but did not extend to more than 10% of the area until 1972-73 and they continued to increase slowly (Herdt and Capule 1983). By 1980, it was estimated that MVs may have covered 30% of Nepal's rice area, but the rate of increase was still low (Herdt and Capule 1983). According to Upadhyay (1996), modern varieties covered about 40% of the area by 1990. After the mid-1990s, their area coverage increased, and they now cover 87.6% of the cultivated rice area (MoAC 2009). However, the increase in rice yields following the adoption of MVs has not been as dramatic as in other rice-growing Asian countries such as Bangladesh, Vietnam, and the Philippines (IRRI 2009). Despite the high proportion of area covered by MVs in recent years (87%), most of them are old and low yielding, developed and released during the early 1970s and 1980s. The variety replacement rate is very low as the country has been releasing at the rate of 12 varieties per decade averaged for the last five decades of varietal development work. The lowest number of releases occurred during 1960-69 (n = 6) and the highest during 1980-89 (n = 14). Furthermore, the development and release of high-yielding new-generation stress-tolerant rice varieties are limited.

Incidence and effect of drought stress

The country's macro-economy is more affected by drought than any other natural hazard (MOHA 2009). Drought is a critical abiotic stress in rice production since two-thirds of the rice area in the country is rainfed and prone to weather-related risks. Upadhyay (1996) reported that drought was the number-one constraint to the rice crop among the different types of biotic (weeds, pests, diseases) and abiotic (drought, submergence, poor soils) stresses studied during the early 1990s, which reduce yield by as much as 36% in Nepal. Drought caused by low, erratic, and untimely rainfall has resulted in low rice production growth. In recent years, Nepal has experienced frequent dry spells in various parts of the country, particularly during 2001, 2002, 2004, 2005, 2006, and 2009. Rainfed rice production environments are the hardest hit by the dry spells due to the absence of irrigation facilities. The literature shows that, in the past 50 years,

Nepal had drought problems mainly in 1964, 1967, 1973, 1974, 1977, 1979, 1980, 1983, 1992, 1994, 2001, 2002, 2005, 2006, and 2009 (MOPE 2002, MOHA 2009).

The occurrence of early-stage drought is most common in Nepal. This causes a substantial reduction in area planted to rice. This was most common during 2006 and 2009, with a significant reduction in area sown and yield losses. The prolonged dry spells of 2006 caused a substantial reduction in national rice production, which decreased by 13%, and in some districts the reduction reached 40%. In the eastern Terai districts of Siraha and Saptari, the reduction in rice production in 2006 was 38% and 46%, respectively (FAO/WFP 2007).

Site and stress characterization

Description of survey sites

General features of survey sites. A socioeconomic baseline survey was conducted in three representative locations (districts) where rice is cultivated mainly under rainfed and stress-prone conditions (Table 5). The prevalence of drought stress and proportion of rainfed rice area were the two major criteria for the selection of sites. Among these three sites, two are located in the Terai region (eastern and mid-western) and one in the mid-Hill region in the western Hills. These sites are located in Banke, Siraha, and Tanahun districts of the Terai and Hill regions, respectively. These sites are also the major on-farm technology testing sites (e.g., PVS and other on-farm trials) for NARC (RARS, Nepalganj; NRRP, Hardinath) and IAAS, Lamjung Campus, of the STRASA project in Nepal.

Banke District in mid-western and far-western Nepal and Siraha District in eastern Nepal are rainfed and drought-prone districts of Nepal. Similarly, Tanahun District in the mid-Hill region also has a large portion of its rice production in a rainfed system (*Tar* area) near the river basin and lower hills. These districts also have a higher incidence of poverty than many of the rice production districts in Nepal.

From these selected rainfed districts, villages that are most representative of rainfed rice production environments are selected for the baseline survey in Nepal. In Banke District, these include Puraina (Puraina VDC) and Parbatipur (ward #8) villages of Shamsherganj VDC that are close (5–15 km) to the Nepalganj Market. In

Table 5. Survey sites/districts, villages, and responsible institutions, Nepal.

Site/district	Institution[a]	Site	Village	VDC[a]
Banke	RARS, NARC, Nepalganj	Banke	Puraina and Parbati pur	Puraina VDC and Shamsherganj
Siraha	NRRP, NARC Hardinath	Siraha	Baluwa	Naraha-Balkawa
Tanahun	IAAS, Lamjung	Tanahun	Bhansar and Purkot	Bhanu and Purkot

[a]VDC refers to village development committee, RARS = Regional Agricultural Research Station, NARC = Nepal Agricultural Research Council, NRRP = National Rice Research Program, IAAS = Institute of Agriculture and Animal Sciences.

Siraha, this is Baluwa Village in Naraha-Balkawa VDC about 15 km northwest from the district headquarters in Siraha. Similarly, in Tanahun, Bhansar, and Purkot villages, which are located in Bhanu (ward #1, 5, 6, 7, 8) and Purkot VDCs (ward #1, 5, 6, 7), respectively, are selected. These villages in Tanahun are also part of the scaling-up sites for the IRRI/IFAD project.

Biophysical profile of the study sites. All three sites are accessible by motorable road and located close to market centers. Banke and Siraha are located in lowland flat plains at an altitude range of 100–250 m, with an average rainfall of 1,300–1,400 mm (Table 6). However, the Tanahun site is located in the mid-Hill region at altitude that ranges from 360 to 1,000 m. This site also has relatively higher average rainfall of 1,700 mm per year. Rice-wheat and rice-lentil are the major cropping patterns at the two Terai sites while Tanahun has rice/maize and blackgram-fallow patterns. Rice-fallow is common at all the sties. Sandy loam to clay loam are the major soil types at the Banke site, with clay loam at Siraha and clay loam to silty loam at Tanahun.

Ethnic profile of the households. The study villages have various ethnic and caste groups living together (Table 7). These include high-caste Hindus (Brahmin-Chhetri), Yadav, other Terai mixed caste (Kurmi, Teli, Burma), Janjati (indigenous hill people), Dalit (lower caste disadvantaged Hindus), and Muslims. Yadav are mainly concentrated in Siraha (61%), whereas Dalits are predominant in Banke (43%) and Siraha (16%). Brahmin-Chhetri (64%) and Janjati (27%) are concentrated in the Hill villages in Tanahun. Muslims are found in both Banke and Siraha at Terai sites.

Description of stress situations

Farmers perceived that 2006 was the most recent drought year at all three sites. The national literature and rainfall information obtained from the government of Nepal also indicate that 2006 was a severe drought year (MoHA 2009). The national and

Table 6. Biophysical profile of the study sites Banke, Siraha, and Tanahun, Nepal.

Characteristics	Banke	Siraha	Tanahun
Latitude and longitude	81°32′–82°05′E and 27°52′–28°14′N	86°05′ and 86°26′E; 26°16′N	28°04′–28°09′N; 84°43′–84°48′E
Altitude (m)	150–250	102	360–1,000
Average rainfall (mm)	1,319	1,467	1,750
Temperature (°C)	5–40	5–38	2–35
Soil type	Sandy loam	Clay loam	Clay loam
	Clay loam		Silty loam
Cropping system	Rice-lentil	Rice-fallow	Rice-fallow
	Rice-wheat	Rice-lentil	Rice-maize
	Rice-fallow	Rice-wheat	Blackgram-fallow
Access to roads	Dirt road	Paved road	Paved road
Nearest market (km)	5–12	5	3–17

Source: Based on focus group discussions and key informant surveys.

Table 7. Ethnicity of the sample households (%) in the study villages, Nepal.

Ethnicity	Banke	Siraha	Tanahun	All
Brahmin-Chhetri[a]	8	0	64	24
Yadav	12	61	0	24
Other Terai castes[b]	16	3	0	6
Muslim	20	16	0	12
Janjati[c]	1	0	27	9
Dalits+	43	20	9	24
Total	100	100	100	100

[a]Brahmin-Chhetri are upper-caste Hindus. [b]Other Terai castes include Teli, Kalwar, Kurmi, Burma, etc. [c]Janjati include indigenous groups (Gurung, Magar, Bhujel, Kumal, etc.). Dalits+ include disadvantaged lower-caste groups such as Biswokarma, Lohar, Chamar, Harizan, Mahara, Dhobi, and Pariyar.

Table 8. Economic effects of drought incidence at the study sites, Nepal.

Item	Banke	Tanahun	Siraha	All
Recent drought year	2006	2006 and 2007	2006	2006
Stage and timing of crop growth	Planting, seedling, booting	Planting/ seedling	Planting/ seedling	Planting/ seedling
Duration (days)	20–45	20–25	20–45	20–30
% rice area affected by stress	30	20	40	25
% households affected by stress	40	30	45	40
% Yield loss	70	40	65	60

Source: Based on focus group discussions and key informant surveys.

district-level rainfall data compiled by the Department of Meteorology, Nepal, show that rainfall for 2006 was less than the average rainfall of 1997-2006. For instance, the average rainfall for the country for 1997-2006 was 1,875 mm, whereas rainfall for 2006 was 1,583 mm. Similarly, for Banke and Siraha districts, rainfall for 2006 was 1,245 mm and 1,361 mm, respectively, compared with the district 10-year average of 1,305 mm and 1,530 mm, respectively.

The economic effects of drought in terms of rice area, households affected, and yield losses as perceived by farmers in the recent drought years (2006) is presented in Table 8. Farmers perceived that 2006 was a severe drought affecting rice production and economic losses for farmers at all sites. The total area sown or damaged during crop growth stages in the villages ranged from 20% to 40% depending upon the severity at the sites. At the household level, many farmers (30–45%) are affected by drought due to yield losses and reduced income. The costs incurred in rice farming were completely lost for many farmers, thus affecting next-season food security and livelihood options. During the drought period, yield declined by 60% of that of a normal season in 2006. Among the three sites, the severity of drought was more in Siraha in the eastern Terai

since farmers at this site have more rice land in the upper toposequence (upland and medium land), where moisture scarcity is critical during low-rainfall years. Moreover, the drought of 2006 affected this district more than the western Terai districts. FAO/WFP (2007) estimated that drought in 2006 was more severe, affecting an estimated 38% of the area in Siraha District. The critical drought period in rice production ranges from June to August (2–3 months) depending on the location. In recent years, a negative impact of drought was observed more during August-September in Banke, when the crop was at booting and heading stages, whereas, in Siraha, negative impact was observed in July-August. At Tanahun, the effect of drought was most severe during June-July, particularly during crop establishment (transplanting).

Farm-level analysis

Household and farm characteristics

Household demographic characteristics. Sample households have similar demographic features across the surveyed sites (Table 9). The average family size ranges from 6 members in Tanahun to 7 members in Banke in the mid-western Terai. This is slightly higher than the national average household size of 5.5. About two-thirds of the household members are adults (above 16 years of age). The respondent farmers are mainly in the middle age level (42–45 years). The level of formal education of the respondent farmers is very low (3–5 years) at all the sites. However, national statistics show that the literacy rate of the people at the district level is higher, with 62%, 57%, and 38% for Tanahun, Banke, and Siraha, respectively (NLSS 2004).

Primary occupation. Table 10 presents the primary occupation of the sample farm household members, who are economically active and involved in some form of occupation. Agriculture is the primary occupation for 76% of the household members who are economically active and employed in various farm and nonfarm activities. Banke has the highest proportion (81%), followed by Siraha (75%) and Tanahun (72%). The primary occupation of some employed family members (24%) also includes nonagricultural activities, primarily wage labor (unskilled and skilled), foreign employment, service (private and public jobs), and local business and trade. However, some variation occurred across the sites for nonagricultural occupations. Nonfarm wage labor employment was prevalent in Terai sites in Banke (14%) and Siraha (8%), where they have access to work in local factories and transport services (rickshaw pulling) in the nearby market. Overseas employment for household members was mainly reported in Tanahun (15%) and Siraha (10%).

Farm characteristics. Farmers at the study sites have small farm size, ranging from 0.62 to 1.30 ha, and farms are scattered into an average of three parcels (Table 11). Average farm size (combination of three sites) is about 0.89 ha, which is slightly higher than the national average farm size of 0.79 ha for Nepal (CBS 2001). Average farm size in Siraha (eastern Terai) is slighter higher (1.3 ha) than in Banke (mid-western Terai) and Tanahun (western Hills).

On average, farmers own and cultivate crops in three different parcels at all the study sites. The size of parcels is small, accounting for about one-third of a hectare.

Table 9. General household characteristics.

Household characteristics	Banke	Siraha	Tanahun	All
No. of households	100	100	100	300
Average household size	6.9	6.6	6.0	6.5
Average number of adult members	4.2	4.2	4.0	4.1
Average age of respondents	42	45	44	44
Average years of education of respondents	3	5	4	4

Table 10. Primary occupation of economically active household members.

Primary occupation	Banke	Siraha	Tanahun	All
Agriculture (rice-based farming)	81	75	72	76
Service (private + public jobs)	3	6	10	6
Nonfarm wage labor[a]				
Unskilled wage labor	11	7	0	6
Skilled wage labor	3	1	0	2
Business	2	1	3	2
Foreign employment	0	10	15	8
Total	100	100	100	100

[a]Unskilled wage labor includes working as wage labor in factories, transport (rickshaw pulling, etc.), construction work, etc. Skilled wage labor includes working as a carpenter, plumber, mechanic, driver, etc.

Table 11. Farm characteristics of the sample households.

Farm characteristic	Banke	Siraha	Tanahun	All
Average farm size (ha)	0.75	1.30	0.62	0.89
Average number of parcels per household	3.2	3.1	3.1	3.1
Average area of parcels (ha)	0.25	0.46	0.42	0.30
Percentage of area irrigated				
Wet season	9.1	20.7	28.7	21.0
Dry season	6.5	21.1	8.1	14.0

Farmers normally plant each rice variety separately on different parcels or sometimes in different parts of the same parcel (based on land type and irrigation source). The parcels are recognized based on the location, land type, tenure, or source of irrigation. Farmers also subdivide parcels into plots and subplots to fit their different crops and rice varieties.

Irrigation facilities are very much limited at the study sites as no large-scale irrigation infrastructure is available. The percent irrigated area ranges from less than 10% in Banke to about 30% in Tanahun during the rainy season. Irrigation to the rice

crop during the wet season is mainly for supplemental purposes when moisture scarcity occurs due to the scarcity of rainfall. The main sources of supplemental irrigation are local streams, ponds, tube wells, and tanks. During the dry season, the source of irrigation is quite limited through these sources, except in Siraha, where some farmers have shallow tube wells for irrigating cash crops such as vegetables and potato. However, this is less than the average of the district irrigated area estimated during the national census, which shows irrigated area of 38%, 32%, and 11% for Siraha, Banke, and Tanahun districts, respectively (ICIMOD 2003).

Farm size distribution. The largest concentrations of farmers are smallholders with less than 1.0 ha. However, farm size distribution varies by sites (Fig. 3). For instance, nearly 70% of the farmers in Tanahun have farm size of 0.4 ha. Similarly, about 95% of the farmers in Tanahun and 85% of the farmers in Banke have less than 1 ha of land. However, in Siraha, 35% of the farmers have more than 1 ha of land.

Tenancy pattern. Farmers are mostly owner-operators, and more than two-thirds of the farmers are cultivating their own land. Less than one-third of the sample farmers (24%) are involved in share tenancy (leasing in or out). This is slightly higher than the national average of 12% under tenancy for all households and similar (20%) to the national average of agricultural households that are under share tenancy (NLSS 2004).

About one-third of the farmers in Banke and Tanahun and a small proportion of farmers in Siraha are involved in various forms of tenancy (renting in and out and sharecropping) in rice and other crops (Table 12). Because of inadequate farm size, marginal farmers rent-in land for both sharecropping and on a fixed-rent basis. However, sharecropping is the most common form of tenancy pattern at the study sites. In sharecropping, the harvest is usually divided between the landlord and sharecropper, with each receiving about half of the harvest. Sometimes, sharecropping and land-owning

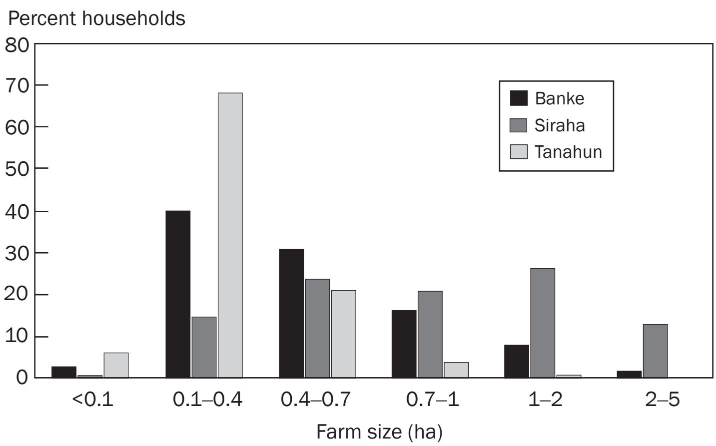


Fig. 3. Farm size distribution in Nepal.

households also share the use of farm animals and production inputs. Renting out of the land is also practiced among relatively large land owners, especially in Tanahun, due to the difficulty of cultivating land as a result of labor scarcity or engagement in other nonfarm activities.

Land endowment. Farmers own and cultivate rice on different land types (field types) with different topographical sequence and moisture level and fit their rice varieties and crops to meet their diverse production and consumption needs (Table 13). Generally, rice scientists and farmers both recognize and classify rice fields into three different types based on field hydrology and soil type: lowland, medium land, and upland (upper fields). Lowlands are located in the lower toposequence of the fields. Uplands are located in upper fields, with less moisture availability and poor soil quality (sandy soils with less water retention capacity). Medium land is intermediate between lowland and upland.

The proportion of lower field types is higher at the Tanahun Hill site, followed by Banke at the mid-western Terai site. However, the proportion of medium land type is higher (84%) in Siraha in the eastern Terai, with the largest total cultivated area at the surveyed sites in Nepal.

Rice-based cropping systems. Rice is a predominant crop and it is mainly grown in the wet season during July to November. Dry-season cropping after rice is limited to wheat and maize (winter). Other crops (minor) are mustard, potato, some legumes,

Table 12. Tenancy patterns of farm households (% area).

Farm characteristics	Banke	Siraha	Tanahun	All
Percentage of farm area by tenure status				
Land owners	66	85	68	76
Renting in	3	14	9	10
Sharecropping	31	1	0	9
Renting out	0	0	22	5
Total	100	100	100	100

Table 13. Land endowments by land type (% share).

Land endowment	Banke	Siraha	Tanahun	All
Average farm size (ha)	0.75	1.30	0.62	0.89
Share of different land types (%)				
Upland (upper fields)	23	11	45	22
Medium land (medium fields)	34	84	0	51
Lowland (lower fields)	43	6	55	28

oilseeds (mustard and linseed), and some vegetables (Table 14). Rice occupied about half of the total gross cropped area in 2008. The share of rice area as a percentage of gross cropped area is higher in Siraha (54%) than in Banke (46%) and Tanahun (45%). Cropping intensity—a measure of land-use intensity—is higher at both the Terai sites (166–170%) than at Tanahun (hill) site (153%). The low cropping intensity in Tanahun is due to a lack of irrigation in the dry season, resulting in the presence of a high proportion of fallow land.

Rice is grown only in the wet season in Banke and Siraha. However, in Tanahun, rice is also grown in a small proportion (3%) in spring (*Chaite* season) and the early wet season (19%). The early wet-season crop is mainly upland rice (*Ghaiya*) planted in unbunded field terraces during March/April using premonsoon rains and harvested in August. Spring rice is mainly an irrigated crop grown in lowland (*khet* land).

Cropping calendar and crop establishment methods. Rice, wheat, legumes, mustard, and potato are the major crops grown by the sample farm households across the sites. Rice is mainly grown in the wet season after the onset of monsoon rains from July to December, wheat from November to March/April, and legumes (lentil, chickpea, peanut, etc.) and mustard from November to February/March (Fig. 4). Some crops are specific to each location, for which the cropping calendar varies. These include upland rice (April-August), spring rice (March-June), maize (March-June/July), and black gram (August-November) in Tanahun, and sugarcane (year-round) in Siraha and pigeon pea (year-round) in Banke.

Transplanting is the dominant crop establishment method for rice at all the sites, even though some (19%) farmers practice direct seeding in Tanahun, mainly for upland rice during the early rainy season. In Banke, only 1% of the farmers practice direct seeding, mainly in the upper fields. However, in Siraha, all farmers (100%) practice transplanting. Direct seeding for lowland rice is not a common practice in the study areas of the Terai, even during the drought period, when farmers have to abandon rice production.

Adoption patterns of modern rice varieties

Adoption of crop varieties is generally measured by two indicators: the incidence and intensity of adoption. The incidence of adoption is defined as the percentage of farmers using an MV (technology) at a specific time. The intensity of adoption refers

Table 14. Gross cropped area (%) in rice and other major crops.

Crops (% gross area)	Banke	Siraha	Tanahun	All
Rice	46	54	45	50
Wheat	33	18	1	20
Maize	5	0.1	33	7
Other minor crops	17	28	21	23
Cropping intensity (%)	166	170	153	165

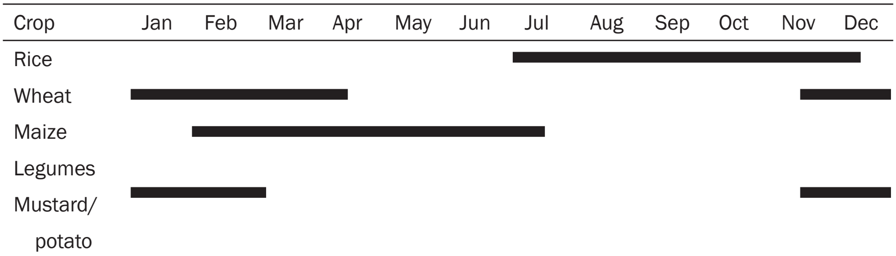


Fig. 4. Crop production calendar at the study sites, Nepal.

Table 15. Adoption pattern of rice varieties (% area and % farmers).

	Banke	Siraha	Tanahun	All
Area (%)				
MVs	98	84	71	86
TVs	2	16	29	14
All	100	100	100	100
Farmers (%)				
MVs only	93	54	47	65
TVs only	1	3	23	9
Both MVs and TVs	6	43	30	26
All	100	100	100	100

to the proportion of area allocated to MVs. The extent of adoption of MVs in terms of both intensity and incidence is described below.

Pattern of MV adoption. The extent of adoption of modern rice varieties in terms of both proportion of area and farmers growing them varies by site and season. The extent of adoption of MVs is higher at Terai sites (Banke and Siraha) than at the hill site in Tanahun (Table 15 and Appendix 1). Among the three sites, Banke has both the highest proportion of area (98%) and farmers (99%) growing MVs, followed by the farmers in Siraha. Compared with the Terai sites, a relatively higher proportion of the farmers (23%) in Tanahun grow TVs on about one-third of the rice area. On average, MVs covered 86% of the total rice area at the survey sites in 2008, which is similar to MV area coverage (87.56%) reported by the national statistics of Nepal for the same year (MoAC 2008-09).

Hybrid rice is also grown either solely or in combination with other varieties by some farmers in Banke (14%) and Tanahun (7%), with different names and brands that are coming from private local agro-dealers supplied from India.

MV adoption by land type. Modern varieties are predominantly grown in lowland and medium land. In upper fields (upland), particularly in unbunded fields, the adoption (measured as the percentage area under MVs) of modern rice varieties is limited

(Table 16). Many promising varieties are adapted to both lowland and medium lands. In all cases, the proportion of farmers growing MVs is higher (91%) than the proportion of area under MVs (86%) for Nepal, indicating that adopter farmers also grow some traditional varieties on some portion of their farms. Low adoption in unbunded upper fields in Tanahun can be attributed to the poor hydrological features, leading to frequent drought in such fields. In addition, many MVs are not suited to the traditional direct-seeding practices of the local farmers in the unbunded dry hill terraces.

MV adoption by season. Other than in a normal wet season (kharif), rice is also grown in the dry season (spring), including upland type (direct seeded) in the early season at the Tanahun (hill) site (Table 17). Limited adoption of MVs is found in early-season upland rice (unbunded fields), whereas full adoption is found in spring (dry) season rice at this site.

Table 16. Adoption pattern (% area) of improved rice varieties by land type.

Percentage adoption	Banke	Siraha	Tanahun	All
Upland (upper fields)				
% MV area	72	79	11	50
% TV area	28	21	89	50
Medium land				
% MV area	98	85	0	87
% TV area	2	15	0	13
Lowland				
% MV area	100	83	86	92
% TV area	0	17	14	8
All land types				
% MV area	98	84	71	86
% Farmers growing MVs	99	97	77	91

Table 17. Pattern of adoption of improved rice varieties by season.

Percentage adoption	Banke	Siraha	Tanahun	All
Wet season				
% MV area	98	84	85	88
% TV area	2	16	15	12
Dry season (spring season)				
% MV area	0	0	100	100
% TV area	0	0	100	100
Early season (upland rice)				
% MV area	0	0	8	8
% TV area	0	0	0	0

Adoption patterns of new- and old-generation MVs

The agricultural research system in Nepal has been developing and delivering new generations of modern rice varieties to suit the needs of diverse ecosystems and populations. According to recent statistics of the government of Nepal (MoAC 2008-09), improved varieties cover 87.56% of the rice area. However, we have inadequate information about the pattern and type of different generations of the rice varieties that are being adopted in farmers' fields (Launio et al 2008).

In this study, rice varieties are categorized into two groups: new and old generation, based on their release year. Varieties released in or before 1990 are considered old generation while those released after 1990 are referred to as new-generation MVs. Farmers at the study sites allocated a large proportion of their rice areas to MVs, most of them of the older generation that was released in the early 1970s and 1980s (Tables 18 and 19). Some farmers in Banke and Tanahun have also adopted hybrid varieties on some portion of their rice area (15% in Banke and 7% in Tanahun) coming from private companies in India through different local informal channels, whose sources, origins, and release years are not known to us. Therefore, in this study, we include only inbred MVs[2] (excluding hybrids) for the adoption pattern of new- and

Table 18. Adoption (% area) of new and old MVs in Nepal, 2008.

Percentage adoption (area)	Banke	Siraha	Tanahun	All
New MVs				
Radha-4	33	0	28	13
Meghdoot (Radha-11)	0	23	0	13
Rambilas (sister line of Radha-11)	0	4	0	2
Radha-9	0	3	0	2
Hardinath-1	3	0	10	2
Others (Panta-12, Judi-572, OR-367)	5	4	27	8
% Total new MVs	41	34	65	40
Old MVs				
Janaki	52	0	0	14
Masuli	1	25	9	16
Sonamasuli	0	12	0	7
Kanchhimasuli	0	8	0	5
Sabitri	0	1	17	3
Others (Sarju-52, Bhola, Jiri, Lalgulab, Makawanpur-1, etc.)	6	20	9	15
% Total old MVs	59	66	35	60
Total MVs (new + old)	100	100	100	100

[2]The analysis also showed that farmers also cultivate hybrids on a small proportion of rice area (5%), which is not accounted for in the new- or old-generation MVs. The details on the proportion of rice area for MV inbreds, hybrids, and total MVs, including old and new MV by generation, are presented in Appendix 1.

Table 19. Characteristics of major modern varieties adopted by farmers, 2008.

Modern varieties	Duration (days)	Year of release	Yield potential (t/ha)	Ecosystem[a]	Progeny/ cross	Origin
NewMVs						
Radha-4	125	1994	3.2	RLL	IR8423-156-2-2-1 (BG34-8/ IR2071-625-1)	IRRI
Hardinath-1	110	2004	5.0	RLL/UL	BG1442	Sri Lanka
Radha-7	148	1991	3.5	RLL/PIR	NR15013-401-1 (Janaki × Masuli)	
Radha-11 (Meghdoot)	135	1994	4.0	RLL	Selection TCA80-4	India/INGER
Radha-12	155	1994	4.6	RL/PIR	OR 142-99 (TN1/ T141/Annapurna)	IRRI (India)
Ramdhan	133	2006	4.9	RLL	OR-367	India
Radha-32	125	2010	3.0	RUL	IR44595-70	IRRI
Judi-572	110	Pipeline	3.0	Spring	Radha-32/ KII	Nepal
Old MVs						
Janaki	135	1979	4.3	RLL	BG90-2 (Peta*3/ TN1/Remadja)	Sri Lanka
Sabitri	140	1979	4.0	RLL	IR2071-124-6-4	IRRI
Masuli	156	1973	3.5	RLL	Mayang Ebos80*2/ Taichung65	Malaysia
Makawanpur-1	150	1987	4.8	RLL	BG400-1 (Ob78/ IR20/H4)	Sri Lanka
Sonamasuli	145	1982	5.0	RLL	–	Andhra Pradesh, India

[a]RLL = rainfed lowland, PIR = partially irrigated conditions, UL = upland, RUL = rainfed upland.
Source: NARC (2009). Various sources.

old-generation MVs that are developed and released by the national and international systems, whose sources, origins, and release years are known from various literature and national research systems. The findings show that old-generation MVs account for about 60% of the MV inbred area (excluding hybrids), whereas new-generation MVs account for 40% of the total MV inbred area.

The most popular new-generation varieties mainly adopted by farmers are Radha-4 and Radha-11 (Meghdoot), which are the oldest among the recently released varieties after 1990. Radha-4 is a dominant variety in both Banke (33% of the area) and Tanahun (28% of the area). Radha-11 is a dominant variety in Siraha in eastern Nepal, occupying 23% of the area. This finding is similar to the recent findings of Witcombe et al (2009), who reported that Radha-4, Radha-11, and Radha-12 were the most widely grown varieties of the recently released varieties in Nepal's Terai.

Hardinath-1, a recently released (2004) variety, is also grown on a small proportion at Banke and Tanahun sites. OR-367, Rambilas (a sister line of Radha-11), Panta-12 (an Indian variety), and Judi-572 (*Chaite* rice) are some of the newer generation rice varieties grown at the study sites. An important point to note from this finding is that farmers still grow a number of varieties that were 20–30 years old, released primarily before 1990. Estimation of average area-weighted age of rice varieties revealed that rice varietal age obtained from the survey was very high, with over 20 years in all three studied districts. This implies that the replacement rate of rice varieties in farmers' fields is currently very low. A study by Witcombe et al (2009) confirms this finding, indicating that old varieties (more than 20 years old) made up half of the adopted rice varieties in the Terai (21 districts including Makawanpur).

MV generation by land type. The presence of new and old generations of modern rice varieties varies by land type across the sites (Table 20). Within specific land types, a varying proportion of both old- and new-generation MVs is grown. Old-generation

Table 20. Adoption pattern (% area) of MVs by generation and land type.

Percentage adoption	Banke	Siraha	Tanahun	All
Upland (upper fields)				
% New-generation MVs	35	9	79	23
% Old-generation MVs	65	91	21	77
Medium land				
% New-generation MVs	30	35	0	34
% Old-generation MVs	70	65	0	66
Lowland				
% New-generation MVs	50	44	64	55
% Old-generation MVs	50	56	36	45
All land type				
% New-generation MVs	41	34	65	40
% Old-generation MVs	59	66	35	60

MVs persist mostly in uplands (upper fields) and medium lands. This was more prevalent in Banke and Siraha. Old-generation MVs are also dominant in medium lands in Siraha. The highest percentage of new-generation MV area was found in Tanahun. In aggregate of three sites, new-generation MVs are grown more in the lowland.

General features of new- and old-generation MVs. The general characteristics of dominant new- and old-generation MVs in terms of their release year, origin, parental sources, and recommended ecosystem are presented in Table 19. Radha-4 and Radha-11 are the most dominant new-generation rice varieties at the study sites. Radha-4 is adopted mainly in Banke and Tanahun and Radha-11 in Siraha were both released in 1994 for rainfed regions of the mid-/far-western and central Terai region, respectively. These two varieties have some tolerance of drought and hence are popular in farmers' fields. Masuli and Janaki are the two dominant old-generation Nepalese rice varieties that were developed and released by the government of Nepal in 1973 and 1979, respectively.

The other dominant old-generation rice varieties grown in Siraha in eastern Nepal are Sonamasuli and Kanchhi masuli, which came from India through informal sources and are not yet released in Nepal. Sonamasuli (Sona Mahasuri in India) was released by Andhra Pradesh (state) of India in 1982, whereas the exact source of origin of Kanchhi masuli in India and its release status are not known. Kanchhi masuli has been grown in eastern Nepal since the early 1990s and it is popular among farmers' fields due to its wide adaptation, good yield, and medium grain quality.

Most of the dominant new-generation MVs are medium to shorter duration varieties with a maturity period ranging from 110 to 135 days (e.g., Radha-4, 125 days; Radha-11, 135 days; OR-367, 133 days; Judi-572, 110 days; Radha-32, 125 days; Hardinath-1, 110 days) and suited to rainfed conditions, they have some tolerance of drought (e.g., Radha-4), or they escape drought due to a short maturity period (e.g., Hardinath-1). However, most of the dominant old-generation MVs have medium to long duration, with a maturity period ranging from 135 to 156 days (e.g., Masuli, 156 days; Sonamasuli, 145 days; Sabitri, 140 days; and Janaki, 135 days). The sources of origin for many of these MVs are either IRRI or neighboring Asian countries. Janaki, Hardinath, and Makawanpur-1 came from Sri Lanka, Radha-4 and Radha-32 came from IRRI, whereas Radha-11 (Meghdoot) and OR-367 (Ram dhan) originated from India, and came through INGER. Masuli is a Malaysian variety introduced in the early 1970s and Sonamasuli came from Andhra Pradesh, India, through informal sources.

Yield effects of modern variety adoption

Yield effects of MVs over TVs. The average yield of MV rice across the sites during the survey years was 3.0 t/ha (Table 21). This yield is higher than the national average of 2.9 t/ha for Nepal but lower than in many Asian countries. Between the variety types, yields of MVs are higher than TVs and are statistically significant at all the sites. The yield effects of MVs are relatively higher in Banke and Tanahun.

Yield effects of MV adoption by land type. Rice is grown on all three land types except in Tanahun, where rice is grown on two land types (upland and lowland). Yield effects of MV adoption by land type are presented in Table 22. MVs have no superiority

Table 21. Average yield (t/ha) effects of MVs over TVs of rice.[a]

Item	Banke	Siraha	Tanahun	All
Average yield	3.01	2.14	4.34	3.02
Variety type				
MV	3.05 (0.068)	2.19 (0.045)	4.82 (0.135)	3.09 (0.057)
TV	1.50 (0.180)	1.94 (0.644)	3.40 (0.155)	2.69 (0.109)
Difference	1.55*	0.25*	1.42*	0.40*

[a]* = showing statistically significant difference in mean yield between MVs and TVs at $P<0.05$ probability level. Numbers in parentheses are standard errors.

Table 22. Yield effects (t/ha) of MVs over TVs in different land types.[a]

MV and TV types	Banke	Siraha	Tanahun	All
Upper fields (upland)				
Average yield	2.44	1.89	3.23	2.64
MVs	2.56 (0.190)	1.89 (0.126)	3.021(0.397)	2.43 (0.140)
TVs	1.63 (0.126)	1.90 (0.093)	3.028 (0.138)	2.81 (0.128)
Difference	0.930*	–0.014	0.007	–0.38*
Medium land				
Average yield	2.76	2.16	n/a	2.34
MVs	2.80 (0.82)	2.21(0.758)	n/a	2.41 (0.045)
TVs	1.39 (0.313)	1.89(0.681)	n/a	1.86 (0.095)
Difference	1.41*	0.31*	n/a	0.55*
Lowland				
Average yield	3.33	2.18	4.81	4.00
MVs	3.33	2.14 (0.152)	4.94(0.136)	4.02 (0.098)
TVs	n/a	2.36 (0.256)	4.09 (0.327)	3.82 (0.300)
Difference	n/a	–0.22	0.85*	0.20

[a] * = showing statistically significant difference in mean yields between MVs and TVs at $P<0.05$ probability level. Numbers in parentheses are standard errors. n/a = not applicable, i.e., Tanahun site has no medium land.

Table 23. Average rice yield by MV generation.[a]

Item	Banke	Siraha	Tanahun	All
MV Gentype				
New GenMV	3.00 (0.126)	2.13 (0.078)	4.54 (0.177)	3.27(0.104)
Old GenMV	3.00 (0.090)	2.20 (0.055)	4.90 (0.235)	2.80 (0.066)
Difference	0.00	–0.07	-0.36	0.47*

[a] * = showing statistically significant difference in mean yield between new MV and old MV at $P<0.05$ probability level. Numbers in parentheses are standard errors.

in yield in upland fields in Tanahun and in uplands and lowlands of Siraha. However, yields of MVs are higher in uplands and medium lands in Banke and lowlands in Tanahun. Average yields of both MVs and TVs are higher in Tanahun than at the two Terai sites. Clearly, yield effects of MVs over TVs vary by site. Since many of the MVs adopted in Siraha are not very high yielding compared with the existing adapted TVs in rainfed environments, yield effects of MVs are not distinct at this site. Similarly, yield effects of MVs in upland rice in Tanahun are also not clearly observed.

Yield effects of MV generation. There are no clear yield effects of new MVs over old generations by individual site (Table 23). However, in aggregate of all the sties, the yield superiority of new MVs is statistically significant over older generation MVs. The dominant new-generation MVs such as Radha-4 and Radha-11 have yield similar to that of dominant old-generation MVs such as Janaki, Mashuli, Sabitri, Makawanpur-1, etc.

Yield effects of MV generation by land type. The yields of new- and old-generation MVs by land type are presented in Table 24. New-generation MVs are not statistically superior to old-generation MVs at each site across different land types. However, in aggregate of sites (pooled data), the performance of new and older MVs varied across land types. For instance, new MVs are superior and better performing in lowlands, whereas older MVs are better performing in medium fields.

Dominant new and old rice varieties and their productivity. The major rice varieties with their average yields are presented in Table 25. The important rice varieties grown at the study sites are Radah-4 at Banke and Tanahun and Masuli, Meghdoot (Rahda-11), and Sonamasuli in Siraha and Janaki at the Banke site. Hybrid rice is also grown on a small proportion of area at the Banke and Tanahun sites. The other important modern rice varieties grown are Sabitri, Makawanpur-1, and Judi-572 in Tanahun, Shamba masuli, Panta-12 in Banke, and Jiri and Bhola at Siraha sites. Hardinath-1 is also grown by a few farmers in Banke and Tanahun. Among traditional varieties, Chobo is more prevalent in Tanahun and Basmati at the Siraha site. A majority of MVs have an average of 3 t/ha of rice yield, whereas TVs have about 2 t/ha of rice yield. Judi-572 is the only rice variety (MV) grown in the spring (*Chaite*) season in Tanahun. The yield of most MVs (both inbreds and hybrids) is higher in Tanahun than at Siraha and Banke sites as indicated by the statistical significance of the t-test.

Farmers' perceptions and reasons for adoption of new and old MVs. Radha-4 and Radha-11 (Meghdoot) are popular new-generation varieties whereas Masuli and Janaki are old-generation common varieties at the study sites. Farmers have provided their perceptions on the traits of specific new- and old-generation rice varieties (Table 26). Farmers expressed preference for specific modern rice varieties for traits such as high yield, resistance to lodging, good taste (eating quality), and tolerance of diseases, pests, and abiotic stresses, including straw yield and quality (other positive traits). Most of the surveyed farmers responded that high yield and good taste (eating quality) are their most preferred traits for adoption. New rice varieties are mainly preferred for higher yield and resistance to lodging (Radha-4), and good taste or eating quality (Radha-11). Farmers' continued cultivation and preference for older generation MVs

Table 24. Yield (t/ha) by MV generation in different land types.[a]

MV and TV types	Banke	Siraha	Tanahun	All
Upland				
Average MV yield	2.62	1.90	2.48	2.49
New GenMV	2.60 (0.311)	1.92 (0.137)	3.16 (0.416)	2.83 (0.268)
Old GenMV	2.65 (0.269)	1.89 (0.144)	1.80 (n/a)	2.15 (0.0147)
Difference	–0.05	0.03	1.36	0.68*
Medium land				
Average MV yield	2.71	2.19	0.0	2.34
New GenMV	2.60 (0.134)	2.14 (0.082)	0.0	2.26 (0.072)
Old GenMV	2.83 (0.110)	2.25 (0.061)	0.0	2.43 (0.057)
Difference	–0.23 (0.198)	–0.11 (0.105)	0.0	–0.17*
Lowland				
Average MV yield	3.26	2.10	4.86	3.90
New GenMV	3.30 (0.189)	2.04 (0.400)	4.69 (0.175)	4.14 (0.145)
Old GenMV	3.22 (0.153)	2.17 (0.159)	5.02 (0.225)	3.66 (0.144)
Difference	0.08	–0.13	–0.33	0.48*

[a] * = test showing statistically significant difference in mean yield between new MV and old MV at $P<0.05$ probability level. Numbers in parentheses are standard errors.

Table 25. Area (%) and yield (t/ha) by major new, old, and other rice varieties.[a]

Rice varieties	Banke		Siraha		Tanahun	
	% area	Yield	% area	Yield	% area	Yield
New MVs						
Radha-4	26.8	3.0	–	–	18.2	4.3
Radha-9	2.8	2.3	2.6	2.2	–	–
Radha-11	–	–	19.0	2.1	–	–
Hardinath-1	0.1	4.0	–	–	3.1	5.4*
Old MVs						
Janaki	42.9	3.0	–	–	–	–
Masuli	1.2	2.9	20.1	2.2	6.1	5.2*
Sonamasuli	–	–	11.0	2.4	–	–
Kanchhimasuli	0.5	3.0	7.0	2.3	–	–
TVs						
Basmati	–	–	6.5	1.8	0.2	4.1
Chobo	–	–	–	–	9.8	3.0

[a]The area (%) under a specific rice variety is from the total rice area. * indicates statistically significant yield superiority of the varieties between the sites. Blank cells mean that varieties are not grown at the sites.

Table 26. Comparative reasons for adoption by farmers (%) of new and old MVs.

Item	New-generation MVs		Old-generation MVs	
	Radha-4	Radha-11	Masuli	Janaki
Desirable traits[a]				
1. High yield	40	19	15	37
2. Resistance to lodging	18	0	2	4
3. Resistance to pests and diseases	4	1	1	3
4. Good taste	10	41	39	17
5. Good grain type	10	3	5	3
6. Good market price	1	0	4	0
7. Other traits (straw yield, drought tolerance, early maturity)	17	36	34	36

[a]The information is the percent response of the farmers who grow the specific variety. A farmer may have a multiple response for more than one trait.

such as Masuli and Janaki at the study sites are due to their superior traits such as high yield (Janaki), better taste or eating quality (Masuli), and fairly good straw yield for livestock (Masuli).

Determinants of adoption of new MVs: econometric analysis

The factors affecting the adoption of new MVs were analyzed using probit and tobit models as described earlier (see Chapter 2 for details). The results show that the awareness of new modern rice varieties and participation in training and organizations are significant in both probit and tobit models, whereas land type is significant in the tobit model (Table 27). The significance of marginal effects in the probit model and elasticity in the tobit model indicates that both the probability and extent of adoption are higher if a farmer has better awareness of new MVs and participates in agricultural and rural development training programs. This is as expected since increasing awareness of farmers of new rice varieties reduces the fixed cost of adoption and uncertainty of the expected output of the technology (Herdt and Capule 1983, Doss 2006). The significance of the land-type variable in the tobit model indicates that endowment of lowland fields is important in increasing the intensity of new MV adoption. This is expected in rainfed drought-prone environments in Nepal, where lower fields in the toposequence have better moisture availability for the cultivation of new modern rice varieties.

Socioeconomic variables such as household size, age, education, and gender have no statistically significant effect on the adoption of new-generation MVs below 5% probability level. This finding is consistent with earlier studies in Nepal for the gender variable, that household decisions related to farming are made in consultation with female members and men are not the only decision makers for the choice of rice varieties (Bajracharya 1994, Subedi et al 2000).

Table 27. Results of the probit and tobit (censored regression) model for the adoption of new-generation modern rice varieties in Nepal, wet season, 2008.[a]

Explanatory variables	Probit model		Tobit model	
	Coefficients	Marginal effects	Coefficients	Elasticity
Intercept	–0.535*		–0.231	
Age (years) of the household head	–0.008	–0.003	–0.002	–0.137
Education of the household head (no. of years)	0.085	0.003	0.007	–0.001
Household size (adult members only)	0.032	0.011	0.014	0.061
Decision makers' gender in rice variety choice (male only = 1; otherwise = 0)	0.144	0.053	0.075	0.023
Farm size (ha)	–0.484	–0.017	0.059	0.055
Lowland (yes = 1; otherwise = 0)	0.172	0.026	–	–
Land type (percent lowland)	–	–	0.360*	0.166*
Awareness: stress-tolerant MV (yes = 1; otherwise = 0)	0.276*	0.102*	0.352*	0.124*
Participation in training and organization (yes = 1; otherwise = 0)	0.297*	0.105*	0.324*	1.160*
District dummy (District 1: Banke)	–0.211	–0.076	–0.383*	–0.139*
District dummy (District 2: Siraha)	0.206	–0.077	–0.003	–0.001
No. of observations	668		272	
Log-likelihood	–402.7		–248.29	
Significance	Prob>$\chi 2$ = 0.000		Prob > $\chi 2$ = 0.000	

[a]* Significance at P< 0.05 (*) level and sign (+) = positive; (–) = negative. The regressions are estimated using STATA 10.0.

The relatively higher elasticity value for some significant variables in the tobit model such as endowment of lowland fields, participation in training and organization, and awareness levels indicates that greater impact is likely to be achieved by increasing farmers' access to endowment of lowland fields and strengthening extension and demonstration programs on new stress-tolerant rice varieties. Land type is a critical factor that needs to be considered for targeting new rice varieties in rainfed environments. Favorable policies on decentralized R&D programs, strengthening farmer participatory research to enhance the flow of information, and faster delivery of new seed varieties to farmers are critical to increasing the adoption rate. Similarly, well-focused and targeted local capacity-building programs for farmers through increased training programs, membership in local farmers' organizations, and extension demonstrations are needed to enhance adoption and likely impact. Future studies need to account for the likely effect of farmers' perceptions of the attributes of new rice varieties and constraints to seed access for newer varieties, which could not be included in this study due to a lack of relevant information.

Economics of rice production and household economy

Input use and costs and returns in rice production. The important inputs used in rice production are seeds, chemical fertilizer, organic fertilizer (FYM/compost), labor, and animal power (Table 28). Some farmers, particularly at Banke and Siraha (Terai) sites, also use tractors for land preparation and threshing. A few farmers also use pesticides (insecticides and fungicides, including herbicides) in controlling diseases, pests, and weeds. The use of irrigation is limited. It is mainly used for supplemental purposes during moisture-scarcity periods. The different types of inputs used are briefly outlined below.

- ***Seeds***

Seed use per hectare varies across sites: the lowest is in Siraha (52 kg/ha), it is intermediate in Banke (83 kg/ha), and it is very high in Tanahun (119 kg/ha). The seeding rates are higher in Tanahun largely to compensate for poor germination and stand establishment caused by uncertainty of rainfall and water shortage. For direct-seeded rice (early-season upland rice), the seeding rates are much higher than for transplanted rice.

- ***Fertilizer***

The use of chemical fertilizers is widespread among farmers at the study sites. The survey found that 94% of the farmers use chemical fertilizers such as urea, diammonium phosphate (DAP), and muriate of potash (MOP). The nutrient form in urea is 46% nitrogen, DAP with 18:46:0 (N and P_2O_5), and MOP with 60% percent K_2O. The average use of fertilizer at the study sites ranges from 40 to 48 kg N/ha, 6 to 10 kg P/ha, and 2 to 7 kg K/ha, which is higher in terms of national average use (30 kg

Table 28. Input use in rice production for wet-season rice in Nepal, 2008.

Item[a]	Banke	Siraha	Tanahun	All
Seed (kg/ha)	83	52	119	84
Fertilizer (kg/ha)				
N	47	40	48	45
P	6.3	10.0	10.0	8.9
K	1.9	7.5	3.8	3.8
Organic fertilizer (manure) (kg/ha)	3,062	2,108	5,287	3,424
Pesticide use (L/ha)	0	0	0.19	0.06
Labor (days/ha)	178	167	299	212
Power				
-Bullock labor (days/ha)	13.4	16.0	39.1	22.3
-Tractor (hours/ha)	2.4	2.8	0.3	1.9
-Thresher (hours/ha)	0.7	0.3	0.0	0.3

[a]*P and K are in the elemental form (they are derived from the conversion of P_2O_5 and K_2O using 0.83 for P_2O_5 and 0.44 for K_2O). The input use comes from the largest parcels.

N/ha) but much lower than the 78 kg N/ha for India (Indiastat.com), Bangladesh, and other Asian countries (FAOSTAT 2007).

- ***Organic fertilizer***

Farmyard manure (FYM), compost, and poultry manure are the most commonly used organic manures at the study sites. The use of organic fertilizer is fairly high, ranging from about 2 t/ha in Siraha to 5 t/ha in Tanahun. Farmers normally use more organic manure in the hills than in the Terai. The low use of organic manure in the Terai is due to limited access to forests for firewood and increased use of cow dung (a major source of organic fertilizer) in cooking as the main household energy source.

- ***Labor***

Labor use (person-days/hectare) varies across the sites, with higher use in Tanahun in the hills. The higher labor use for rice production in Tanahun is due to shorter working hours (6–7 per day), low use of tractors for production, harvesting, and postharvest activities, and more labor time required for cultivating on small terraces in the hills. Moreover, the use of organic fertilizer (which is bulky and weighty in nature) for transport and application in fields through foot trails on hill slopes also significantly increases labor required. Farmers also put more care and management into the rice crop at the site as rice is a prestigious crop compared with maize and millet in the hills. Overall, labor use per hectare is higher in Nepal due to the limited use of machinery for cultivation, threshing, and transport of inputs and outputs for rice farming.

- ***Animal power***

Bullocks are mainly used for heavy agricultural operations such as plowing and leveling fields, and transporting output from fields to the yard of the homestead (mainly in Terai) and threshing the crop. They are used in pairs and are owned or hired for specific operations. The use of animal power is higher in Tanahun (a hill site) due largely to the limited use of tractors for land preparation.

- ***Mechanical power***

The use of mechanical power is most common in Banke and Siraha. Tractors and threshers are the most common mechanical power used in the cultivation and threshing of rice. Tractors (power tillers and tractors) are used for plowing, land leveling, and transporting inputs (fertilizer, manure) to fields and harvested products (grains and straw) to the homestead. Threshers are used for separating grains from the straw after the harvest of the crops.

Labor use in different rice production activities. Human labor is used in all rice production activities from land preparation to harvesting and postharvest activities (Table 29). Farmers use more labor (person-days per hectare) for crop establishment (transplanting), harvesting, weeding, and threshing activities as these are the main operations consuming labor for rice farming. Weeding consumes the most person-days/ha in Tanahun (71.9). The proportion of labor use by different rice production activities is presented in Appendix 2, which indicates that crop establishment, weeding,

Table 29. Labor use (days/ha) in rice production activities, wet season, 2008.

Labor use (person-days/ha)	Banke	Siraha	Tanahun	All
Land preparation	20.7	24.0	53.0	31.9
Crop establishment	49.9	24.7	45.9	40.0
Application of organic fertilizer	8.9	10.2	14.4	11.1
Application of chemical fertilizer	5.1	2.4	3.6	3.7
Application of pesticides	0.2	4.8	0.6	1.9
Weeding	25.0	27.1	71.9	40.3
Irrigation	0.9	2.7	16.7	6.4
Harvesting	33.2	27.9	40.2	33.5
Threshing	20.8	26.6	36.4	27.7
Postharvest activities	13.3	16.7	17.0	15.6
Total	178	167	299	212

and harvesting account for the highest share across all the sites among various rice production activities. The use of total labor in Tanahun is higher than in Banke and Siraha for the reasons mentioned above (see "Labor" on page 65).

Costs and returns in rice production. The costs of cultivation and returns were calculated separately for modern and traditional varieties from the largest parcel (intensive data plots). Both the paid-out costs of material inputs and imputed value of family-owned inputs were estimated separately. The analysis of costs and returns in rice production across sites revealed that rice is a profitable crop at all sites, with an average of US$456 of returns above cash costs per hectare (Table 30). Net returns from rice production for the wet season were positive even after accounting for noncash costs (imputed value of family-owned resources). Farmers in Tanahun receive the highest value of grain (NRs 68,816 or $930/ha) and value of straw (NRs 18,637 or $252/ha) due to high grain yield of their rice varieties (5.06 t/ha), including relatively higher yield of straw. The value of rice straw is also an important component of the returns due to its higher demand for livestock feed during the dry season. The share of rice straw in total returns is 13–21%, and it is lowest in Banke and highest in Tanahun.

Cash (paid-out) costs account for more than half of the costs, and they are especially higher (68%) in Siraha due largely to the use of contract labor for various activities. Returns above cash costs as well as net returns from total costs from rice production are highest in Tanahun and lowest in Siraha, despite the higher cost of production in Tanahun (hills). Farmers obtain higher net returns in Tanahun due to their higher rice yield and relatively higher price of grain and rice straw. Farmers in Siraha obtained very low net returns and returns above cash costs as rice yields are low and cash costs are high.

Comparative input use for MV and TV rice production. The use of material inputs (seeds, fertilizer, organic manure) and labor for MVs and TVs varies by sites (Table 31). In two of the Terai sites (Banke and Siraha), farmers apply more chemical fertilizer and use labor for the cultivation of MVs. Labor use is higher for MVs in

Table 30. Costs and returns (NRs 000/ha) in wet-season rice production, 2008.[a]

Costs and returns	Banke	Siraha	Tanahun	All
No. of farmers (plots)	100	100	90	290
Grain yield (t/ha)	3.21	2.18	5.06	3.43
Value of grain (NRs 000/ha)	36.69 (496)	24.55 (332)	68.82 (930)	42.47 (574)
Value of straw (NRs 000/ha)	5.40 (73)	5.13 (69)	18.64 (252)	9.41 (127)
Gross returns (NRs 000/ha)	42.08 (569)	29.68 (401)	87.45 (1,181)	51.89 (701)
Cash costs (NRs 000/ha)	10.17 (137)	18.72 (253)	26.32 (356)	18.13 (245)
Returns above cash costs	31.91 (431)	10.95 (148)	61.14 (826)	33.75 (456)
Net returns	11.66 (158)	1.96 (26)	30.22 (408)	14.07 (190)

[a]The yield data, input use, and costs include from the largest parcel (intensive data plots) of the farm households. The values in parentheses are in US$/ha. The value was converted from local currency to U.S. dollars at the prevailing exchange rate of US$1= NRs 74.0 in 2008.

Table 31. Input use in rice production for MVs and TVs for the wet season.

Item	Banke		Siraha		Tanahun		All	
	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TV
Seeds (kg/ha)	91	92	52	52	125	151	87	114
Fertilizer (kg/ha)								
N	46.8	21.0	40.0	37.0	47.0	55.0	45.0	42.0
P	6.3	0	10.0	9.5	10.0	10.0	8.4	9.5
K	1.9	0	7.5	5.7	3.8	1.9	3.8	3.8
Organic fertilizer (manure) (kg/ha)	3,092	0	2,180	1,528	6,681	5,004	3,796	3,609
Pesticide use (L/ha)	0		0		0.24		0.07	
Labor (days/ha)	179	97	171	141	287	355	207	262
Power								
Bullock (days/ha)	13	16	16	19	37	48	21	35
Tractor (hours/ha)	2.4	0	2.9	0	0	0	2.0	0
Thresher (hours/ha)	0.7	0	0.3	0	0	0	0.4	0

[a]The P and K are in the elemental form (they are derived from the conversion of P_2O_5 and K_2O using 0.83 for P_2O_5 and 0.44 for K2O).

Banke and Siraha. However, at the hill site in Tanahun, farmers use relatively more labor, animal power, and N and P fertilizers for TVs.

The amount of seed use varies by sites for different types of technologies. Relatively more seeds are used for TVs than for MVs, which is more evident in Tanahun. Seeds of TVs are farm-saved whereas the major portion of MVs are purchased from the market (Agrovets), research farms, and extension agencies. Farmers tend to use more seeds per unit area of land for TVs due to the perceived belief among farmers in the relatively poorer quality (e.g., in terms of germination percentage) of farm-saved seeds.

The use of mechanical power (tractors and threshers) was most common in Banke and Siraha. Farmers use more animal power for TVs and more mechanical power for MVs. Animal power (bullock) is mainly used for land preparation for TVs and tractors for MVs. The total period of tractor use is higher for MVs, even though the use of animal power is higher for TVs.

Family and hired labor for MV rice. The estimates of the share of family and hired labor for modern and traditional varieties across the sites are presented in Table 32. The share of family and hired labor use varies by sites for MV and TV rice cultivation. The share of hired labor in the cultivation of MVs is very high (72%) in Siraha, intermediate (49%) in Tanahun, and very low (17%) in Banke. Farmers in Banke do not use hired labor for the cultivation of TVs (e.g., Satha rice variety).

Comparative costs and returns in MV and TV rice production. MVs are more profitable than TVs with their higher net returns and net returns above cash costs (Table 33; Appendix 3) due largely to the higher yield of modern varieties. The higher profitability (returns above cash costs) of MVs over TVs was statistically significant. Overall, MV cultivation provides 13% higher incremental returns above cash costs across the study sites. However, variation occurs by site. Farmers in Banke receive very high incremental returns (155%) above cash costs from MVs over TVs, followed by moderately high for farmers in Tanahun (38%) and Siraha (37%). But, the actual net returns above cash costs for MVs are higher for Tanahun (NRs 63,028 or US$852) from the cultivation of MV rice than for the Banke and Siraha sites.

The value of grain and straw constitutes the major returns for rice farming. The share of major components of the return and cost items for MVs in comparison with TVs for the wet season is given in Appendix 3. Compared with MVs, TVs have a relative higher share of straw value in total returns (15–22%) at all the sites (see Appendix 4) due to their higher straw yields as a result of taller plant height.

Labor, chemical fertilizer, organic fertilizer (manure), power use, and seeds constitute the major costs for farmers in both MV and TV rice production. Many of these costs are not actually paid by the farmers. Some of these costs are imputed mainly from those that are family-owned resources. The bulk of the cost of organic fertilizer, human labor, and animal power is imputed from the value of family-owned resources. However, farmers need to incur higher cash costs in hired labor, chemical fertilizers, and power use (see Appendix 4 for details).

Factor shares in the cost of production for MVs. The share of each input in total costs for both MVs and TVs of rice production is briefly outlined below and presented in Table 34, with details in Appendix 3 and 4.

Table 32. Percent share of labor use in MV rice production for wet season, 2008.

Type of labor	Banke		Siraha		Tanahun		All	
	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TVs
Family labor	83	100	28	36	60	59	59	54
Hired labor	17	0	72	64	40	41	41	46
Total	100	100	100	100	100	100	100	100

Table 33. Costs and returns (NRs 000/ha) in MV rice production for the wet season, 2008.[a]

Costs and returns	Banke		Siraha		Tanahun		All	
	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TVs
Total returns	42.33 (572)	18.00 (243)	30.56 (413)	22.49 (304)	89.35 (1,208)	78.65 (1,063)	51.61 (698)	54.42 (735)
Value of grain	36.90 (499)	15.23 (206)	25.32 (342)	18.28 (247)	70.46 (952)	61.21 (827)	42.45 (574)	42.70 (577)
Value of straw	5.42 (73)	2.77 (37)	5.24 (71)	4.21 (57)	18.89 (255)	17.44 (236)	9.17 (124)	11.72 (158)
Total costs	30.61 (414)	16.15 (218)	28.40 (384)	24.25 (328)	56.53 (764)	67.72 (909)	37.27 (504)	48.46 (655)
Paid-out cost	10.22 (138)	5.44 (74)	19.32 (261)	14.42 (195)	26.00 (351)	32.88 (444)	17.99 (240)	24.57 (332)
Imputed cost	20.38 (275)	10.71 (145)	9.08 (123)	9.83 (133)	30.53 (413)	34.39 (468)	19.50 (264)	23.90 (323)
Returns above cash costs	32.11 (434)	12.55 (170)	11.34 (152)	8.10 (109)	63.35 (856)	45.78 (619)	33.84 (457)	29.90 (403)
Net returns	11.72 (158)	1.80 (25)	2.16 (29)	–1.76 (–24)	32.82 (444)	11.39 (154)	14.34 (194)	5.96 (81)
% incremental returns (above cash cost) of MVs over TVs	155		40		38		13	

[a]Values in parentheses are in U.S. dollars (US$1= NRs 74.0 in 2008).

Table 34. Share (%) of different inputs in total cost in MV rice production.

Input cost types	Banke		Siraha		Tanahun		All	
	TVs	MVs	MVs	TVs	MVs	TVs	MVs	TVs
Seeds	7	9	3	3	4	4	4	4
Chemical fertilizer	12	8	11	12	7	7	10	8
Organic fertilizer	10	0	4	3	8	8	8	7
Pesticide	0	0	1	1	0	1	0	1
Irrigation fees	0	0	0	0	0	0	0	0
Labor cost	55	54	57	53	67	69	60	65
Animal power	11	29	17	23	13	12	13	14
Mechanical power (tractor + threshers)	5	0	9	6	0	1	4	2
Total	100	100	100	100	100	100	100	100

- ***Seed costs***

Seed costs account for a small proportion of the total costs (3–9%) and are similar for MVs and TVs across the sites (Table 34). MVs have a relatively higher share of cash costs since farmers need to buy seeds from the market (Appendix 4).

- ***Fertilizers and other agrochemicals***

On average, the share of the costs of chemical fertilizer in total costs is higher for MVs (10%) than for TVs (8%) across the sites. Agrochemicals other than fertilizers that are used on the rice farm include pesticides (insecticides, fungicides, herbicides). But these account for a very tiny fraction of the total cost of production.

- ***Cost of organic fertilizers***

The proportion of cash costs for organic fertilizer is low at all sites compared with noncash costs as most of these organic fertilizers (mostly farmyard manure and compost) are produced on the farm. The amount of total cost for organic fertilizer is similar for both MVs and TVs.

- ***Labor costs***

Labor costs account for the largest share (53–69%) of total costs in both MV and TV rice production at all the sites. The share of labor costs does not vary much between MV and TV rice cultivation. Among the three sites, farmers in Tanahun incur the highest labor costs for both MV and TV rice, which is two-thirds (67–69%) of the total cost of production. This is due largely to the higher use of labor and higher wage rate of labor in Tanahun. The share of hired labor cost is higher in Siraha whereas the share of family labor cost is higher in Banke and Tanahun (Appendix 4). The higher share of hired labor cost in Siraha (eastern Terai) is due to higher contract costs for labor in rice farming.

- ***Power use costs***

The total costs for power use are similar for both MVs and TVs despite differences in the type of power used for cultivation. The cost of animal power is more for TVs, while the cost of mechanical power is more for MVs. In aggregate, the total costs of power use between the types of technologies are not much different across sites.

Comparative input use and costs and returns for new and old MVs

Input use by new and old MVs. The data on farmers' use of material inputs (seeds, fertilizer, organic manure) and labor for the new and old MVs are presented in Table 35. Analysis showed that there are some differences between old and new MVs for the use of inputs (e.g., seeds, N fertilizer, and labor). Farmers use relatively more or fewer inputs for new MVs depending on the nature of the new MVs grown at the site and farmers' differences in the perceived stress characteristics. Farmers use a higher seed rate for old MVs in Banke, but, in Tanahun, they use it for new MVs. However, the seed rate for both new and old MVs is similar in Siraha. Since old MV seeds (e.g., Janakai

Table 35. Input use in rice production for new and old MVs for the wet season.

Item	Banke		Siraha		Tanahun		All	
	New MVs	Old MVs	New MVs	Old MVs	New MVs	Old MVs	New MVs	Old MVs
Seeds (kg/ha)	90	101	51	52	130	119	98	87
Fertilizera (kg/ha)								
N	50.5	46.0	31.5	45.0	49.7	46.0	44.7	45.0
P	5.1	6.3	8.9	11.0	10.0	10.5	8.6	8.9
K	1.5	1.9	6.2	7.5	3.6	1.9	3.8	3.8
Organic fertilizer (manure) kg/ha	2,438	3,809	2,268		5,472	6,433	3,852	3,530
Pesticide use (L/ha)	12.8	0	0.1	0	0.2	0	0.1	0
Labor (days/ha)	172	185	151	181	297	293	226	201
Bullock labor (days/ha)	12.9	13.1	14.1	16.6	38.5	38.2	25.6	18.6
Tractor use (hours/ha)	2.9	1.6	2.6	3.1	0	0	1.4	2.0
Thresher use (hours/ha)	1.1	0.8	0.4	0.2	0	0	0.4	0.4

[a]The P and K are in the elemental form (they are derived from the conversion of P_2O_5 and K_2O using 0.83 for P_2O_5 and 0.44 for K_2O).

variety) are mostly farm produced and degenerated, farmers in Banke use higher seed rates for them. But, in Tanahun, the higher seed rate for new MVs is due to farmers planting newer MVs such as Radha-4 in more marginal drought-prone fields, where a higher seed rate is used to get more secure plant growth during rainfed conditions.

Farmers also use a higher N fertilizer (urea) rate for old MVs in Siraha since many of the old MVs grown at this site are more fertilizer responsive such as Sonamasuli, Kanchhimasuli, and Sabitri. Similarly, farmers in Banke and Tanahun use more compost for old MVs because they perceive that old MVs (Janaki and Masuli) require more nutrients to perform well compared with new MVs such as Radha-4, which can be grown with less added nutrients in marginal fields.

The use of human labor per hectare is also higher for old MVs in Banke and Siraha as many of the old MVs are longer duration and relatively higher yielding (e.g., Sonamasuli in Siraha and Janaki in Banke) compared with new MVs such as Radha-4 in Banke and Radha-11 in Siraha. Hence, farmers use more human labor due to the longer period of crop cultivation and additional labor for harvesting, transport, and threshing of the additional product due to its relatively higher yield (e.g., Sonamasuli in Siraha). However, in aggregate of the sites, no clear differences were observed on the use of farm power (both animal and machines) and the use of P and K fertilizers between old and new MVs.

The comparative costs and returns (in NRs/ha and US$/ha) between old and new MVs for the wet season are given in Table 36 and Appendix 5. New MVs are relatively more profitable than old MVs only in aggregate by providing 33% higher incremental returns (above cash costs) over older MVs. However, they are not profitable individually in Banke and Siraha and are only marginally profitable in Tanahun.

Table 36. Costs and returns for new and old MV rice production (NRs 000/ha).[a]

Costs and returns	Banke		Siraha		Tanahun		All	
	New MVs	Old MVs	New MVs	Old MVs	New MVs	Old MVs	New MVs	Old MVs
No. of farms/parcels	26	57	32	57	54	22	112	136
Grain yield (t/ha)	3.30	2.98	2.06	2.35	4.68	5.35	3.61	3.10
Value of grain	38.21	34.32	22.86	26.70	69.31	74.09	48.82	37.56
	(516)	(464)	(309)	(361)	(937)	(1,001)	(660)	(508)
Value of straw	5.73	5.29	5.88	4.88	18.42	20.69	11.89	7.61
	(77)	(71)	(79)	(66)	(249)	(280)	(161)	(103)
Total returns	43.94	39.61	28.74	31.58	87.73	94.78	60.71	45.17
	(594)	(535)	(388)	(427)	(1,186)	(1,281)	(820)	(610)
Total costs	35.21	29.98	29.40	29.65	57.56	57.14	44.33	34.24
	(476)	(405)	(397)	(401)	(778)	(772)	(599)	(463)
Paid-out cost	15.47	6.37	21.21	20.09	17.16	25.33	19.25	13.97
	(209)	(86)	(287)	(272)	(232)	(342)	(260)	(189)
Imputed cost	19.73	23.61	8.20	12.49	37.65	31.82	25.07	17.27
	(267)	(319)	(111)	(169)	(509)	(430)	(339)	(274)
Returns above cash cost	28.50	33.00	7.50	14.42	67.80	69.45	41.62	31.20
	(385)	(449)	(102)	(195)	(917)	(939)	(560)	(422)
Net returns	8.7	9.6	–0.6	1.9	30.2	37.6	16.4	10.9
	(118)	(130)	(–9)	(26)	(408)	(509)	(221)	(148)
% Incremental returns (above cash costs) of new MVs over old MVs	–14		–48		–2		33	

[a]Values in parentheses are in U.S. dollars (US$1= NRs 74.0 in 2008).

Paid-out costs are higher for new MVs than for old MVs at the Terai sites (Banke and Siraha), due largely to the higher use of chemical fertilizers and use of more purchased seeds. However, at the hill site in Tanahun, imputed (noncash) cost is relatively higher for new MVs despite total costs for the old and new MVs being the same. This is because farmers allocate a higher share of family labor costs (and lower share of hired labor cost) to the total cost of production for new MVs as against old MVs (Appendix 6).

Costs and returns for major nonrice crops

The costs and returns for major nonrice crops are analyzed based on cash costs without taking into consideration noncash costs that include the imputed value of family-owned resources (family labor, owned organic fertilizers, seeds, animal power, etc.). Wheat and maize are two important nonrice crops that are important for the food security and livelihood of the farmers at the study sites (Tables 37 and 38).

Wheat. Wheat is grown during the dry season after the rice harvest. The summary of costs and returns in wheat production is presented in Table 37. There is a high variation in yield of wheat among sites. The yield of wheat is high in Banke (3.5 t/ha), intermediate in Siraha (2.06 t/ha), and low in Tanahun (1.12 t/ha). Gross returns therefore are highest in Banke (NRs 47,755/ha or $645/ha) and lowest in Tanahun (NRs 18,564 or $251/ha).

The cash costs for the wheat crop are very low ($28–58/ha) as a limited amount of hired labor, machinery, and fertilizer is used for wheat production. The returns above cash costs for wheat production (for average of three sites) appear to be fairly high ($473/ha) due to its low cash cost of production.

Maize. Farmers at the study site choose to grow a portion of the farm area for the cultivation of maize, particularly in the upper fields (uplands) and on hill slopes, where rice cultivation is not possible. However, during the dry season (spring and winter months), maize is mainly grown in rice fields. A large portion of farmers (94%) in Tanahun grow maize during both the wet and spring seasons. During the wet season, maize is grown on both unbunded hill slopes in hills (e.g., Tanahun) and in upland fields in Terai (e.g., Banke and Siraha), where water availability is not adequate for growing rice. Yield of maize in Siraha is fairly high (4.34 t/ha) since it is being grown during the dry season as a cash crop, and most of it is hybrids. The summary of costs and returns in maize production is given in Table 38. The cash costs incurred for the cultivation of maize are low at all the sites but the gross returns are fairly high, particularly in Siraha (NRs 64,710/ha or $874/ha) due to the cultivation of hybrid maize. The average returns above cash costs for maize are relatively high ($416/ha) due to its very low cash cost of production.

Rice production, consumption, and other uses

Rice is an important staple crop of the farmers at the study sites, since almost all of the sample households (90–95%) produce rice for their livelihood needs (Table 39). Rice production is mainly semi-subsubsistence in nature, in which most of the rice (71%) produced is consumed in the households. Data showed that a small proportion (12%)

Table 37. Costs and returns for wheat at the study sites, Nepal.[a]

Costs and returns	Banke	Siraha	Tanahun	All
	(n = 90)	(n = 83)	(n = 15)	(n = 188)
Area (ha)	0.47	0.49	0.06	0.44
Yield (t/ha)	3.51	2.06	1.12	2.65
Price (NRs/ha)	14 (0.19)	15 (0.20)	17 (0.23)	14 (0.19)
Gross returns (NRs 000/ha)	47.75 (645)	29.52 (399)	18.56 (251)	37.51 (507)
Total cash costs (NRs 000/ha)	2.34 (32)	4.26 (58)	2.07 (28)	2.54 (34)
Returns above cash costs (NRs 000/ha)	45.41 (614)	25.25 (341)	16.49 (223)	34.97 (473)

[a]Exchange rate: US$1= NRs 74 in 2008. The values in parentheses are in US$/ha. Net returns over total costs were not estimated due to a lack of information collection on noncash costs.

Table 38. Costs and returns for maize at the study sites, Nepal.

Costs and returns	Banke	Siraha	Tanahun	All
	(n = 38)	(n = 2)	(n = 94)	(n = 134)
Area (ha)	0.18	0.11	0.26	0.23
Yield (t/ha)	1.83	4.34	2.51	2.35
Price (NRs/ha)	15 (0.20)	15 (0.20)	15 (0.20)	15 (0.20)
Gross returns (NRs 000/ha)	27.48 (371)	64.71 (874)	37.73 (510)	35.23 (476)
Total cash costs (NRs 000/ha)	2.79 (38)	2.19 (30)	4.88 (66)	4.42 (60)
Returns above cash costs (NRs 000/ha)	24.69 (334)	62.52 (845)	32.84 (444)	30.81 (416)

[a]Exchange rate: US$1 = NRs 74 in 2008. The values in parentheses are in US$/ha. Net returns over total costs were not estimated due to a lack of information collection on noncash costs.

of the produce is sold in the local market. Farmers have a practice of keeping some part of the produce also for seeds and payment for various purposes such as for land rent, hired labor, and livestock feed, including some expenditure needs (other uses). The per capita availability of rough rice for consumption is estimated to be 135 kg (90 kg of milled rice) averaged over the three sites. This availability is higher than the national average availability of about 90 kg of rough rice for Nepal (FAOSTAT 2007).

Structure and sources of household income

The sample farmers are engaged in a multiple set of farm, off-farm, and nonfarm activities and they derive their household income from these activities. The total

Table 39. Household rice production, consumption, and uses.

Item	Banke	Siraha	Tanahun	All
% Rice-producing households	95	95	90	93
% Rice-selling households	15	38	15	23
Average rice production (kg/hh)	1,652	2,541	1,300	1,831
Per capita rice production (kg)	225	381	217	275
Per capital rice consumption (kg)	187	182	24	135
Household uses of rice (kg/hh)				
% Consumed at home	83	55	85[a]	71
% Sold in the market	9	17	4	12
% Used as seed	3	3	0	2
% Used as feed	0	1	1	1
% Used in payment	2	15	10	8
% Other uses	3	9	0	6
Total	100	100	100	100

[a]The proportion of rice consumed also includes that kept for future use, mainly for consumption in Tanahun.

household income was estimated by combining gross income of the households from rice, nonrice crops, and various other farm and nonfarm activities for the study period (2008). These include the sum of the value of all goods and services produced on the farm, off-farm, and nonfarm activities by deploying land and labor—the major assets of rural households. Farm income constitutes the gross income obtained from rice, nonrice crops, and livestock. Off-farm income constitutes the income earned by the household as farm labor. Nonfarm income is the income arising from nonagricultural labor and nonfarm employment activities and includes sources such as business (trade and retail shops), salary, services, remittances, and labor earnings and employment in industry.

The size, structure, and sources of household income estimates for the study sites are presented in Table 40. Farm income accounts for 64% and 54% of the total income in Banke and Siraha, respectively. However, its share is relatively low in Tanahun (31%). The average of the three sites represents 47% of the total household income, which is very much comparable with the average national household income (47.8%) as reported by the Nepal Living Standard Survey Data (NLSS 2004). Rice accounts for a relatively lower share (10–24%) in total household income among the studied sites. Banke has a relatively higher share of both rice and nonrice crop income in household income. The farmers at the hill site (Tanahun District) have the lowest share of rice in total household income due to their smaller proportion of rice area suited for rice cropping on hill slopes and in river basins and their higher share of nonfarm income. This average share of rice income (13%) in total household income is close to the findings of the NLSS survey (2004). The study finding reports the share of rice income at 15% and the expenditure share at 25% among agricultural households (NLSS 2004).

Table 40. Household income (NRs/hh) and percentage share in total income.[a]

Income structure	Banke	Siraha	Tanahun	All
Household income (NRs)	80,324	212,402	202,762	166,917
Per capita income (NRs)	11,548	32,280	34,078	25,693
Income (US$/capita)	156	436	461	347
% Share in total income				
Farm income	64	54	31	47
Crop income	59	48	24	41
Rice	24	14	10	13
Nonrice crops	35	34	14	27
Livestock income (sale)	5	6	7	6
Off-farm labor income	2	1	0.3	1
Nonfarm income	34	45	69.3	52
Nonfarm labor income	24	2	0.3	5
Other income (business, job, remittance)	10	44	69	48
Total	100	100	100	100

[a]Exchange rate: US$1 = NRs 74 in 2008.

The share of income from wage labor in agriculture (off-farm) is very low at all the sites, even though nonfarm labor income is fairly high (24%) in Banke. Nonagricultural income obtained mainly from remittance, trade, business, and jobs constitutes a major source of income in Tanahun and Siraha, contributing 69% and 44% to household income, respectively. On average across the three sites, nonagricultural income constitutes 52% of total income, which is similar to national average nonagricultural income as reported by the NLSS (2004). This implies that the livelihood strategy of the farm households has been based on mainly the nonfarm sector, as farm size is small, which is inadequate to support the livelihood of households year-round.

Among the three sites, Banke study villages have the lowest household income, as nonfarm remunerative income sources (e.g., remittance, business, and services) are limited despite their higher share in nonfarm agricultural wage labor. This lower share from the nonfarm sector is due to the predominance of their involvement in low-paid unskilled wage labor in the nonfarm sector (wage labor in nearby factories and market centers, etc.). Therefore, the average per capita income of the household member is NRs 11,548 ($156), which is reasonably low compared to other sites, indicating a higher incidence of poverty among households at this site. Nonincome indicators of household welfare, such as years of schooling (3.6 years), low farm size, and less proportion of farm area under irrigation described above (Table 9 and Table 11), also confirm the general picture of a low living standard at this site. Compared with Banke, the per capita income of farmers in Siraha and Tanahun is relatively high (above $400) due to a higher share of income from nonfarm employment mainly from business, salaried jobs, and remittances. The average per capita income of three sites for Nepal ($347) is close to the World Bank estimates for 2008 ($400) and national

average per capita reported by the NLSS (2004), which is equivalent to $300 (at the 2003 exchange rate).

Employment in farm and nonfarm labor. The household members in all the study villages are partly employed as farm labor in off-farm and nonfarm labor work, particularly in the nearby market centers (Table 41). The percent family members working in nonfarm labor is significantly higher than those working in off-farm (agricultural) wage labor at all the sites. Employment in nonfarm labor is higher in Banke due to the availability of labor work in the nearby market town in Nepalganj and the higher proportion of marginal farmers and landless laborers in the villages. Almost all households (96%) have at least one adult member working either off-farm or in nonfarm labor compared with less than half of the households in Siraha and Tanahun. The average days worked in off-farm and nonfarm labor is also higher in Banke, where family members are engaged for about 134 days (equivalent to 4.5 months for an adult member) compared with 96 days for Siraha (3.0 months) and 15 days (a half-month) for Tanahun. This indicates that nonfarm and off-farm labor provide more employment opportunities for the household members in Banke. However, income earned from nonfarm and off-farm labor is very low in Banke due to the low-paid unskilled jobs. Despite lower employment in nonfarm and off-farm work in Siraha and Tanahun, households have higher income from other nonfarm sources such as remittances, including business, trade, and services (salaried jobs). The role of remittance income in rural Nepal is rapidly increasing, mainly driven by increased access to urban and overseas markets for labor employment, including recent changes in macroeconomic factors.

Borrowing cash and noncash items. Borrowing cash and noncash food and other important items plays an important role in reducing the negative impact on consumption and livelihood needs during stress years when farmers have to suffer from production and income losses. The findings show that a majority of the farm households borrow cash to meet their consumption shortfall (Table 42). Noncash borrowing, particularly foods, seeds, etc., is not common except for borrowing seeds in Tanahun. A larger proportion of farm households in Banke (44%) and Siraha (23%) is not involved in

Table 41. Employment in off-farm (farm labor) and nonfarm labor activities.

Employment	Banke	Siraha	Tanahu	All
Av. household size (no. of members)	6.9	6.6	6.0	6.5
Av. number of adult members	4.2	4.2	4.0	4.1
% HH with one working member in off-farm labor	20	29	40	30
% HH with one working member in nonfarm labor	76	17	6	33
% HH with one working member in both off-farm and nonfarm labor	96	46	46	63
Av. no. of days worked in farm labor	84	91	11	59
Av. no. of days worked in nonfarm labor	149	113	42	137
Av. no. of days worked in farm and nonfarm labor	134	96	15	96

Table 42. Percentage of households borrowing cash and noncash items, 2008.

% Households borrowing	Banke	Siraha	Tanahun	All
Cash borrowers	54	75	73	67
Noncash borrowers of food	1	–	6	3
Noncash borrowers of seed	1	2	20	5
Other noncash borrowers	0	0	0	0
Not involved	44	23	0	25
Total	100	100	100	100

any sort of cash or noncash borrowing. Since access to farm and nonfarm wage labor is more easily available at the Terai sites, small farmers are less involved in borrowing from informal sources (e.g., money lenders), who tend to charge a higher interest rate on the borrowed amount. However, poor farmers in Tanahun tend to borrow from informal sources at a high interest rate (36% per annum) to meet their consumption needs. Furthermore, unlike other rural areas of Nepal, the survey data and field observations also indicated that the current survey sites have limited involvement of NGOs and other institutions in providing micro-credit to the rural poor.

Household coping strategies

Households at the study sites adopt different strategies (both short and long term) to reduce, mitigate, and cope with risks and shocks that affect them through drought stress in rice production. The range of strategies available to households depends on their asset portfolio, options available within and outside the communities, and availability of external assistance during the most vulnerable period of the year. Many households in the vulnerable groups alter their rice production, consumption, and expenditure patterns as a short-term strategy to cope with food-deficit periods and times of hardship. When the drought stress is severe, they are forced to sell their productive and durable assets, change their livelihood strategies, and seek employment in other sectors to cope with the negative effect of the stress. Some of the important production, consumption, and household expenditure strategies to reduce and cope with stress effects are presented below.

Rice food-sufficiency status and food consumption adjustment. Rice is an important component of household income and food intake in the surveyed households. A very high proportion of households use it for their own consumption. In a normal year, half of the sample households across the sites reported being self-sufficient in rice for a year for their own consumption needs (Table 43). However, during a stress year (drought), 17% can meet their household food requirement only from rice. When rice production fails due to drought and other stresses, farmers become most food insecure and vulnerable. Among the sites in the three districts, farmers in Banke are more food insecure and vulnerable than the farmers in Tanahun (better off). During stress years, only 4% of the households are food secure in Banke, indicating a higher incidence of food insecurity and vulnerability during drought stress. This is because

Table 43. Decline in rice food sufficiency and food consumption in stress years.

Household rice food sufficiency	Banke	Siraha	Tanahun	All
% Self-sufficient for 12 months				
Normal year	45	58	72	58
Stress year	4	14	32	17
% HH consuming 3 meals/day				
Normal year	60	86	98	81
Stress year	22	66	84	59
% HH eating less food during stress years	35	11	14	20
% HH eating food items not eaten in normal years	67	28	12	36

larger proportions of farmers in Banke (mainly Partbatipur Village) are marginal farmers and sharecroppers who have not only small-size rainfed landholdings but also have to share half of their produce with the landlord as their part of land rent. In addition, they have limited alternative nonfarm occupations and other sources of income (e.g., remittances) compared with the hill site in Tanahun, where farmers are less food insecure despite their small size of landholdings.

The number of meals eaten per day is also an indicator of food sufficiency and consumption status. Generally, lunch, dinner, and snacks/breakfast are the three meals eaten daily for meeting health conditions in rural Nepal. During a normal year, almost all households (98%) eat three meals a day in Tanahun, whereas only 60% of the households eat three meals a day in Banke. Farmers in Siraha are in an intermediate situation, where 86% eat three meals a day during a normal year. During a stress year, Tanahun farmers are better off, with 86% of them eating three meals compared with only 22% in Banke. Households reduce their food intake significantly in terms of both quantity and frequency during stress years. A significant proportion of households, particularly in Banke, consume inferior food that is generally not eaten during normal years. These inferior food items include coarse grains (maize, millet, sorghum, yams, etc.).

Adjustment in the type of food intake. Farmers reduce their consumption of rice, pulses, vegetables, and milk during stress years (Table 44) although these are considered standard food items in the Nepalese diet. Wheat is also considered a preferred food item in a major part of the far-western and mid-western region in Nepal. When farmers suffer from production and income loss, they generally switch to socially inferior food staples such as maize, millet, and other minor cereals (barley, buckwheat, etc.). Consumption of vegetables also decreases as these are also expensive commodities if not produced on farmers' own homesteads. The most significant reduction is observed in the consumption of milk as milk is considered an expensive food item for the poor. The use of meat and fish is not common in the daily diet of poor farmers in rural Nepal.

Table 44. Household adjustment in consumption of food items in a stress year.[a]

Daily consumption	Banke		Siraha		Tanahun		All	
	NY	SY	NY	SY	NY	SY	NY	SY
% HH consuming rice	97	81	100	88	99	99	99	89
% HH consuming wheat	64	60	71	66	0	0	45	40
% HH consuming maize	14	21	0	2	0	3	5	9
% HH consuming minor cereals+	0	0	2	1	12	0	5	0
% HH consuming pulses	53	41	59	40	71	64	61	48
% HH consuming vegetables	97	77	98	85	94	98	96	87
% HH consuming milk	61	14	54	14	51	2	55	3
% HH consuming meat	2	3	2	0	0	0	1	1

[a]NY = normal year; SY = stress year. +Minor cereals include finger millet, barley, buckwheat, oat, etc.

Households' other adjustments for food security and production needs

Small and marginal farmers during drought years adopt a range of strategies to secure immediate household food needs as well as seed needs for the subsequent crop production cycle. Some of these include distress sale of immediately harvested crops and resorting to increasing food, seed, and cash borrowing from neighbors or relatives (Table 45). Analysis indicated that a small proportion of households opt only for selling more harvested crop (distress sale). The main reason for this is that many of them fear a scarcity of food needs during a later period. However, they opt for other strategies to minimize risk such as increasing their food and cash borrowing from neighbors and relatives in the local community. About one-third of the households, particularly in Banke (38%), increase their food borrowing during stress years, even though this was not a prominent strategy at other sites such as Siraha (16%) and Tanahun (25%). Some 50–70% of the surveyed households also increase their borrowing of cash during stress years, which was more prominent in Siraha.

Similarly, an average of one-fifth of the households (with a range of 15–33%) are also engaged in borrowing seeds during stress years, which is required for the next cropping cycle. This happens mainly in Banke (33%) because many poor farm households consume reserve seeds during stress years due to immediate household food needs.

Broader household livelihood adjustment strategies

Poor farm households use several strategies to cope with immediate consumption and livelihood needs during drought stress. These include resorting to alternative income sources, deferring loan payments, using household savings, selling/mortgaging productive and durable household assets, and having children drop out of school (Table 46). The findings show that about 43% of the households resort to alternative income sources to meet their consumption and other immediate livelihood needs. More than one-third of the households also tend to defer their loan payments during a stress year, which was more prominent in Siraha (58%). A large number of households

Table 45. Households' immediate adjustment in meeting food security needs.

Household consumption behavior	Banke	Siraha	Tanahun	All
% HH selling more harvested crops	4	1	2	2
% HH increasing their food borrowing	38	16	25	26
% HH increasing seed borrowing	33	15	15	21
% HH increasing their cash borrowing	51	70	50	57

Table 46. Broader household livelihood adjustment strategies during stress years.

	Banke	Siraha	Tanahun	All
% HH resorting to alternative income sources	42	35	51	43
% HH deferring loan payments	33	58	37	43
% HH using their savings	96	71	68	78
% HH selling/mortgaging productive assets	6	11	3	7
% HH selling/mortgaging durable assets	14	6	4	8
% HH with children dropping out from school	14	3	1	6

(68–96%) use their limited savings to meet their food and expenditure needs to cope with emergencies and the unexpected need for cash during a stress year. This was more prominent in Banke, where about 96% of the sample farm households reported having used this coping strategy during drought years. However, only a small proportion of households are actually involved in selling/mortgaging their productive and durable assets during stress years. Households withdrawing children from their school during stress years is also not common. Among the sites, some marginal farm households in Banke tend to withdraw their children from school due to their higher incidence of food insecurity and poverty. This indicates that the drought stress that they faced in rural Nepal in the past was milder than the more severe form that was reported from eastern India during 2001-02 (Pandey et al 2007).

Crop adjustment and coping mechanisms

Farmers modify and adjust production practices and input use depending on drought incidence and period. The most important tactical adjustment is that they delay rice transplanting if rainfall is delayed. If early-season drought is severe, area sown to rice declines drastically due to the lack of moisture availability. Farmers prefer to use healthy well-grown young seedlings for transplanting in moisture-stress fields during drought stress. The rationale for this is that healthy seedlings can establish faster in moisture-stress conditions. However, if younger healthy seedlings are not available, farmers are forced to use old weak seedlings during severe drought stress situations. The use of chemical fertilizers, particularly urea, decreases during a drought period. Farmers have to invest more labor inputs for weeding as weeds are a major problem due to moisture-stressed conditions during the early drought period. As the weeds grow more, more labor is required for weeding the crop, resulting in increased cost

of production compared with a normal year. In severe cases, farmers have to forego crop yield and they face increased costs of production incurred on the crop.

During a severe drought period, when the crop fails, farmers, particularly the small and marginal ones, switch to nonfarm employment in the nearby market area and meet their livelihood needs through rickshaw pulling and wage labor in factories since growing a second crop is limited due to a lack of irrigation facilities.

The most recent drought that farmers faced at all the sites occurred in 2006. However, farmers in Tanahun faced a drought situation also in 2007. Early-season and mid-season droughts were more frequent at all the study sites in Nepal. Terminal drought was not observed in the severe form. The rice production calendar is extended when early-season drought is severe as farmers have to wait for rainy days to re-transplant the crop. During the drought period, in addition to an area reduction, rice yield also declines significantly, at least 1 t/ha (30% of the normal season). In a severe drought season, however, yield reduction is very high due to partial or complete failure of the crop.

During early-season drought, transplanting of paddy becomes late and only part of the cultivable land is planted. The prolonged period of drought in 2006 delayed planting even further, resulting in overmature paddy seedlings, which when transplanted remained more vulnerable to diseases and reduced production (about 20–30% less). Delayed planting and late harvesting also affected the planting of dry-season crops such as wheat, lentils, and mustard. In addition, late transplanting required denser planting of seedlings, which ultimately resulted in higher seedling and labor costs. Some farmers also reported that they grow traditional varieties, particularly at the hill site in Tanahun as they are more adapted to moisture-stressed situations so that they can harvest at least some crops.

Farmers modify and adjust production practices and input use depending on drought incidence and period. The most important tactical adjustment is that they delay rice transplanting if rainfall is delayed. Some adjustment in seedling/seed rates (higher amount) and limited use of fertilizer application (e.g., urea) and postponing of weeding are also common. When crops completely fail, the small and marginal farmers switch to nonfarm employment in the nearby market area to cope with the negative impact of drought on livelihood.

Relief and mitigation programs

Currently, no government-sponsored or NGO-initiated relief programs are reported at many of the study sites during drought years. However, some farmers in Siraha reported having received a limited amount of wheat seeds during postmonsoon planting as a relief package during the 2006 drought year after the failure of the rice crop in the monsoon season. The government of Nepal recently formulated and approved the National Strategy for Disaster Risk Management (2009) to manage various disasters, including drought in the country (MOHA 2009). However, the government has yet to formulate specific rules, regulations, and procedures and to develop relevant institutional mechanisms to implement the strategies. Currently, the country lacks plans,

policies, and programs for long-term drought mitigation and adaptation mechanisms, including specifically designed relief programs. India has already developed an elaborate institutional setup for drought relief, which mainly takes the form of employment generation through public works. Some inputs and credits are provided as well (Pandey et al 2007). However, such a mechanism currently doesn't exist in Nepal. There is a need for broader policies for water resource development, weather forecasting and preparedness, income diversification, and crop insurance, including research policies for suitable technology design and targeting to mitigate and reduce the impact of drought stress on poor farmers in rainfed and risk-prone environments in Nepal.

Vulnerability to stress

Marginal farm households, sharecroppers (mostly landless farm households), and wage earners are most vulnerable as they are the most food insecure and have extremely limited options to cope with drought stress. Small and marginal farmers who have more land area located in the upper toposequence of fields (e.g., uplands) are more vulnerable as upland fields are the most drought-prone. Similarly, households that have limited nonfarm opportunities and less social connection with the outside world are also more vulnerable. Women and children are the most vulnerable among the household members, as women are the last to eat after meals are left and they rarely go out of the village for securing alternative income and employment. Children also suffer more from less food and malnutrition, including a lack of educational opportunities during severe drought-stress situations.

Currently, there are no formal public-sponsored relief programs for mitigating the negative effects of production and welfare loss on the poor and vulnerable people. In addition, local community initiatives and efforts for mitigating the negative effects of drought are not observed at the study sites. As a result, the poorest households from disadvantaged social groups (lower castes, women, children, etc.) and those of marginal farmers who have rice fields in the upper drought-prone toposequence tend to be more vulnerable during drought periods.

Awareness and sources of stress-tolerant varieties

The study tried to capture the level of awareness of farmers of stress-tolerant modern varieties. The reference for stress-tolerant varieties includes new IRRI stress-tolerant varieties being tested in the country, including existing MVs that are being recommended that are slightly drought tolerant (e.g., Radha-4, Radha-32, etc.). The findings revealed a wide variation in the amount of awareness of stress-tolerant rice varieties among the farmers at the study sites (Table 47). Farmers in Siraha and Banke have very limited awareness of stress-tolerant rice varieties. However, a fairly high proportion of farmers (81%) in Tanahun reported having some awareness and a good proportion of them have already planted varieties that have some drought tolerance such as Radha-4, Radha-32, IR51672, etc. But, very few farmers in Banke and Siraha planted slightly stress-tolerant varieties such as Radha-4 and Radha-11. A relatively higher

Table 47. Awareness and sources for stress-tolerant varieties (STVs).

	Banke	Siraha	Tanahun	All
% Households heard of STVs	17	13	81	37
% Households planted STVs	7	10	65	27
% Households willing to plant STVs	98	95	30	74
Source (%) of information on STVs				
Extension workers and researchers	4	10	20	11
Neighbors, relatives, and friends	3	3	58	22
Others (radio, TV, and newspapers)	0	0	2	0
No sources of information	93	87	20	67
Total	100	100	100	100

farmers' awareness of stress-tolerant rice varieties in Tanahun was due to farmers' earlier exposure to some new rice varieties such as IR51672, Radha-4, Radha-32, and Hardinath-1 through the IFAD upland rice project (2005-08), since this site was a part of the up-scaling of the project for the IAAS-Lamjung campus.

Since farmers currently have no reliable access to stress-tolerant varieties in Banke and Siraha, a very large proportion of them are willing to plant new promising stress-tolerant varieties. Since their current dominant modern varieties are old, low-yielding, and not tolerant of various stresses, this will provide them with good options for enhancing their rice productivity. However, in Tanahun, only one-third of the surveyed households are willing to plant new ones, as two-thirds have already planted some types of newer modern varieties slightly tolerant of some stresses (e.g., Radha-4, Radha-32, etc.). One-third of the farmers who were aware of stress-tolerant rice varieties have not been growing such varieties for various reasons. First, farmers do not know with certainty the future occurrence of drought in advance during seedling-raising time. So, they do not plan for the production of such varieties. Second, most of the drought-tolerant varieties available in the study are of poor eating quality. Third, some landowners urge tenant-cultivators to grow those varieties, which are good in taste irrespective of their drought-tolerance capacity and yield potential.

Reliable sources of agricultural information are critical to enhancing agricultural productivity. The analysis shows that currently a large number of farmers, particularly in Banke (93%) and Siraha (87%), have had no sources of information for stress-tolerant varieties. Local extension and research farms were the major sources of information for 4–20% of the farmers. For those farmers, particularly in Tanahun, who have already planted stress-tolerant varieties, the main sources of the stress-tolerant varieties for them were their own informal sources (58%) such as neighbors, relatives, and friends, followed by formal sources (20%), mainly extension workers and researchers. The formal sources of information were extension agencies such as the District Agriculture Development Office (DADO) and its local Agricultural Service Centers, a research institute such as NARC, and its regional research stations and teaching institutes such as the Institute of Agriculture and Animal Sciences (IAAS).

Dependency on mass media such as radio and television as a source of information was found much less. These are the sources basically for the acquisition of information on weather forecasts.

Gender division of responsibility and decision making

Gender roles and decision making have an important influence on rice farming and the sustenance of farmers' livelihood in stress-prone rainfed areas. This section outlines gender analyses in relation to division of the labor force and women's participation in rice production, including decisions on household livelihood and Women's Empowerment Index.

Gender division of labor force and women's participation in rice production. Men and women farmers provide a differential share of labor contribution in different rice production activities. The proportion of total male and female labor force participation in rice production activities is presented in Table 48 and details by sites in Appendix 4. Crop establishment (mainly transplanting), harvesting, and weeding are the major domains of women's labor at all the sites. Women are more involved in the application of organic fertilizers in fields before land preparation. At the hill site in Tanahun, this is a sole activity of the women members. Land preparation is mainly a men's activity at all the sites as it requires more heavy work such as plowing and leveling fields. The application of agro-chemicals is the sole activity of male members.

Men are also more involved in threshing of rice (separating grains out of the straw) using both manual beating and animal traction. However, both men and women are involved in a differential proportion in many activities such as harvesting, threshing, postharvest (drying, cleaning grains, transporting, and marketing), weeding, and irrigation, including crop establishment.

When labor force participation is segregated by family and hired labor, the proportion of women's and men's contribution varied by sites (Table 49). The contribution

Table 48. Proportion of male and female labor participation in rice farming.

Rice production activities	Males (%)	Females (%)	All (%)
Land preparation	12	3	15
Crop establishment methods	5	14	19
Application of organic fertilizer	2	3	5
Application of chemical fertilizer	2	0	2
Application of pesticides	1	0	1
Weeding	6	13	19
Irrigation	2	1	3
Harvesting	6	10	16
Threshing	8	5	13
Postharvest activities	4	3	7
Total	48	52	100

Table 49. Family and hired men's and women's labor participation in rice farming.[a]

Item	Banke	Siraha	Tanahun	All
Total labor days/hectare	178	167	299	212
Family labor days/hectare	148	48	180	123
% Family male labor	45	18	19	26
% Family female labor	38	10	41	32
Hired labor days/hectare	30	119	120	89
% Hired male labor	6	37	19	20
% Hired female labor	11	35	21	22
% Total male labor	51	55	38	46
% Total female labor	49	45	62	54
Total	100	100	100	100

[a]Contract labor was used only in Siraha District, which is not accounted for in this estimation.

of women's labor in rice production is higher at the hill site in Tanahun than at the two Terai (Siraha and Banke) sites. This indicates that, in hill environments, women have a major role to play in rice farming and sustaining household livelihood activities. The share of family labor is higher in Banke, followed by Tanahun, whereas the share of hired female labor is higher in Siraha in the eastern Terai than at the other sites. The hired component in terms of share of both male and female labor is higher in Siraha because of well-developed labor markets and the scarcity of family labor due to a higher proportion of young farmers involved in off-farm employment overseas (in Gulf countries).

Decision making and women's empowerment. Gender division of responsibilities and decision making in terms of the Women's Empowerment Index and percent male and female involvement in various activities is presented in Table 50.

Results showed that most of the decisions related to household use of agricultural technologies, farm production, and marketing activities, including broader household livelihood options, are made jointly in consultation with other male or female members. The proportion of women (principal females) solely making decisions in farm, nonfarm, and livelihood activities is very much limited. Women have a greater role mainly in what type of food to consume, followed by raising of children and hiring of labor as indicated by the higher Women's Empowerment Index in these activities.

As shown by the data, the highest proportions of decisions are made equally by both the male and female together, followed by the male only. The principal males only (men) make major decisions mainly on selling harvested products, purchasing farm implements, and obtaining credit. However, some variations in gender participation and decision making occur across the sites (Table 51). In Tanahun (hill areas), women have more decision-making power and household responsibilities due to the more open culture in the hill areas than at the Terai sites such as in Banke and Siraha in Nepal. The higher responsibility and empowerment of women in decision making at the hill site was higher in the selection of rice varieties, hiring farm labor, selling or

Table 50. Division of responsibilities, decision making (%), and Women's Empowerment Index in various agricultural and other livelihood activities.[a]

Decisions	Husband only	Wife only	Both				WEI
			Husband more influential	Wife more influential	Both equally influential	All	
What rice variety(ies) to grow	26	16	12	8	37	57	2.77
Who and number of farm laborers to hire	22	18	10	14	35	59	2.95
Whether to sell/consume harvested crop	18	14	13	10	44	67	2.88
Quantity of output to sell and consume	18	14	10	10	46	66	2.92
When and where to sell the harvested crop	37	14	14	8	35	57	2.67
What price at which to sell the output	28	14	14	9	34	57	2.68
What farm implements to purchase	38	12	14	7	28	49	2.41
Whether to slaughter and sell animals	24	13	12	10	39	61	2.74
Adoption of technology in rice production	30	12	14	9	35	58	2.58
Allocation of farm income	22	11	13	10	43	66	2.75
Allocation of household income	16	10	13	10	48	72	2.84
What types of food to consume in times of crisis	10	16	6	13	53	72	3.18
Children's education	19	5	15	7	52	74	2.63
Where to borrow	32	8	15	10	34	59	2.45
Participation in voting/politics	14	4	9	4	67	80	2.74
Number of children to raise	5	2	7	5	75	87	2.91

[a]Husband and Wife and Both (All) columns should add up to 100%. Some columns have less than 100% due to nonresponse problems.

Table 51. Women's Empowerment Index in various livelihood activities.

Decision on	Banke	Siraha	Tanahun	All
1. What rice variety(ies) to grow	2.54	2.32	3.45	2.77
2. Who and number of farm laborers to hire	2.66	2.71	3.50	2.95
3. Whether to sell/consume harvested crop	2.66	2.61	3.37	2.88
4. Quantity of output to sell and consume	2.68	2.71	3.36	2.92
5. When and where to sell the harvested crop	2.52	2.21	3.28	2.67
6. What price at which to sell the output	2.45	2.23	3.34	2.68
7. What farm implements to purchase	2.38	2.13	2.72	2.41
8. Whether to slaughter and sell animals	2.62	2.25	3.25	2.74
9. Adoption of technology in rice production	2.47	2.15	3.13	2.58
10. Allocation of farm income	2.66	2.53	3.07	2.75
11. Allocation of household income	2.78	2.82	2.90	2.84
12. What types of food to consume in crisis time	2.82	3.21	3.51	3.18
13. Children's education	2.65	2.56	2.68	2.63
14. Where to borrow	2.58	2.10	2.69	2.45
15. Participation in voting/politics	2.60	2.59	3.05	2.74
16. Number of children to raise	2.77	3.00	3.96	2.91
Overall WEI				2.76

consuming harvested crops, and quantity of output to sell as many men are involved in various nonfarm activities and are out of the village for nonfarm employment. Earlier studies related to gender in farming and decision making also indicate that women in the Hills in Nepal have greater decision-making power than the farmers in the Terai, where strict Hindu and Muslim culture provides some restrictions on the involvement of women from higher social status in farming and other livelihood activities (Pradhan 1984, Bajracharya 1994, Subedi et al 2000).

Training and participation in organizations

Households with both male and female members participate in various agricultural and rural skill-oriented training and community-based organizational activities. The training here refers to short-term skill and exposer-oriented training programs on different aspects of agricultural and rural development activities. Most of them are on crop production, livestock raising, fruit farming, kitchen gardening, and microcredit. Some of the other aspects of skill-oriented and income-generating training include plumbing, driving, tailoring, auto mechanic, weaving, and handicrafts, etc. The organizational activities cover farmers' (both men and women) membership and participation in various formal and informal organizations/social institutions that include cooperatives, farmers' and women's groups, community water and forest users' groups, microcredit institutions, local youth clubs, and religious groups, etc. The proportion of farmers participating in training and organizational activities is presented in Table 52. A higher

Table 52. Participation (male + female) in training programs and local organizations.

	Response	Banke	Siraha	Tanahun	All
Participation in organizations	Yes	43	52	82	59
	No	57	48	18	41
Participation in agricultural and other training	Yes	33	20	100	51
	No	67	80	0	49

proportion of farmers' (principal males and females) members in Tanahun participate in training and organizational activities than the farmers in Siraha and Banke. Nearly half of the household principal male and female members from these Terai sites do not participate in training and organizational activities.

When data were analyzed by gender disaggregation, female participation in training was more than male participation in Tanahun. However, in Banke and Siraha, male participation was higher than female participation for the same. Women's participation in local farmers' organizations was also more in Tanahun at the hill site than at the Terai sites in Banke and Siraha. Higher women's participation in training and organizational activities is mainly due to local group formation for credit and saving activities among women farmers by the earlier IRRI-IFAD project. In addition, in recent years, there is increased focus of both government and nongovernment organizations on women's participation and empowerment at the site. Another important reason behind it was women's staying at home in the village and men's migration to other places for nonfarm employment (Panta 2010). The findings also showed that males have membership and participation in diversified local community-based organizations, while females were confined mainly to credit and savings and vegetable farmers' groups.

Summary of the findings

- Farm households at the study sites have similar demographic features, primary occupation, and production environment. Access to irrigation, cropping intensity, and production differences is not evident among the sites. However, farm size at the Siraha site (1.3 ha) is relatively bigger than at the Banke and Tanahun sites and also that of national average farm size (0.80 ha) of Nepal.
- Rice is grown only in the wet season at two of the Terai sites while at the hill site (Tanahun) it is also grown in the spring (dry) season as an irrigated crop in a very tiny portion of the area (0.9 ha). This hill site also has upland rice (direct-seeded) cultivated on unbunded terraces during the early season (March-August).
- Early-season drought is a most common feature in Nepal. Currently, farmers have limited technological options and flexibility to cope with drought stress. Uncertainty of monsoon rains and low irrigation potential are the key constraints to improving rice and overall agricultural productivity of the area.

- Farmers have adopted modern varieties on a major part of their rice farm, covering about 71% in Tanahun, 84% in Siraha, and 98% in Banke. However, most of the MVs adopted by the farmers are very old and were released before the 1980s.
- The average area-weighted age of rice varieties obtained from the survey is above 20 years. Both Banke (western Terai) and Tanahun (hills) sites had an average area-weighted age of 21 years for rice varieties, while it was 26 years for Siraha. This implies that, currently, the replacement rate of rice varieties in farmers' fields is very low.
- Yields of MVs are significantly superior to the yields of TVs at all the sites. Yield effects, however, vary by site. The yield effects of MVs are stronger at Tanahun and Banke sites than in Siraha.
- Newer generation MVs account for about 40% of the total MV area at the study sites. The dominant newer generation MVs are Radha-4 in Banke and Tanahun and Radha-11 (Meghdoot) in Siraha.
- Despite the lower extent of adoption of MVs in Tanahun, farmers at this site have adopted more new-generation MVs (e.g., Radha-4, Radha-32, Judi-572, OR-367, etc.) due to their better access to newer materials from the previous IRRI-IFAD project.
- The yield of newer generation rice varieties is not superior to that of old-generation MVs despite their better adaptability to rainfed conditions (e.g., Radha-4 and Radha-11). However, new MVs are relatively better performing in lowland fields in moisture-stressed rainfed conditions.
- Econometric analysis revealed that endowment of favorable land type (e.g., lowlands), adult household size, age of farmers, and awareness of new rice varieties and participation in training and local farmers' organizations are key factors influencing the probability and intensity of the adoption of new-generation MVs.
- The profitability of the rice crop varies across sites, with higher net returns in Tanahun as farmers obtain higher average yields of 5.0 t/ha from their current rice varieties.
- MVs are more profitable (both net returns and higher returns above cash costs) than TVs due to their higher yields. On average, MV cultivation provides 13% higher incremental returns above cash costs at the study sites.
- Labor is the major component of production costs, accounting for more than half of the total costs. Chemical fertilizer accounts for 8–10% of the costs in rice production.
- Compared with MVs, TVs have a relatively higher share of straw value in total returns (15–22%) due to their higher straw yields as a result of their taller plant height.
- New MVs are relatively more profitable than old MVs when data are pooled across the sites. But, profitability (returns above cash costs) varies by sites, with new MVs marginally superior to old MVs in Tanahun but not in Banke and Siraha.

- Farm households reduce their food intake in terms of frequency, quantity, and quality during stress years as a result of reduced production and income shortfall. Farmers' coping strategies include resorting to alternative income sources, off-farm employment, deferring loan payments, using household savings, and selling/mortgaging productive assets.
- Most of the current decisions on choice of technologies, production, marketing, and livelihood are mainly made by men (principal males) in consultation with female members. Decision-making roles of women regarding farm management are limited.
- Diversification of income and employment sources is one of the prevalent household strategies for coping with drought risk and vulnerability in rural Nepal, where economic and agro-climatic conditions are less favorable for rice production in rainfed environments. Farmers were found to use this strategy where such opportunities exist.

Implications of the findings

- The design of new technologies should consider the development of new rice varieties and management technologies that allow greater flexibility in planting and timing of input use from drought stress to minimize yield reduction and income losses.
- The low adoption of new MVs in upper fields (uplands) implies that efforts are needed to develop new varieties suitable to marginal moisture-stress field conditions and to make them available to farmers. It also implies that land-type differences across locations and households should be considered in defining the target domains for technology development and targeting.
- Newer generation MVs with tolerance of drought need to also have better grain quality as returns from improved grain quality (premium market price) are high.
- Econometric results imply that farm and farmer-specific variables are critical for explaining adoption behavior, implying that it is important to take farmers' endowment of land-type conditions and farmers' socioeconomic circumstances into consideration in the design of an R&D program.
- Increasing farmers' awareness and training programs on new stress-tolerant rice varieties are more likely to have a greater impact on increasing the adoption rate in Nepal. This requires increased emphasis on information dissemination, extension demonstration, and farmers' participatory research and training programs to popularize new rice varieties and enhance their adoption rate.
- Land type is a critical factor that needs to be considered for targeting new rice varieties in rainfed environments. Similarly, planners and decision makers need to consider farmers' availability of an adult family labor force and age of the farmers to enhance and promote the adoption of a newer generation of rice varieties.
- Rice research should focus not only on enhancing yield but also on increas-

ing the income of farmers by developing technologies that increase profit and reduce the unit cost of production. This requires the development of varieties and crop management technology that facilitates crop diversification and reduces the use of more purchased inputs.

- The high share of labor costs in total costs and high share of nonfarm income in total household income imply that researchers and policymakers should take into account the effect of new technology on labor productivity in addition to crop yield. The adoption of technologies that require more labor may be constrained by the high opportunity costs of labor.
- An important pathway for reducing poverty in the study area is to focus on technological innovations that increase rice productivity in ways that release household labor and land resources for income-generating activities while enabling households to more easily fulfill their subsistence demand for rice.
- Future studies need to account for the likely effect of farmers' perceptions of attributes of the new rice varieties in the adoption models and institutional constraints to seed access and variety replacement by the more recent generation. A study on institutional bottlenecks and variety replacement may provide more insights and information on the adoption constraints to newer rice varieties.

References

Adesina AA, Zinnah MM. 1993. Technology characteristics, farmers' perceptions and adoption decisions: a Tobit model application in Sierra Leone. Agric. Econ. 9:297-311.

Adesina A, Seidi S. 1995. Farmers' perceptions and adoption of new agricultural technology: analysis of modern Mangrove rice varieties in Guinea-Bissau. Quart. J. Int. Agric. 34:358-385.

Bajracharya B. 1994. Gender issues in Nepalese agriculture: a review. Research report no. 25; Winrock International, Kathmandu, Nepal.

Bellon M, Taylor JE. 1993. "Folk" soil taxonomy and the partial adoption of new seed varieties. Econ. Dev. Cultural Change 41:763-786.

CBS (Central Bureau of Statistics). 2001. Sample census in agriculture. National Planning Commission, Kathmandu, Nepal.

Doss CR. 2006. Analyzing technology adoption using micro-studies: limitations, challenges, and opportunities for improvement. Agric. Econ. 34:207-219.

FAO/WFP. 2007. Food security assessment program for Nepal. Special Report. July 2007. Rome (Italy): UN Food and Agriculture Organization and World Food Programme.

FAOSTAT. 2007. FAOSTAT on-line database on different commodities. FAO. http://faostat.fao.org/site/339/default.aspx.

Feder G, Just RE, Zilberman D. 1985. Adoption of agricultural innovations in developing countries: a survey. Econ. Dev. Cultural Change 33:255-298.

Gauchan DY, Ghimire N, Gautam S, Subedi M, Khadka R. 2008. Socioeconomic report on upland rice for ensuring household food security and rural livelihood in Nepal, A Report of Participatory Rural Appraisals, Baseline Survey and Rapid Market Appraisals of IRRI/IFAD NARC Research Project Sites. IRRI/IFAD Project, IRRI.

Herdt RW, Capule C. 1983. Adoption, spread and production impact of modern rice varieties in Asia. Los Baños (Philippines): International Rice Research Institute.

Hossain M, Bose ML, Ahmad A. 2004. Nature and impact of women's participation in economic activities in rural Bangladesh: insights from household surveys. CPD-IRRI, Policy Brief 7. Dhaka, Bangladesh, IRRI.

ICIMOD (Central Bureau of Statistics and International Center for Integrated Mountain Development). 2003. Districts of Nepal: indicators of development. Update 2003. Nepal: ICIMOD.

IRRI (International Rice Research Institute). 2009. World rice statistics derived from FAO 2004-2006 database—three years' average. Los Baños (Philippines): IRRI.

Langyintuo A, Mungoma C. 2008. The effect of household wealth on the adoption of improved maize varieties in Zambia**.** Food Policy 33:550-559.

Launio CC, Redondo GO, Beltran JC, Morooka Y. 2008. Adoption and spatial diversity of later generation modern rice varieties in the Philippines. Agron. J. 100(5):1380-1389.

Maddala GS. 1983. In: Limited dependent and qualitative variables in econometrics. Econometric Society Monographs, vol. 3. Cambridge University Press, Cambridge.

Mallick RN. 1981. Rice in Nepal. Kathmandu (Nepal): KalaPrakasan.

McDonald JF, Moffitt RA. 1980. The uses of tobit analysis. Rev. Econ. Stat. 62:318-321.

MoAC (Ministry of Agriculture and Cooperatives). 2009. Statistical information on Nepalese agriculture. MoAC, Government of Nepal, Singh Durbar, Kathamandu, Nepal.

MOF (Ministry of Finance). 2009. Economic survey. MOF, Government of Nepal, Kathmandu.

MOHA (Ministry of Home Affairs). 2009. Nepal disaster report 2009: the hazardscape and vulnerability. MOHA, Government of Nepal, with the support of European Commission. DPNet Nepal/Oxfam and UNDP. Kathamndu, Nepal.

MOPE. 2002. Nepal: national action program on land degradation and desertification in the context of United Nations Convention on Combating Desertification (UNCCD). Kathmandu (Nepal): Ministry of Population and Environment of Nepal.

NARC (Nepal Agricultural Research Council). 2009 and 2010. Released and registered crop varieties for Nepal. Kathmandu (Nepal): NARC.

NLSS (Nepal Living Standard Survey). 2004. Nepal Living Standard Survey 2003/2004, Central Bureau of Statistics, National Planning Commission, Kathmandu, Nepal.

Pandey S, Bhandari H, Hardy B, editors. 2007. Economic costs of drought and rice farmers' coping mechanisms. Los Baños (Philippines): International Rice Research Institute.

Panta H. 2010. Baseline survey report of Tanahun site, western Mid-Hills, Nepal. A preliminary draft report submitted to Social Sciences Division (STRASA project), IRRI, Philippines.

Paris T, Singh A, Cueno A, Singh VN. 2008. Assessing the impact of participatory research in rice breeding on women farmers: a case study in eastern Uttarpradesh, India. Exp. Agric. 44:97-112.

Subedi A, Gauchan D, Rana B, Vaidya SN, Tiwari PR, Chaudhary P. 2000. Gender roles and decision making in rice production and seed management: experience from different agro-ecological conditions of Nepal. In: Sthapit B, Upadhyaya M, Subedi A, editors. A scientific basis of in situ conservation of agrobiodiversity on-farm. Nepal's contribution to the global project. NP Working Paper No. 1/99. NARC/LIBIRD/IPGRI. p 33-48.

Upadhyay HK. 1996. Rice research in Nepal: current state and future priorities. In: Evenson RE, Herdt RW, Hussain M, editors. Rice research in Asia: progress and priorities. CAB International/International Rice Research Institute.

Witcombe J, Lal KK, Joshi KD. 2009. Scoping study on adoption of rice varieties from client-oriented breeding in the Nepal rice innovation system. UK: CAZS Natural Resources, Bangor University.

World Bank. 2008. Agriculture for development. World Development Report. Washington, D.C. (USA): World Bank.

Notes

Authors' addresses: D. Gauchan, S. Gautan, and M.B. Nepali, Socioeconomics & Agricultural Research Policy Division, Nepal Agricultural Research Council (NARC), Kathmandu Khumaltar, Lalitpur, Nepal; H.K. Panta, Institute of Agriculture and Animal Science, Lamjung Campus, Lamjung, Nepal.

Appendix 1. Adoption (% area) of modern varieties by type and generation, 2008.

Item	Banke	Siraha	Tanahun	Nepal
Total rice area (ha)	57	120	33	211
Percent area in rice area				
NewGenMV	34	29	42	32
OldGenMV	49	55	23	48
MV inbred	82	84	65	81
Hybrid	15	0	7	5
Total MV	98	84	71	86
TV	2	16	29	14
Total all rice	100	100	100	100
Percent in total MV area				
NewGenMV	35	34	59	37
OldGenMV	50	66	32	56
MV inbred	84	100	91	94
Hybrid	16	0	9	6
Total MV	100	100	100	100
Percent in MV inbred area				
NewGenMV	41	34	65	40
OldGenMV	59	66	35	60
MV inbred	100	100	100	100

Appendix 2. Labor use (% share) in rice production activities, wet season, 2008.

Labor use	Banke	Siraha	Tanahun	All
Land preparation	12	14	18	15
Crop establishment	28	15	15	19
Application of organic fertilizer	5	6	5	5
Application of chemical fertilizer	3	1	1	2
Application of pesticide	0	3	0	1
Weeding	14	16	24	19
Irrigation	0	2	6	3
Harvesting	19	17	13	16
Threshing	12	16	12	13
Postharvest activity	7	10	6	7
Total	100	100	100	100

Appendix 3. Details of costs and returns (NRs/ha) in MV and TV rice production, 2008.

Costs and returns (NRs/ha)	Banke		Siraha		Tanahun		All	
	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TVs
Returns								
Grain	36,905	15,232	25,323	18,284	70,461	61,209	42,448	42,704
Straw	5,426	2,769	5,241	4,213	18,895	17,445	9,168	11,722
Total returns	42,331	18,001	30,564	22,497	89,356	78,654	51,616	54,426
Material input cost								
Seeds								
Own	847	1,477	239	231	1,186	2,223	736	1,414
Purchased	1,209	0	523	467	969	297	908	353
Seed total	2,056	1,477	762	698	2,155	2,520	1,644	1,767
Chemical fertilizers	3,599	1,292	3,091	2,878	4,007	4,445	3,542	3,717
Organic fertilizer								
Own	3,148	0	710	419	4,549	4,094	2,715	2,504
Purchased	44	0	343	236	132	975	171	650
Organic fertilizer total	3,192	0	1,053	655	4,681	5,069	2,886	3,154
Pesticides	42	0	188	0	286	176	152	101
Irrigation fees	0	0	0	0	38	0	11	0
Labor cost								
Family labor	13,655	8,655	3,880	4,016	21,735	25,348	12,617	16,371
Hired labor	3,114	0	10,446	6,999	16,193	20,830	9,299	14,652
Contract labor	0	0	1,855	1,787	0	0	630	702
Total labor	16,769	8,655	16,181	12,802	37,928	46,178	22,546	31,725

Continued on next page

Appendix 3 continued

Power use cost								
Animal power								
Bullock (own)	2,578	577	3,945	5,166	2,737	2,546	3,087	3,505
Bullock (hired)	841	4,154	754	504	4,544	5,461	1,857	3,467
Total bullock	3,419	4,731	4,699	5,670	7,281	8,007	4,944	6,972
Machines								
Thresher (own)	116	0	0	0	0	0	144	0
Tractor (own)	0	0	119	0	0	0	40	0
Thresher (hired)	226	0	150	0	0	138	136	0
Tractor (hired)	1,190	0	2,157	1,550	158	732	1,227	1,027
Machines total	1,532	0	2,426	1,550	158	870	1,547	1,027
Total cash costs	10,265	5,446	19,507	14,421	26,327	33,054	17,933	24,669
Total imputed costs	20,344	10,709	8,893	9,832	30,207	34,211	19,339	23,794
Total overall costs	30,609	16,155	28,400	24,253	56,534	67,265	37,272	48,463
Returns above cash costs	32,066	12,555	11,057	8,076	63,029	45,600	33,683	29,757
Net returns	11,722	1,846	2,164	-1,756	32,822	11,389	14,344	5,963

Appendix 4. Share (%) of costs and returns in MV and TV rice production, Nepal, 2008.

Share	Banke		Siraha		Tanahun		All	
	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TVs
Output								
Grain	87	85	83	81	79	78	82	78
Straw	13	15	17	19	21	22	18	22
Total output	100	100	100	100	100	100	100	100
Material input cost								
Seeds								
Own	3	9	1	1	2	3	2	3
Purchased	4	0	2	2	2	0	2	1
Seed total	7	9	3	3	4	4	4	4
Chemical fertilizers	12	8	11	12	7	7	10	8
Organic fertilizer	0	0	0	0	0	0	0	0
Own	10	0	3	2	8	6	7	5
Purchased	0	0	1	1	0	1	0	1
Total organic fertilizer	10	0	4	3	8	8	8	7
Pesticides	0	0	1	0	1	0	0	0
Irrigation fees	0	0	0	0	0	0	0	0
Labor cost								
Family labor	45	54	14	17	38	38	34	34
Hired labor	10	0	37	29	29	31	25	30
Contract labor	0	0	7	7	0	0	2	1
Total labor	55	54	57	53	67	69	60	65

Continued on next page

Appendix 4 continued

Animal power								
Bullock (own)	8	4	14	21	5	4	8	7
Bullock (hired)	3	26	3	2	8	8	5	7
Total animal power	11	29	17	23	13	12	13	14
Machine power								
Thresher (own)	0	0	0	0	0	0	0	0
Tractor (owned)	0	0	0	0	0	0	0	0
Thresher (hired)	1	0	1	0	0	0	0	0
Tractor (hired)	4	0	8	6	0	1	3	2
Machines total	5	0	9	6	0	1	4	2
Total overall costs	100	100	100	100	100	100	100	100
Total imputed costs	67	66	32	41	54	51	52	49
Cash costs as % of total overall costs	33	34	68	59	46	49	48	51

Appendix 5. Details of costs and returns in new and old MV rice production, Nepal.

Costs and returns	Banke		Siraha		Tanahun		All	
	New MVs	Old MVs	New MVs	Old MVs	New MVs	Old MVs	New MVs	Old MVs
Returns								
Grain	38,210	34,316	22,866	26,703	69,307	74,091	48,819	37,560
Straw	5,730	5,290	5,880	4,882	18,426	20,693	11,894	7,611
Total returns	43,940	39,606	28,746	31,585	87,733	94,784	60,713	45,171
Material input cost								
Seeds								
Own	833	1,019	236	241	1,498	1,420	983	758
Purchased	970	463	520	525	579	287	653	461
Seed total	1,803	1,482	756	766	2,077	1,707	1,636	1,219
Chemical fertilizers	7,706	3,515	6,056	3,400	1,583	3,886	4,283	3,527
Organic fertilizer								
Own	2,455	3856	748	689	4,664	5,901	3,032	2,872
Purchased	67	46	297	369	238	18	215	177
Organic fertilizer total	2,522	3,902	1,045	1,058	4,902	5,919	3,247	3,049
Pesticides	89	32	124	202	149	53	127	107
Irrigation fees	0	0	0	0	0	73	0	12
Labor cost								
Family labor	13,052	12,492	3,041	4,348	25,076	18,504	15,989	10,890
Hired labor	3,999	2,318	9,391	11,003	14,250	21,015	10,482	8,983
Contract labor	0	0	2,193	1666	0	0	627	698
Total labor	17,051	14,810	14,625	17,017	39,326	39,519	27,098	20,571

Continued on next page

Appendix 5 continued

Power use cost								
Animal power								
Bullock (own)	2,784		3,676		3,304		3,290	
Bullock (hired)	610		498		3,111		1,784	
Total bullock	3,394	0	4,174	0	6,415	0	5,074	0
Machines								
Threshor (own)	0		0		0		0	
Tractor (owned)	0		0		0		0	
Thresher (hired)	566		165		0		178	
Tractor (hired)	1470		1,964		0		902	
Machines total	2,036	0	2,129	0	0	0	1,080	0
Total cash costs	15,476	7,839	21,208	20,095	19,910	28,734	20,175	16,356
Total imputed costs	19,734	22,143	8,199	9,560	37,653	28,410	25,078	17,883
Total overall costs	35,210	29,982	29,407	29,655	57,563	57,144	44,330	34,239
Returns above cash costs	28,462	33,232	7,538	14,420	67,823	69,452	41,462	31,205
Net returns	8,730	9,624	-661	1,930	30,170	37,641	16,383	10,931

Appendix 6. Share (%) of costs for new and old MV rice cultivation, Nepal.

Costs and returns	Banke		Siraha		Tanahun		All	
	New MVs	Old MVs	New MVs	Old MVs	New MVs	Old MVs	New MVs	Old MVs
Output								
Grain	87	87	80	85	79	78	80	83
Straw	13	13	20	15	21	22	20	17
Total output	100	100	100	100	100	100	100	100
Material input cost								
Seeds								
Own	2	3	1	1	3	2	2	2
Purchased	3	2	2	2	1	1	1	1
Seed total	5	5	3	3	4	3	4	4
Chemical fertilizer	22	12	21	11	3	7	10	10
Organic fertilizer	0	0	0	0	0	0	0	0
Own	7	13	3	2	8	10	7	8
Purchased	0	0	1	1	0	0	0	1
Organic fertilizer total	7	13	4	4	9	10	7	9
Pesticides	0	0	0	1	0	0	0	0
Irrigation fees	0	0	0	0	0	0	0	0
Labor cost								
Family labor	37	42	10	15	44	32	36	32
Hired labor	11	8	32	37	25	37	24	26
Contract labor	0	0	7	6	0	0	1	2

Continued on next page

Appendix 6 continued

Total labor	48	49	50	57	68	69	61	60
Power use cost								
Animal power								
Bullock (own)	8	0	13	0	6	0	7	0
Bullock (hired)	2	0	2	0	5	0	4	0
Total bullock	10	0	14	0	11	0	11	0
Machines								
Thresher (own)	0	0	0	0	0	0	0	0
Tractor (owned)	0	0	0	0	0	0	0	0
Thresher (hired)	2	0	1	0	0	0	0	0
Tractor (hired)	4	0	7	0	0	0	2	0
Machines total	6	0	7	0	0	0	2	0
Total cash costs	44	21	72	58	35	44	43	41
Total imputed costs	56	79	28	42	65	56	57	59
Total overall costs	100	100	100	100	100	100	100	100

Chapter 4

Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas of Assam, India

Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas of Assam, India

N. Deka and D. Gauchan

Introduction

State background

Assam is the largest among the seven northeastern states of India. It is located between 24° and 28°18′N latitude and 89°4′ and 96.0°E longitude and endowed with abundant fertile land and water resources. The total area of the state is 78,438 km^2, with a population of 26.4 million. A majority of the state's population (almost 87%) lives in rural areas, where the mainstay of income is from agriculture (Bhowmick et al 2005). Agriculture is the major source of income and employment for the people. After agriculture, industry and mining are the next two important sources of income and employment. However, the agricultural sector is growing marginally at 2–3% per year as compared with the higher growth rate in nonagricultural sectors. In recent years, the economy of Assam in terms of gross state domestic product (GSDP) has been growing at almost the same pace of 7–8% per annum as the national economy of India (Economic Survey Assam 2007-08). The incidence of poverty in the state fell to 19.7% in 2004-05 compared with 40.86% in 1993-94. This population below the poverty line is lower than in many neighboring states of eastern India and the all-India figure of 27.50% in 2004-05 (Economic Survey India 2009-10). According to recent estimates, per capita income in Assam at 1993-94 constant prices reached INR 20,000 (US$470) in 2008, which is slightly better than many eastern states of India such as Orissa, Bihar, and Jharkhand but lower than the national average of $739 for all-India in 2008 (World Bank 2008).

This report is the outcome of a baseline socioeconomic survey carried out under Objective 7 (Impact assessment and targeting) of the STRASA (Stress-Tolerant Rice for Africa and South Asia) project. The specific objectives of the study follow.

Objectives

1. To assess farmers' livelihood systems in the selected submergence-prone environments
2. To analyze the patterns of varietal adoption and factors influencing the adoption of modern rice varieties
3. To analyze the economics of rice production by the type of variety
4. To document coping strategies of farmers for submergence stress
5. To understand gender roles in rice production and women's participation in decision making
6. To serve as a baseline for rice technology design, targeting, and policy reforms in stress-prone areas

Organization of the report

This report is organized into six major sections. The first section gives a general background of the state and the objectives of the study. This is followed by a short description of the research design and data generation. The third section gives a brief description of the broader trends in rice production in Assam using state-level time-series data. The fourth section provides a general description of the survey sites and stress situations using information gathered from focus group discussions and key informant surveys. Section five provides farm-level analysis of the socioeconomic survey describing the livelihoods of farmers, adoption pattern, economics of rice production, consumption pattern, coping strategies, and gender analysis. The final section provides a summary of the findings and implications.

Research design and data generation

This research was implemented in close collaboration and partnership with Assam Agricultural University (AAU), Assam, India. Data for this study were collected by combining rapid rural appraisals methods, secondary sources, and specifically designed household surveys from two representative rainfed rice-producing locations of Assam, India (Fig. 1). The survey was carried out for the 2008 rice cropping season under the STRASA project in South Asia. The prevalence of submergence stress and proportion of rainfed rice area were two major criteria for the selection of districts and study villages. Household surveys were conducted in 200 randomly selected households (100 households in each district) covering representative rainfed districts that are prone to flash floods. These districts include Golaghat and Sibsagar from the Brahmaputra Valley in Assam. In each district, two villages were selected for the detailed household survey covering 50 households from each village. One of the selected surveyed villages in Sibsagar District was also the on-farm participatory varietal selection (PVS) site for the STRASA project. The survey sites and stress situations were characterized by using focus group discussions and key informant surveys.

Fig. 1. Map of Assam showing the STRASA survey sites.

Detailed information on farmers' livelihoods, socioeconomic features, rice production systems, variety adoption patterns, input use, costs and returns, income structure, farmers' coping strategies, and gender-disaggregated data on rice farming was collected from the specifically designed household surveys. Survey data were compiled, managed, cleaned, and validated by developing a standard "Database Management System" in MS Access. The STATA statistical package was used for econometric and statistical analyses.

The annual growth rate for rice area, production, and yield was estimated using a semi-log trend equation. Before fitting the trend equation for each period and the overall growth rate estimation (1970-2009), data were smoothed using a five-year moving-average process. The adoption of modern varieties (MVs) in terms of area and farmers growing them was estimated and compared across sites. For analyzing specific adoption patterns of new MVs, we classified the existing MVs adopted by farmers into two groups: those that were released before 1990 were considered as "old generation" and those that were released after 1990 were considered as "new generation." The area-weighted age of rice varieties was computed for each site using the proportion of rice area covered by each variety with the age of that specific variety measured from the year of release. The yield effects of MV adoption were analyzed by variety and field type (land type) across the locations. Econometric analysis was carried out using censored regression (tobit) and probit models to identify the major factors determining the probability and the rate of adoption of new-generation modern varieties. Yield and detailed input use data from intensive data plots obtained from household surveys were used to analyze the costs and returns of rice production by variety types (MVs and TVs) and the generation of modern varieties (new and old MVs). The sources and structure of household income and farmers' coping strategies were assessed and documented. Gender analyses in terms of women's participation

and decision making related to rice production and overall livelihood activities were carried out using gender-disaggregated data. The Women's Empowerment Index was computed using 16 gender-related indicators to document the status of women's empowerment at the study sites.

Agriculture and trends in rice production

Agriculture accounts for more than a third of Assam's income and employs 69% of the total workforce (Economic Survey Assam, 2007-08). Rice is the principal crop in the cropping pattern and is the staple food of the population. It plays a significant role in the state economy by being the single major source of agricultural GDP. Rice occupies nearly 88% of the net area sown of the state and almost 90% of the population depends on rice as a main food staple. Rice cultivation is gaining importance in the state due to its gradual increase in demand as a result of population growth and migration of people into the state (Bhowmick and Borthakar 2002).

Assam is a riverine state, where riverine area covers more than one-fourth of the total geographical area. The mighty Brahmaputra River, with more than 120 tributaries and subtributaries, and the Barak River, with nine important tributaries, constitute the two-river system of the state. The Brahmaputra Valley, which makes up more than 75% of Assam's geographical area, has the most fertile land in the flood plains, and it is very densely populated. Assam is administratively divided into 27 districts. These districts fall into three broad physiographic units: (1) the Brahmaputra Valley in the north, (2) the Barak Valley in the south, and (3) the Hills region that lies in between the two valleys. Specifically, the state is divided into six broad agro-climatic zones based on geo-hydrological and physiographic characteristics (Bhowmick et al 2005):

1. North Bank Plains Zone (NBPZ)
2. Upper Brahmaputra Valley Zone (UBVZ)
3. Central Brahmaputra Valley Zone (CBVZ)
4. Lower Brahmaputra Valley Zone (LBVZ)
5. Barak Valley Zone (BVZ)
6. Hills Zone (HZ)

Within each ecological region, rice is cultivated in different ecosystems: irrigated, rainfed lowland, rainfed upland, and deep water. The state has more than 80% of the area under rainfed lowland and deepwater ecosystems, with a high occurrence of natural calamities such as floods. Rice can be grown in three seasons: a wet season (*sali*) in July to December and in dry seasons from January to May (*boro*) and November to May (*ahu*). Deepwater rice (*bao*) is also grown in low-lying areas in deepwater areas (with water stagnation beyond 50 cm for more than a month) during the wet season. Dry-season rice is very much limited in the state. Boro rice currently occupies only 12% of the rice area, despite its great potential for surface-water and groundwater facilities. Some farmers grow it depending upon the availability of irrigation and market support facilities. The cropping intensity is moderately low (129%)

due largely to limited irrigation, poor input supply, and inadequate market facilities (www.indiastat.com; ASSAMSFAC 2005).

Trends in rice area, production, and yield

Rice is the main cereal crop of the state, covering 70% of the net cultivated area. Assam accounts for about 6% of the national rice area and 4% of the production of India (DRD, 2010). The average productivity of rough rice in Assam in 2008 was 2.2 t/ha compared with the national average of 3.0 t/ha (indiastat.com). In 2009, the state produced 5.39 million tons of rice on an area of 2.46 million ha, with average productivity of 2.19 t/ha (www.indiastat.com). A careful examination of the historical data on rice area, production, and yield revealed that rice production increased from 3 million tons in 1970 to 5.4 million tons in 2009 (Fig. 2). The highest production was achieved in 2008 with 6 million tons of rice. However, area grew very slowly in the beginning, from 1.9 million ha, and reached a peak of 2.77 million ha in 2000. The area then declined slightly and remained almost stagnant at around 2.5 million ha after 2000. Yield was very low during 1970, with 1.5 t/ha of rough rice, which started increasing slightly after 1980. The highest yield was obtained in 2008, with 2.42 t/ha. However, in 2009, yield declined slightly to 2.19 t/ha due to low rainfall and drought conditions prevailing in the state during the rice-planting period.

The growth rate in area, yield, and production per annum in Assam for the different periods in 1970-2009 is presented in Table 1. The analysis indicates that growth in rice production remained positive during 1970-2009. Production and yield sustained positive growth during 1980-1999, but growth declined and yield stagnated in recent years (2000-09). From 1970 to 2009, overall rice production in Assam grew at 1.9% per annum, with yield growth accounting for 1.3% per annum. This growth is lower

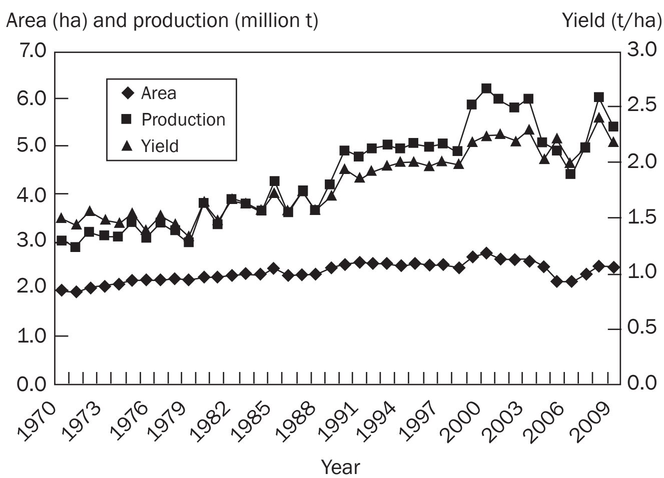


Fig. 2. Trends in rice area, yield, and production in Assam.

Table 1. Growth rates (% per year) of area, yield, and production of rice (rough) in Assam, 1970-2009.a

Years	Area	Production	Yield
1970-79	1.45**	1.12**	−0.33
1980-89	0.73**	2.14*	1.39**
1990-99	0.49**	2.34**	1.88**
2000-09	−1.62*	−1.37*	0.25
All (1970-2009)	0.63**	1.91**	1.27**

than the yield growth of eastern India (1.96%) and that of all-India level (1.95%) per year during 1970-2009. The relatively low yield growth of rice in the state may be largely due to limited irrigation facilities and inadequate development and release of high-yielding modern varieties suited to different ecosystems and flood-prone conditions.

Input use

The state has limited use of modern inputs such as modern variety seeds, irrigation, chemical fertilizers, pesticides, and machine power in farming. Only about 50% of the area is currently covered by MV seeds of rice. The area covered by irrigation facilities is only about 23%, which is lower than in many western and southern states of India (Economic Survey Assam 2007-08). The fertilizer consumption in Assam is very low (18 kg/ha gross nutrients) compared with the national average of 128 kg/ha gross nutrients in 2009 (indiastat.com). Farmers consider fertilizer application in wet-season rice to be a risky proposition. Heavy rainfall within a few months from May to September results in waterlogging and flood and the runoff water washes out fertilizer from the fields (Bhowmick and Borthakar 2002). The inherent poor response of traditional varieties and older generation modern rice varieties limits fertilizer usage and various types of losses restrain farmers from investing more in fertilizer. The low use of technology in terms of working capital per ha, lack of irrigation facilities, erratic and scanty rainfall, and damages caused by flood and drought, insects, and pests are some of the important reasons for low yield and stagnation in rice productivity in the state.

Incidence and effect of submergence stress

The state's macro-economy is more affected by flood than any other natural hazards. Flooding has a profound impact on the state economy and agriculture, specifically on rice production. Flooding is considered a critical abiotic stress in rice production since two-thirds of the rice area in the state is rainfed and prone to flood. Out of 27 districts, 23 face regular flooding and are prone to various levels of submergence stress with varying intensity and duration over time and space. At present, 17.3% of the net sown area is chronically affected by flood (Economic Survey Assam, 2007-08). Flood can begin

at the onset of monsoon in June to early October every year but the timing, severity, and frequency vary from year to year. Moderate to severe flooding occurs every 2–3 years, even though mild flooding (for 2–3 days) is common every year. Most of the currently available improved varieties cannot tolerate such prolonged periods under water and farmers face high crop losses. The years 1962, 1988, 1994, 1998, 2004, 2007, and 2009 had major floods for the entire Brahmaputra Valley. In recent major events, floods have become more devastating, mainly because of breaches in and erosion of the embankments (Das et al 2009). The farming community of the state in general and the rice growers in particular suffer much from damages caused by floods in the form of crop losses, human and cattle lives lost, and above all a substantial income loss. The damages caused by flood every year in the state are very high. The total economic losses in the state, including those of livestock, human lives, and physical damage, were estimated to be equivalent to US$36 million and the economic losses due to crop damage alone were about $4 million (Economic Survey Assam 2007-08).

Site and stress characterization

Description of survey sites

General features of survey sites. Sibsagar and Golaghat are the two districts out of 27 districts of the state where a socioeconomic baseline survey for submergence stress has been carried out for the STRASA project. These two districts represent part of the Brahmaputra flood-prone plains, where flooding is a major constraint to increased rice production. These districts are located 300–369 km away to the east of Guwahati City, the capital of Assam. Rice is the main crop of these districts. Two villages from each district representing flash-flood and water stagnation situations were selected to represent the submergence situations of Assam (Fig. 3). These selected villages are Mogorahat and Gorkasoria from Sibsagar District and Mithamchapori and Kenduguri from Golaghat District (Table 2). Some 80–89% of the cultivated area is under rice cropping and 95% of the rice area has no irrigation facilities. Limited irrigation is available through tube wells, homestead ponds, depressed low-lying areas (*beel* or *nabul*), and from nearby river canals. However, the proportion of area irrigated is very small in all the villages. Irrigation is available mainly during the wet season from homestead ponds and *beel*. Dry-season irrigation is very much limited.

A brief profile of the sites is presented in Table 2. The villages are located 3–5 km away from the main market centers and most of them are accessible by dirt roads. They are located at 100 to 120 meters above mean sea level. The study sites are inhabited by different ethnic groups such as *Ahom*, Hindu with different castes, indigenous people (*Adibasi*), and Nepali. At the Golaghat site, Hindu caste (Kalita) dominated the population, followed by *Adibasi* and Nepali, whereas, in Sibsagar, *Ahom* caste dominated the sample population, followed by *Koch* and Hindu caste.

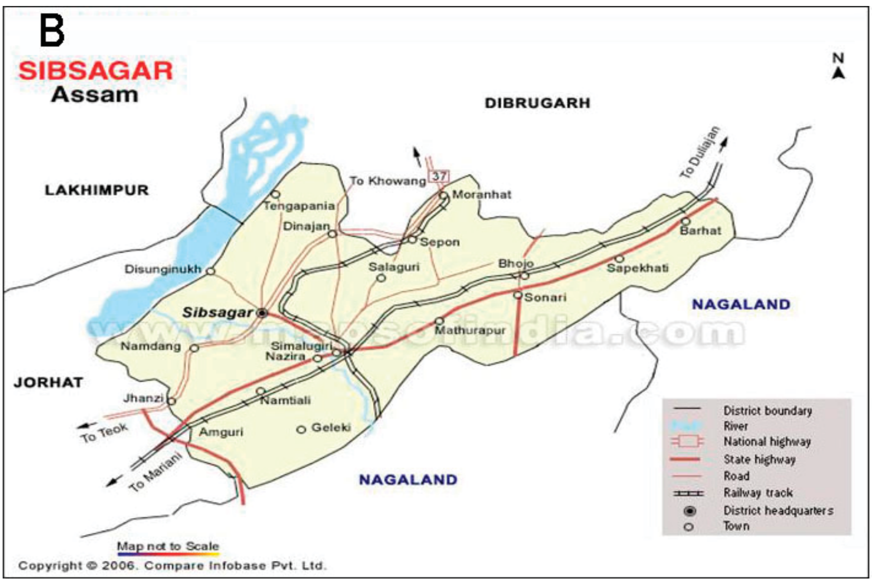


Fig. 3. Map of (A) Golaghat District and (B) Sibsagar District showing study villages.

Broadly, there are not many differences in other parameters among the study sites in terms of physical access, farm land types, irrigation infrastructure, and cropping systems. However, some internal differences exist between the villages regarding the incidences of flooding stress and other parameters.

Rainfall trends and patterns. The annual rainfall (mm) in the study districts (Assam) is relatively high (Fig. 4). The annual normal rainfall ranges from 1,500 to 2,400 mm, of which more than 70% occurs during June to September. Heavy, erratic, and torrential rains cause recurrent floods in many parts of the districts. The study sites are rich in good-quality groundwater, which is yet to be fully exploited.

Table 2. Profile of the study sites Sibsagar and Golaghat, Assam.

Characteristics	Golaghat	Sibsagar
Villages	Mithamchapori and Kenduguri	Mogorahat and Gorkasoria
Latitude and longitude	26–27°N; 93–94°18′E	24°8′–27°56′N; 89°82′–90°60′E
Altitude (m)	100	120
Soil type	Clay-loam	Clay-loam
Percent irrigated area	3	25
Access to roads	Gravel road	Paved road
Nearest market center	3 km	5 km
Ethnicity	Ahom, Koch, and Kalita (Assamese Hindu),	Kalita (Assamese Hindu), Adibasi, Nepali
Cropping system	Rice-fallow, rice-mustard, rice-vegetables	Rice-fallow, rice-mustard, rice-vegetables

Source: Based on focus group discussions and key informant surveys.

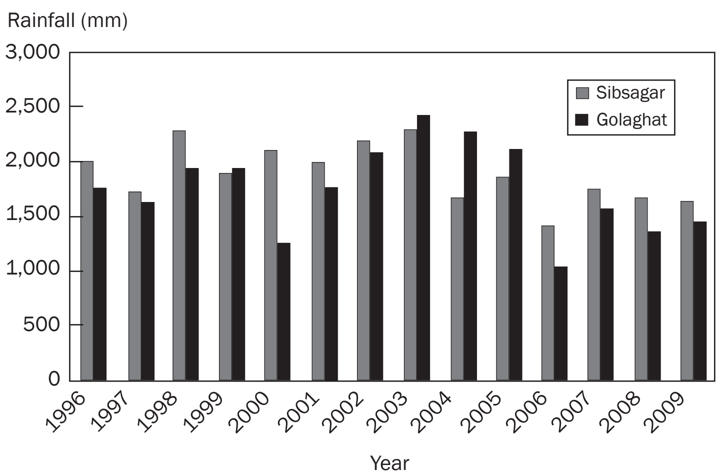


Fig. 4. Rainfall patterns in the survey districts, Assam.

Description of stress situations

Flood occurrence, nature, intensity, and trends. The nature of the flooding at the study sites is presented in Table 3. Recurrent flooding is a common problem at both Sibsagar and Golaghat sites. The recent flood that occurred at the study sites was during 2006 and 2007. Flooding was also observed in 2004, 2000, 1998, and 1994. The occurrence of flood starts from the onset of monsoon in June and can occur until early October every year but the timing, severity, and frequency vary from year to year. Moderate to severe flooding occurs every 2–3 years, even though mild flooding (for 2–3 days) occurs every year. Rice production is delayed when early-season flooding is severe and farmers have to wait to transplant the crop after flood recedes. During flood years, when rice transplanting is delayed due to early flooding, harvesting of the crop is also delayed by about a month (e.g., January). During flood stress, yield declines substantially and, in some cases, when flooding is severe, farmers either fail to plant the crop or the crop is completely damaged with almost complete yield losses. Flooding occurs mostly during July to October in both districts. In some years, flooding occurs three times. Early flooding is during June-July, second flooding takes place in July-August, and third flooding occurs during late August-September. September (late-season) flooding is the most devastating for rice production. The survey year 2008 was a normal year for the area, though some flooding occurred for 2 weeks or more during the early part of the season.

The duration of flooding is 10–15 days in Sibsagar while in Golaghat it is 15–20 days. The depth of flooding goes from 60 to 70 cm, which is common in lowland. Flooding is most commonly observed during tillering and panicle initiation stages. Sometimes seedbeds are also damaged by floods. The incidence and damage caused by flood are severe in Golaghat District as 90–95% of the area and more of the house-

Table 3. Nature of flooding stress at Sibsagar and Golaghat sites, Assam.

Flood effects	Golaghat	Sibsagar
Recent stress years	2004 and 2006	2006 and 2007
Normal year	2008	2008
Duration of flood	15–20 days	10–15 days
Flood depth	60–65 cm	60–70 cm
Timing of flood	June-October	July-September
Source of flooding	Rain and river	River
Frequency of flood	Every 2–3 years	Every 2–3 years
Stage of flooding	Tillering-heading	Tillering-heading
Severity of flood	Severe	Moderate
% Flood-affected area	90–95	84–90
% HH affected by flood	90–95	61–80
% Yield losses	80–90	60–70

Source: Based on focus group discussions and key informant surveys.

holds (90–95%) are affected by flood. Moreover, yield losses caused by flooding are also perceived to be high (80–90%) in Golaghat compared with Sibsagar (60–70%). The flooding caused by rainwater and river overflow is the most common and severe form in the study villages. The major source of river flooding is the back flow of water coming from rivulets of the Brahmaputra River at both Sibsagar and Golaghat sites (e.g., Dikhow and Namdang in Sibsagar and Dhansir in Golaghat).

Farm-level analysis

Household and farm characteristics

Household demographic characteristics. Sample households have almost similar demographic features across the surveyed sites (Table 4). The average family size ranges from 5 members in Golaghat to 6 members in Sibsagar. About 80% of the household members are adults (above 16 years' age). The respondent farmers are mainly in middle age (47–50 years). The number of years of schooling of the respondent farmers is 8–10 at both sites.

Primary occupation of the households. Agriculture (mainly rice farming) is the primary occupation for 82% of the household members who are economically active (Table 5). Farmers in Golaghat are fully dependent on agriculture (97%) with very limited engagement in labor wage employment outside agriculture. However, a pro-

Table 4. General characteristics of respondent households.

Household characteristics	Golaghat	Sibsagar	All
No. of households	100	100	200
No. of respondents (household heads)			
Males	97	97	97
Females	3	3	3
Average household size	5	6	5
Av. percentage of adult members	82	78	81
Average age of respondents	47	50	49
Av. years of education of respondents	8	10	9

Table 5. Primary occupation of the economically active household members.

Primary occupation	Golaghat	Sibsagar	All
Agriculture (rice-based farming)	97	66	82
Business/local trading	0	11	5
Nonfarm skilled employment	0	1	1
Service (private + public jobs)	0	16	8
Labor wages and others	3	6	4
Total	100	100	100

portion of the farmers in Sibasagar also depend on public and private jobs (services) and business and local trading (e.g., shops, agroentrepreneurs, etc.).

Farm characteristics. Farmers are smallholders with average farm size of about 1.5 ha (Table 6). Percent area irrigated in both the wet and dry season is very much limited, indicating a predominance of rainfed farming. The farm size and percent area irrigated are similar at both study sites. On average, farmers own and cultivate crops in three different parcels. They normally plant each rice variety separately in different parcels or sometimes in different parts of the same parcels (based on land type and irrigation source). The average parcel size is 0.5 ha. The parcels are recognized based on the locations, land types, tenure, or source of irrigation. Farmers also subdivide parcels into plots and subplots to fit their different crops and rice varieties.

Farm size distribution. The distribution of farm size among sample farms is presented in Figure 5. The largest concentrations of farmers (70–80%) own and cultivate about 1–2 ha of land. Farmers with less than 1 ha account for less than 20% of the sample farmers. Tenancy in the form of sharecropping and renting in and out of the land is not common at the study sites. Almost all of the farmers (100% in Sibsagar and 99% in Golaghat) are owner-operators.

Table 6. Farm characteristics in Assam.

Farm characteristics	Golaghat	Sibsagar	All
Average farm size (ha)	1.51	1.42	1.47
Average number of parcels/household	3.0	3.0	3.0
Average area of parcels (ha)	0.5	0.5	0.5
Percentage area irrigated			
Wet season	16	18	17
Dry season	15	16	15

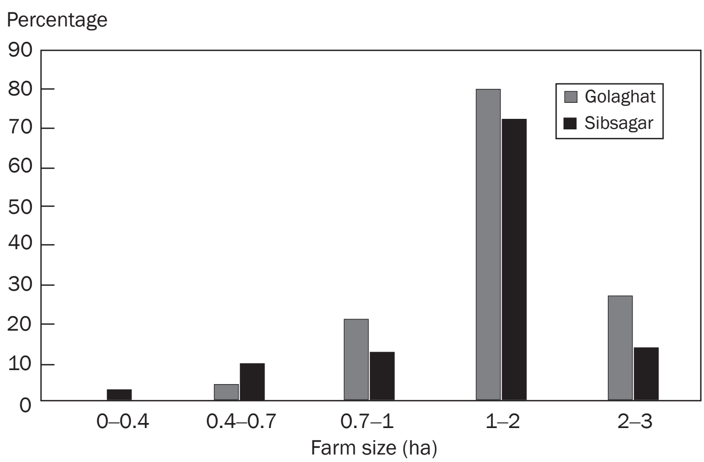


Fig. 5. Farm size distribution in Assam.

Ethnic composition. Farmers with diverse ethnic composition reside at the survey sites. They include *Adibasi* (indigenous groups) to different Hindu caste groups and Muslim (Table 7). The composition of the ethnic groups varies by sites. Golaghat site has a larger number of *Adibasi* (indigenous) and Kalita ethnic groups while Sibsagar has a large proportion of *Ahom*.

Household endowment of land type. Generally, farmers recognize and classify crop fields into three different land types based on field hydrology, which is related to toposequence. These include lowland, medium land, and upland (upper fields). Farmers cultivate different crops and rice varieties on these different land types to meet their diverse production and consumption needs. The proportion of different land types is presented in Table 8.

Lowlands are located in the lower toposequence of the fields, where moisture retention capacity is higher. Uplands are located in upper fields with lighter soil that has less water retention capacity. Medium land is intermediate between lowland and medium lands. Households own and cultivate a higher proportion of lowland field

Table 7. Ethnic composition of respondent households.

Percent households	Golaghat	Sibsagar	All
Adibasi (indigenous)	22	1	11
Ahom	5	57	31
Brahmin	7	6	7
Gossin	0	2	1
Guggi	2	0	1
Kalita	34	14	24
Koch	2	20	11
Muslim	2	0	1
Nepali	16	0	8
Scheduled caste	10	0	5
All	100	100	100

Table 8. Land endowments by land type (% share).

Land endowments	Golaghat	Sibsagar	All
Average farm size (ha)	1.51	1.42	1.47
Share of different land types (%)			
Upland (upper fields)	11	18	14
Medium land (medium fields)	33	33	33
Lowland (lower fields)	56	49	53
All	100	100	100

types, followed by medium land types. However, the proportion of upland field types is smaller and they are mainly used for the cultivation of nonrice crops such as vegetables, potato, mustard, and fruit and fodder trees.

Rice-based cropping systems

Rice is the dominant crop, occupying 81–89% of the area at the sites in the wet season (Table 9). Dry-season cropping after wet-season rice is very much limited due to a lack of irrigation facilities. As a result, cropping intensity is relatively low (113%) at the study sites compared with the state average of 129% for Assam (indiastat.com). Farmers currently allocate a smaller proportion of their area to nonrice crops. The nonrice crops grown include vegetables, potato, and perennial crops such as betel nut, tea, bamboo, fruit crops, mustard, and legumes. Vegetable crops rank second after rice. Sibsagar has a relatively higher share of area under vegetable crops (15%) than Golaghat (7%). Mustard is the main dry-season crop grown in rainfed conditions. Potato and perennial crops such as fruits, tea, and betel nuts occupy a very small proportion of the current cultivated area. No sample farmers grow rice during the dry season, even though some farmers in nearby villages are known to grow rice during the dry season.

Adoption pattern of modern rice varieties

The adoption of crop varieties is generally measured by two indicators: the incidence and intensity of adoption. The incidence of adoption is defined as the percentage of farmers using an MV (technology) at a specific point in time. The intensity of adoption refers to the proportion of area allocated to MVs. The extent of adoption of modern rice varieties in terms of both intensity and incidence is described below.

Pattern of MV adoption. The extent of adoption of modern rice varieties in terms of the proportion of area (intensity) is fairly high (59–63%) at both the surveyed sites (Table 10). Almost all of the households (94–99%) grow both MVs and TVs. MV adoption by farmers is very high but the adoption is only on part of their land (partial).

Table 9. Percent gross area under rice and nonrice crops, and cropping intensity.

Major crops (% gross area)	Golaghat	Sibsagar	All
Rice+[a]	89	81	85
Vegetables	7	15	11
Potato	1	0	1
Perennial crops[b]	3	4	3
Total	100	100	100
Cropping intensity (%)	109	118	113

[a]+Rice is grown only during the wet (kharif) season among the sample households.
[b]Perennial crops include betel nut, bamboo, tea, fruits, etc.

Table 10. Adoption pattern of rice varieties (% of area and % of farmers).

Item	Golaghat	Sibsagar	All
Area (%)			
MVs	63	59	61
TVs	37	41	39
All	100	100	100
Farmers (%)			
MVs only	1	3	2
TVs only	0	3	1
Both MVs and TVs	99	94	97
All	100	100	100

Table 11. Adoption pattern (% of area) of improved rice varieties by land types.

Percentage adoption	Golaghat	Sibsagar	All
Medium land			
MV area (%)	17	59	37
TV area (%)	83	41	63
Lowland			
MV area (%)	91	59	76
TV area (%)	9	41	24
All land types			
MV area (%)	63	59	61
Farmers growing MVs (%)	100	97	97

MV adoption by land types. Farmers match different rice varieties and crops based on the toposequence of land types (field types). Rice is mainly cultivated in lowland and medium land. Upland fields are mainly allocated for the cultivation of nonrice crops due to limited moisture availability. The adoption of MVs in different land types varies by sites (Table 11). In Golaghat, MVs are mainly adopted in lowlands. Medium lands have a lower proportion of MVs (17%) adopted than lowlands (91%). This is because lowland fields are perceived to be more fertile with adequate moisture availability due to the regular inflow of nutrients and water through early flooding from nearby rivers. Since the area is fully rainfed with sandy river-bed soils, receiving floodwater from nearby rivers in lowland fields provides a congenial environment for the cultivation of MVs. In the upper fields, however, this is less likely; hence, more TVs are cultivated that are adapted to moisture-stressed and low-fertility conditions. However, in Sibsagar, such differences between lower and upper fields do not exist; hence, the adoption of MVs is similar in both lowlands and medium lands.

Adoption pattern of new- and old-generation MVs

A more detailed understanding of the adoption patterns of newer MVs in farmers' fields is important because it relates to the impact of public plant breeding research that continues to develop and release new varieties. In this study, therefore, rice varieties are categorized into two groups, new and old generation, based on their release year. Varieties released in or before 1990 are considered old generation whereas those released after 1990 are referred to as new-generation MVs. Farmers cultivate both old- and new-generation MVs in almost a similar proportion in both Golaghat and Sibsagar, ranging from 53–56% adoption of new MVs to 44–47% adoption of old MVs (Tables 12 and 13). In aggregate, old-generation MVs account for 45% of the MV area, while new-generation MVs account for 55% of the total MV area.

The most dominant new-generation MV mainly adopted by the farmers is Ranjit, occupying 37% of the total MV area. Bahadur and Luit are also grown in a smaller proportion at both sites. Some farmers in Sibsagar also grow some other new-generation MVs such as Prafulla, Piyolee, Jalashree, Jalakunwari, and TTB-18 on a very limited proportion of their rice area. Among the-old generation MVs, Mahsuri is the most dominant variety, occupying nearly one-third of the rice area (28–32%) at both sites. Swarna and Pankaj are also grown by some farmers in a small proportion of their rice area. Very few farmers also grow Manoharsali and Jaya in a very small proportion of their rice area. The relatively recent releases of rice varieties such as, Piyolee, Jalashree, Jalakunwari, and TTB-18 that were released in 2000 are grown in a smaller proportion of the area.

An important point to note from this finding is that a few modern varieties such as Ranjit, Mahasuri, Bahadur, and Pankaj dominate the rice landscape at the study sites. A previous study also reported that MVs such as Bahadur, Ranjit, and Mahsuri

Table 12. Adoption (% of area) of new and old MVs in Assam, 2008.

Adoption (% of area)	Golaghat	Sibsagar	All
New MVs			
Ranjit	35	39	37
Bahadur	13	8	11
Luit	8	3	6
Others (Prafulla, Piyolee, Jalashree, Jalakunwari, TTB-18, etc.)	0	3	1
Total new MVs	56	53	55
Old MVs			
Mahsuri	28	32	30
Pankaj	12	3	8
Swarna	1	11	5
Others (Manoharsali, Jaya)	3	1	2
Total old MVs	44	47	45
Total MVs (new + old)	100	100	100

covered nearly 70% of the rice area in Assam (Barah and Pandey 2005). Moreover, farmers still grow a number of varieties that were 20–35 years old and released primarily before 1990. The old varieties (more than 20 years old) accounted for 45% of the area under improved rice varieties in Assam.

General features of new- and old-generation MVs. The general characteristics of dominant new- and old-generation MVs in terms of their release year, origin, parental sources, and recommended ecosystem are presented in Table 13. Ranjit was released in 1994 for Assam and recommended for medium lands. It was developed by crossing Pankaj and Mahsuri. Many rice varieties that originated from Pankaj parents (Peta × Tongkai Rotan) are dominant at the study sites. Bahadur (IET-13358) and Piyolee were

Table 13. Characteristics of major modern varieties cultivated in Assam, 2008.

Modern variety	Duration (days)	Year of release	Ecosystem	Progeny/cross	Recommended for
Ranjit (IET-12554)	155–160	1992	Rainfed shallow lowland/ medium land	Pankaj × Mahsuri	Assam
Bahadur (IET-13358)	155–160	1994	Rainfed medium land	Pankaj × Mahsuri	Assam and Nagaland
Luit (TTB-127-216-2)	90–100	1997	Rainfed upland	Heera × Annanda	Assam Nicobar
Manoharsali	145	1968	Rainfed shallow lowland	Lati sali × Guachari	Assam
Pankaj	150–155	1978	Rainfed lowland	Peta × Tongkai Rotan	Bihar, Orissa, West Bengal, Tamil Nadu
Piyolee	145–150	1992	Rainfed shallow lowland	Pankaj × Mahsuri	Assam
Jaya (IET-723)	130	1969-78	Irrigated	T(N)1 × T-141	All India
Prafulla	–	2000	–	Akisali × Kushal	Assam
Mahsuri	125–130	1972	Rainfed shallow lowland	Taichung 65/ Mayang Ebos 6080/2	All India
Swarna (MTU7029)	155	1982	Rainfed shallow lowland	Vasisth/Mashuri (IET5656)	Andhra Pradesh, Tamil Nadu, West Bengal, etc.
Jalashree	–	2000	Lowland	Pankaj × FR-13A	Assam
Jalakunwari	–	2000	Lowland	Pankaj × FR-13A	Assam

Source: DRR (2008); www.drricar.org, http://dacnet.nic.in/rice/Ricevarieties/India.htm, http://agropedia.iitk.ac.in.

also developed from crosses of Pankaj and Mahsuri and hence they are sister lines of Ranjit. Luit (TTB-127-216-2) is a short-duration MV released in 1997 suited for medium and upland (bunded) fields. Jalashree and Jalakunwari are the newest among the new-generation MVs released in 2000 for Assam, particularly in submergence-prone environments. Both of these varieties have been bred for submergence-prone environments by crossing FR-13A (submergence-tolerant TVs from Orissa) with Pankaj.

Mahsuri is a dominant very old variety originated in Malaysia. It was released in India in 1972 but is still popular in the study districts in Assam because of its good grain quality, straw yield, and adaptation to rainfed conditions. The other dominant old-generation rice varieties grown at the study sites are Swarna and Pankaj. Swarna was released by Andhra Pradesh in 1982 and many other states of India (West Bengal, Kerala, Karnataka, and Tamil Nadu). Similarly, Pankaj was released in 1978 for lowland conditions for many states such as Bihar, Orissa, Tamil Nadu, Kerala, and Karnataka. Swarna matures in 155 days with shorter plant height (95–100 cm), profuse tillering, white short bold grains, and seed dormancy. It is resistant to bacterial leaf blight (BLB) and suited to delayed planting. Most of the dominant MVs are longer duration except Luit, which is adapted to upland situations. The sources of origin for many of these MVs are India, IRRI, or neighboring Asian countries.

Adoption of new and old MVs by land types. The adoption of new- and old-generation modern rice varieties varies by land types (field toposequence) across the sites (Table 14). A varying proportion of both old- and new-generation MVs is grown in medium and lowland fields at both sites. A higher proportion of old-generation MVs persists in medium lands compared with lowlands. New-generation MVs are more dominant in lowlands at both Golaghat and Sibsagar sites. Ranjit and Bahadur are grown in both medium land and lowlands. Bahadur has a higher proportion of its area in lowlands, while Ranjit was dominant equally in both lowlands and medium lands but has a slighter higher proportion of area in lower lands. Swarna was found relatively more adopted in medium lands than in lowlands. As expected, Jalashree and Jalakunwari were found in lowland fields in a small proportion of rice area.

Table 14. Adoption pattern (% of area) of MVs by generation and land types.

Percentage adoption	Golaghat	Sibsagar	All
Medium land			
NewGen MVs (%)	40	39	39
OldGen MVs (%)	60	61	61
Lowland			
NewGen MVs (%)	58	62	59
OldGen MVs (%)	42	38	41
All land types			
NewGen MVs (%)	56	53	55
OldGen MVs (%)	44	47	45

An estimation of area-weighted age of rice varieties for both Golaghat and Sibasagar sites showed that average varietal age was very high (about 30 years), indicating a very slow replacement rate of rice varieties in farmers' fields.

Yield effects of modern variety adoption

Yield effects of MVs over TVs. The average yield of rice across all variety types during the survey year was 3.2 t/ha (Table 15). This yield is higher than the state average of 2.4 t/ha for Assam in 2008 but comparable with the average yield of India (3.1 t/ha). Yields of MVs are significantly higher than those of TVs by more than 1 t/ha. Yield is higher particularly in Sibsagar compared with Golaghat.

Yield effects of MV adoption by land types. Yield effects of MV adoption by land types are presented in Table 16. MVs have statistically significant yield superiority in both lowlands and medium lands. Between the sites, the yield effects vary due to differences in local biophysical conditions. MVs have higher yield effects over TVs in lowlands in Golaghat, but, in Sibasagar, MVs have higher yield effects in medium

Table 15. Yield effects (t/ha) of modern varieties over traditional varieties.

	Golaghat	Sibsagar	All
Average yield	2.9	3.4	3.2
Variety type			
MVs	3.46 (0.048)	4.33 (0.078)	3.85 (0.048)
TVs	2.30 (0.029)	2.63 (0.050)	2.47 (0.030)
Difference[a]	1.16*	1.70*	1.38*

[a] * = showing statistically significant difference of mean yield between MVs and TVs at $P<0.05$ probability level. Numbers in parentheses are standard errors.

Table 16. Yield difference (t/ha) by MV/TV type in different land types.[a]

MV and TV types	Golaghat	Sibsagar	All
Medium land			
Average yield	2.38	3.62	2.94
MVs	2.82 (0.172)	5.14 (0.106)	4.55 (0.128)
TVs	2.32 (0.029)	2.29 (0.070)	2.31 (0.030)
Differencea	0.50*	2.85*	2.24*
Lowland			
Average yield	3.41	3.30	3.36
MVs	3.54 (0.047)	3.75 (0.077)	3.62 (0.041)
TVs	2.25 (0.115)	2.88 (0.062)	2.79 (0.058)
Difference	1.39*	0.87*	0.83*

[a] * = showing statistically significant difference of mean yield between MVs and TVs at $P<0.05$ probability level. Numbers in parentheses are standard errors.

lands. MVs perform well in lowlands in Golaghat as they are perceived to be more fertile due to the overflow of nutrients and fertile soils from flooded rivers. However, MVs perform better in medium lands in Sibsagar since water stagnation (submergence stress) is lower in medium lands than in lowlands. Many of the currently available high-yielding MVs such as Ranjit and Swarna are more suited and produce higher yields in medium-land conditions.

Yield effects of MVs. The data on mean yields of new- and old-generation MVs are presented in Table 17. The average yields of new MVs are higher by 0.7 t/ha than old MVs in Golaghat while average yields of old MVs are higher by 0.17 t/ha in Sibsagar. However, the data do not show any statistically significant yield advantage of new MVs over old-generation MVs at both sites.

Yield effects of MV generation by land types. The data on mean yields and their differences by land types for both new- and old-generation MVs are presented in Table 18. Yields of both MVs are higher in medium land in Sibsagar as these lands are relatively free from submergence stress (water stagnation). Moreover, farmers also perceive that these medium lands are more fertile and productive than lowlands in Sibsagar. However, new-generation MVs are not statistically superior to old-generation MVs across the land types in both Golaghat and Sibsagar. This indicates that the dominant

Table 17. Average rice yield by MV generation.[a]

Generation	Golaghat	Sibsagar	All
MVGentype			
NewGenMVs	3.49 (0.062)	4.25 (0.103)	3.83 (0.062)
OldGenMVs	3.42 (0.076)	4.42 (0.118)	3.87 (0.075)
Difference	0.07	−0.17	−0.04

[a]Numbers in parentheses are standard errors.

Table 18. Yield (t/ha) by MV generation in different land types.[a]

MV by generation	Golaghat	Sibsagar	All
Medium land			
Average MV yield	2.82	5.14	4.55
NewGenMVs	3.05 (0.337)	5.30 (0.150)	4.77 (0.189)
OldGenMVs	2.65 (0.168)	5.00 (0.149)	4.37 (0.174)
Difference	0.40	0.30	0.40
Lowland			
Average MV yield	3.54	3.75	3.62
NewGenMVs	3.53 (0.060)	3.71 (0.089)	3.60 (0.050)
OldGenMVs	3.56 (0.076)	3.81 (0.141)	3.64 (0.069)
Difference	−0.03	−0.10	−0.04

[a]Numbers in parentheses are standard errors.

new-generation MVs such as Ranjit, Bahadur, and Luit have specific adaptation but may not perform as well as MVs such as Mahasuri, Pankaj, and Swarna across locations.

Dominant new and old modern rice varieties and their productivity. The major rice varieties with their average yields are presented in Table 19. The important improved rice varieties grown at both study sites are Ranjit, Bahadur, and Luit that are released after 1990 (new MVs) and Mahsuri, Pankaj, and Swarna (MTU-7029) that are released before 1990 (old MVs). Ranjit and Mahsuri are the two most dominant old and new MVs adopted by the farmers in 37% and 30% of the MV rice area, respectively. Bahadur and Pankaj occupy 11% and 8% of the area, respectively. Luit and Swarna are grown on a very small proportion of the MV area.

A majority of the MVs have about 3 t/ha of rice yield. Among the MVs, Swarna and Ranjit have higher yield (with above 4.0 t/ha) in Sibsagar than in Golaghat and are statistically significant. These yields of MVs at the study sites are relatively higher than the average of eastern India and all India average yield of 3.0 t/ha.

Farmers' perceptions and reasons for growing new and old MVs. Farmers have provided their perceptions on the traits of specific new- and old-generation rice varieties. The perceptions on the major traits of dominant new (Ranjit, Bahadur, and Luit) and old (Mahsuri, Pankaj, and Swarna) varieties are presented in Table 20. Farmers expressed preference for specific modern rice varieties for traits such as high yield, resistance to lodging, good cooking and grain quality, higher market price, tolerance of diseases, pests, and abiotic stresses, and other positive traits such as straw yield, quality, maturity, and adaptability. Most of the farmers responded that high yield, good taste (eating quality), and a good market price are their most preferred traits for adoption. New rice varieties are mainly preferred for their higher stable yield, tolerance of pests and diseases, and many other desirable traits such as good taste, maturity period, and vegetative growth.

Table 19. Area (%) of total MV area and yield (t/ha) by major new and old MVs.[a]

Rice varieties	Golaghat		Sibsagar		All	
	% area	Yield	% area	Yield[a]	% area	Yield
MVs						
New MVs						
Ranjit	35	3.54	39	4.61*	37	4.01
Bahadur	13	3.41	8	3.44	11	3.42
Luit	8	3.49	3	3.26	6	3.43
Old MVs						
Mahsuri	28	3.51	33	4.36	30	3.85
Swarna	1	3.33	11	5.26*	5	5.19
Pankaj	12	3.51	3	3.29	8	3.47

[a]The area (%) under specific new and old MVs is from the total MV rice area. * indicates statistically significant yield superiority of the varieties between the sites.

Table 20. Perceived reasons for adoption by farmers (%) for new and old MVs.

Reasons for adoption (% of farmers)	New-generation MVs			Old-generation MVs		
	Bahadur	Luit	Ranjit	Mahsuri	Pankaj	Swarna
Desirable traits[a]						
1. High yield	34	50	27	27	33	36
2. Resistance to lodging	1	0	0	0	0	0
3. Good taste	27	0	23	23	30	14
4. Good market price	4	0	23	24	3	13
5. Other positive traits (grain quality, straw yield, adaptability, maturity)	35	50	27	26	33	36

[a]The information presented in the table is percent responses and is given only by the farmer who grows that particular variety during the survey year. A farmer has multiple responses for more than one desirable and undesirable trait.

Farmers continue to cultivate older generation MVs such as Mahsuri, Pankaj, and Swarna at the study sites owing to their superior preferred traits such as high yield (Ranjit, Swarna, Mahsuri) and better taste or eating quality (Mahsuri and Ranjit). Mahsuri still occupies about 30% of the rice area at the study sites due to its farmer-preferred grain quality, and it is productive under low-input conditions in addition to its taller plant height that can withstand water up to 70 cm. However, this variety is susceptible to pests and diseases.

Determinants of the adoption of new MVs: econometric analysis

The factors affecting the adoption of new MVs were analyzed using probit and tobit models as described earlier (see Chapter 2 for details).

The results of both the probit and tobit estimation (Table 21) indicate that favorable land type (endowment of lowland fields) is an important factor determining the adoption decisions of the households as indicated by statistical significance. The probability and the rate of adoption are higher if a farmer has a higher proportion of lowland fields. In many fields of Golaghat in Assam, farmers' endowment of lowland is critical as rice could be transplanted only after receiving floodwater from a nearby river. In the upper fields, it is less likely to get adequate water. In addition, the farm size variable in the tobit model also showed significance, but with a negative sign, indicating that larger farmers are less likely to adopt new-generation MVs. Smaller farmers may likely adopt new-generation MVs, probably because they are likely to be more motivated in searching for new technology due to their subsistence pressure and they may be willing to accept newer varieties in their changing circumstances. This finding is supported by earlier studies in many parts of Asia (David and Otsuka 1994, Hossain et al 2006).

Many other variables such as adult household size, gender, market distance, awareness level, and participation in training and organizations did not show statistical significance for the adoption of new-generation MVs. This indicates that many of the socioeconomic, farm, and market variables do not seem to matter in making decisions to adopt new-generation modern rice varieties in these stress-prone environments. Similarly, districts (sites) selected were similar, with no statistically significant difference in district dummy, indicating that selected rainfed districts are similar in terms of probability and the intensity of adoption of new-generation MVs.

The elasticity value of 0.28 for land type in the tobit model indicates that a 1% increment of lowland endowment for farmers would increase the adoption rate of new MVs by 28%. This indicates that endowment of lowland fields is a critical factor that needs to be considered for targeting new rice technologies.

Table 21. Results of the probit and censored regression (tobit) model for the adoption of new-generation modern rice varieties in Assam, wet season, 2008.

Explanatory variables	Probit model		Tobit model	
	Coefficients	Marginal effects	Coefficientsa	Elasticity
Intercept	0.709		0.814**	
Age (years) of the household head	−0.008	−0.003	−0.002	−0.133
Education of the HH head (no. of years)	−0.031	−0.012	−0.015	−0.136
Household size (adult members only)	0.0147	0.005	0.005	0.241
Decision makers' gender to choose rice variety (male only = 1; otherwise = 0)	0.122	0.048	0.062	0.039
Farm size (ha)	−0.073	−0.028	−0.082*	−0.121*
Lowland (yes = 1; otherwise = 0)	0.447**	0.176**	–	–
Land type (percent lowland)	–	–	0.457**	0.281**
Market distance (km)	−0.045	−0.018	−0.027	−0.171
Awareness: stress-tolerant MV (yes = 1; otherwise = 0)	−0.014	−0.030	0.001	0.0008
Participation in training and organization (yes = 1; otherwise = 0)	−0.104	−0.047	−0.049	−0.039
District dummy (district 1: Sibsagar)	0.203	−0.079	−0.028	−0.001
No. of observations	n = 488		n = 197	
Log likelihood	−326.2		−110.5	
Significance	Prob>Chi2 = 0.09	Prob >Chi2 = 0.01		

[a]Significance at P< 0.01 (**) and 0.05 (*) and sign (+) = positive; (−) = negative. The regressions are estimated using STATA 10.0.

Economics of rice production and household economy

Input use and costs and returns in rice production. The important inputs used in rice production are seeds, chemical fertilizers, organic fertilizer (FYM/compost), labor, and animal power (Table 22). Very few farmers use tractors for land preparation and threshing. The use of pesticides (insecticides, fungicides) in controlling diseases, pests, and weeds is also limited. Irrigation source is limited and is mainly used by a few farmers for supplemental purposes during a moisture-scarcity period. The different types of inputs used are briefly outlined below.

Seed use is similar for both Golaghat and Sibsagar, and ranges from 65 to 68 kg per hectare. Farmers use a limited proportion of chemical fertilizers (N, P, and K). Urea, SSP (single superphosphate), and muriate of potash (MOP) are commonly used chemical fertilizers at the study sites. A few farmers also use DAP (diammonium phosphate). The average use of fertilizer in N form is 8–9 kg/ha, P form is 3–8 kg/ha, and K is 3–4 kg/ha. This amount is very low compared with the national (Indian) average use of 78, 27, and 7 kg N, P, and K per ha, respectively, in 2008-09 (indiastat.com).

Since crop cultivation in the wet season faces natural risks such as floods, the use of chemical fertilizers at the study sites has been low. Farmyard manure (FYM) and compost are the commonly used organic manures, which are used in a fairly low amount of 0.3 t/ha. Average human labor use (person-days/ha) is low at the study sites, ranging from 73 to 87 days per hectare. The use of animal labor (bullocks) is also low and similar at both sites, with an average of 13 animal pair days per hectare. Animals (bullocks) are mainly used for land preparation (e.g., plowing and leveling fields) and threshing to separate grains out of straw. The use of mechanical power is very much limited and found only at Sibsagar site.

Table 22. Input use in rice production for wet-season rice.[a]

Inputs	Golaghat	Sibsagar	All
Seeds (kg/ha)	65	68	67
Fertilizer (kg/ha)			
N	8.0	9.4	8.7
P	2.8	4.1	3.4
K	5.7	7.5	6.6
Organic fertilizer (manure) (kg/ha)	258	253	256
Labor (days/ha)	73	87	80
Power			
Animal power (days/ha)	12	14	13
Tractor use (hours/ha)	0	0.2	0.1

[a]The P and K are in the element form (they are derived from conversion of P_2O_5 and K_2O using 0.83 for P_2O_5 and 0.44 for K_2O).

Labor use in different rice production activities. Human labor is used in all rice production activities from land preparation to harvesting and postharvest activities (Table 23). Farmers use more labor per hectare for land preparation, crop establishment, and harvesting, including threshing activities.

The total labor use per ha is lower in Golaghat than in Sibsagar, even though farmers at both sites use contract labor in various rice production activities. They use contract labor mainly for land preparation, crop establishment, harvesting, and threshing.

Costs and returns in rice production. The costs of cultivation and returns were calculated separately for modern and traditional varieties from the largest parcel (intensive data plots). Both the paid-out (cash) cost of material inputs and imputed value of family-owned inputs were estimated separately. Family-owned resources were valued at prevailing market prices because the estimation of shadow prices for various components was more difficult. Analysis of costs and returns in rice production across sites revealed that rice is a profitable crop at the sites, with an average of Rs 29.5 thousand (US$633) of returns above cash costs per hectare (Table 24). Net returns from rice production were profitable even after accounting for noncash costs (imputed value of family-owned resources).

Farmers in Sibsagar received relatively higher value of grain (Rs 39,050 or $835/ha) compared with farmers in Golaghat (Rs 29,619 or $636/ha). The value of rice straw also accounts for a 4% share in the total returns. Cash (paid-out) costs account for more than half of the costs at both sites. Farmers in Sibsagar obtain both higher net returns and returns above cash costs because they obtain higher rice yield (4.4 t/ha).

Table 23. Labor use (days/ha) in rice production activities, wet season, 2008.

Labor use	Golaghat	Sibsagar	All
Land preparation	13.4	14.5	13.9
Crop establishment	15.0	17.3	16.2
Application of organic fertilizer	3.0	3.8	3.4
Application of chemical fertilizer	2.4	3.4	2.9
Application of pesticide	0	0.2	0.1
Weeding	2.8	4.6	3.7
Irrigation	0	0.5	0.3
Harvesting	15.6	18.6	17.1
Threshing	11.8	13.0	12.4
Postharvest activity	8.8	10.8	9.8
Total	73.0	87.0	80.0

[a]Both the study sites use contract labor in rice production, which is not included in the total labor use but accounted for in the cost of production.

Table 24. Costs and returns in wet-season rice production, Assam, 2008.[a]

Costs and returns (Rs 000)	Golaghat	Sibsagar	All
No. of farmers (plots)	100	100	200
Grain yield (t/ha)	3.3	4.4	3.9
Value of grain (Rs 000/ha)	29.62 ($636)	39.05 ($838)	34.33 ($737)
Value of straw (Rs 000/ha)	1.80 ($23)	1.60 ($33)	1.31 ($28)
Gross returns (Rs 000/ha)	30.74 ($659)	40.70 ($871)	35.60 ($765)
Cash costs (Rs 000/ha)	5.87 ($128)	6.40 ($138)	6.20 ($132)
Returns above cash costs	24.82 ($533)	34.17 ($733)	29.50 ($633)
Net returns (Rs 000/ha)	21.1 ($453)	29.86 ($641)	25.47 ($547)

[a]The values in parentheses are in US$/ha. The value is converted from local currency to U.S. dollars at the prevailing exchange rate of US$1= Rs 46.6 in 2008.

Table 25. Input use in rice production for MVs and TVs for the wet season.[a]

Item	Golaghat		Sibsagar		All	
	MVs	TVs	MVs	TVs	MVs	TVs
Seeds (kg/ha)	67	70	70	58	68	63
Fertilizer (kg/ha)						
N	8.8	2.2	10.0	6.6	9.3	4.8
P	3.2	0.0	4.3	3.3	3.7	1.9
K	6.4	0.0	7.9	6.2	7.0	3.8
Organic fertilizer (manure) (kg/ha)	245	352	273	164	258	240
Labor (days/ha)	74	68	85	96	79	85
Power						
Animal labor (days/ha)	11.6	11	13.5	15	12.5	14
Tractor use (hours/ha)	0.0	0	0.21	0	0.10	0

[a]The P and K are in the element form (they are derived from conversion of P_2O_5 and K_2O using 0.83 for P_2O_5 and 0.44 for K_2O).

Comparative input use and costs and returns for MV and TV rice production. The use of material inputs (seeds, fertilizers, organic manure) and labor for MVs and TVs varies by sites (Table 25). A higher rate of chemical fertilizers is applied in MVs at both sites. However, seed rate, labor, and power use do not vary by the type of variety (MV vs TV), even though variation exists by sites. Farmers use a relatively higher rate of seeds and organic fertilizers for MVs in Sibsagar but they use more for TVs in Golaghat. More human labor (person-days) is used for MVs in Golaghat while it is used more for TVs in Sibsagar. MVs require more labor due to their intensive care and management in Golaghat.

Family and hired labor use in MV and TV rice. The estimates of the share of family and hired labor for modern and traditional varieties across the sites are presented in Table 26. Family labor accounts for two-thirds of the labor use (days/ha) in rice production. Between the two sites, not much variation was observed between MVs and TVs in the share of family and hired labor use. Farmers use relatively more family labor in the cultivation of TVs than MVs.

Costs and returns in MV rice production. MVs are more profitable than TVs with their higher net returns and net returns above cash costs (Table 27; Appendix 1) due largely to the higher yield of MVs. MV cultivation provides higher returns above cash costs at both sites. The profitability effect of MVs over TVs was significant. Farmers receive relatively higher net returns ($609/ha) and returns above cash costs ($775/

Table 26. Percent share of labor use in MV rice production for the wet season, 2008.

Labor share (days/ha)	Golaghat		Sibsagar		All	
	MVs	TVs	MVs	TVs	MVs	TVs
Family labor	66.8	68.1	66.5	73.6	66.6	71.8
Hired labor	33.2	31.9	33.5	26.4	33.4	28.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table 27. Costs and returns (Rs 000/ha) in MV rice production for the wet season, 2008.[a]

Costs and returns	Golaghat		Sibsagar		All	
	MVs	TVs	MVs	TVs	MVs	TVs
Total returns	32.02 (687)	20.97 (450)	42.90 (921)	30.16 (647)	37.27 (800)	26.49 (568)
Value of grain	30.89 (663)	20.30 (436)	41.20 (884)	29.22 (627)	35.86 (770)	25.65 (550)
Value of straw	1.13 (24)	6.76 (15)	1.69 (36)	0.94 (20)	1.40 (30)	0.84 (18)
Total costs	12.60 (270)	11.31 (243)	14.53 (312)	15.16 (325)	13.53 (290)	13.63 (292)
Paid-out cost	6.15 (132)	3.80 (82)	6.77 (145)	4.90 (105)	6.45 (139)	4.46 (96)
Imputed cost	6.44 (138)	7.51 (161)	7.76 (167)	10.26 (220)	7.08 (152)	9.16 (197)
Returns above cash costs	25.8 (555)	17.2 (369)	36.1 (775)	25.2 (542)	30.8 (661)	22.0 (473)
Net returns	19.4 $417)	28.4 (207)	9.6 (609)	14.99 (322)	23.7 (509)	12.8 (276)
% Incremental returns (above cash costs) of MVs over TVs	50		43		40	

[a]The values in parentheses are in US$/ha. The exchange rate was US$1= Rs 46.6.

ha) from MV rice production in Sibsagar compared with Golaghat. MVs use higher cash costs (Appendix 2). Total costs for MVs are higher in Golaghat but farmers in Sibsagar incur higher total costs for TVs. Imputed costs are relatively higher for TVs than for MVs at both sites. The value of grain and straw constitutes the major return for rice farming.

Cultivation of MVs provides relatively higher (40%) incremental returns (returns above cash costs) aggregate of both sites. Farmers in Golaghat and Sibsagar receive about 53% and 42% higher incremental returns, respectively, by growing MV rice.

Factor shares in the cost of production for MVs. The share of each input in total costs for both MVs and TVs is briefly outlined below and presented in Table 28 and details in Appendix 2.

- Seed costs
  Seed costs account for 7–11% of the total cost of production. Farmers normally do not incur any cash costs in TVs as they are home produced. The cash costs are mainly for MVs, which are purchased in local markets or from neighbors.
- Fertilizers and other agrochemicals
  The share of the costs of chemical fertilizer in total costs is 2.7–3.1% and 0.8–2.6% for MVs and TVs, respectively, at the sites. Pesticides and other agrochemicals do not account for any costs, particularly in Golaghat. A very negligible amount of insecticide use cost was found for MVs in Sibsagar.
- Cost of organic fertilizers
  Organic fertilizer costs account for only a small proportion (2–6%) of the total costs at the study sites. Farmers mainly use organic fertilizers from their own farms; hence, they incur no cash costs for them.
- Labor costs
  Labor costs account for the largest share of total costs in rice production at both sites. About two-thirds of the total costs in rice production are accounted for by labor alone (see Table 28; Appendix 2). Among the type of labor costs, the share of family labor costs is higher for both MVs and TVs than for hired and

Table 28. Share (%) of different inputs in total cost in MV rice production.

Type of input cost	Golaghat		Sibsagar		All	
	MVs	TVs	MVs	TVs	MVs	TVs
Seeds	10.5	10.8	9.0	6.9	9.7	8.2
Chemical fertilizer	2.7	0.8	3.1	2.6	2.9	2.0
Organic fertilizer	3.7	5.9	3.7	1.9	3.7	3.2
Pesticide	0	0	0.5	0	0.2	0
Labor	72.6	72.2	72.3	76.2	72.5	74.9
Animal power	9.2	10	9.3	10.3	9.2	10.5
Mechanical power (tractor, threshers)	1.2	0.4	2.2	2.2	1.7	1.6
Total	100.0	100.0	100.0	100.0	100.0	100.0

contract labor costs. However, between variety types and study sites, there is not much variation in both the total and components of the labor costs. Contractual payment for labor during transplanting, weeding, and harvesting is a common practice, which accounted for 15–17% of the total costs and above one-fifth of the total labor costs. This contractual cost was higher for MVs.

- Power use costs
  Animal power is the major power used in rice production. Therefore, animal power (bullock for land preparation and threshing) accounts for 9–10% of the total costs of production. Mechanical power use accounts for a small fraction of the costs (less than 2%) in the total costs of production. The total costs for power use do not vary much between MVs and TVs at the study sites.

Comparative input use and costs and returns in new and old MVs

Input use by new and old MVs. The data on farmers' use of material inputs (seeds, fertilizer, organic manure) and labor use for new and old MVs are presented in Table 29. Analysis showed no distinct differences between old and new MVs in most of the input uses (e.g., seed rate, fertilizer, and power use). However, some minor variation was found in the use of pesticides and human labor in Sibsagar. Farmers use pesticides only for new MVs in Sibsagar.

Comparative costs and returns between new and old MVs. The comparative costs and returns between old and new MVs with their different components are given in Table 30 and Appendix 3 and 4. Analysis showed no statistically distinct differences between old and new MVs for costs and returns and profitability at the study sites. Incremental returns (above cash cost) from growing new MVs are not higher than growing of old MVs across the study sites. Between the sites, the returns from cultivation of new MVs was marginally higher in Sibasagar but was not statistically significant.

Costs and returns for major nonrice crops. The costs and returns for major nonrice crops are determined based on cash costs without taking into consideration the imputed value of family-owned resources (family labor, owned organic fertilizers, seeds, animal power, etc.). Vegetables, mustard, and potato are the important nonrice crops that are commonly grown at the study sites. This report gives an analysis of the costs and returns of vegetables and potato (Tables 31 and 32).

- Vegetables
  Vegetables are mainly grown in upland (upper) fields and around homesteads. A small proportion of the farmers also grow them in rice fields after harvest of the crops whenever irrigation facilities are available. A summary of the costs and returns in vegetable production is presented in Table 31. The main vegetables grown in the area are cabbage, cauliflower, brinjal, and leafy vegetables such as broad-leaf mustard, etc. Farm-gate prices of the vegetables do not vary much between the two sites. However, vegetable yields are higher in Sibsagar than in Golaghat; hence, gross returns ($1,303/ha) and returns above

Table 29. Input use in rice production by MV generation for wet-season rice, 2008.

Inputs	Golaghat			Sibsagar			All		
	New MVs	Old MVs	Difference	New MVs	Old MVs	Difference	New MVs	Old MVs	Difference
Seeds (kg/ha)	66.4	67.2	–0.8	69.6	69.8	–0.2	67.9	68.5	–0.6
Fertilizer[a] (kg/ha)									
N	8.6	8.7	–0.1	10.4	9.3	1.1	9.4	9.0	0.4
P	2.9	3.5	–0.6	4.6	3.7	0.8	3.7	3.6	0.1
K	2.8	3.6	–0.8	4	4.2	–0.2	3.4	3.8	–0.14
Organic fertilizer (manure) (kg/ha)	242	250	–8	283	259	24	261	255	6
Pesticide use (L/ha)	0	0	0	11.2	0	11.2	5.2	0	5.2
Labor (days/ha)[b]	74	72	2	88	80	8	81	76	5
Animal power (days/ha)	11.4	11.9	–0.5	14.7	11.9	2.8	12.9	11.9	1
Tractor use (hours/ha)	0.28	0.50	–0.22	0.96	1.40	–0.44	0.59	0.90	–0.31

[a]The P and K are in the element form (they are derived from the conversion of P_2O_5 and K_2O using 0.83 for P_2O_5 and 0.44 for K_2O). [b]This labor use per hectare does not account for contract labor, which is common at both study sites. This is also one reason for the fairly low labor use at the sites.

Table 30. Costs and returns (Rs 000/ha) in new and old MV rice production, 2008.[a]

Costs and returns	Golaghat		Sibsagar		All	
	New MVs	Old MVs	New MVs	Old MVs	New MVs	Old MVs
No. of farmers/parcels	56	33	48	33	104	66
Yield (t/ha)	3.36	3.59	4.72	4.58	3.99	4.08
Value of grain	30.07 (645)	31.94 (685)	41.80 (897)	40.77 (875)	35.49 (762)	36.35 (780)
Value of straw	1.07 (23)	1.21 (26)	1.79 (38)	1.57 (34)	1.40 (30)	1.39 (30)
Total returns	31.15 (669)	33.15 (712)	43.59 (936)	42.34 (909)	36.98 (792)	37.75 (810)
Total costs	12.68 (272)	12.29 (264)	15.01 (322)	13.98 (300)	13.75 (295)	13.14 (282)
Paid-out cost	6.65 (134)	5.85 (122)	6.70 (144)	6.94 (149)	6.46 (139)	6.34 (137)
Imputed cost	6.42 (138)	6.44 (138)	8.30 (178)	7.04 (151)	7.29 (156)	6.74 (145)
Returns above cash costs	24.9 (534)	27.3 (586)	36.9 (792)	35.4 (760)	30.4 (653)	31.3 (673)
Net returns	18.5 (396)	20.8 (448)	28.6 (622)	28.3 (614)	23.1 (608)	24.6 (497)
% Incremental return (above cash cost) of new MVs over old MVs	–8.8		4.2		–2.9	

[a]The values in parentheses are in US$/ha. The data come from intensive data plots.
The value is converted from local currency to U.S. dollars at the prevailing exchange rate of US$1 = Rs 46.6 in 2008.

Table 31. Costs and returns for vegetables in Assam.[a]

Costs and returns for vegetables	Golaghat	Sibsagar	All
Area (ha)	0.53	0.55	0.55
Yield (t/ha)	4.96	6.10	5.73
Price (Rs/ha)	10.1 (0.22)	9.9 (0.22)	10 (0.22)
Gross returns (Rs 000/ha)	50.01 (1,074)	60.74 (1,303)	57.26 (1,228)
Total cash costs (Rs 000/ha)	0.81 (17)	1.71 (37)	1.42 (30)
Returns above cash costs (Rs 000/ha)	49.26 (1,057)	59.02 (1,267)	55.85 (1,198)

[a]Exchange rate: US$1= Rs 46.6 in 2008. The values in parentheses are in US$/ha.

Table 32. Costs and returns for potato at the study sites, Assam.[a]

Costs and returns for potato	Golaghat	Sibsagar	All
Area (ha)	0.36	0.20	0.32
Yield (t/ha)	5.94	4.13	5.42
Price (Rs/ha)	10.4 (0.23)	10.0 (0.22)	10.3 (0.22)
Gross returns (Rs 000/ha)	61.50 (1,320)	41.31 (887)	56.03 (1,202)
Total cash costs (Rs 000/ha)	0.71 (15)	2.08 (45)	1.10 (24)
Returns above cash costs (Rs 000/ha)	60.79 (1,304)	39.23 (842)	54.92 (1,179)

[a]Exchange rate: US$1= Rs 46.6 in 2008. The values in parentheses are in US$/ha.

variable costs ($1,267/ha) are higher in Sibsagar. The average cash costs for vegetables are very low ($30/ha) as a limited amount of hired labor, machinery, and fertilizer is used for vegetable production.

- Potato

  Farmers at the study site choose to grow a small portion of the farm area for potato in the homestead and upper fields (uplands) after the harvest of rice (winter crop). A summary of the costs and returns in potato production is given in Table 32. The cash cost for potato is very low and the gross returns are fairly high, particularly in Golaghat (Rs 61,505/ha or $1,320/ha). The average returns above cash costs for vegetables in Golaghat are also relatively high ($1,304/ha). The higher gross returns and net returns in Golaghat are due to farmers' attainment of higher yield. Farm-gate prices of vegetables do not vary much by site.

Rice production, consumption, and other uses

Rice is an important staple crop of the farmers at the study sites, as most of the sample households (99%) produce rice for their livelihood needs (Table 33). More than two-thirds of the produce (64–69%) is consumed in the household. A large proportion of the households (79–96%) sell part of their surplus production to meet livelihood and household expenditure needs. Farmers sell about one-fourth of the produce (24%) in the market to meet their expenditure needs. Aside from household consumption and market sales, rice is also used as seed, feed, and for other various uses (e.g., paying for farm labor, gifts to relatives and friends, etc.).

Households use the bulk of rice for consumption purposes. The per capita consumption of milled rice is estimated to be on average 180 kg (278 kg rough rice). This is higher than the national average per capita consumption of about 71 kg of milled rice for India (FAOSTAT 2009).

Structure and sources of household income

The sample farmers are engaged in a multiple set of farm, off-farm, and nonfarm activities and they derive their household income from these activities. The household income reported here includes the gross income of the households from rice, nonrice crops, and other various farm and nonfarm activities for the study period (2008). These include the sum of the value of all goods and services produced on the farm, off-farm, and nonfarm activities by deploying land and labor—the major assets of rural households. Farm income constitutes the gross income obtained from rice, nonrice crops, and livestock. Off-farm income constitutes the income earned by the household as farm labor. Nonfarm income is the income arising from nonagricultural labor and

Table 33. Household rice production, consumption, and uses.

Item	Golaghat	Sibsagar	All
% Rice-producing households	99	99	99
% Rice-selling households	96	79	88
Average rice production (kg/hh)	3,966	3,996	3,981
Per capita rice production (kg)	793	714	751
Per capita rice consumption (kg)	293	286	278
Household uses of rice (kg/hh)			
% Consumed at home	64	69	67
% Sold in the market	25	22	24
% Used as seed	6	3	4
% Used as feed	1	2	1
% Used in payment	1	1	1
% Other uses	3	3	3
Total	100	100	100

nonfarm employment activities and includes sources such as business (trade and retail shops), salary, services, and labor earnings and employment in industry.

The size, structure, and sources of household income estimates for the study sites are presented in Table 34. Between the two study sites, farmers in Sibsagar are relatively better off, with higher income in terms of both total household and per capita income. The per capita income of on average $406 (Rs 18,905) for 2008 is lower than the national average per capita income of $739 in 2008 for India (World Bank 2008).

Farm income accounts for 47% and 43% of the total income in Golaghat and Sibsagar, respectively. The share of rice income is quite high at both sites, which accounts for one-third (33%) of the total household income and two-thirds of the farm income. Farmers in Golaghat have a relatively higher share of rice income (38%) than those in Sibsagar (29%).

The share of other nonfarm income constitutes more than half (53–57%) of the total household income. Other income constitutes mainly nonfarm sources such as small-scale local business (trading, running local grocery shops), involvement in rural enterprises such as small-scale industries, weaving, masonry work, etc. This also includes income generated by the households from selling of forest and fruit products and fishing.

Income from off-farm migration and remittance was not prevalent at both of the study sites. A share of income from farm and nonfarm wage labor is nonexistent at the study sites. Field observations and focus group discussions also reveal that most of the farm household members do not work as farm wage labor. Agricultural operations are mainly done by labor exchange rather than on a payment basis.

Table 34. Household income (Rs/hh) and percentage share in total income.[a]

Income structure	Golaghat	Sibsagar	All
Household income (Rs 000)	85.22	116.45	100.86
Per capita income (Rs 000)	14.59	24.11	18.90
Income (US$/capita)	313	517	406
% Share in total income			
Farm income	47	43	45
Crop income	42	36	39
Rice	38	29	33
Nonrice crops[b]	5	7	6
Livestock income (sales)	4	7	6
Off-farm labor income	0	0	0
Nonfarm income			
Nonfarm labor income	0	0	0
Other nonfarm income (business, small-scale industries)	53	57	55
Total	100	100	100

[a]US$ exchange rate: US$1 = Rs 46.6 in 2008. [b]Nonrice crops include mainly vegetables, potato, and mustard.

Household coping strategies

Floods are regular phenomena at the study sites. Hence, farm households adopt different strategies to reduce, mitigate, and cope with risks and shocks that affect them from flooding stress. The range of strategies available to households depends on their asset portfolio, community support, and availability of external assistance during the most vulnerable period of the year. Many households in the vulnerable groups alter their rice production, consumption, and expenditure patterns as a short-term strategy to cope with food-deficit periods. When the flooding effect is severe, households are forced to adopt a long-term strategy to cope with the stress, which includes selling their productive and durable assets, changing their livelihood strategies, and seeking employment in other sectors. Some of the current farmers' important production, consumption, and household expenditure strategies to reduce and cope with stress effects are presented below.

Adjustment in the type of food intake. Farmers normally do not make an adjustment in the amount of rice intake during a stress year as it is the staple diet, which is even eaten during stress years by borrowing and purchasing it from the local market and neighborhood. They may make an adjustment only in other food intake and expenditure patterns. Farmers make some adjustment and reduce slightly their consumption of pulses, vegetables, milk, and fish during stress years but not of the main staple rice (Table 35). Wheat is also considered a preferred food item and no changes in its intake are observed during stress years among the farming population.

Households' other adjustments for food security and production needs. Small and marginal farmers in flood years adopt a range of strategies to secure immediate household food needs in addition to seed needs for the subsequent crop production cycle. Some of these strategies include distress sale of immediately harvested crops and resorting to increasing food, seed, and cash borrowings from neighbors or relatives (Table 36). Analysis indicated that a small proportion of households, mainly in Sibsagar, opt for selling more harvested crop (distress sale) and increasing food, seed, and cash borrowing. An average of one-fifth of the households in Sibsagar are engaged in selling harvested products for livelihood needs. Similarly, about one-fourth of the

Table 35. Household adjustments in consumption of food items in a stress year.

Daily intake	Golaghat		Sibsagar		All	
	NY[a]	SY	NY	SY	NY	SY
% HH consuming rice	100	100	100	100	100	100
% HH consuming wheat	32	32	15	13	24	23
% HH consuming pulses	100	94	99	94	100	94
% HH consuming vegetables	98	94	98	94	98	94
% HH consuming milk	46	43	41	33	44	38
% HH consuming fish	1	0	8	3	5	2

[a]NY = normal year; SY = stress year.

Table 36. Households' immediate adjustments in meeting food security needs.

Household consumption behavior	Golaghat	Sibsagar	All
% HH selling more harvested crops	0	21	11
% HH increasing their food borrowing	7	5	6
% HH increasing their seed borrowing	14	25	20
% HH increasing their cash borrowing	0	6	3

Table 37. Broader household livelihood adjustment strategies during stress years.

Household consumption behavior	Golaghat	Sibsagar	All
% HH resorting to alternative income sources	98	78	88
% HH deferring loan payments	54	58	56
% HH using their savings	58	56	57
% HH selling/mortgaging assets	10	9	10
% HH reducing expenditure on clothing and festivals	51	13	32
% HH with children leaving school	16	1	9

households are involved in borrowing seeds during stress years that are required for the next cropping cycle. However, the proportion of households involved in seed borrowing is relatively low (14%) in Golaghat.

Broader household livelihood adjustment strategies. Poor farm households use a number of strategies to cope with immediate consumption and livelihood needs during flood stress. These include resorting to alternative income sources, deferring loan payments, using household savings, selling/mortgaging household assets, pulling children from school, etc. (Table 37). The finding shows that a large proportion (78–98%) of the households resort to alternative income to meet their consumption and other immediate livelihood needs. More than half of the households also tend to defer their loan payments during a stress year, which was prominent at both sites. About half of the households use their limited savings to meet their food and expenditure needs to cope with emergencies and the unexpected need for cash during a stress year. However, only a small proportion (10%) of households are actually involved in selling/mortgaging their productive and durable assets during stress years. Some proportion of the households, mainly in Golaghat, were involved in pulling their children from school during stress years.

Crop adjustment and coping mechanisms. The various tactical adjustments used by farmers to avoid or minimize negative effects of flooding stress are outlined in Box 1. Farmers normally use traditional varieties that are taller and tolerant of flooding,

particularly in lower lands, where flooding is more severe. When a transplanted crop is fully damaged at the beginning of crop growth, farmers go for replanting/resowing of the crop, which is a common adjustment method. Farmers also use a higher seed rate in seedbeds and more seedlings during transplanting to the main fields to minimize risks of flooding. Aged seedlings are used for transplanting when flooding occurs during the early stage. If their seedlings are fully damaged in severe flooding, farmers buy seedlings from neighbors who have raised them from upland fields. Some time gap fillings and staggered transplanting of rice seedlings are done in those fields where some seedlings (not all) are damaged. When the crop is damaged by late flood and there is no time for re-transplanting of the crop, area transplanted or sown to rice declines drastically.

Farmers apply fertilizer (mainly nitrogenous fertilizer) to regenerate growth of damaged plants when flooding damage is observed during the vegetative stage of crop growth. In case of severe flooding, no fertilizer is applied as crops are fully damaged or farmers believe that plants will not recover from flood stress. Weeding is delayed when the crop is affected at tillering stage. Farmers prepare for second crops in advance, particularly vegetables, mustard, etc., when replanting is not possible to get good crop yield. If irrigation facilities are available, they favor dry-season rice cropping (in November or December) to compensate for wet-season crop failures. Farmers also have a tendency to store extra seeds to use them for re-sowing/replanting if the first-seeded/transplanted crop is damaged. The maturity period for the rice crop is extended when the crop is affected by flood stress or replanted. Hence, instead of harvesting the rice crop during late December, they harvest the crop in January during flood years.

Box 1. Tactical adjustments in rice cropping during flooding

- Use of flood-tolerant traditional varieties
- Decrease in area planted to rice
- Delay in transplanting and seeding
- Replanting/re-sowing of crops fully or staggered planting
- Increase in seed rate and seedling number in transplanting
- Transplanting of aged seedlings
- Delayed, limited, or no application of fertilizer
- Delayed weeding
- Delayed harvesting of the crop

Relief and mitigation programs. Some government-sponsored relief programs are reported during flood years, which include the distribution of a limited amount of seeds and food, construction of embankments along the side of rivers, and some provisions for re-settlement for the poorest and most affected people through the establishment of relief camps. Relief and rehabilitation work in Assam is looked after by the district administration with support from the Department of Revenue and Disaster Management. A calamity relief program (fund) exists in both Sibsagar and Golaghat

districts that is to some extent serving as an important safety net for the local poor and vulnerable people during flood years. A crop insurance scheme of the government does exist in the state but it covers many fewer farmers and is not effective in the area.

In Golaghat, the government's "100 Days Youth Employment Scheme" or "Job Card" is in operation particularly for poor and vulnerable people, who are more likely to be affected by various types of disasters and epidemics, including floods. Its objective is to provide employment for jobless rural youth who are below the poverty line and are vulnerable. Community-level organized local initiatives and efforts for reducing the negative impact of flooding are not very prevalent, even though some support in terms of food and clothes from local friends and relatives appears to occur. Farmers have great expectations from the government to receive more relief support in terms of more cash for buying food and housing materials during a severe flooding period.

Vulnerability to stress. Poor and marginal farmers who have land area located along river banks and those who have a higher proportion of rice area in lowland flood-prone areas are more vulnerable. Women and children are the most vulnerable within the household as women are the last to eat after meals are left and they rarely go out of the village for securing alternative income and employment. Children also suffer more from less food and malnutrition as well as dropping out from school during stress years. Moreover, during flood years, school buildings are used as relief camps for flood victims and many times the school remains closed, thus negatively impacting the education of children. In terms of ethnic group, the *Ahum* in Sibsagar, the Nepali in Mithunchapoi, and lower caste Assamese Hindus in Kundugiri of Golaghat are more vulnerable as they are the most food insecure and poor at the study sites.

Awareness and sources of stress-tolerant varieties

Rice production in Assam suffers every year from flash floods and water stagnation during the vegetative stage of crop growth. This study tried to capture the amount of awareness of farmers and their willingness to plant newly developed stress-tolerant modern varieties that survive under short flooding (submergence). The reference for stress-tolerant varieties includes new IRRI stress-tolerant varieties (e.g., Sub1) being promoted and tested in the state, including existing stress (submergence)-tolerant MVs that are being recommended in Assam by the Assam Agricultural University and ICAR research institutes (e.g., Jalashree, Jalakunwari, etc.). The findings revealed some variation in the amount of awareness of stress-tolerant rice varieties among farmers between Golaghat and Sibsagar (Table 38). Farmers in Golaghat have less awareness (36%) of stress-tolerant rice varieties than farmers in Sibsagar (83%). A small proportion of the farmers (17–19%) have already planted varieties that have some submergence tolerance such as Jalashree and Jalkunwari in a small proportion of their rice fields. The relatively higher awareness of farmers of stress-tolerant rice varieties in Sibsager is due to their current involvement in participatory varietal selection (PVS) testing of Sub1 varieties under the STRASA project.

Since farmers currently have no reliable access to stress-tolerant varieties at these sites, a much larger proportion of them are willing to plant promising new stress-tolerant varieties. The proportion of households willing to plant rice varieties

Table 38. Awareness of and sources for stress-tolerant varieties (STVs).

Item	Golaghat	Sibsagar	All
% Households heard of STVs			
Yes	36	83	60
No	64	17	40
% Households planted STVs			
Yes	17	19	18
No	83	81	82
% Households willing to plant STVs			
Yes	47	65	56
No	50	23	37
No response	3	12	7
Source (%) of information on STVs			
Extension workers (Dept. of Agriculture)	0	7	2
AAU researchers and extensionists	0	4	2
Neighbors, relatives, and friends	0	0	0
Others (radio, TV, and newspapers)	0	1	0
No sources of information	100	88	94
Total	100	100	100

is higher in Sibsager as many farmers are aware of the benefit of Sub1 varieties as influenced by the PVS testing of STRASA Sub1 varieties. Since farmers' existing dominant modern varieties are old, degenerated, and not tolerant of various stresses, access to new stress-tolerant varieties will provide them with good options to enhance their rice productivity.

Reliable sources of agricultural information are critical to enhancing agricultural productivity. The analysis shows that a large number of farmers at the study sites have had no regular sources of information on stress-tolerant varieties. A very limited proportion of the farmers in Sibsagar now have some source of information, mainly from researchers and extension officials of the State Agricultural University and Department of Agriculture. Dependency on mass media such as radio and television as a source of information was almost nonexistent. These are the basic sources for the acquisition of information on weather forecasts but not for stress-tolerant rice varieties.

Gender division of responsibility and decision making

Gender roles and decision making have an important influence on rice farming and sustenance of farmers' livelihood in stress-prone rainfed areas. This section outlines gender analyses in relation to division of labor force and women's participation in

rice production, including decisions on household livelihood and Women's Empowerment Index.

Gender division of labor force and women's participation in rice production. Men and women farmers provide a differential share of labor contribution in different rice production activities. The proportion of total male and female labor force participation in rice production is presented in Table 39. Crop establishment (mainly transplanting), harvesting, and postharvest activities are the sole domains of women at both sites. However, land preparation, application of inorganic and organic fertilizers, weeding, and threshing are the sole domains of men. Interestingly, weeding activity, which is a woman's domain in many parts of rural Asia, is undertaken by men at the study sites.

Table 40 presents the proportion of men and women labor force participation segregated by family and hired labor. There is not much variation in the contribution of women's labor in rice production between the two sites. This indicates that the two selected sites are similar in terms of women's participation in rice farming activities.

Decision making and women's empowerment. Gender division of responsibilities and decision making in terms of the Women's Empowerment Index and percent male and female involvement in various livelihood activities are presented in Table 41. Data showed that most of the decisions related to household use of agricultural technologies, farm production, and marketing activities, including broader household livelihood options, are made either by the male only or jointly in consultation with

Table 39. Proportion (%) of male and female labor participation in rice production activities.

Rice production activity	Golaghat			Sibsagar			Assam		
	Males	Females	All	Males	Females	All	Males	Females	All
Application of fertilizer	4	0	4	4	0	4	4	0	4
Application of pesticide	0	0	0	0	0	0	0	0	0
Application of organic fertilizer	4	0	4	4	0	4	4	0	4
Crop establishment	0	21	21	0	20	20	0	20	20
Harvesting	0	21	21	0	21	21	0	21	21
Irrigation	0	0	0	1	0	1	0	0	0
Land preparation	18	0	18	17	0	17	17	0	17
Postharvest	0	12	12	1	12	12	1	12	12
Threshing	16	0	16	15	0	15	15	1	16
Weeding	4	0	3	6	0	6	4	0	4
Total	46	54	100	47	53	100	46	54	100

Table 40. Family and hired men's and women's labor participation in rice farming.

Labor use by gender	Golaghat	Sibsagar	Assam
Total labor days/hectare[a]	73	87	80
% Family males	32.98	34.46	33.78
% Family females	33.93	33.47	33.68
% Hired males	12.86	12.40	12.61
% Hired females	20.24	19.67	19.93
% Total male labor	45.84	46.86	46.39
% Total female labor	54.16	53.14	53.61
Total	100	100	100

[a]This labor days/ha does not include contract labor used in rice farming.

other male or female members. The highest proportion of decisions is made mainly by males in decisions related to farming, technology adoption, and allocation of household income. But, decisions related to food consumption and children's education and participation in voting/politics are mainly made jointly by male and female members. Womens have a greater role mainly in children's education and selling and slaughtering of farm animals, followed by number of children to raise as indicated in the Women's Empowerment Index for these activities.

The proportion of women (principal females) making decisions solely on farm, nonfarm, and livelihood activities is very much limited. The lowest level of the Women's Empowerment Index was found in activities related to rice farming and marketing decisions such as what price and where to sell outputs as well as what rice varieties to grow, including hiring of farm labor for rice farming. Similarly, women's participation and decision making were found to be very low in the allocation of farm and household income and what farm implements to purchase for agricultural operations (mainly for rice farming). This finding indicates that there is an increasing need for women's empowerment in rice production and marketing as well as in various household livelihood decisions.

Training and participation in organizations. Households with both male and female members are members of various formal and informal local community-based organizations and they participate in agricultural and rural skill-oriented training activities.

The organizational activities cover membership and participation in various formal and informal organizations/social institutions that include local farmers' groups, self-help groups (SGH), cooperatives, women's groups, community management groups, local youth clubs, religious groups, etc. Men are mainly members of a field management committee (FMC), which is a state-implemented farmers' organization that is designed for rural development and empowerment to the farming community (NCAP 2007). Women are members of local self-help groups within the village and the community. A very small proportion of farmers in Golaghat are also members of farmers' organizations such as cooperatives. A women's self-help group is a common

Table 41. Division of responsibilities, decision making (%), and Women's Empowerment Index in various agricultural and other livelihood activities.[a]

	Husband only	Wife only	Both				WEI
			Husband more influential	Wife more influential	Both equally influential	All	
What rice variety(ies) to grow	62	2	16	–	21	37	1.63
Who and number of farm laborers to hire	63	2	18	1	18	36	1.58
Whether to sell/consume harvested crop	66	1	15	1	18	33	1.54
Quantity of output to sell and consume	67	1	16	1	16	33	1.51
When and where to sell the harvested crop	70	2	17	2	11	30	1.44
At what price to sell the output	72	1	18	1	9	28	1.39
What farm implements to purchase	68	2	18	–	13	31	1.49
Whether to slaughter and sell animals	15	23	21	12	29	62	3.07
Adoption of technology in rice production	40	2	19	3	37	59	2.07
Allocation of farm income	58	4	18	2	19	39	1.73
Allocation of household income	55	4	18	3	20	41	1.80
What types of food to consume in times of stress	22	3	26	2	48	76	2.38
Children's education	6	26	6	2	61	70	3.11
Where to borrow	41	2	23	1	33	57	1.98
Participation in voting/politics	6	1	21	–	73	94	2.68
Number of children to raise	1	1	7	1	91	98	2.93

* Husband and Wife and Both (All) columns should add up to 100%. Some columns have less than 100% due to nonresponse problems.

Table 42. Farmers' (males + females) participation in organizations and training.

% Share by gender	Golaghat		Sibsagar		All	
	Males	Females	Males	Females	Males	Females
Participation in organizations	38	36	52	41	41	39
Participation in agriculture and other training activities	43	31	0	0	–	–

feature in all the villages and it is being promoted by the state government for income generation, employment, empowerment, and mobilization of rural women. Credit and saving schemes are common in these self-help groups. Weaving is one of the common schemes used for the employment and income generation of women members.

Men mainly participate in training related to agricultural production, rice farming, including seed production, and disease and pest management offered by the District Agricultural Office as well as AAU. Women receive training mainly related to food processing, weaving such as hand loom making, and some income-generating and postharvest activities. The training is designed mainly for short-term skill- and exposure-oriented programs on different aspects of agricultural and rural development activities.

The proportion of training and organizational activities participated in either by principal male or female members within the household is presented in Table 42. About one-third or more of the household male and female members participate in organizational activities at both study sites. However, farmers' participation in training was found only in Golaghat. Men farmers in Golaghat have memberships and participation in diversified local community-based organizations, whereas women farmers are confined mainly to self-help groups. Overall, 30–40% of the females are members of local organizations. Women's memberships are mainly in self-help groups, which are designed for women's involvement and empowerment.

Summary of the findings

- Farm households at the study sites have similar biophysical and socioeconomic characteristics, including similar stress incidence and effects. Access to irrigation, cropping intensity, and soil type differences are not very evident between the sites.
- Agriculture (mainly rice farming) is the primary occupation for 82% of the economically active households across the sites. Farmers' dependence on agriculture and rice farming is higher (97%) in Golaghat than in Sibasagar (66%).
- Excess rainfall and overflow of river water cause flooding at the study sites. Currently, farmers have limited technological options and flexibility to make adjustments to cope with flooding stress. Both excess and uncertainty of monsoon rains with low irrigation potential are key constraints to improving rice productivity.

- Farmers have adopted modern varieties on a major portion of their rice farms. Only a handful of MV rice dominates the rice area at the study sites. The dominant MVs are Ranjit, Mahsuri, Bahadur, Luit, and Pankaj. Swarna was also grown by some farmers in a small proportion of the area.
- Newer generation MVs account for about 55% of the total MV area at these sites. The major newer generation MVs are Ranjit (released in 1992), Bahadur (released in 1994), and Luit (released in 1997).
- MVs outyield TVs on all the land types and across the sites. However, the yield of newer generation rice varieties is not significantly superior to that of old MVs despite some of their preferred traits of tolerance of diseases, pests, and some submergence (e.g., Jalashree, Jalakunwari).
- Favorable field type (land type) plays a key role in the adoption of new-generation modern varieties. Both censored regression (tobit) and probit models indicated that the probability and intensity of adoption of new-generation MVs are higher if a farmer has an endowment of more favorable lowland fields that have better soil quality.
- Preferred attributes (desirable traits) of a variety are the major reasons cited by farmers for adopting a particular modern variety. High yield, high market price, and good taste (eating quality) are the most preferred traits for the cultivation of MVs.
- Farmers at the study sites now use a limited amount of chemical fertilizers and other modern inputs (e.g., machine power). Cropping intensity is also very low and farmers have limited access to irrigation facilities.
- Most current decisions on choice of technologies, production, marketing, and livelihood are made mainly by men (principal males) or jointly with female members. Women have low sole decision-making power and therefore they have a low Women's Empowerment Index (less than 2.0) for many rice production, marketing, and income-related decision-making activities.
- Profitability of the rice crop varies across sites, with higher net returns in Sibsagar as farmers obtain relatively higher average yields from their current rice varieties.
- MVs are more profitable than TVs due to their higher yields. On average, MV cultivation provides relatively higher (40%) incremental returns (returns above cash costs) than TVs across the sites. This profitability effect of MVs over TVs is statistically significant.
- Labor is the major component of production costs, accounting for more than two-thirds of the total costs. Chemical fertilizer accounts for only 2–3% of the costs in rice production.
- New and old MVs are similar in input use and profitability (both net returns and returns above cash costs). There are no significant higher incremental benefits of growing new MVs over old MVs across the sites. The key drivers of profitability such as yield and output price were similar for both variety types.
- Farmers derive income from rice, nonrice, and various farm and nonfarm employment activities. Rice is an important component of household income, contributing one-third of the income share in total household income.

- Poor farm households use a number of strategies to cope with immediate consumption and livelihood needs during flooding stress. These include resorting to alternative income sources, deferring loan payments, using household savings, and selling/mortgaging assets.
- Some farmers are aware of and also cultivate a relatively newer generation of stress-tolerant MVs such as Jalashree and Jalakunwari that are suited to submergence-prone conditions. Few farmers in Sibsagar are aware of new Sub1 lines being tested in PVS. Large-scale on-farm testing and seed dissemination are yet to take place.

References

Adesina AA, Zinnah MM. 1993. Technology characteristics, farmers' perceptions and adoption decisions: a Tobit model application in Sierra Leone. Agric. Econ. 9:297-311.

Adesina A, Seidi S. 1995. Farmers' perceptions and adoption of new agricultural technology: analysis of modern Mangrove rice varieties in Guinea-Bissau. Quart. J. Int. Agric. 34:358-385.

ASSAMSFAC. 2005. Assam Small Farmers' Agribusiness Consortium. Government of Assam's Platform for Farmers-Government-Bank-Institution and Private Partnership in Agri Business. http://assamagribusiness.nic.in/agri3.htm.

Barah BC, Pandey S. 2005. Rainfed rice production systems in eastern India: an on-farm diagnosis and policy alternatives. Indian J. Agric. Econ. 60(1): Jan-March 2005.

Bellon M, Taylor JE. 1993. Folk soil taxonomy and the partial adoption of new seed varieties. Econ. Dev. Cult. Change 41:763-786.

Bhowmick BC, Borthakar N. 2002. Socioeconomic dynamics of changes in rice production systems in Assam. NATP(ICAR)/IRRI Project. Department of Agricultrual Economics, Assam Agricultural University, Jorhat, Assam.

Bhowmick BC, Barah BC, Pandey S, Barthakur N. 2005. Changing pattern of rice production systems and technology in Assam: a spatio-temporal analysis of performance and prospects. Policy Paper 22. National Centre for Agricultural Economics and Policy Research (NCAP). Indian Council of Agricultural Research, New Delhi, India.

Brush SB, Taylor JE, Bellon MR. 1992. Biological diversity and technology adoption in Andean potato agriculture. J. Dev. Econ. 39:365-387.

David C, Otsuka K. 1994. Modern rice technology and income distribution in Asia. Los Baños (Philippines): International Rice Research Institute.

Das P, Chutiya D, Hazarika N. 2009. Adjusting to floods on the Brahmaputra plains, Assam, India. International Center for Integrated Mountain Development, Kathmandu, Nepal.

Details of Rice Varieties in India (http://dacnet.nic.in/rice/RiceVarieties in India.htm).

DRD (Directorate of Rice Development). 2010. Rice in India during Tenth Plan, prepared and edited by Dr. M.C. Diwakar, director. Government of India, Ministry of Agriculture, (Dept. of Agriculture and Cooperation), Patna, Bihar.

DRR (Directorate of Rice Development). 2008. DRR Newsletter, Vol 6(1) Jan 2008. ICAR. Rajendranagar, Hyderabad, India. (www.drricar.org).

Doss CR. 2006. Analyzing technology adoption using microstudies: limitations, challenges, and opportunities for improvement. Agric. Econ. 34:207-219.

Economic Survey, Assam 2007-08. State Government of Assam, India.
Economic Survey 2009-10. India. http://exim.indiamart.com/economic-survey09-10/.
Feder G, Just RE, Zilberman D. 1985. Adoption of agricultural innovations in developing countries: a survey. Econ. Dev. Cult. Change 33:255-298.
FAOSTAT. 2009. FAOSTAT on-line database on different commodities. FAO. http://faostat.fao.org/site/339/default.aspx.
Hossain M, Bose ML, Ahmad A. 2004. Nature and impact of women's participation in economic activities in rural Bangladesh: insights from household surveys. CPD-IRRI, Policy Brief 7. Dhaka, Bangladesh, IRRI.
Hosssain M, Bose ML, Mustafi BA. 2006. Adoption and productivity impact of modern rice varieties in Bangladesh. Dev. Economies XLIV-2 (June 2006):149-166.
Indiastatistics (www.indiastat.com), Government of India.
Langyintuo A, Mungoma C. 2008. The effect of household wealth on the adoption of improved maize varieties in Zambia. Food Policy 33(2008):550-559.
Maddala GS. 1983. Limited dependent and qualitative variables in econometrics. Econometric Society Monographs, vol. 3. Cambridge University Press, Cambridge.
McDonald JF, Moffitt RA. 1980. The uses of tobit analysis. Rev. Econ. Stat. 62:318-321.
NCAP (National Academy of Agricultural Sciences). 2007. Innovations in rural institutions: drivers for agricultural prosperity. Policy paper 39. New Delhi: NCAP.
Paris T, Singh A, Cueno A, Singh VN. 2008. Assessing the impact of participatory research in rice breeding on women farmers: a case study in eastern Uttar Pradesh, India. Exp. Agric. 44:97-112.
Rice varieties notified from 1996 to 2007 in different states and their salient features (http://agropedia.iitk.ac.in).
Umatsu H, Mishra AK. 2010. Net effect of education on technology adoption by U.S. farmers. Selected paper prepared for presentation at the Southern Agricultural Economics Association.Annual Meeting, Orlando, FL, 6-9 February 2010.
World Bank. 2008. World development indicators. Washington, D.C. (USA): The World Bank.

Notes

Authors' addresses: N. Deka, Department of Agricultural Economics, Assam Agricultural University, Jorhat, Assam; D. Gauchan, Socioeconomics & Agricultural Research Policy Division, Nepal Agricultural Research Council (NARC), Kathmandu Khumaltar, Lalitpur, Nepal.

Appendix 1. Details of costs and returns (Rs/ha) in rice production, wet season, 2008.

Costs and returns	Golaghat		Sibsagar		All	
	MVs	TVs	MVs	TVs	MVs	TVs
Returns						
Grain	30,890	20,300	41,207	29,220	35,896	25,652
Straw	1,130	676	1,695	944	1,402	837
Total returns	32,020	20,976	42,902	30,163	37,269	26,488
Material input cost						
Seeds						
Own	0	1212	242	1,014	117	1,093
Purchased	1,317	0	1,063	0	1,194	0
Total seeds	1,317	1,212	1,305	1,014	1,311	1,093
Chemical fertilizer	346	85	448	379	395	261
Organic fertilizer						
Own	465	659	537	278	500	430
Purchased	6	0	0	0	3	0
Total organic fertilizer	471	659	537	278	503	430
Pesticides	0	0	66	0	32	0
Labor cost						
Family labor	4,664	4,389	5,343	6,741	4,992	5,800
Hired labor	2,296	2,035	2,656	2,379	2,470	2,242
Contract labor	2,192	1,682	2,517	2,151	2,349	1,963
Total labor	9,152	8,106	10,516	11,271	9,811	10,005

Continued on next page

Appendix 1 continued

Power use cost						
Animal power						
Bullock (own)	1,161	1,120	1,347	1522	1,251	1,361
Bullock (hired)	0	0	0	0	0	0
Total animal power	1,161	1,120	1,347	1,522	1,251	1,361
Machines						
Tractor (owned)	155	47	293	325	221	214
Tractor (hired)	0	0	27	0	13	0
Total machine costs	155	47	320	325	234	214
Total cash costs	6,156	3,802	6,777	4,909	6,455	4,466
Total cost of own resources	6,445	7,426	7,763	9,881	7,081	8,881
Total overall costs	12,601	11,229	14,539	14,789	13,536	13,365
Net returns	19,419	9,747	28,363	15,374	23,733	13,123
Returns above cash costs	25,864	17,174	36,125	25,254	30,814	22,022

Appendix 2. Share (%) of components of costs and returns in MV and TV rice production.

Share of components (%)	Golaghat		Sibsagar		All	
	MVs	TVs	MVs	TVs	MVs	TVs
Output						
Grain	96	97	96	97	96	97
Straw	4	3	4	3	4	3
Total output	100	100	100	100	100	100
Material input cost						
Seeds						
Own	0.0	10.8	1.7	6.9	0.9	8.2
Purchased	10.5	0.0	7.3	0.0	8.8	0.0
Total seeds	10.5	10.8	9.0	6.9	9.7	8.2
Chemical fertilizer	2.7	0.8	3.1	2.6	2.9	2.0
Organic fertilizer						
Own	3.7	5.9	3.7	1.9	3.7	3.2
Purchased	0.0	0.0	0.0	0.0	0.0	0.0
Total organic fertilizer	3.7	5.9	3.7	1.9	3.7	3.2
Pesticides	0.0	0.0	0.5	0.0	0.2	0.0
Labor cost	0.0	0.0	0.0	0.0	0.0	0.0
Family labor	37.0	39.1	36.7	45.6	36.9	43.4
Hired labor	18.2	18.1	18.3	16.1	18.2	16.8

Continued on next page

Appendix 2 continued

Contract labor	17.4	15.0	17.3	14.5	17.4	14.7
Total labor	72.6	72.2	72.3	76.2	72.5	74.9
Power use cost	0.0	0.0	0.0	0.0	0.0	0.0
Animal power	0.0	0.0	0.0	0.0	0.0	0.0
Bullock (own)	9.2	10.0	9.3	10.3	9.2	10.2
Bullock (hired)	0.0	0.0	0.0	0.0	0.0	0.0
Total animal cost	9.2	10.0	9.3	10.3	9.2	10.2
Machines	0.0	0.0	0.0	0.0	0.0	0.0
Tractor (owned)	1.2	0.4	2.0	2.2	1.6	1.6
Tractor (hired)	0.0	0.0	0.2	0.0	0.1	0.0
Total machine cost	1.2	0.4	2.2	2.2	1.7	1.6
Total cash costs	48.9	33.9	46.6	33.2	47.7	33.4
Total cost of own resources	51.1	66.1	53.4	66.8	52.3	66.4
Total overall costs	100	100	100	100	100	100

Appendix 3. Details of costs and returns in new and old MV rice production (Rs/ha).

Costs and returns	Golaghat		Sibsagar		All	
	New MVs	Old MVs	New MVs	Old MVs	New MVs	Old MVs
Returns						
Grain	30,075	31,941	41,805	40,769	35,491	36,355
Straw	1,075	1,215	1,793	1,573	1,407	1,394
Total returns	31,154	33,156	43,598	42,342	36,897	37,749
Material input cost						
Seeds						
Own	0	36	269	211	124	124
Purchased	1,315	1,280	1,011	1,146	1,175	1,213
Total seeds	1,315	1,316	1,280	1,357	1,299	1,337
Chemical fertilizer	329	363	465	428	392	396
Organic fertilizer						
Own	475	452	527	554	499	503
Purchased	0	15	0	0	0	8
Total organic fertilizer	475	467	527	554	499	511
Pesticides	0	0	112	0	52	0
Labor cost						
Family labor	4,647	4,630	5,727	4,808	5,146	4,719
Hired labor	2,363	2,150	2,617	2,736	2,480	2443
Contract labor	2,257	2,044	2,487	2,579	2,363	2,312

Continued on next page

Appendix 3 continued

Total labor	9,267	8,824	10,831	10,123	9,989	9,474
Power use cost						
Animal power						
Bullock (own)	1,136	1,188	1,461	1192	1,286	1,190
Bullock (hired)	0	0	0	0	0	0
Total animal cost	1,136	1,188	1,461	1,192	1,286	1,190
Machines						
Tractor (owned)	163	137	307	281	229	209
Tractor (hired)	0	0	5	26	2	13
Total machine cost	163	137	312	307	231	222
Total cash costs	6,265	5,852	6,703	6,943	6,467	6,398
Total cost of own resources	6,420	6,443	8,302	7,045	7,289	6,744
Total overall costs	12,685	12,295	15,005	13,988	13,756	13,141
Returns above cash costs	24,889	27,304	36,895	35,399	30,430	31,352
Net returns	18,469	20,861	28,592	28,354	23,141	24,608

Appendix 4. Share (%) of costs in new and old MV rice production, Assam, 2008.

Share (%) of costs and returns	Golaghat		Sibsagar		All	
	New MVs	Old MVs	New MVs	Old MVs	New MVs	Old MVs
Material input cost						
Seeds						
Own	0	0.3	1.8	1.5	0.9	0.9
Purchased	10.2	10.4	6.7	8.2	8.5	9.2
Total seeds	10.2	10.7	8.5	9.7	9.4	10.2
Chemical fertilizer	2.6	3.0	3.1	3.1	2.8	3.0
Organic fertilizer						
Own	3.7	3.7	3.5	4.0	3.6	3.8
Purchased	0	0.1	0	0	0	0.1
Total organic fertilizers	3.7	3.8	3.5	4.0	3.6	3.9
Pesticides	0.0	0.0	0.7	0.0	0.4	0.0
Labor cost	0.0	0.0	0.0	0.0	0.0	0.0
Family labor	36.1	37.7	38.2	34.4	37.4	35.9
Hired labor	18.4	17.5	17.4	19.6	18.0	18.6
Contract labor	17.6	16.6	16.6	18.4	17.2	17.6
Total labor	72.1	71.8	72.2	72.4	72.6	72.1
Power use cost						
Animal power						
Bullock (own)	8.8	9.7	9.7	8.5	9.3	9.1
Bullock (hired)	0.0	0.0	0.0	0.0	0.0	0.0
Total animal cost	8.8	9.7	9.7	8.5	9.3	9.1
Machines	0.0	0.0	0.0	0.0	0.0	0.0
Tractor (owned)	1.3	1.1	2.0	2.0	1.7	1.6
Tractor (hired)	0.0	0.0	0.0	0.2	0.0	0.1
Total machine cost	1.3	1.1	2.1	2.2	1.7	1.7
Total cash costs	49	48	45	50	47	49
Total cost of own resources	51	52	55	50	53	51
Total overall costs	100	100	100	100	100	100

Chapter 5

Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas of Bangladesh

Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas of Bangladesh

M.R. Islam, M.A. Islam, M.S. Rahman, A. Salam, S. Alam, E. Harun, and M. Bool-Emerick

Introduction

Country background

Bangladesh is located in the northeastern part of South Asia with India bordering the west, north, and east and Myanmar bordering the southeast. It has a total land area[1] of 130,170 km^2 with a population of 162 million in 2009. Agriculture is the mainstay of the Bangladeshi economy, contributing 19% to the gross domestic product (GDP).

Rice, the main food crop, is grown extensively and can be harvested 2 to 3 times a year. In 2008-09, Bangladesh produced 43.8 million tons of rice with aus, aman, and boro rice accounting for 10%, 42%, and 48%, respectively (Bangladesh Rice Research Institute 2011). Rice is cultivated in different ecosystems that include irrigated, rainfed lowland areas, and uplands. In rainfed areas, rice farms are affected by varied levels of submergence, drought, and salinity. The occurrences of these abiotic stresses cause substantial crop damage in the country. To improve the food security and livelihoods of poor farming households, collaborative efforts with NARES have been made to develop stress-tolerant rice varieties to achieve higher productivity growth in the country.

Objectives

This report is an outcome of the baseline socioeconomic survey under Objective 7 (Impact assessment and targeting) of the STRASA project. The objectives of the study are the following:

- To analyze farmers' livelihood systems in selected drought-prone, submergence-prone, and salinity environments in Bangladesh.
- To analyze the patterns of varietal adoption and the factors that influence the adoption of modern rice varieties.
- To analyze the economics of rice production by type of variety and season.
- To document farmers' coping strategies due to different stress situations (drought, submergence, and salinity).
- To understand gender roles in rice production and women's participation in decision-making.
- To serve as a baseline for rice technology design, targeting, and policy reforms in the stress-prone areas.

[1]Land area excludes area under inland water bodies such as major rivers and lakes.

Organization of the report
This report is organized into six major sections. The first section gives a general country background and objectives of the study. This is followed by a short description of research design and data generation. The third section provides a brief description of the trends in rice production. The fourth section provides a general description of the survey sites and stresses using information gathered from focus group discussions (FGD) and key informant surveys (KIS). Section five presents the detailed farm-level analyses of the socioeconomic survey describing the livelihood of farmers, adoption of modern varieties, economics of rice production, consumption patterns, coping strategies, and gender analysis. The final section provides a summary of the findings.

Research design and data generation

This research was implemented in partnership with the Bangladesh Rice Research Institute (BRRI) in Gazipur and Bangladesh Agricultural University (BAU) in Mymensingh. Data for this study were collected by combining rapid rural appraisal methods, secondary sources, and specifically designed household surveys.

The survey was carried out for the 2008 rice cropping season under the STRASA project in South Asia. Prevalence of stress (drought, submergence, and salinity) and proportion of rainfed rice area were two major criteria used in selecting districts and study villages. Household surveys were conducted in 500 randomly selected households covering the representative rainfed districts in Bangladesh. The districts included were Habiganj, Jamalpur, Kurigram (submergence), Rajshahi (drought), and Satkhira (salinity). Within each district, at least two villages were selected for the detailed household survey. The survey sites and stress situations were characterized using information gathered from focus group discussions and key informant surveys.

Detailed information on farmers' livelihoods, socioeconomic features, rice production systems, variety adoption patterns, input use, costs and returns, income structure, farmers' coping strategies, and gender-disaggregated data on rice farming was collected from the socioeconomic household baseline survey.

The basic analytical framework followed is given in Chapter 2. The study used a combination of secondary and primary data. Temporal data on rice area, yield, and production covering 1970 to 2008 were used to provide general trends at the aggregate level. Various statistical and econometric analyses were employed to meet the study objectives. Using time-series data obtained from national statistics, annual growth rates for rice area, production, and yield were estimated using a semi-log trend equation.[2] The compound growth rate was estimated for each decade from 1970 to 2008. Before fitting the trend equation for each period, data were smoothed using a five-year moving-average process.

[2] The functional form of the semi-log equation is given by $\ln Y_t = a + bT$, where Y_t is the series of area/production/yield, a is the constant, b gives the annual exponential growth rate of area/production/yield, and T is the trend term.

The adoption of improved varieties was measured using various indicators such as the proportion of farmers growing modern varieties (MVs) and the proportion of area under MVs. The incidence and intensity of adoption were compared not only across sites and stress situations but also between aman and boro seasons.

The nature of MV adoption[3] in Bangladesh did not allow us to use censored regression (tobit) and probit models to identify the major factors determining the probability and the rate of adoption of new-generation modern varieties. Instead, past literature on the dominant rice varieties from 1980 to the present was reviewed.

Agriculture and trends in rice production

Agriculture is one of the major sectors in the Bangladeshi economy, contributing 48% to the country's total employment (Worldbank Indicators 2010). In 2008, the agricultural sector accounted for 19% of the GDP. More than 70% of the population thrives in rural areas, where agriculture is the major source of livelihood.

Agricultural land consists of 70% of the country's total land area. Farm landholdings in the country are characterized as small and fragmented. Of the total number of farm landholdings, 89% are considered marginal or small, where area is below 1.0 ha.

More than 60% of the total agricultural land is irrigated. The different sources of irrigation are power pumps, shallow tube wells (STW), deep tube wells (DTW), and traditional sources such as canals. More than 90% of the irrigated area is planted to the country's major crops such as cereals (rice, wheat) and potato. The country's land area under cereal production increased from 10.9 million ha in 1992 to 12.4 million ha in 2008 (www.tradingeconomics.com). Expansion in cereal[4] production can be attributed to irrigation expansion such as the installation of shallow tube wells. Aside from cereal crops, major cash crops such as jute, sugarcane, cotton, tobacco, tea, and betel leaves are also cultivated. The overall cropping intensity was estimated at 179% in 2008-09 (BRRI 2011).

Trends in rice area, production, and yield

The different cropping seasons for rice in Bangladesh are aus, aman, and boro. The aus season overlaps the boro and aman seasons. Aus rice or early summer rice is planted in April and harvested in August. On the other hand, aman rice (wet-season rice) is usually transplanted in June/July and harvested in November/December while boro rice or dry-season irrigated rice is planted in December/January and harvested in May/June.

The total rice area increased from 9.9 million ha in 1971 to 11.7 million ha in 2008. Rice production grew significantly by more than 2% annually from 1974 to 2008,

---

[3]MV adoption is very high at selected survey sites and not much variation was observed across sites. During the aman season, most rice areas are grown to old-generation MVs while the reverse is observed during the boro season.

[4]Cereals include wheat, rice, maize, barley, oats, rye, millet, sorghum, and mixed grains.

which was mainly driven by growth in yield (Fig. 1). Growth in production and yield was made possible by the adoption of high-yielding varieties, installation of shallow tube wells, and rapid uptake of fertilizers and pesticides (Hossain et al 2009).

The growth rates for different periods are presented in Table 1. Overall, significant growth in rice area by 0.2% per year was observed from 1974 to 2008. Similarly, dramatic growth in yield is observed for all periods. On average, rice yield increased by 2.4% per annum from 1974 to 2008. The area expansion and improvements in yield caused a significant rice production growth of 2.6% per annum.

Some of the growth in production can be explained by the expansion of boro rice cultivation. In 1971, aus rice occupied 32% of the total rice area while boro rice accounted for only 9%. From 1976 to 1988, boro rice area increased slowly while aus area declined gradually (Fig. 2). Boro rice area continued to increase from 1988 to 2008 while aus rice continued to drop. In 2008, boro rice occupied 37% while aus rice accounted for only 13% of the total rice area.

Half of the total rice area is planted to aman rice. Despite this, rice yield is highest during the boro season and lowest in aus. Improvements in rice yields for all seasons were very slow until the late 1990s, when yield surpassed 3.0 t/ha nationally. By 2008, rice yield reached 4.05 t/ha with mean boro yield of 5.34 t/ha while aus and aman rice yield averaged 3.08 and 3.36 t/ha, respectively (BRRI 2011). Figures 3, 4, and 5 show the trends in rice area, production, and yield by season from 1971 to 2008.

During the 1970s, the majority of the rice area was grown to traditional rice varieties (TVs). Over the years, the shift from low-yielding traditional varieties to

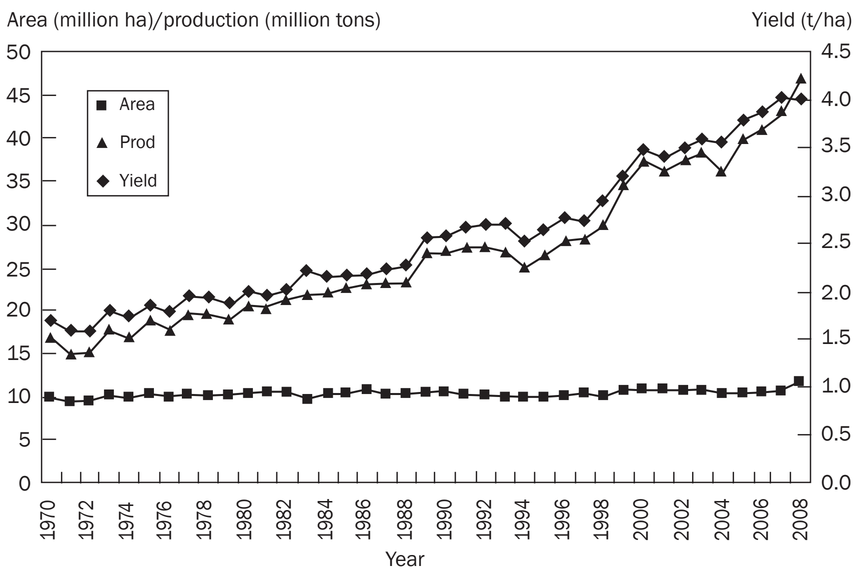


Fig. 1. Rough rice area, production, and yield in Bangladesh, 1970-2008. Data source: World rice statistics (FAO data), 2010.

Table 1. Growth rates[a] (% per year) of rice area, yield, and production.

Period	Area	Yield	Production
1974-80	0.7***	2.2***	2.9***
1981-90	0.2***	2.1***	2.3***
1991-2000	–0.1	1.8***	1.7***
2001-08	0.1***	2.6***	2.7***
1974-2008	0.2***	2.4***	2.6***

[a]Using the semi-log trend equation, the annual compound growth rates of area, yield, and production are computed using a 5-year moving average of the raw data centered on the end years.
*** indicates statistical significance at the 1% level.
Data source: World rice statistics, 2011.

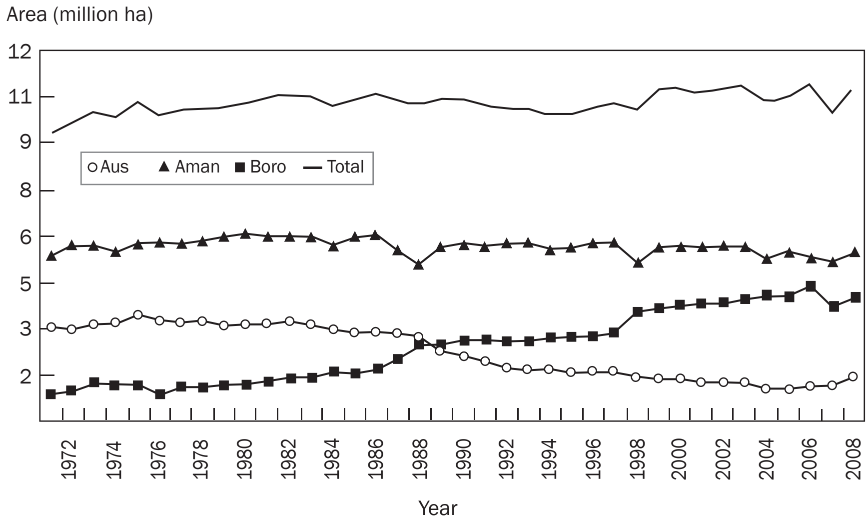


Fig. 2. Rough rice area by season in Bangladesh, 1971-2008. Data source: BRRI (2010).

high-yielding modern rice varieties was very slow, especially in the aman and aus seasons. On the other hand, the conversion of rice areas cultivated from TVs to MVs started early in the boro season. The adoption of MVs increased substantially during the 1980s, when MVs accounted for more than 60% of the total rice area. By 1995, MV coverage during the boro season reached 95% (Fig. 6). In 2008, the share of MV rice in the country's total rice area was 82%.

According to BRRI, 71 high-yielding rice varieties (including four hybrid rice varieties) had been released in Bangladesh as of 2010. Some 61% of the modern varieties were released after 1990. However, only a few varieties are being adopted. Dominant MVs include BR11, BR10, and Guti swarna during the aman season and BRRI dhan28 or BRRI dhan29 during the boro season.

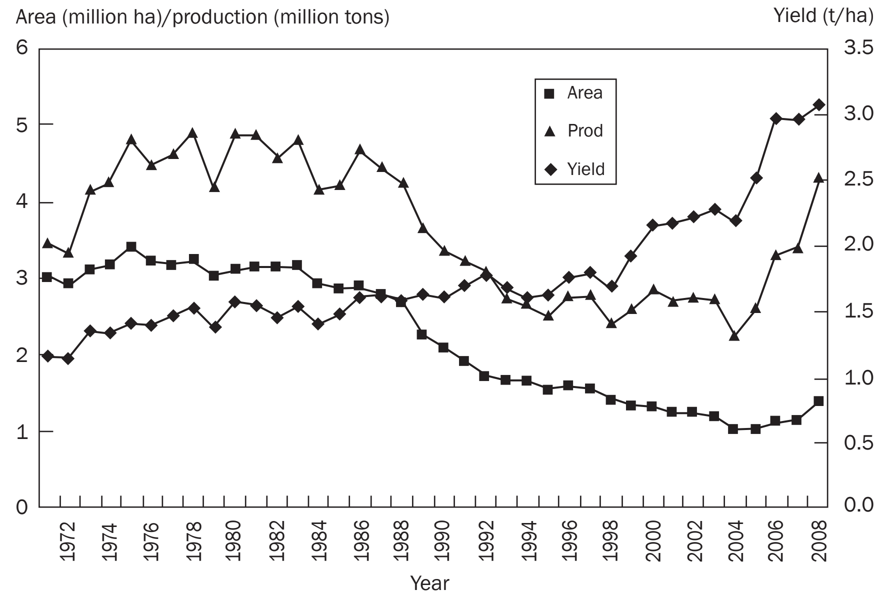


Fig. 3. Area, yield, and production for aus rice, 1971-2008. Data source: BRRI, 2010.

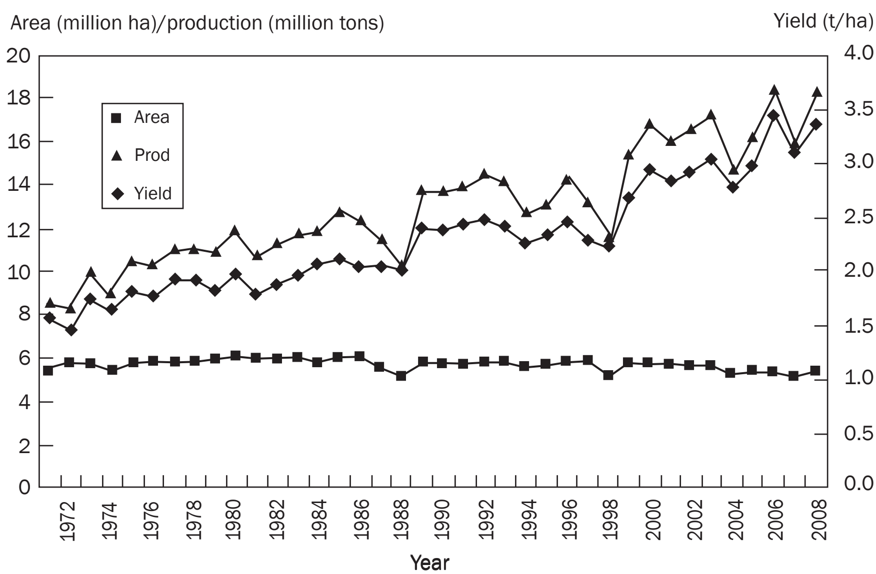


Fig. 4. Area, yield, and production for aman rice, 1971-2008. Data source: BRRI, 2010.

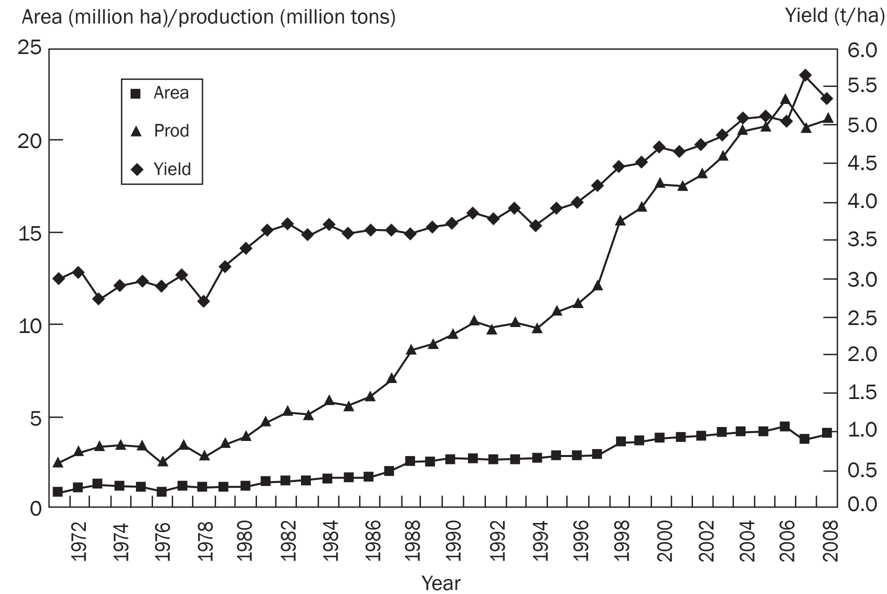


Fig. 5. Area, yield, and production for boro rice, 1971-2008. Data source: BRRI, 2010.

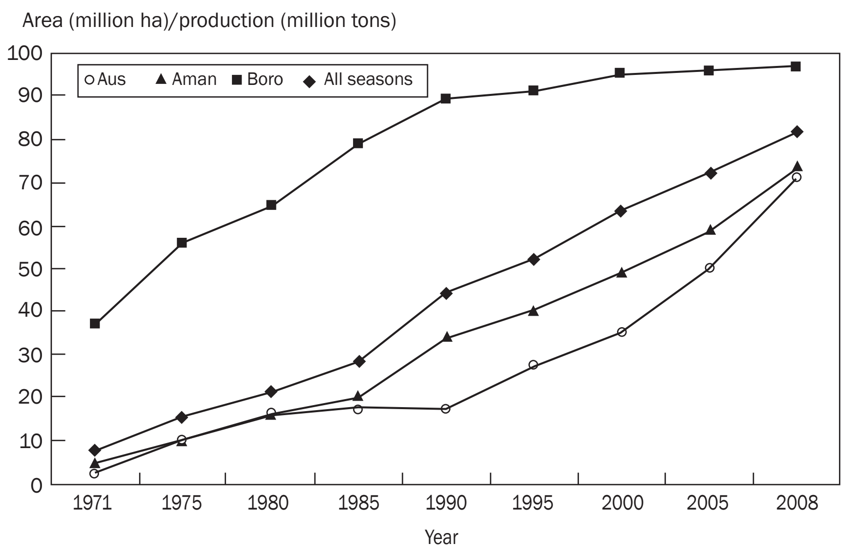


Fig. 6. Share of MV area in total rice area, 1971-2008. Data source: BRRI, 2010.

Site and stress characterization

Site and village description

Location of sites. Bangladesh is a low-lying coastal country situated on the deltas of big rivers flowing from the Himalayas. The large rivers Ganges, Brahmaputra, and Meghna converge in the delta and eventually flow into the Bay of Bengal. The major abiotic stresses affecting agriculture are submergence, drought, and salinity.

Five key districts, Habiganj, Jamalpur, Kurigram, Rajshahi, and Satkhira, were selected to represent the stress-prone rice areas in Bangladesh (Fig. 7). Habiganj, Jamalpur, and Kurigram represent the submergence-prone rainfed rice environment while Rajshahi and Satkhira represent the drought-prone and saline-affected rice environments, respectively.

In each district, two or more villages were selected to represent the rainfed rice production domain. The number of villages covered for each district varies depending on spatial variability in the area. Satkhira, a village not affected by salinity, was identified to allow comparison of rice production, crop management practices, and livelihood strategies between salinity-affected and nonsaline areas. Figure 7 shows the location of the sites representing the stress-prone rice areas in Bangladesh and Table 2 lists the selected districts and corresponding villages covered by the socioeconomic baseline survey.

The survey is composed of 500 households from five representative districts in Bangladesh. The households considered are those involved in rainfed rice farming and those that normally face a problem of submergence, drought, or salinity in rice production. In addition, the major occupation of the households selected in these districts is rice farming.

Description of the major abiotic stress

The characteristics of the major abiotic stress in selected districts are presented in Table 3. Submergence-prone areas are represented by three districts. In 2008, farmers in these locations did not experience submergence. The most recent flood as reported by farmers was in 2007 for Jamalpur and in 2004 for Habiganj and Kurigram. Submergence often occurs during the aman season in August and September, when rice crops are at the seedling or vegetative stage. The duration and depth of submergence vary across villages as some experience multiple flooding. According to farmers' estimates, the 2007 submergence affected more than 75% of the rice area in selected villages in Jamalpur while the 2004 submergence affected 55–75% of the total rice area in selected villages in Habiganj and Kurigram. The number of households affected by the stress in Habiganj and Kurigram was 40–50% while a majority of the sample households in selected villages of Jamalpur were affected by the 2007 submergence.

Rajshahi is located in the northwestern part of Bangladesh where drought often occurs. Most farmers in these drought-prone areas are poor and most rely on rainfall to irrigate their crops. Depending on the degree and timing of drought, crops can be partially or completely damaged, causing significant losses in farmers' livelihood.

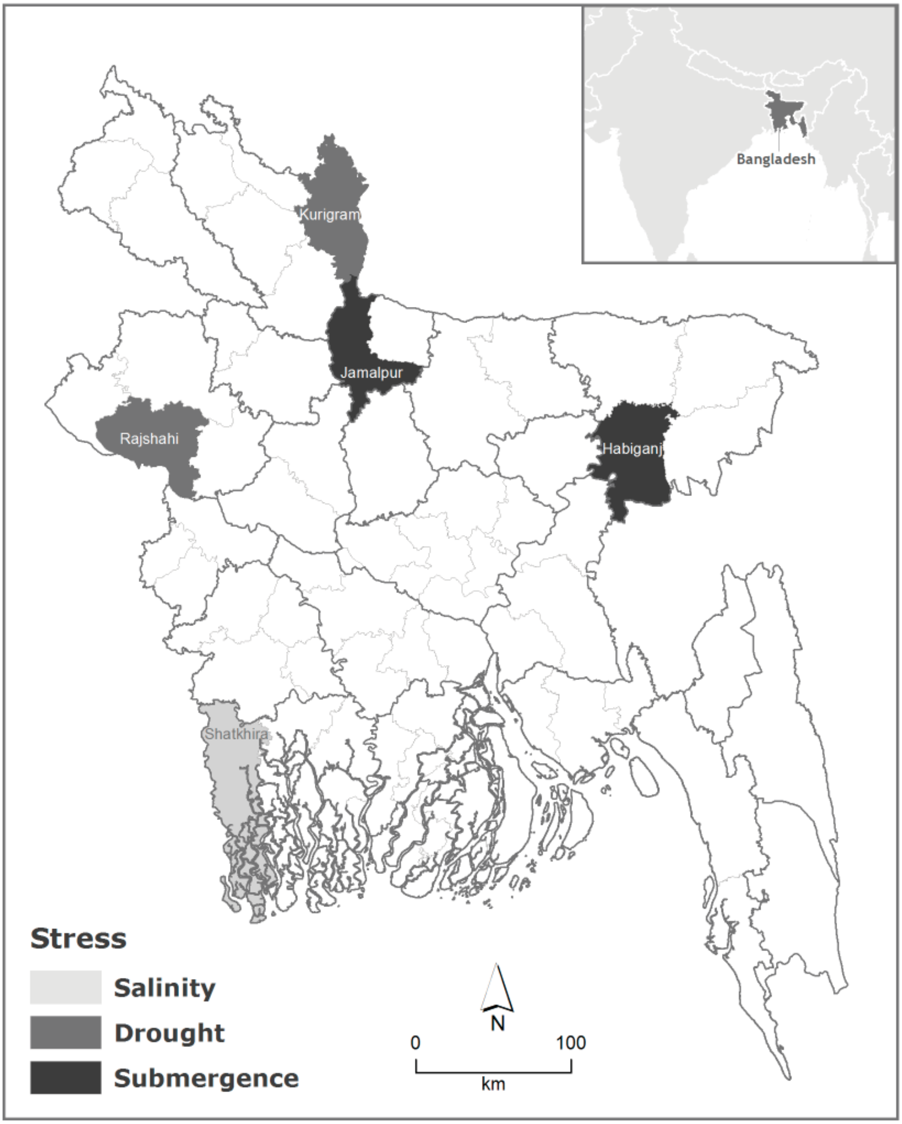


Fig. 7. Site locations for the socioeconomic baseline survey in Bangladesh.

Table 2. Selected survey sites representing stress-prone rice areas in Bangladesh.

Stress	District	Villages	Sample size	Institution
Submergence	Habiganj	Suraboi, Nurpur, Purasanda	100	BRRI
	Jamalpur	Titpolla, Sonakata	100	BAU
	Kurigram	Harirdanga, Fulbari	100	BRRI
Drought	Rajshahi	Agolpur, Balia Dung, Biroil, Borgitola, Dolia para, Edulpur, Giolmari, Gohomabona, Jaoipara, Kamlapur, Lalmatia, Malompara, Norsingor Adorsho, Shahana para, Shreerampur	100	BRRI
Salinity	Satkhira	Atulia, Beajua, Biralaxmi, Hogla, Joypotrokati, Sreedharkati	100	BRRI
Total	5	29	500	

Table 3. Stress characteristics in survey locations.[a]

Item	Jamalpur	Habiganj	Kurigram	Rajshahi	Satkhira
Stress	Submergence	Submergence	Submergence	Drought	Salinity
Rice production in 2008	Normal	Normal	Normal	Normal	n/a
Most recent stress	2007	2004	2004	2006	n/a
Frequency in 10 years	2	2	2	4	n/a
Season affected	Aman	Aman	Aman	Aman	Boro
Duration	40 days	60 days	20–30 days	15–30 days	n/a
Depth of flood (m)	1.8–2.1	1.8–2.1	1.8–2.1	n/a	n/a
Stages of crop affected by stress	25 days after transplanting	Seedling	Seedling	Seedling, flowering	Panicle initiation
% Rice area affected by most recent stress	>75	75	55	70–80	60
% Households affected by stress	90	50	40–45	80	60

[a]Not applicable is denoted by n/a.
Source: STRASA focus group discussion, 2008.

Drought occurred 4 times in the last 10 years in selected villages in Rajshahi. The most recent drought was experienced in 2006, which affected 70–80% of the villages' total rice areas and 80% of the households.

More than 30% of the net cultivable area in Bangladesh is on the coast. Out of 2.85 million hectares of coastal and off-shore areas, about 0.833 million hectares of arable land are affected by varying degrees of soil salinity (Karim et al 1990). The soil becomes saline as it is exposed to sea water and continues to be inundated during high tides. As cited by Haque (2006), the factors that contribute significantly to the development of saline soils are tidal flooding during the wet season (June-October), direct inundation by saline or brackish water, and upward or lateral movement of saline groundwater during the dry season (November-May). Soil salinity limits rice production, especially during the boro season when salinity is high. Rice production is less affected by salinity during the aman season when salts are flushed off by the monsoon rains. However, the problem of high salt concentration during the initial stage of crop growth remains a major obstacle to increasing production in rice-growing coastal areas during the boro season. In Satkhira, sample farmers reported that 60% of the total rice area is affected by salinity (focus group discussion, 2008).

Depending on the severity of abiotic stresses, the occurrence of these stresses can cause substantial reductions in yield. Based on focus group discussions, sample farmers revealed a 40% to 50% decrease in yield during stress years in submergence-prone areas. During normal years, farmers get 3.5 to 4.2 t/ha of rice during aman, whereas, under stress conditions, farmers can get only 1.7–2.3 t/ha. In drought-prone areas, farmers estimated a 49% yield reduction in the event of drought. On average, rice yield during normal years in aman is 3.5 t/ha and during a stress year is 1.8 t/ha. On the other hand, the yield difference between salinity-affected and nonsaline sites in Satkhira is around 23% during the boro season (Table 4).

Cropping calendar and major crops. Based on focus group interviews, rice can be grown in three overlapping seasons (Fig. 8). Planting during the aus season starts in April while harvesting is done around July to August. Farmers grow transplanted aman rice from June to December while boro rice is planted in December and harvested in May/June. Rice is the major crop during aman and boro seasons while nonrice crops such as potato, tomato, jute, and wheat are also grown during the aus season.

Farm-level analysis

Socio-demographic characteristics

Ethnicity. A majority of the sample households at the survey sites are Muslims except in Kurigram and Rajshahi, where 30% of the households interviewed belong to Hindu or other ethnic groups (Table 5). Kurigram and Rajshahi are located along the boundaries of the country, bordering some Indian districts. Migration of people across the border may explain the variety of ethnic groups in the district.

Respondents by gender, age, and education. The respondents interviewed are mostly household heads or those who are active and knowledgeable in rice farming

Table 4. Rice yield (t/ha) of modern varieties during normal and stress years.[a]

Rice yield	Submergence			Drought	Salinity	
	Jamalpur	Habiganj	Kurigram	Rajshahi	Satkhira	
					Saline	Nonsaline
Normal year	3.5	4.2	3.8	3.5	4.0	4.9
Stress year	1.7	2.0	2.3	1.8	n/a	n/a
Yield difference	51%	48%	39%	49%	23%	

[a]Yield rates presented are based on the season when the abiotic stress is a major problem. At submergence and drought sites, yields refer to rice in the aman season while yield at the salinity site refers to the boro season. Not applicable is noted by n/a.
Source: STRASA focus group discussion, 2008.

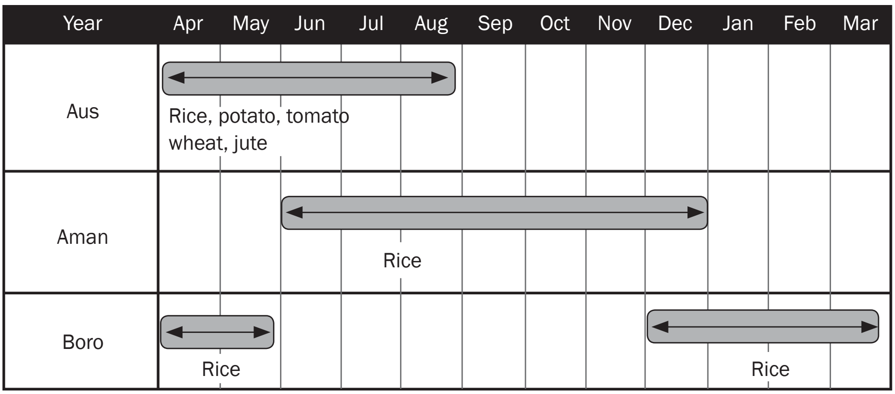


Fig. 8. Cropping calendar and major crops grown.

Table 5. Composition of sample households by ethnicity.

Ethnicity	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
No. of households	100	100	100	100	50	50	500
Ethnicity (%)							
Muslim	100	99	70	70	100	82	86
Hindu	0	1	30	7	0	18	9
Others	0	0	0	23	0	0	5

during the survey year. Most of the respondents are men and only 2% are women. On average, the respondents are around 44 years old and have 4–6 years of education for males and 0–3 years of education for females (Table 6). The small number of females representing the households and low average number of schooling years among female respondents reflect the patriarchy system or male dominance within domestic units in Bangladesh.

With the increasing roles of women in agriculture, improvements in educational status could be a stepping stone toward empowerment. Women's roles and participation in decision-making are presented in the latter section of this report.

Household characteristics. Table 7 shows the general characteristics of the selected households. Average household size ranges from 4 to 6 members with the number of male members dominating the number of females by 10%. Seventy percent of the total number of household members are adults (more than 15 years old) with 6 years of formal schooling on average. Moreover, results show an education gap of two years between the male and female adult members of the household.

Occupation. More than 65% of the household members are composed of adults 15 to 65 years old. Farming is the major activity of adults, especially in Kurigram and Rajshahi, where more than 80% of the adult members are engaged in farm-related activities (Table 8). Other primary employment as reported in the survey includes salaried jobs, labor services, and small-scale business such as the operation of small shops.

Table 6. General characteristics of the respondents.

Respondents' characteristics	Submergence			Drought	Salinity		All
					Satkhira		
	Habiganj	Jamalpur	Kurigram	Rajshahi	Saline	Nonsa-line	
No. of households	100	100	100	100	50	50	500
Age (years)	46	43	45	43	42	41	44
Gender of respondent							
% Males	100	98	100	97	98	96	98
% Females	0	2	0	3	2	4	2
No. of years of schooling							
Males	6	5	6	4	6	5	5
Females	–	0	–	3	3	0	2
All	6	5	6	4	6	5	5

Table 7. General characteristics of the sample households.

Households' characteristics	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
No. of households	100	100	100	100	50	50	500
Av. household size	6	5	4	5	6	5	5
Household composition							
% Males	54	55	57	55	53	55	55
% Females	46	45	43	45	47	45	45
Age group (%)							
Below 16 years old	33	29	27	30	29	29	30
16 to 50 years old	55	60	63	61	58	56	59
> 50 years old	12	11	10	9	13	15	11
Years of schooling[a]							
Males	7	7	7	6	7	6	7
Females	6	5	5	5	5	4	5
All	7	6	6	5	6	5	6

[a]Adult members only (age is 16 years and older).

Table 8. Employment (%) of adult household members (only between 16 and 65 years old).

Primary occupation	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Farming activities	61	65	95	82	67	80	75
Small-scale business	21	10	1	2	13	10	9
Salaried jobs	0	17	0	0	2	3	4
Services	8	2	3	11	13	7	7
Others[a]	10	6	1	5	5	0	5
Total	100	100	100	100	100	100	100

[a]Other occupations include fishing, livestock production, mason, factory worker, wood engraver, and driver.

Farm land characteristics

Landholdings. Table 9 shows the general characteristics of the households' landholdings. The average farm sizes of sample households in the districts range from 0.4 to 1.2 ha. Generally, farms are further divided into 3 to 5 parcels based on agroecological characteristics. The parcel area of the sample household ranges from 0.1 to 0.4 ha. Based on Table 9, sample households in Kurigram have the smallest average farm size while sample households in Rajshahi and Satkhira (saline site) have the largest farms, with areas of more than 1.0 ha on average.

The farm size distribution of selected households in different stress-prone environments is given in Figure 9. The distribution shows that farm sizes are mostly positively skewed, meaning that the farm size of most households is below the average. Around 80% of the samples at submergence-prone sites have landholding that is less than 1.0 ha while the farm size of sample households at the drought site has a wider distribution. Similarly, farm size distribution among households in saline areas in Satkhira is wider than that of households in the nonsaline group. These findings indicate inequality in land endowments of the sample rice farming households both within and across stress-prone environments.

Land tenure. Table 9 shows that most sample households own their farms except in Rajshahi, where most farmers interviewed are landless. Much of the rice area in Rajshahi is owned by absentee landlords or is sharecropped (73%) while 80% to 90% of the lands are owned by sample farmers in Jamalpur, Kurigram, Habiganj, and Satkhira.

Land type. The type of abiotic stress affecting an area may depend on its land type. In submergence areas, the proportion of land under lowland conditions is 32% to 55% while the share of lowland in drought area is only 15%. This is consistent with the conventional wisdom that low-lying lands are prone to submergence while those in relatively higher parts of the toposequence are drought-prone. Medium land consists of 69% of the land at drought-prone sites and only 13% to 49% of the land at submergence-prone sites.

In Satkhira, most lands are under medium land conditions, which comprise more than 80% of the total land area of the sample households.

Irrigation and land use. Crop cultivation during the boro season is made possible by the availability of irrigation facilities such as low-lift pumps, deep tube wells, and shallow tube wells. Low-lift pumps and shallow/deep tube wells are the common sources of irrigation in Bangladesh. In fact, more than 80% of the total irrigated area in 2008 was irrigated by tube wells. Table 9 shows that sample households in submergence and saline areas are able to provide irrigation to most of their farm while only 56% of the farms receive irrigation in drought-prone areas during the boro season. Generally, irrigation is not required in the aman season as there is enough rainfall for farmers to use in watering the crops.

Table 10 shows that cropped area during the aman season is about 90% or more at most sites. However, during the boro season, small areas are planted in drought-prone and saline areas. The small area under crops in Rajshahi and Satkhira (saline site) can be attributed to the limited area irrigated during the boro season. Most crops

Table 9. General farm characteristics.

Farm characteristics	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Av. farm size (ha)	0.8	0.9	0.4	1.2	1.1	0.5	0.8
Av. no. of parcels							
per household	4	5	4	3	4	4	4
Av. parcel area (ha)	0.2	0.2	0.1	0.4	0.3	0.1	0.2
Area by tenure (%)							
Owned	79	90	89	27	83	84	69
Rented-in[a]	19	9	11	73	17	16	30
Rented-out	2	1	0	0	0	0	1
Area by land type (%)							
Upland	19	24	32	16	0.1	11	18
Medium land	49	30	13	69	99.8	85	56
Lowland	32	46	55	15	0.1	4	26
Irrigated area (%)							
Aman season	0	6	0	48	0	0	15
Boro season	100	99	100	56	100	100	87

[a]Includes sharecropping, government-owned, and mortgaged-in.

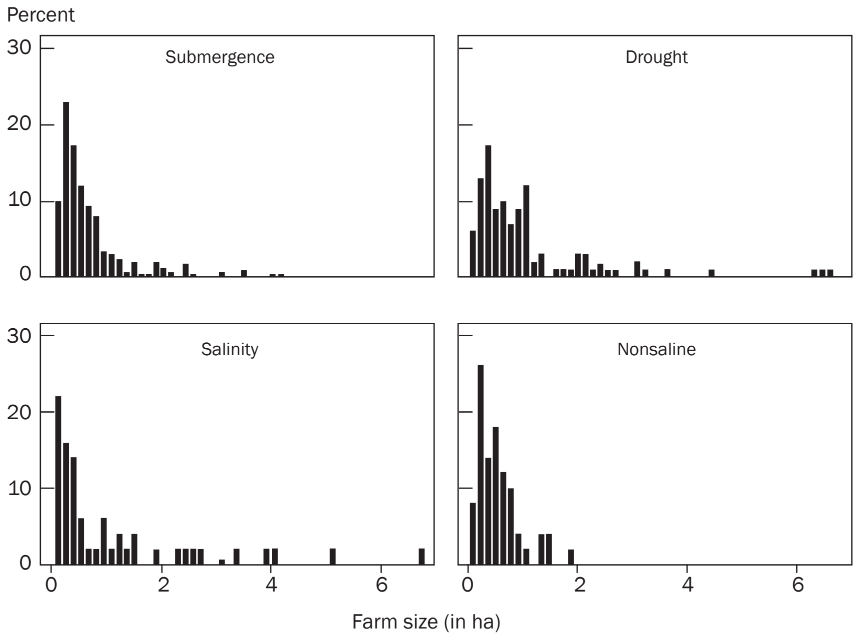


Fig. 9. Farm size distribution of sample households by different stress environments. Data source: STRASA baseline survey, 2008.

Table 10. Proportion of cropped area (%) to total land area by season.[a]

Cropped area	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Aman	89	92	96	91	92	79	91
Boro	88	98	95	56	12	95	72
Aus	0	1	3	16	0	0	5

[a]Remaining areas not cropped are either kept fallow or rented out.

are grown during the aman season at the saline site because of low salinity during the aman season. During the boro season, the degree of salt accumulation in the soil caused by seawater intrusion becomes severe. As a result, fields become less suitable for crop cultivation. During the boro season, cropped area is limited at the salinity-affected site where only 12% of the total area is grown to crops.

Characteristics of the rice-based cropping system

Rice is the main crop during aman and boro seasons. Cultivation of a third crop is also reported at some of the survey sites. Cropped area in the aus season accounts for only 1% to 16% of the land area. Major crops grown during aus are rice, potato, wheat, jute, and tomato.

The predominant cropping pattern in most areas is rice-rice while the major cropping pattern at the salt-affected site is rice-fallow. Other cropping sequences observed are rice-rice-potato, rice-rice-jute, rice-rice-tomato, and others. However, rice is the sole crop cultivated in saline-affected areas. The cropping patterns show the importance of rice as the main staple food in Bangladesh. The major nonrice crops in each sample district are potato in Habiganj, potato and jute in Jamalpur and Kurigram, tomato and wheat in Rajshahi, and potato and sugarcane in nonsaline areas in Satkhira.

Table 11 shows the cropping intensity (CI) index as given by the proportion of gross cropped area to the total net cropped area. The gross cropped area is the total area planted to crops in all seasons while the net cropped area is the total operational area. Results show that the degree of intensification at all survey sites except for saline-affected areas in Satkhira is more than 160%, which implies that most farmers cultivate their land twice a year. On the other hand, the CI index at the saline site shows that most farmers are monocropping and cultivate rice only during the aman season. In fact, only 54% of the farmers are able to grow boro rice.

Patterns of rice varietal adoption

Combination of rice types grown. Farmers may grow a combination of rice varieties such as a modern rice variety (MV) in one parcel and a traditional variety (TV) in another parcel. Results show that most households grow MVs only in all rice parcels during both the aman and boro seasons except in Kurigram, where more than 54% of the farmers grew both MVs and TVs during the aman season (Table 12). In Satkhira, most farmers grew MV rice only during the aman season. Farmers who were able to grow boro rice also grew MVs and 11% of the sample farmers adopted hybrid rice in the boro season in selected saline areas.

Rice area by season and land type. Based on Table 13, around 50% of the gross rice area is planted to aman rice and boro rice at submergence-prone and nonsaline sites. In Satkhira, 89% of the gross rice area at the saline site is planted to aman rice while a very small area is planted to boro rice. Salinity is relatively more severe during the boro season as there is not enough rainfall to flush out the salts in the soil. As a result, rice cultivation is constrained and only households with available irrigation sources are able to grow rice during the boro season. On the other hand, 60% of the gross rice area is planted during the aman season in Rajshahi while only 36% is planted during the boro season. Rice is mostly transplanted but a small area under broadcast rice is reported in Rajshahi.

Based on Table 14, modern rice varieties dominate the total rice area during the aman season in all districts. On average, MVs cover more than 90% of the total rice area of the selected households except in Kurigram, where MVs cover only about two-thirds of the total rice area during the aman season. In Kurigram, more than 35% of the total aman rice area is grown to Aloi, a traditional variety.

However, only a few farmers are growing traditional rice varieties and most are adopting high-yielding rice varieties such as MVs and hybrid rice during the boro season. In Kurigram, rice farmers grow MVs and TVs during aman and MVs and

Table 11. Share of rice in gross cropped area and cropping intensity index in selected areas in Bangladesh.

Area	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Gross cropped area							
Share of rice (%)	99	99	98	94	100	94	97
Share of nonrice (%)	1	1	2	6	0	6	3
Cropping intensity	179	193	193	163	104	173	168

Table 12. Types of rice grown by sample households (%) during aman and boro seasons.

Season and rice type	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Aman season							
MV only	92	87	37	96	100	98	81.9
TV only	1	3	9	0	0	0	2.6
Hybrid only	1	0	0	0	0	0	0.2
MV and TV	6	9	54	4	0	0	14.9
Hybrid and TV	0	0	0	0	0	2	0.2
MV and hybrid	0	1	0	0	0	0	0.2
Boro season							
MV only	93	81	74	100	89	56	83.2
TV only	0	0	0	0	0	2	0.2
Hybrid only	1	0	4	0	11	14	3.3
MV and TV	0	0	0	0	0	2	0.2
MV and hybrid	5	19	22	0	0	24	12.7
Hybrid and TV	0	0	0	0	0	2	0.2
Combination MV, TV, and hybrid	1	0	0	0	0	0	0.2

Table 13. Proportion of rice area (%) to gross rice area by season.

Season	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Aman	51	48	51	60	89	48	56
Boro	49	52	49	36	11	52	43
Aus	0	0	0	4	0	0	1

Table 14. Proportion (%) of rice area by type and season.

Season and type	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Aus							
MV	0	0	0	97	0	0	97
TV	0	0	0	3	0	0	3
Aman							
MV	95	95.7	65	98	100	98.2	93.5
TV	4	4.1	35	2	0	1.5	6.2
Hybrid	1	0.2	0	0	0	0.3	0.3
Boro							
MV	95.8	87	81	100	93	70	89.8
TV	0.4	0	0	0	0	2	0.3
Hybrid	3.8	13	19	0	7	28	9.9

hybrids only during the boro season. The cropping season plays an important role in farmers' decision on which type of rice to grow. During the boro season, farmers grow mostly MVs and hybrids because farms are irrigated and yields are expected to be relatively higher and more stable.

The type of rice varieties grown does not vary much across land types. Most lands are grown to MV rice. However, in the lowlands of Kurigram, more than 60% of the area is being planted to TVs (particularly Aloi) during the aman season. Farmers reported that Aloi has the ability to withstand submergence.

Area under modern rice varieties. To further describe the patterns of adoption, the generation of MVs was identified to determine the age of the rice varieties being adopted. For simplicity purposes, MVs are classified into two groups based on the year of release. "Old"-generation MVs are those varieties released before 1990 while "new"-generation MVs are those released in 1990 and subsequent years.

Table 15 summarizes the generation of MVs grown in selected districts in Bangladesh. Findings show a strong correlation between rice cropping season and the generation of MVs grown. During the aman season, rice farmers grow mostly old-generation MVs while the reverse is observed during the boro season. Interestingly, old rice varieties are widely adopted during the aman season despite the release of about 23 aman varieties after 1990. A recent study found that the major reason for the low MV replacement is the research system's inability to develop new varieties with grain quality that is superior to that of the existing varieties (Hossain et al 2006).

Major rice varieties. Among the modern rice varieties grown during the aman season, BR11 dominates in selected submergence-prone areas while Guti swarna and Swarna occupy more than 95% of the total MV rice area at selected drought-prone

Table 15. Percent of MV rice area by generation and season.

MV generation[a]	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Aman							
Old	94	92	98	96	90	83	93
New	6	8	2	4	10	17	7
Boro							
Old	1	12	12	5	0	1	7
New	99	88	88	95	100	99	93

[a]New-generation MVs occupy 59% of the area grown to MV rice during the aus season in Rajshahi.

sites. On the other hand, BR10, a very popular rice variety in the southern region, is the predominant variety in the saline-affected villages in Satkhira (Table 16). BR11 is an old-generation rice variety that has an average growth duration of 145 days and 115-cm plant height (Adhunik Dhaner Chas, BRRI 2007, as cited by Hossain et al 2009).

The major boro rice varieties cultivated in selected stress-prone districts are presented in Table 17. During the boro season, new-generation MVs dominate the rice areas in Bangladesh. Rice mega-varieties such as BRRI dhan28 and BRRI dhan29 are very popular, covering 91% of the total MV rice area of the sample farmers. The average growth duration of BRRI dhan28 and BRRI dhan 29 is 140 days and 165 days, respectively. The plant height of these boro rice varieties is 90 to 95 cm (Adhunik Dhaner Chas, BRRI 2007, as cited by Hossain et al 2009).

The crop duration of rice mega-varieties BR11 and BR28 is similar. However, plant height characteristics of these varieties are different. During the boro season, the mega-varieties adopted have relatively shorter plant height while taller varieties are grown during the aman season. This may imply that taller varieties are not needed during the boro season when the risk of submergence is very low.

Out of 71 modern rice varieties[5] released by the different institutions in Bangladesh, only 5 dominate during the boro and aman seasons. The major aman rice varieties, BR10, BR11, and Guti swarna, were released in 1980 while the popular boro rice varieties, BRRI dhan28 and BRRI dhan29, were released in 1994. This shows that rice varieties released 30 years ago are still being adopted and the adoption of old varieties is high during the aman season.

Yield effects by type and generation

Table 18 shows the yields of different types of rice during the aman and boro season. Generally, rice yields during the boro season are relatively higher than yields in the aman season. High yields can be attributed to the more favorable rice production

[5]As of 2010, 71 rice varieties were released in Bangladesh. This includes four hybrid rice varieties released by BRRI (Appendix 1).

Table 16. Percent of MV area under new- and old-generation rice varieties in the aman season.

Variety and type	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Old generation							
BR10	0	1	0	0	87	19	14
BR11	63	69	93	0	1	9	35
BR14	0	0	0	0	0	0	0
BR22	22	0	1	0	0	6	4
BR23	0	4	0	0	2	49	4
Guti swarna	0	0	0	88	0	0	27
Swarna	0	0	5	8	0	0	3
Pajam	9	17	0	0	0	0	6
Parijat	0	0	0	0	0	0	0
All	94	92	98	96	90	83	93
New generation							
BRRI dhan28	0	0	0	1	0	0	0
BRRI dhan29	0	0	0	0	0	0	0
BRRI dhan30	0	0	0	0	10	17	3
BRRI dhan32	0	0	0	1	0	0	1
BRRI dhan34	2	0	0	0	0	0	0
BRRI dhan39	0	0	0	2	0	0	1
BRRI dhan40	3	4	0	0	0	0	1
BRRI dhan41	0	2	2	0	0	0	1
BRRI dhan50	1	0	0	0	0	0	0
Others	0	2	0	1	0	0	1
All	6	8	2	4	10	17	7

Table 17. Percent of MV area under new- and old-generation rice varieties in the boro season.

Variety and type	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Old generation							
BR14	0	12	12	0	0	0	5
Others	1	0	0	5	0	1	2
All	1	12	12	5	0	1	7
New generation							
BRRI dhan28	8	37	75	88	0	93	52
BRRI dhan29	87	51	13	0	97	6	38
Others	4	0	0	6	3	0	3
All	99	88	88	95	100	99	93

Table 18. Average rice yield (t/ha) by type and season.[a]

Season and type	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Aman							
MV	3.55	2.22	2.83	3.50	4.00	3.33	3.11
	(1.10)	(1.50)	(1.40)	(0.50)	(1.00)	(1.00)	(1.30)
TV	3.57	1.69	1.15	2.58	–	4.98	1.53
	(0.90)	(1.30)	(0.60)	(0.80)		(0.60)	(1.10)
Hybrid	2.51	4.44	–	–	–	4.67	3.19
	(0.20)	n/a				n/a	(1.10)
All	3.54	2.20	2.26	3.48	4.00	3.38	2.96
	(1.10)	(1.50)	(1.40)	(0.50)	(1.00)	(1.10)	(1.40)
Boro							
MV	4.50	5.06	5.32	4.49	5.50	5.85	5.02
	(1.20)	(1.00)	(0.70)	(0.60)	(1.60)	(1.10)	(1.00)
TV	4.12	–	–	–	–	5.00	4.85
	n/a					(0.50)	(0.60)
Hybrid	4.90	6.29	6.39	–	4.97	6.47	6.24
	(1.20)	(0.80)	(0.70)		(0.80)	(2.20)	(1.40)
All	4.52	5.15	5.52	4.49	5.45	5.96	5.14
	(1.20)	(1.00)	(0.80)	(0.60)	(1.50)	(1.50)	(1.10)

[a]Standard deviation is given in parentheses. Not applicable or n/a is given when there is only one observation.

during the boro season, when most rice farms are irrigated. Farmers also reported that abiotic stress at the survey sites usually occurs during the aman season except in Satkhira, where salinity is highest during the boro season. In addition, some of the yield difference in aman and boro rice is due to the type of rice varieties adopted. During the boro season, 10% of the rice area is grown to hybrid rice, which has an average yield potential of 4.9 to 6.47 t/ha.

At most submergence sites, yields are more stable during the boro season relative to yields in the aman season while yield variation in Satkhira is higher, especially during the boro season. The high yield at saline sites during the boro season may imply farmers' active selection of areas that are not affected by salinity. Farmers may have planted boro rice only in areas where there is no or minimal salt water intrusion as only 11% of the gross rice area of sample farmers is planted during the boro season. This implies that the effect of salinity is not just a decrease in yield but also a substantial reduction in area during the boro season.

Rice yields by generation of MV are shown in Table 19. Yield differences between old- and new-generation MVs may be attributed to the varietal differences and to other factors such as farmers' practice, land characteristics, and climatic factors. In selected submergence-prone and salinity areas, mean yields for new and old MVs are

Table 19. Rice yield (t/ha) of MVs by generation and season.[a]

Season and generation	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Aman							
Old	3.55	2.15	2.81	3.51	4.02	3.41	3.09
	(1.1)	(1.5)	(1.3)	(0.5)	(1.0)	(1.0)	(1.3)
New	3.66	3.23	3.47	3.13	3.83	2.94	3.33
	(1.1)	(1.4)	(2.0)	(0.4)	(0.9)	(1.1)	(1.2)
Difference	0.11	1.08	0.66	–0.38***	–0.19	–0.47	0.24
Boro							
Old	5.17	4.99	5.71	4.13	–	5.71	5.15
	(1.8)	(1.0)	(0.5)	(0.4)		n/a	(0.9)
New	4.49	5.07	5.27	4.51	5.50	5.85	5.00
	(1.2)	(1.0)	(0.7)	(0.6)	(1.6)	(1.1)	(1.1)
Difference	–0.68	0.08	–0.44	0.38**	5.50	0.14	–0.15

[a]Standard deviation is given in parentheses. Not applicable or n/a is given when there is only one observation. *** and ** indicate statistical significance at the 1% and 5% levels, respectively. Test of means corrected for the dependence of errors within a season.

not statistically different for both seasons. On the other hand, old MVs in Rajshahi outperform new-generation MVs by 12% during the aman season while new MVs yield 9% higher than old MVs during the boro season.

During the aman season, a majority of the sample farmers in Rajshahi adopt old-generation MVs that yield more than new-generation MVs while, during the boro season, most sample farmers grow new-generation MVs that outperform old-generation MVs. This may imply that the new-generation MVs adopted in the aman season are inferior to the old mega-varieties such as Guti swarna.

Reasons for growing the dominant rice varieties

The dominant rice varieties are BR10, BR11, and Guti swarna during the aman season and BRRI dhan28 and BRRI dhan29 are the major rice varieties grown in the boro season. Farmers prefer these varieties for various reasons. Table 20 presents the characteristics farmers like about these rice varieties.

Table 20. Characteristics that farmers liked about their rice varieties.[a]

Season and characteristics	Submergence			Drought	Salinity
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira
	(% of households)				
Aman					
Dominant rice variety	BR11	BR11	BR11	Guti swarna	BR10
Desirable characteristics					
High yield	59	63	68	84	77
Does not lodge	3	0	4	0	0
Pest-tolerant	1	0	0	8	4
Good taste	0	13	4	9	84
Good grain	43	15	1	20	46
High market price	1	0	31	24	44
Others	3	33	5	50	11
Boro					
Dominant rice variety	BRRI dhan28 and 29				
Desirable characteristics					
High yield	72	72	24	35	83
Does not lodge	1	0	1	3	2
Pest-tolerant	14	3	2	0	3
Good taste	17	60	22	64	78
Good grain	23	65	18	34	44
High market price	5	25	71	63	54
Others	54	22	59	43	19

[a]Households were allowed to provide multiple answers. Each value represents the percentage of households reporting each characteristic.

Results show that high yield, good grain quality, and high market price are the characteristics most farmers like about BR11 and Guti swarna. In Satkhira, 84% of the farmers indicated good taste as a desirable characteristic of BR10, a dominant aman rice variety. Similarly, farmers reported the same qualities they like about the major boro rice varieties, BRRI dhan28 and 29.

Adoption of new-generation MVs

Based on the survey, MV coverage is at least 90% of the total rice area for all seasons. The pattern of MV adoption shows that rice varieties released before 1990 dominate the MV rice area in the aman season while new-generation MVs dominate the total MV area in the boro season. Moreover, mega-varieties dominate each cropping season, with BR11, BR10, and Guti swarna during the aman season and BRRI dhan28 and BRRI dhan29 during the boro season.[6]

The dominance of BR11 and BR10 during the aman season shows that rice varieties released 30 years ago are still being grown. Table 21 presents the popular aman and boro varieties from large-scale national sample surveys in 1979-81, 1990, 1995-96-1996-97, and 2000 as cited by Hossain et al (2006). Based on a survey in

[6]In analyzing technology adoption, two parametric models, probit and tobit, dominate the practice. However, the skewness of data on MV adoption in Bangladesh did not allow us to use such analysis. Instead, previous studies on varietal adoption patterns were reviewed.

Table 21. Popular boro and aman varieties from previous surveys.[a]

Survey years	Institution (source)	Popular rice varieties	
		Aman	Boro
1979-81	International Fertilizer Development Corporation	Pajam IR20	IR8 Purbachi
		BR1	BR1
		BR3	BR3
1990	Agricultural Economics Division, BRRI	BR11 (64%)	Purbachi (21%)
		Pajam (15%)	BR3 (19%)
		BR4 (8%)	IR8 (12%)
1995-96, 1996-97	Department of Agricultural Extension, BRRI	BR11 (52%) Pajam (10%)	BR14 (24%) BR3 (19%)
		BR10 (10%)	BR1 (9%)
		BR23 (5%)	
2000	IRRI and Bangladesh Institute of Development Studies	BR11 (42%) Swarna (23%)	BRRI dhan28 (11%) BR14 (11%)
		Pajam (13%)	BRRI dhan29 (9%)
			BR1 (7%)
			BR8 (6%)

[a]Estimates were based on a large sample survey as cited by Hossain et al (2006).

early 1970, the popular aman rice varieties were Pajam and IR20. In a 1990 survey, results showed that BR11 accounted for more than 60% of the total MV area, which may have indicated that some areas cultivated under Pajam and IR20 were replaced by this mega-variety, which has remained popular. Indian varieties such as Swarna and Guti swarna are the second most popular aman varieties in Bangladesh. Swarna was released in 1982 and was reported to enter Bangladesh through informal channels.

Prior to the release of BRRI dhan28 and BRRI dhan29, the popular boro rice varieties based on estimates from large sample surveys were IR8, Purbachi, BR1, and BR14. Among the popular boro varieties, BR3 remained the variety with the highest yield potential until the release of BRRI dhan29. The yield potential of the varieties released by BRRI is given in Appendix 1. Because of their high-yield characteristic, BRRI dhan28 and 29 gained popularity among farmers during the boro season. Based on an IRRI-BIDS survey in 2000, the coverage of BRRI dhan28 and BRRI dhan29 reached 20% of the total MV area in the boro season, whereas, in the 2008 survey, these boro rice varieties occupied 90% of the total MV area during the boro season in selected stress-prone areas.

The number of rice varieties released has been increasing in the past five decades. In fact, almost 60% of the rice varieties were released after 1990 (Table 22). Despite the continued production of improved rice varieties in Bangladesh, farmers still grow old varieties, especially during the aman season.

BR11 is still the mega-variety during the aman season even with the release of more than 40 varieties after 1990 (Table 23), of which 50% were aman varieties. The slow varietal replacement, especially during the aman season, is because none of the new-generation aman varieties has exceeded the 6.5 t/ha yield potential of BR11. This is also supported by the results in Table 19, which show that the difference in mean yields between old- and new-generation MVs are not statistically significant in the aman season.

According to Hossain et al (2006), Bangladeshi farmers replace MVs if the new ones are of shorter maturity and the yield surpasses that of the existing ones. Farmers prefer short-duration varieties, especially during the boro season, when there is not enough rainfall and supplemental irrigation is required. In addition, early-maturing rice varieties allow farmers to harvest early and cultivate a third crop.

A significant contribution in varietal development for the aman season was made in 2010 when the National Seed Board of the Ministry of Agriculture officially released the submergence-tolerant mega-varieties BRRI dhan51 (Swarna-Sub1) and BRRI dhan52 (BR11-Sub1). These Sub1 varieties are expected to replace the old aman varieties in subsequent years, especially in submergence-prone areas.

Economics of MV production

Seeds and chemical fertilizer use are presented in Table 24. Seed use per unit area does not vary by season but across locations. Farmers in selected submergence-prone areas use a relatively lower seed rate than sample farmers in selected drought-prone and salinity-affected areas. Farmers use low seed rates as a management option in

Table 22. Number of improved rice varieties released from 1960 to 2010.

Period	No. of varieties	Percentage
1960-69	5	7
1970-79	9	13
1980-89	15	21
1990-99	20	28
2000-10	22	31
Total	71	100

Data source: BRRI (2010).

Table 23. Number of varieties released by target season.

Season	No. of varieties	Percentage
Before 1990		
Aman	9	30
Aus	2	7
Boro[a]	19	63
Total	30	100
After 1990		
Aman	23	56
Aus	6	15
Boro	12	29
Total	41	100

[a]Twelve boro varieties can also be grown in the aus season.
Data source: BRRI (2010).

Table 24. Input use in MV rice production.

Inputs	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Aman							
Seeds (kg/ha)	43	58	51	67	65	64	57
Fertilizer (kg/ha)							
N	58	57	109	78	76	94	75
P	3	1	4	9	8	15	6
K	0.2	2	17	15	17	28	11
Labor[a] (person-days/ha)	128	95	129	93	131	183	121
Boro							
Seeds (kg/ha)	42	61	46	68	61	60	55
Fertilizer (kg/ha)							
N	69	112	151	82	115	176	110
P	9	12	5	11	14	26	11
K	0.6	17	21	17	23	43	17
Labor[a] (person-days/ha)	133	130	172	102	155	209	143

[a]Labor use reported excludes hired labor under contract.

submergence-prone areas because high seed rates could result in thinner and weaker seedlings that are more prone to early flood damage (Ismail 2009).

Farmers use various chemical fertilizers such as urea, DAP, TSP, and MP. Moreover, farmers also apply micronutrients such as gypsum and zinc. In general, fertilizer rate and labor use during the boro season are higher than in the aman season. According to the results, N-fertilizer use is higher by an average of 35 kg/ha. The fertilizer rate for P and K is also higher by 5 kg/ha and 6 kg/ha, respectively, during the boro season. The average fertilizer use reported by the sample is more or less comparable to the fertilizer use cited by Gregory et al (2010). The mean fertilizer rates in 2007 were 103 kg/ha for N, 15 kg/ha for P_2O_5 (6.5 kg/ha P), and 12 kg/ha for K_2O (10 kg/ha K).

Aside from higher fertilizer rates during the boro season, labor use is also higher. On average, boro rice cultivation uses an additional 22 person-days/ha. The additional labor is used for activities such as weeding, irrigating crops, harvesting, and postharvest during the boro season (Tables 25 and 26).

Appendices 2 and 3 show the input use by generation of MVs during aman and boro seasons, respectively. Based on the results, the average input use between old- and new-generation MVs did not vary much in each season.

Costs and returns analysis of rice production using modern varieties

Rice production is the main source of livelihood in selected stress-prone districts. Table 27 presents the costs and returns of MV rice production in boro and aman seasons. Most farms are transplanted but there are cases (less than 1%) of direct seeding reported in Rajshahi.

Labor costs comprise 30% to 73% of the total costs while power cost is 5% to 13% of the total costs (Appendix 4). Aside from land rent, fertilizer and irrigation costs comprise the bulk of material input costs during the boro season while fertilizer and seeds make up most of material input costs during the aman season. Imputed costs from own inputs and family labor account for 9% to 30% of the total cost of production.

Net returns (above cash costs) from MV rice production vary by season and across sites. In general, net returns from rice production during the boro season are significantly higher than in the aman season. This is often attributed to the more favorable climate during the boro season. The variations in net income across sites could also be explained by various factors such as crop management practices of farmers, severity of stress, land characteristics, and others.

Around 6% of the rice area during the aman season is planted to traditional rice varieties. The net returns (above cash costs) from traditional rice varieties average $100/ha during the aman season, whereas returns from MV production are $100/ha more. Table 27 shows the costs and returns of MV rice production. In representative submergence areas, sample households receive average net returns of $250/ha during aman and $600 during the boro season from rice production. On the other hand, sample households receive around $150/ha from aman rice cultivation and $300/ha from boro rice cultivation in selected drought-prone areas of Rajshahi. In saline-affected areas in

Table 25. Labor use (person-days/ha) in MV rice production during the aman season, 2008.

Inputs	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Seedbed preparation	11	0	12	0	10	15	7
Land preparation	24	9	12	9	10	14	13
Crop establishment	14	30	28	30	32	35	27
Fertilizer application	8	3	9	3	6	8	6
Herbicide application	0	0	0	0	0	0	0
Insecticide application	0	1	0	1	5	6	2
Application of organic fertilizers	0	1	0	4	0	0	1
Irrigation	4	0	0	1	1	1	1.3
Weeding	14	9	33	28	53	59	28.0
Harvesting, carrying, and threshing	32	23	21	8	2	31	21.0
Postharvest	22	19	0	0	0	0	8
Others[a]	0	0	13	10	12	14	8
Total	128	95	127	94	131	182	121

[a]Others includes drying and storing.

Table 26. Labor use (person-days/ha) in MV rice production during the boro season, 2008.[a]

Inputs	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Seedbed preparation	11	0	12	0	12	15	7
Land preparation	24	10	11	9	11	15	14
Crop establishment	14	32	30	31	36	40	28
Fertilizer application	9	3	13	2	6	9	7
Herbicide application	0	2	0	1	0	0	1
Insecticide application	0	2	0	2	5	7	2
Application of organic fertilizers	0	5	0	5	0	0	2
Irrigation	6	6	18	3	8	11	9
Weeding	14	19	39	28	62	65	30
Harvesting, carrying, and threshing	32	30	29	8	2	35	26
Postharvest	24	21	20	13	13	14	19
Total	133	130	172	102	156	209	143

[a]Labor use reported excludes hired labor under contract. Contract labor is common in Jamalpur and Rajshahi, especially in land preparation, crop establishment, harvesting, and threshing. Low labor use in harvesting activities in Rajshahi is due to contract labor. Seedbed preparation is included in land preparation in Jamalpur and Rajshahi.

Table 27. Costs and returns (in US$/ha) from MV production during aman and boro seasons.[a]

Items	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Aman season							
Total returns	899	504	766	889	881	835	790
Costs							
Total material input cost	448	99	234	371	283	304	297
Total labor cost	273	382	226	381	327	317	322
Total power cost	73	46	69	87	58	57	67
Total cash cost	605	391	432	730	586	564	558
Total noncash cost	189	140	97	109	82	114	128
Total costs	794	531	529	839	668	678	686
Returns above total costs	105	- 27	237	50	213	157	104
Returns above cash costs	294	113	334	159	295	271	232
Boro season							
Total returns	1,107	1,391	1,324	1,242	1,661	1,861	1,339
Costs							
Total material input cost	582	348	363	512	482	722	478
Total labor cost	284	500	303	438	419	351	379
Total power cost	74	75	69	86	59	60	73
Total cash cost	739	749	511	912	872	1,002	758
Total non-cash cost	201	174	223	124	87	130	172
Total costs	940	923	734	1,036	959	1,133	930
Returns above total costs	167	468	590	206	702	729	409
Returns above cash costs	368	642	813	330	789	859	581

[a]Material inputs include land rent.

Satkhira, sample farmers grow only modern rice varieties and profits are around $300/ha from aman rice and $850/ha in the boro season. The profitability of rice production during the boro season is not representative of the saline-affected areas in Satkhira. Rice cultivation is limited in the boro season because of high salinity and only farmers with access to irrigation are able to plant. In fact, only 11% of the sample rice area is grown to boro rice at salinity-affected sites.

Table 28 presents the costs and returns by dominant MVs during the aman season. Most rice areas are grown to MVs, particularly old-generation MVs such as BR11, BR10, and Guti swarna. Generally, farmers planting these dominant rice varieties obtain higher gross returns than those farmers growing other MVs. On average, farmers growing BR11, BR10, or Guti swarna during the aman season could get additional net income of around $50/ha.

On the other hand, the dominant rice varieties grown are mostly new-generation MVs such as BRRI dhan28 and BRRI dhan29 during the boro season. Table 29 shows the costs and returns for the dominant boro rice varieties and other MVs. Cultivation of dominant MVs such as BRRI dhan28 and BRRI dhan29 during the boro season gives an additional $40/ha compared with other MVs during the boro season. However, the difference in mean profitability between old- and new-generation MVs is not statistically significant except in salinity-affected areas during the aman season and in Kurigram in the boro season.

Crop production and disposal

Most households interviewed sell a portion of their rice ouput in the market. In selected submergence-prone areas, households sell more than 50% of their rice production in the market while 31–43% is used for home consumption (Table 30). In selected drought-prone areas, 32% of the households sell rice in the market while the other 32% is used as payments. Note that most households in Rajshahi are landless farmers and about 73% of the lands are rented-in or sharecropped. A percentage of rice output is usually used as land rent payment.

In saline-prone areas, households allocate as much as 65% for food and only 17% for selling. Also, households allocate around 15% as payments while only 17–20% is sold in the market. Because most farmers in selected saline areas cannot grow rice during the boro season, farmers allocate a substantial portion of the harvest for home consumption.

Different sources of income

Aside from crop production, households derive income from various activities. Table 31 summarizes the different sources of income of households in selected districts. At selected sites, 48–75% of the household income comes from rice production. The fairly large share of income coming from rice production highlights the importance of rice farming in the households' livelihood. This suggests that any shock in rice produc-

Table 28. Costs and returns (in US$/ha) from dominant MV rice production during the aman season.[a]

Items	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
BR11, BR10, and Guti swarna							
Total returns	928	559	752	889	874	850	814
Costs							
Total material input cost	459	109	236	373	277	288	307
Total labor cost	271	386	225	382	328	327	322
Total power cost	73	47	69	85	57	56	69
Total cash cost	611	404	433	730	577	556	571
Total noncash cost	192	144	98	110	84	115	127
Total costs	803	548	530	841	661	671	698
Returns above total costs	125	11	221	49	213	179	116
Returns above cash costs	317	155	319	159	297	294	243
Other MVs							
Total returns	821	410	1,197	898	943	830	712
Costs							
Total material input cost	419	82	178	295	338	309	264
Total labor cost	278	375	237	353	326	314	324
Total power cost	74	44	58	139	67	58	60
Total cash cost	591	368	397	711	668	566	517
Total noncash cost	180	132	76	77	63	114	132
Total costs	771	500	473	788	731	680	649
Returns above total costs	50	–90	724	110	212	150	63
Returns above cash costs	230	42	800	187	275	264	195

[a]Material inputs include land rent.

Table 29. Costs and returns (in US$/ha) from dominant MV rice production during boro season.[a]

Items	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
BRRI dhan28 and 29							
Total returns	1,110	1,422	1,315	1,241	1,677	1,861	1,345
Costs							
Total material input cost	585	344	365	507	485	722	484
Total labor cost	286	505	302	443	422	351	378
Total power cost	74	74	69	85	60	60	73
Total cash cost	742	744	514	910	880	1,002	762
Total noncash cost	203	178	222	124	87	130	173
Total costs	945	922	736	1,034	967	1,133	935
Returns above total costs	165	500	579	207	710	729	410
Returns above cash costs	368	677	802	331	797	859	583
Other MVs							
Total returns	976	1,238	1,399	1,245	1,289		1,268
Costs							
Total material input cost	454	370	341	556	397		411
Total labor cost	206	475	313	393	356		396
Total power cost	66	79	72	98	33		79
Total cash cost	605	770	493	922	685		722
Total noncash cost	120	154	234	124	100		164
Total costs	725	924	727	1,046	785		886
Returns above total costs	251	314	672	199	504		382
Returns above cash costs	371	468	906	323	604		546

[a]Material inputs include land rent.

Table 30. Rice output and disposal.

Rice disposal	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Households selling rice (%)	73	94	94	87	58	72	83
Uses (% of households)							
Food	40	31	43	32	65	62	40
Sold	53	63	55	34	17	20	45
Seed	1	1	1	1	1	1	1
Feeds	0	0	0	0	0	1	0
Payment	3	4	0	32	15	16	13
Other uses	3	1	1	1	2	0	1

tion will have a great impact on these poor households. Aside from rice production, a small percentage of income is also derived from the cultivation of nonrice crops.

Other sources of income include nonfarm activities such as salaried jobs, small-scale industries, transport operations, remittance, and other labor services. On average, a third of the household's total income comes from nonfarm activities. In submergence-prone and salinity-affected areas, at least 20% of the total household income comes from nonfarm income while only 7% of the income comes from nonfarm activities in selected drought-prone areas. A bulk of income (93%) comes from farming and agriculture-related activities such as animals and sales of by-products, sale of fruits, forest products, and aquaculture.

On average, gross earnings per capita among selected households range from \$300 to \$480 per year or around \$1 per day per capita. Because of limited income, some households rely on borrowing to pay for daily expenditures. More than 50% of the households in Jamalpur, Kurigram, and Satkhira borrow cash and/or noncash from various sources (Table 32). On the other hand, only 23–30% of the households borrow in Rajshahi and Habiganj. In terms of the amount borrowed, sample households in Satkhira have the highest borrowing, averaging about \$350 and \$550 at saline-affected sites and in control villages, respectively.

Household coping strategies

Households exposed to abiotic stresses make necessary adjustments to cope with stress. Adjustments vary by households depending on the options available to them. Poor households with limited assets are seen as the most vulnerable group in the event of submergence or drought. Most adjustments reported in the survey are ex post coping mechanisms that include a decrease in food consumption and an increase in borrowings.

Rice sufficiency. Most households at the study sites keep a portion of rice harvest for home consumption. Table 33 shows the rice sufficiency of households during

Table 31. Share of different sources of income (in US$).[a]

Income sources	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Farm income							
Crop production							
Rice	51	67	48	75	66	61	62
Nonrice crops	2	1	2	7	0	5	3
Other farm income	1	1	0	6	10	2	3
Sale of animals and by-products	2	4	2	5	2	3	3
Aquaculture fish production	2	4	2	0	3	1	2
Fruits and forest products	6	0	1	0	0	0	2
Farm income	65	78	55	93	80	71	75
Nonfarm income							
Business	15	8	27	3	10	23	13
Labor	2	1	6	3	0	0	2
Remittance	9	0	5	0	7	2	3
Assets	2	0	0	0	0	0	0
Salary	5	13	7	1	3	3	6
Pension	0	0	0	0	0	0	0
Others	2	0	0	0	1	1	1
Nonfarm income	35	22	45	7	20	29	25
Total income							
(in $/hh)	2,288	2,321	1,382	2,230	1,568	1,762	1,977
Income per capita ($/capita)	396	479	360	408	296	380	397
Income per capita per day	1.09	1.31	0.99	1.12	0.81	1.04	1.09

[a]Exchange rate used is US$1 = Tk 68.

Table 32. Household borrowing in selected districts.

Borrowing	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
No. of households	100	100	100	100	50	50	500
% of households that borrowed	23	61	56	30	64	76	48
Average amount borrowed (in US$)	87	162	141	69	353	549	182

Table 33. Rice sufficiency of households (%).

Rice sufficiency (months)	Submergence			Drought	All
	Habiganj	Jamalpur	Kurigram	Rajshahi	
Normal year					
0 to 3	0	1	0	8	2
4 to 6	1	4	0	10	4
7 to 9	1	5	4	4	4
10	2	4	7	6	5
11	8	0	0	1	2
12	88	86	89	71	83
Stress year					
0 to 3	1	3	1	24	7
4 to 6	1	16	17	20	14
7 to 9	21	25	32	25	26
10	38	9	21	5	18
11	20	1	0	0	5
12	19	46	29	25	30

normal and stress years. During a normal year, more than 85% of the households are rice-sufficient for 12 months at selected submergence-prone sites. However, during a stress year, the percentage of households that are rice sufficient throughout the year declines to 30% on average as more than 40% of the households become rice-sufficient for only less than 10 months.

Similarly, 71% of the households in selected drought-prone areas in Rajshahi are rice-sufficient for 12 months during a normal year. In the event of stress, the percentage drops to as low as 25% and 69% of the households become rice-sufficient only for less than 10 months. More than 20% of the households reported rice-sufficiency for less than 4 months.

The decrease in rice supply among households during stress years has an effect on the frequency of meals eaten by the households per day. Table 34 shows the frequency of meal consumption of households during normal and stress years. Some 7% to 65% of the households reported a decrease in the frequency of meal intake per day from 3 to 2.

Moreover, sample households also reported reductions in the quantity of food eaten per meal. In submergence-prone areas, 38% to 64% of the sample households reported reductions in food intake per meal. Similarly, 40% of the sample households at drought sites claimed reductions in food quantity intake. During stress years, households may opt to decrease food consumption by skipping meals and/or eating less in order to prolong the household's food supply. This kind of coping strategy or adjustment may cause an adverse effect on health and nutrition of the households.

Consumption patterns. The consumption patterns of households between normal and stress years are given in Table 35. Based on the results, the percentage of households consuming rice on a regular basis did not change much between normal and stress years while a notable decline in the percentage of households consuming fish and pulses on a regular basis was observed during stress years. A slight change in vegetable consumption can be depicted from Table 35. Normally, most households consume a wide variety of food on a daily basis. However, during stress years, the variety of food consumed becomes limited in some households.

Changes in borrowing. Borrowing, in the form of cash or kind, plays an important role in meeting households' consumption deficit. Households borrow cash from formal and informal institutions such as relatives or other social networks. On average, 82% of the sample households in submergence-prone areas reported an increase in cash borrowing during stress years (Table 36). Households also borrow in the form of kind. Households reported an increase in food borrowing during stress years in some submergence-prone areas while food borrowing of most households in the sample in drought-prone areas remained unchanged. An increase in cash borrowing was reported by only 34% of the sample households in Rajshahi during drought years. In addition, a deferred loan payment was reported by some households at the study sites. In Jamalpur, 74% of the households claimed to postpone their loan payments during stress years.

Table 34. Number of meals eaten per day by households.

No. of meals	Submergence						Drought		All	
	Habiganj		Jamalpur		Kurigram		Rajshahi			
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
1	0	2	0	0	0	0	0	0	0	1
2	0	65	5	23	0	7	0	21	1	29
3	98	33	95	77	99	92	100	79	98	70
4	2	0	0	0	1	1	0	0	1	0

Table 35. Daily consumption (% of households) of major food items.

Food item	Submergence						Drought		All	
	Habiganj		Jamalpur		Kurigram		Rajshahi			
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
Fish	86	45	80	42	96	3	14	8	69	25
Fruits	6	2	15	6	0	0	10	9	8	4
Maize	0	0	0	0	0	0	1	3	0.3	1
Meat	7	1	3	0	3	0	4	3	4	1
Milk	10	0	20	7	6	0	12	6	12	3
Pulses	95	77	41	21	91	5	39	30	67	33
Rice	97	100	100	100	99	98	98	92	99	98
Vegetables	96	81	100	100	97	94	87	73	95	87
Wheat	11	5	8	7	1	0	11	12	8	6

Table 36. Other adjustments in borrowing made by farmers to cope with submergence and drought.

Adjustments (% of households)	Submergence			Drought	All
	Habiganj	Jamalpur	Kurigram	Rajshahi	
Change in cash borrowing					
Decreased	0	0	0	17	3
Increased	80	84	82	34	74
No change	20	16	18	49	23
Change in food borrowing					
Decreased	0	3	0	4	3
Increased	100	26	100	7	25
No change	0	71	0	89	72
Deferred loan payment					
No	60	26	98	86	67
Yes	40	74	2	14	33

The incidence of borrowing in the form of cash is high during stress years. Farmers borrow money to meet immediate consumption needs of the household and to purchase inputs for crop production. Reliance on borrowing through banks and informal money lenders during stress years creates the need for a well-developed credit market in these areas.

Aside from borrowing, households reported the use of savings during stress years. Households set aside a portion of income to be used for future needs. The use of savings was reported by 64% to 84% of the sample households in submergence-prone areas and by 31% of the sample households in drought-prone areas. Other adjustments made by households include consuming seed reserves (21%) and selling of assets (31%).

Other adjustments. Farmers interviewed during the FGDs reported decreasing the area devoted to rice production by 20–30% during stress years. The method of establishment has not changed but transplanting is usually delayed when stress occurs. A common practice in submergence-prone areas is replanting, wherein farmers replant using seedlings from other fields when submergence damages the farm. In addition, farming households store extra seeds in anticipation of flood damage. Farmers also reported a decrease in labor use, particularly in weeding, as weed infestation is less after submergence. On the other hand, farmers in Rajshahi reported transplanting delays in the event of early drought, which affects the cultivation of rabi crops. In addition, farmers in drought-prone areas reported an increase in labor use for weeding in the event of drought.

Awareness of stress-tolerant varieties

Sample households were asked about their awareness of the stress-tolerant rice varieties. Some households in Habiganj (47%) and Kurigram (40%) are aware of the stress-tolerant rice varieties or Sub1 varieties while most sample households in Jamalpur and Rajshahi have not heard about these varieties. Although some farmers are aware of these varieties, more than 95% have not planted them but a majority of the farmers reported that they were willing to grow these varieties (Table 37).

Gender division of responsibilities and decision-making

Women make up 45% of the total household members of the sample farmers. Men and women are involved in different farm and nonfarm activities. According to Table 38, 81% of the total labor in rice production is done by men while the labor participation of women accounts for only 19% as most are involved in homestead activities. Women engaged in rice production take responsibility in activities such as weeding, threshing, storing, drying, and postharvest.

Women's roles in decision-making also vary depending on the type of decision that has to be made. Table 39 presents the degree of participation of men and women in various decision-making related to farm and nonfarm activities. According to the results, men dominate in decision-making pertaining to farming activities such as what varieties to grow, adoption of new technology, hiring labor, and selling of harvested crops. Other decision-making with regard to slaughtering of animals, allocation of income, food consumption, borrowing, children's education, number of children to raise, and politics is done in consultation with women. Women's participation in decision-making is highest in decisions regarding the type of food to consume during a crisis and the allocation of household income.

An index is computed to measure the level of empowerment among women in decision-making related to both farm and nonfarm activities. Overall, the Women's Empowerment Index (WEI) of the sample households is 2.13, which indicates a low

Table 37. Farmers' awareness (% of households) of stress-tolerant varieties.

Awareness	Submergence			Drought	All
	Habiganj	Jamalpur	Kurigram	Rajshahi	
Heard about stress-tolerant varieties					
Yes	47	1	40	5	23
No	53	99	60	95	77
Planted stress-tolerant varieties					
Yes	0	0	4	3	2
No	100	100	96	97	98
Willing to plant stress-tolerant varieties					
Yes	97	100	99	92	97
No	3	0	1	8	3

Table 38. Labor participation (person-days/ha) in rice production.[a]

Labor	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Aman season							
Total labor	129	95	125	93	131	182	121
% Male labor	85	86	70	71	88	89	81
% Female labor	15	14	30	29	12	11	19
Hired labor	51	48	79	61	92	124	69
% Male labor	93	100	68	67	87	90	82
% Female labor	7	0	32	33	13	10	18
Family labor	78	48	46	33	39	57	51
% Male labor	80	73	73	79	89	87	79
% Female labor	20	27	27	21	11	13	21
Boro season							
Total labor	134	130	172	102	156	209	146
% Male labor	85	88	71	72	88	86	80
% Female labor	15	12	29	28	12	14	20
Hired labor	51	69	97	64	103	140	81
% Male labor	92	99	68	67	87	85	82
% Female labor	8	1	32	33	13	15	18
Family labor	82	61	75	38	53	69	65
% Male labor	80	75	74	82	90	89	79
% Female labor	20	25	26	18	10	11	21

[a]Labor use reported excludes labor hired under contract.

empowerment among women. This implies that most decisions are made in consultation with women members of the household but the participation of men in decision-making dominates that of women.

Summary of the findings

- Farming is the primary occupation among adult members of the households. The proportion of employed adults engaged in farming activities ranges from 61% in Habiganj to 95% in Kurigram. This may indicate that households in Kurigram have more limited alternative sources of income as most households rely on farming activities.
- Cropping intensity is lowest in saline areas (104%) and highest in submergence-prone areas in Kurigram and Jamalpur (193%) while the CI of drought-prone areas in Rajshahi is intermediate (163%).

Table 39. Division of responsibilities, decision-making (%), and Women's Empowerment Index.

Decisions	Husband only	Wife only	Both			WEI
			Husband more influential	Wife more influential	Both equally influential	
What rice variety(ies) to grow	67	1	4	0	28	1.64
Who and number of farm laborers to hire	71	1	3	1	25	1.59
Whether to sell or consume the harvested crop	66	1	3	1	29	1.68
How much output to sell and consume	60	2	5	1	33	1.81
When and where to sell the harvested crop	64	1	5	0	31	1.70
What price to sell the output at	75	2	5	1	16	1.48
What farm implements to purchase	65	1	4	0	30	1.68
Whether to slaughter and sell animals	45	9	5	1	40	2.24
Adoption of technology in rice production	69	1	5	0	24	1.58
Allocation of farm income	41	2	8	1	48	2.15
Allocation of household income	20	13	9	1	57	2.78
What types of food to consume in times of crisis	15	32	5	2	46	3.31
Children's education	13	3	14	2	68	2.68
Where to borrow	24	1	15	1	59	2.40
Participation in voting/politics	14	1	13	1	71	2.62
Number of children to raise	9	1	14	4	72	2.74
Overall						2.13

- Salinity is a problem during the boro (dry) season, which may explain the low cropping intensity in Satkhira (coastal belt).
- The type of rice varieties grown does not vary much across land types. Most lands, regardless of the type, are grown to MV rice. However, in the lowlands of Kurigram (submergence site), more than 60% of the area is being planted to TVs that are perceived to have some tolerance of submergence conditions during the aman season.
- MV adoption is very high at all the sites. During aman, the highest adoption of MVs (100%) was found at the saline-prone site in Satkhira and the lowest in submergence-prone areas in Kurigram (65%). The relatively low adoption at the Kurigram site is due to high submergence. Available MVs are not able to tolerate long duration and high depth of submergence situations.
- Hybrid rice is found in selected submergence-prone and saline areas during the dry season but not in the Rajshahi area (drought-prone).
- Adoption of newer generation MVs is low during the aman season and high during the boro season. The predominance of old varieties released during the 1980s such as BR11 and Swarna in submergence- and drought-prone areas and BR10 in salinity-prone areas indicates that rice varieties released 30 years ago are still being adopted during the aman season. The high adoption of old aman varieties such as BR11 is because no new variety has surpassed its yield potential.
- The introduction of the Sub1 version of the mega-varieties is expected to trigger varietal replacement in submergence areas during the aman season. This is because these improved Sub1 varieties retain the characteristics of the old-generation mega-variety with improved tolerance of submergence risk.
- On average, the yield of new-generation MVs and old-generation MVs is not statistically different (except in Rajshahi), which may explain the slow varietal replacement in Bangladesh. In addition, the cultivation of old- and new-generation MVs is equally profitable on average.
- The effect of salinity is not just a decrease in yield but also a reduction in area. During the boro season, when salinity is higher, the effect on area is greater than the effect on yield.
- MV rice production is more profitable than using traditional varieties at all the sites even after taking into account family-owned resources (noncash costs). However, the incremental net returns from shifting between old- and new-generation MVs are not statistically significant.
- In general, net returns from rice during the boro season are higher than those of the aman season. This is often attributed to favorable climatic conditions, less stress effect, and better crop management and irrigation availability during the boro season.
- Households in stress-prone areas strongly depend on rice production. The share of rice income in total household income ranges from 48% (Kurigram) to 75% (Rajshahi) in Bangladesh. Nonfarm income is lowest in Rajshahi (7%) and highest in Kurigram (45%).

- Households exposed to abiotic stresses make necessary adjustments to cope with these stresses. Adjustments vary by households depending on the options available to them. Poor households with limited assets are seen as the most vulnerable group in the event of submergence or drought situations. Most adjustments reported in the survey are ex post coping mechanisms, which include a decrease in food consumption and an increase in borrowings.
- More than 80% of the households are rice self-sufficient for a year during normal years. However, the percentage of rice-sufficient households declines drastically during stress years in all areas in Bangladesh. The decrease in rice supply among households during stress years has an effect on the frequency of meals eaten by the households per day.
- At least 40% of the sample households from Kurigram and Habiganj are aware of stress-tolerant varieties. This may be due to PVS and testing of Sub1 varieties at these sites. However, many farmers have not yet planted these stress-tolerant rice varieties.
- Male labor participation in rice farming dominates female participation. The labor participation of women is around 19% of the total labor. Women who are engaged in field work are involved in activities such as weeding, threshing, drying, storing, and other postharvest activities.
- Men dominate in decision-making pertaining to what varieties to grow, adoption of new technology, hiring labor, and selling of harvested crops. Women's participation is reported in decision-making regarding the type of food to consume during a crisis and allocation of household income. Overall, the Women's Empowerment Index of the sample households is 2.13, which indicates low empowerment among women. Women take part in decision-making but men are still considered as the major decision makers in the household.

References

Gregory DJ, Haefele SM, Buresh RJ, Singh U. 2010. Fertilizer use, markets and management. In: Pandey S, Byerlee D, Dawe D, Dobermann A, Mohanty S, Rozelle S, Hardy B, editors. Rice in the global economy: strategic research and policy issues for food security. Los Baños (Philippines): International Rice Research Institute. p 231-265.

Haque SA. 2006. Salinity problems and crop production in coastal regions of Bangladesh. Pakistan J. Bot. 38(5):1359-1365.

Hossain M, Bose M, Mustafi B. 2006. Adoption and productivity impact of modern rice varieties in Bangladesh. Dev. Econ. XLIV-2 (June 2006):149-166.

Hossain M, Asaduzzaman M, Sattar Mandal MA, Deb U, Jones S. 2009. Rice technologies: strategic choices and policy options. BIDS Policy Brief. Number 0903. May 2009.

Islam MR, Salam MA, Bhuiyan MAR, Rahman MA, Gregorio GB. 2008. Participatory varietal selection for salt-tolerant rice. Int. J. BioResearch 4(3):21-25.

Ismail A. 2009. Increasing rice productivity in submergence-prone areas of South Asia. Management options in flood-prone areas. Fact Sheet 4. Los Baños (Philippines): International Rice Research Institute. http://archive.irri.org/flood-proof-rice/Factsheet_4.pdf.

Karim Z, Hussain SG, Ahmed M. 1990. Salinity problem and crop intensification in the coastal region of Bangladesh. BARC Soil Publication. 33:63.

Sources of secondary data

BRRI, retrieved in Jan 2011. Rice area, production, yield from 1971-72 to 2008-09. At www.brri.gov.bd/info_services/index.htm.

Bangladesh Bureau of Statistics, retrieved in Jan 2011. At www.bbs.gov.bd/Home.aspx#.

Trading Economics, retrieved in Jan 2011. Land area under cereal production. At www trading-economics.com/bangladesh/land-under-cereal-production-hectares-wb-data.html.

World Bank Indicators, retrieved in Jan 2011. At http://data.worldbank.org/indicator.

World Rice Statistics, retrieved in Jan 2011. At http://irri.org/our-science/social-science-economics/world-rice-statistics.

Notes

Authors' addresses: M.R. Islam, M.A. Islam, A. Salam, S. Alam, and E. Harun, Agricultural Economics Division, Bangladesh Rice Research Institute, Gazipur 1701, Bangladesh; M.S. Rahman, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Appendix 1. Rice varieties released by BRRI.

Rice variety	Release year	Ecosystem	Season	Yield potential (t/ha)
BR1	1970	Low irrigated/rainfed upland	Boro/aus	5.5/4.0
BR2	1971	Irrigated/rainfed upland	Boro/aus	5.0/4.0
BR3	1973	Irrigated/low rainfed area/rainfed upland	Boro/aus/aman	6.5/4.0/4.0
BR4	1975	Rainfed	T. aman	5.0
BR5	1976	Rainfed	T. aman (aromatic)	3.0
BR6	1977	Low rainfed area/rainfed upland	Boro/aus	4.5/3.5
BR7	1977	Irrigated/rainfed upland	Boro/aus	4.5/4.5
BR8	1978	Irrigated/rainfed upland	Boro/aus	6.0/5.0
BR9	1978	Irrigated/rainfed upland	Boro/aus	6.0/5.0
BR10	1980	Irrigated	Boro	6.5
BR11	1980	Rainfed	T. aman	6.5
BR12	1983	Irrigated/rainfed upland	Boro/aus	5.5/4.5
BR14	1983	Irrigated/rainfed upland	Boro/aus	6.0/5.0
BR15	1983	Irrigated/rainfed upland	Boro/aus	5.5/5.0
BR16	1985	Irrigated/rainfed upland	Boro/aus	6.0/5.0
BR17	1985	Irrigated	Boro	6.0
BR18	1985	Irrigated	Boro	6.0
BR19	1985	Irrigated	Boro	6.0
BR20	1986	High rainfed area	Aus	3.5
BR21	1986	High rainfed area	Aus	3.0
BR22	1988	Flooded area	Aman	5.0
BR23	1988	Saline-affected areas	Aman	5.5
BR24	1992	High rainfed area	Aus	3.5
BR25	1992	Rainfed upland	Aman	4.5
BR26	1993	Rainfed	Aus	4.0
BRRI dhan27	1994	High rainfed	Aus	4.0
BRRI dhan28	1994	Low irrigated	Boro	5.0
BRRI dhan29	1994	Irrigated	Boro	7.5

Continued on next page

Appendix 1 continued

BRRI dhan30	1994	Rainfed	Aman	5.0
BRRI dhan31	1994	Rainfed	Aman	5.0
BRRI dhan32	1994	Rainfed	Aman	5.0
BRRI dhan33	1997	Rainfed	Aman	4.5
BRRI dhan34	1997	Rainfed	Aman	3.5
BRRI dhan35	1998	Irrigated	Boro	5.0
BRRI dhan36	1998	Irrigated	Boro	5.0
BRRI dhan37	1998	Rainfed	Aman	3.5
BRRI dhan38	1998	Rainfed	Aman	3.5
BRRI dhan39	1999	Rainfed	Aman	4.5
BRRI dhan40	2003	Rainfed	Aman	4.5
BRRI dhan41	2003	Rainfed	Aman	4.5
BRRI dhan42	2004	Rainfed upland	Aus	3.5
BRRI dhan43	2004	Rainfed upland	Aus	3.5
BRRI dhan44	2005	Tidal submerged areas	Aman	6.5
BRRI dhan45	2005	Low irrigated	Boro	6.5
BRRI dhan46	2007	Rainfed	Aman	4.7
BRRI dhan47	2007	Irrigated	Boro	6.1
BRRI dhan48	2008	Rainfed	Aus	5.5
BRRI dhan49	2008	Rainfed	Aman	5.0
BRRI dhan50	2008	Irrigated	Boro	6.0
BRRI hybrid dhan1	2001	Irrigated	Boro	8.5
BRRI hybrid dhan2	2008	Irrigated	Boro	8.0
BRRI dhan51	2010	Rainfed	Aman	4.0
BRRI dhan52	2010	Rainfed	Aman	4.0
BRRI dhan53	2010	Rainfed	Aman	4.5
BRRI dhan54	2010	Rainfed	Aman	4.5
BRRI hybrid dhan 3	2009	Irrigated	Boro	8.5
BRRI hybrid dhan 4	2010	Irrigated	Aman	6.0

Source: BRRI (2010).

Appendix 2. Input use in rice production by generation of MVs during aman season.

Inputs	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
New generation							
Seeds (kg/ha)	40	51	40	69	61	65	56
Fertilizer (kg/ha)							
N	61	45	137	46	121	88	77
P	0	6	20	25	3	22	12
K	0	5	13	0	4	17	8
Labor[a] (person-days/ha)	131	101	144	91	132	188	138
Old generation							
Seeds (kg/ha)	43	59	51	67	65	64	57
Fertilizer (kg/ha)							
N	58	57	109	78	73	95	75
P	6	2	6	18	16	30	11
K	0	1	9	8	10	15	6
Labor[a] (person-days/ha)	128	95	129	93	131	182	120

[a]Labor use reported excludes hired labor under contract.

Appendix 3. Input use in rice production by generation of MVs during boro season.

Inputs	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
New generation							
Seeds (kg/ha)	42	61	46	68	61	60	42
Fertilizer (kg/ha)							
N	69	117	151	83	115	176	69
P	17	23	9	21	26	49	17
K	0	8	10	9	12	23	0
Labor[a] (person-days/ha)	133	132	171	102	155	209	133
Old generation							
Seeds (kg/ha)							
Fertilizer (kg/ha)		60	51	75			
N							
P		89	155	27			
K		25	14	31			
Labor[a] (person-days/ha)		11	15	7			

[a]Labor use reported excludes hired labor under contract.

Appendix 4. Percentage of costs under MV rice production during aman and boro seasons.

Costs (in %)	Submergence			Drought	Salinity		All
	Habiganj	Jamalpur	Kurigram	Rajshahi	Satkhira		
					Saline	Nonsaline	
Aman season							
Total material input cost	56	19	44	44	42	45	43
Total labor cost[a]	34	72	43	45	49	47	47
Total power cost	9	9	13	10	9	8	10
Total cash cost	76	74	82	87	88	83	81
Total noncash cost	24	26	18	13	12	17	19
Total costs	100	100	100	100	100	100	100
Boro season							
Total material input cost	62	38	49	49	50	64	51
Total labor cost[a]	30	54	41	42	44	31	41
Total power cost	8	8	9	8	6	5	8
Total cash cost	79	81	70	88	91	88	82
Total noncash cost	21	19	30	12	9	12	18
Total costs	100	100	100	100	100	100	100

[a]Labor use reported excludes hired labor under contract.

Chapter 6

Patterns of adoption of improved rice varieties and farm level impacts in stress-prone rainfed areas of West Bengal, India

Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas of West Bengal, India

B. Bagchi and M. Bool-Emerick

Introduction

Country background

West Bengal lies in the eastern part of India, bordered by Nepal, Bangladesh, and other Indian states. It has a total land area of 88,752 km^2 and a population of 80.2 million, making West Bengal the fourth most populous state in India (Census 2001).

West Bengal is the top rice producer in India. Rice, the state's main staple, is grown extensively. In 2009, India's total rice production reached 131 million tons and West Bengal accounted for 16% of the country's production. Rice is cultivated in varying ecosystems that include irrigated areas, rainfed lowland areas, and uplands. In rainfed areas, rice farms are affected by varied amounts of submergence, drought, and salinity. The occurrences of these abiotic stresses cause substantial crop damage. To improve food security and the livelihoods of poor farming households, collaborative efforts with national agricultural research and extension systems (NARES) have been made to develop stress-tolerant rice varieties to achieve higher productivity in India.

Objective

This report is an outcome of the baseline socioeconomic survey under Objective 7 (Impact assessment and targeting) of the STRASA project. The objectives of the study are the following:

- To analyze farmers' livelihood systems in selected drought-prone, submergence-prone, and salinity environments in Bangladesh.
- To analyze the patterns of varietal adoption and the factors that influence the adoption of modern rice varieties.
- To analyze the economics of rice production by type of variety and season.
- To document farmers' coping strategies due to different stress situations (drought, submergence, and salinity).
- To understand gender roles in rice production and women's participation in decision-making.
- To serve as a baseline for rice technology design, targeting, and policy reforms in stress-prone areas.

Organization of the report

This report is organized into six major sections. The first section gives a general country background and objectives of the study. This is followed by a short description of the research design and data generation. The third section briefly describes the trends in rice production. The fourth section provides a general description of the survey sites and stresses using information gathered from focus group discussions and key informant surveys. Section five presents the detailed farm-level analyses of the socioeconomic survey describing the livelihood of farmers, adoption of modern varieties, economics of rice production, consumption patterns, coping strategies, and gender analysis. The final section provides a summary of the findings.

Research design and data generation

This research was implemented in partnership with the Nadia Zilla Farmers Development Organization (NZFDO). Data for this study were collected by combining rapid rural appraisal methods, secondary sources, and a specifically designed household survey.

The survey was carried out for the 2008 rice cropping season under the STRASA project in South Asia. The prevalence of stress (drought, submergence, and salinity) and proportion of rainfed rice area were the two major criteria in selecting districts and study villages. Household surveys were conducted in 300 randomly selected households covering the representative rainfed districts in West Bengal. The districts included are the following: Nadia (submergence), Purulia (drought), and North 24 Parganas (salinity). Within each district, at least two villages were selected for the detailed household survey. The survey sites and stress situations were characterized using information gathered from focus group discussions (FGD) and key informant surveys (KIS).

Detailed information on farmers' livelihoods, socioeconomic features, rice production systems, variety adoption patterns, input use, costs and returns, income structure, farmers' coping strategies, and gender-disaggregated data on rice farming were collected from the socioeconomic baseline household surveys.

The basic analytical framework followed is given in Chapter 2. The study used a combination of secondary and primary data. Temporal data on rice area, yield, and production covering 1970 to 2008 were used to provide the general trends at the aggregate level. Various statistical and econometric analyses were employed to meet the study objectives. Using time-series data obtained from national statistics, annual growth rates for rice area, production, and yield were estimated using a semi-log trend equation.[1] The compound growth rate was estimated for each decade from 1970 to 2008. Before fitting the trend equation for each period, data were smoothed using a five-year moving-average process. In addition, a 10-year moving growth rate was computed.

[1]The functional form of the semi-log equation is given by $\ln Y_t = a + bT$, where Y_t is the series of area/production/yield, a is the constant, b gives the annual exponential growth rate of area/production/yield, and T is the trend term.

The adoption of improved varieties was measured using various indicators such as the proportion of farmers growing modern varieties and the proportion of area under modern varieties (MVs). The incidence and intensity of adoption were compared not only across sites and stress situations but also between the aman and boro seasons.

Econometric analysis was carried out using censored regression (tobit) models to identify the major factors determining the probability and the rate of adoption of new-generation modern varieties.

Agriculture and trends in rice production

The agricultural sector contributed 17% of the state's domestic product in 2008 (Central Statistical Organisation 2009). It also generated a substantial amount of employment in rural areas where 72% of the state's population live (Census 2001). Statistics show that the share of agriculture in gross domestic product has declined in the last few years. However, agriculture still remains the biggest economic sector as it employs around 60% of the total workforce in India. In rural India, 67% of the males and 84% of the females were engaged in agriculture in 2007 (Ministry of Statistics and Program Implementation 2010).

The state's landholdings are generally small, with 81% of the total operational landholdings being less than 1.0 ha. The average landholding size was 0.8 ha in 2005. The total operational land area is 5.5 million ha, of which 96% is cropped, while gross cropped area is 9.5 million ha. From 1995 to 2006, cropping intensity increased from 164% to 182%. This increase in cropping intensity is attributed mainly to irrigation expansion by various means such as canals, tanks, and tube wells (www.indiastat.com).

In 2006, almost 60% of the net cropped area was irrigated. Area under food grains (rice, wheat, pulses, and other cereals) occupied around 66% of the gross cropped area (www.indiastat.com). The increase in food grain production between 1990 and 2006 was 42%. Aside from cereal crops, major crops such as jute, potato, and oilseeds are grown.

Rice followed by oilseeds and jute are the major crops in terms of area planted. According to Table 1, a slight decrease in rice area was accompanied by an increase in production as rice yields grew by more than 40% between 1990 and 2007. Area under wheat, oilseeds, jute, and potato expanded while improvements in yield rates were observed for all principal crops between 1990 and 2006.

Trends in rice area, production, and yield

Among the major crops grown in the state, rice is the main food crop that can be cultivated one to three times in a year. The different cropping seasons in West Bengal are aus, aman, and boro. The aus crop is sown in March/April and harvested in July/August. Aman rice, the main rice-growing season in the country, is planted in June/July and harvested in October/November while sowing of boro rice starts in November/December and it is harvested in April/May.

The area and production of rice in West Bengal are the highest in the country. Total rice area increased from 5 million ha in 1970 to 5.7 million ha in 2009 (Fig. 1).

Table 1. Area, production, and yield rates of principal crops in West Bengal.

Principal crops	Area (000 ha)		Yield (t/ha)		Production (000 tons)	
	1990-91	2007-08	1990-91	2007-08	1990-91	2007-08
Rice	5,813	5,720	2.69	3.86	15,656	22,079
Wheat	269	353	1.97	2.60	530	917
Other cereals	100	97	1.10	2.33	110	266
Pulses	314	186	0.62	0.80	193	148
Oilseeds	513	707	0.83	1.00	453	705
Jute[a]	509	617	11	13.44	5,542	8,294
Potato	195	401	22.98	24.69	4,482	9,901

[a]Includes *Mesta*. Production is expressed in thousand bales of 180 kg each.
Source: Indiastat.com.

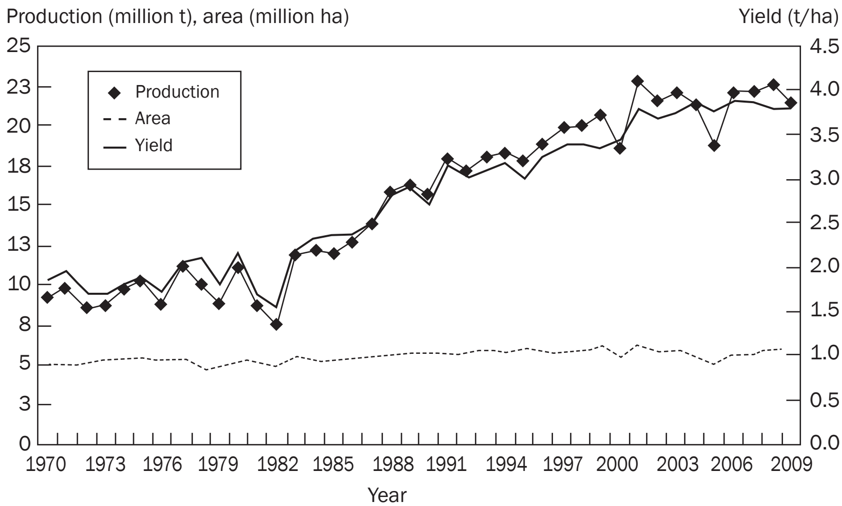


Fig. 1. Production, area, and yield of rough rice in West Bengal, 1970-2009. Data source: www.indiastat.com.

On the other hand, rice yield doubled between 1970 and 2009. The increase in rice yield over the years can be attributed to improved crop management practices, the adoption of high-yielding varieties, and irrigation expansion.

The growth rates for different periods are presented in Table 2. Overall, a significant increase in rice area by 0.4% per year is observed from 1974 to 2009. Similarly, a dramatic growth in yield is observed in all periods, especially during 1981 to 1990, when yield growth was 4.3%. On average, rice yield increased significantly from 1970 to 2008, with a growth rate of 2.6% per annum. Moreover, the state's rice production grew by 3.0% per year during 1970 to 2008.

Aman, followed by boro, is the major rice-growing season. During 2000-08, aman rice area accounted for around 70% of the total rice area. Table 3 shows the rice area, production, and yield by season for 2000 to 2008.

Aus and aman rice account for 5% and 65% of the state's rice production from 2000 to 2008. Over the years, aus and aman rice yield improved. Aus yield increased from 2.6 to 3.11 t/ha from 2000 to 2008 while aman yield increased by around 25%.

Site and stress characterization

Site and village description

Location of sites. West Bengal is located in the eastern part of India, with Bangladesh lying on its eastern border. Abiotic stresses such as submergence, drought, and salinity are known to limit rice production, particularly in the rainfed areas.

Three districts, Nadia, Purulia, and North 24 Parganas, were selected to represent the state's stress-prone rice areas. Nadia represents the submergence-prone rainfed rice

Table 2. Growth rates[a] (% per year) of rice area, yield, and production in West Bengal.

Period	Area	Yield	Production
1974-80	−0.1***	1.7***	1.6***
1981-90	1.1***	4.3***	5.4***
1991-2000	0.5***	1.8***	2.3***
2001-09	−0.8***	1.3***	0.5***
All	0.4***	2.6***	3.0***

[a]Using a semi-log trend equation, the annual compound growth rates of area, yield, and production are computed using a 5-year moving average of the raw data centered on the end years. *** indicates statistical significance at the 1% level.
Data source: www.indiastat.com.

Table 3. Rice area, production, and yield by season from 2000 to 2008.

Year	Area (000 ha)			Yield (t/ha)			Production (000 tons)		
	Aus	Aman	Boro	Aus	Aman	Boro	Aus	Aman	Boro
2000	394	3,640	1,402	2.60	2.97	4.86	1,026	10,804	6,812
2001	403	4,212	1,455	3.13	3.56	4.55	1,263	15,000	6,622
2002	385	4,051	1,406	3.10	3.48	4.48	1,195	14,091	6,298
2003	340	4,127	1,390	3.17	3.51	4.63	1,079	14,480	6,434
2004	321	4,086	1,376	3.05	3.66	4.64	980	14,962	6,386
2005	288	4,113	1,382	3.16	3.60	4.39	909	14,787	6,071
2006	284	4,002	1,401	3.04	3.62	4.84	863	14,470	6,781
2007	282	3,927	1,512	3.49	3.52	4.89	985	13,841	7,389
2008	292	4,087	1,557	3.11	3.70	4.20	908	15,111	6,537

Data source: www.indiastat.com.

environment while Purulia and North 24 Parganas represent the drought-prone and saline-affected rice environments, respectively. In each district, at least two villages were selected for the study. The number of villages covered in each district varies depending on spatial variability in the area. Figure 2 shows the location of the survey sites in West Bengal while Table 4 lists the selected districts and the corresponding villages covered by the socioeconomic baseline survey.

Only rice farming households that normally face the problem of submergence, drought, or salinity in rice production are considered in the survey. A total of 300 households were interviewed.

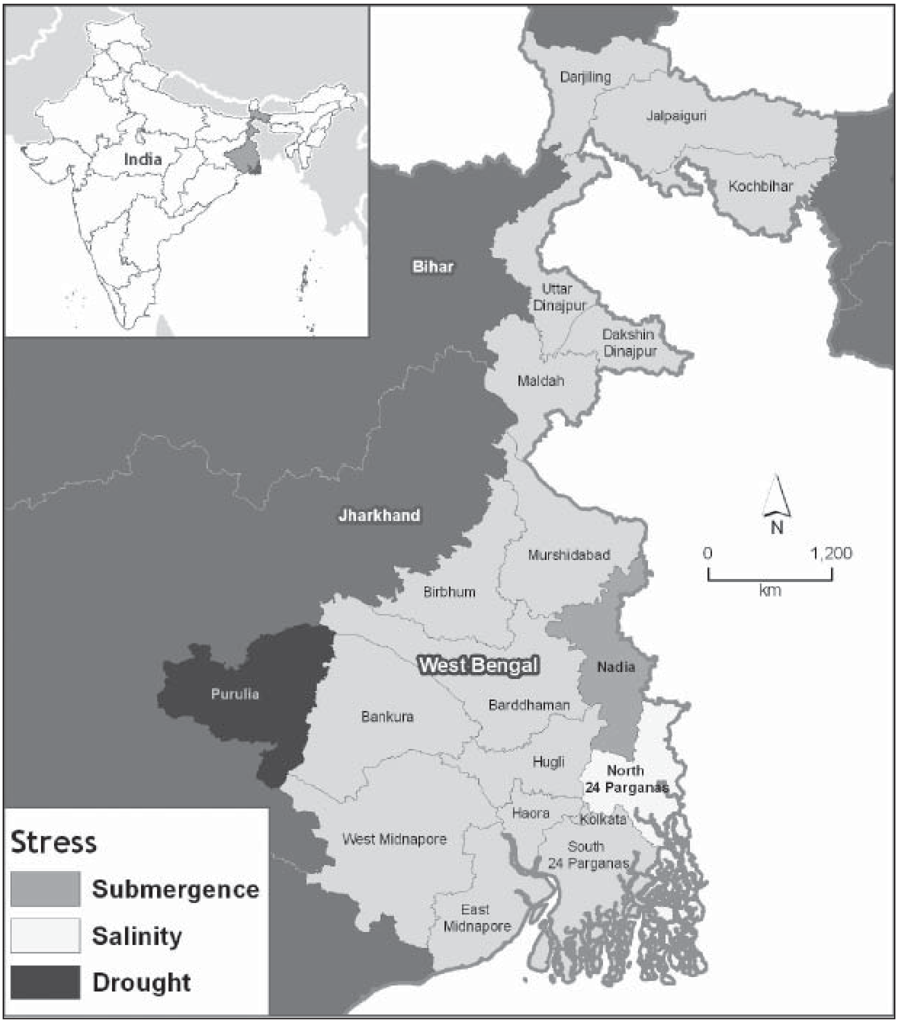


Fig. 2. Site locations for the socioeconomic baseline survey in West Bengal.

Description of the major abiotic stress

The characteristics of the major abiotic stress in selected districts are presented in Table 5. The state has a long recorded history of flood. About 50% of the total area of the state is susceptible to floods. According to Appendix 1, several years are identified as flood-free years during 1971 to 2009. Among the flood years, the flood in 1978 affected around 30,000 km^2, the highest recorded flood-affected area yet. The state suffered consecutively from flood in 1998, 1999, and 2000. Based on focus group discussions conducted at the village level, the most recent flood was in 2007, affecting 60% of the total rice area in Nadia. The flood was around 1 m deep and lasted for 3 weeks. Based on farmers' experience, flooding occurs four times in every 10 years and usually begins around September and October.

In West Bengal, 60 blocks from 4 districts are considered as drought-prone, with 20 blocks located in Purulia District. The state faced severe drought in 1972, 1979, 1987, and 2009 (Appendix 1). According to focus group discussions conducted

Table 4. Selected sites representing stress-prone rice areas in West Bengal, India.

Stress	District	Villages	Sample size	Institution
Submergence	Nadia	Byaspur, Ekperepara, Shibpur	100	NZFDO
Drought	Purulia	Dhuliapara, Ghastoria, Kumardih	100	NZFDO
Salinity[a]	North 24 Parganas	Darirjangal, Kumarjole (control)	100	NZFDO
Total	3	8	300	

[a]Unlike submergence and drought, salinity is prevalent year-round. To be able to compare livelihood and rice production practices, Kumarjole, a nonsaline village in Satkhira, is included in the survey.

Table 5. Stress characteristics in survey locations.

Item	Nadia	Purulia	North 24 Parganas
Stress	Submergence	Drought	Salinity
Rainfall in 2008	Normal	Normal	n/a
Most recent stress year	2007	2006	–
Frequency in 10 years	4	3	–
Season affected	Aman	Aman	Boro
Duration	20–25 days	> 30 days	–
Depth of flood	1–1.5 m	n/a[a]	–
Stages of crop affected by stress	Booting stage (Sep/Oct)	Booting stage (Sep/Oct)	–
% Rice area affected by most recent stress	60	n/a[a]	n/a
% Households affected by stress	65	100	n/a

[a] n/a = data not available.
Source: STRASA focus group discussion, 2008.

at the village level, farmers in Purulia reported that drought usually occurs during the booting stage of the rice crop. The frequency is three times in every 10 years and the most recent drought was in 2006, which affected all the farming households.

The saline zone of West Bengal is composed of 77 blocks from various locations in South 24 Parganas, North 24 Praganas, and Midnapur East districts comprising 17.7% of the state's area. A large area comprising 13 blocks of South 24 Parganas and 5 blocks of North 24 Parganas is popularly known as Sundarban. Soil becomes saline as it is exposed to sea water and continues to be inundated during high tides. The tidal saline water from the sea comes from the rivers Matla, Ichhamati, Piyali, Vidyadhari, Gosaba, and Saptamukhi. Soil salinity limits rice production, especially during the boro season, when salinity is high. Rice production is less affected by salinity during the aman season, when salts are flushed off by the monsoon rain.

Depending on the severity and timing of abiotic stresses, the occurrence of these stresses can cause substantial reductions in yield (Table 6). Based on STRASA focus group discussions conducted at the village level, sample farmers revealed a 27% decrease in yield in Nadia (submergence-prone) during a stress year and a 69% reduction in yield in Purulia (drought-prone) relative to normal years. The reduction in yield is the result of stress in addition to other stochastic factors that affect yield. Average yields in these selected stress-prone locations were found to be lower than the district-level average yields. In Nadia and Purulia, average district-level yields during the wet season were 3.9 and 3.70 t/ha, respectively.

Cropping calendar and major crops. According to the focus group interviews, farmers grow aus or aman rice during June and it is harvested in October/November while sowing of boro rice (rabi) starts in November to February and is harvested in April/May. Aside from rice, households grow jute, sesame, wheat, and mustard, except in Purulia and saline areas in North 24 Parganas, where rice is the sole crop cultivated by the sample farmers.

Farm-level analysis

Socio-demographic characteristics

Ethnicity. The Indian caste system describes the social stratification that refers to the concept of classifying individuals into groups based on power and wealth in society. Most households interviewed belong to the low caste categories or backward caste,

Table 6. Yield (t/ha) during normal and stress years in survey locations.

Item	Nadia	Purulia
Normal year	3.0	2.6
Stress year	2.2	0.8
% Difference	–27	–69

Source: STRASA focus group discussion, 2008.

namely, scheduled caste (SC), scheduled tribes (ST), and other backward caste (OBC). Results show that most households relying largely on rice farming are classified under backward caste. The households in the low caste category are 74%, 98%, and 99% in Nadia, North 24 Parganas, and Purulia, respectively. However, the major ethnic group in Kumarjole (nonsaline) Village is Muslim, accounting for 66% of the sample households (Table 7).

Respondents by gender, age, and education. The respondents interviewed are mostly men and only 2% are women. The average age is 46 while educational attainment averages around 6 years for males and 2 years for females (Table 8). The smaller number of women representing the households and lower level of education

Table 7. Composition of sample households by ethnicity.

Ethnicity	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
No. of households	100	100	50	50	300
Ethnicity (%)					
Backward caste	74	99	98	34	80
Scheduled tribes	–	59	–	–	20
Scheduled caste	67	2	92	26	43
Others	7	38[a]	6	6	17
Forward caste	26	1	2	2	9
Muslim	–	–	–	66	11

[a]About 34% belong to Kurmi ethnicity.

Table 8. General characteristics of the respondents.

Characteristics	Submergence	Drought	Salinity		
	Nadia	Purulia	North 24 Parganas		All
			Saline	Nonsaline	
No. of households	100	100	50	50	300
Av. age of respondents (years)	48	45	47	44	46
Gender (%)					
Males	100	95	98	98	98
Females	–	5	2	2	2
Years of schooling					
Males	6	6	5	5	6
Females	–	0	8	3	2

among female respondents reflect the male-dominated agricultural sector not only in West Bengal. With the increasing roles of women in agriculture, improvements in educational status could be a stepping stone to empowering women. Women's roles and participation in decision making are presented in the latter section of this report.

Household characteristics. Table 9 shows the general characteristics of the selected households. Average household size is 5 members per household. About 75% of the total number of household members are considered adults (more than 15 years old), with 6 years of formal schooling on average. Of the total number of adult household members, around 92% belong to the labor force (16 to 64 years old). Moreover, results show an education gap between the male and female adult members of the households. On average, the education gap between men and women is about 3 years.

Occupation. Some 64% to 72% of the household members are adults with ages of 16 to 64. Among the adult members who are employed, farming is the major economic activity. Table 10 shows that at least 80% of the employed adult members are engaged in farm-related activities. Other occupations include small-scale businesses, working in small shops, and others.

Table 9. General characteristics of the households.

Characteristics	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
No. of households	100	100	50	50	300
Av. household size	5	5	5	5	5
Household composition (%)					
Males	53	53	57	55	54
Females	47	47	43	45	46
Age group (%)					
Below 16 years old	20	28	22	32	25
16 to 50 years old	60	59	64	58	60
More than 50 years old	20	13	14	10	15
Years of education[a]					
Males	8	6	7	6	7
Females	6	3	5	3	4
All	7	5	6	4	6

[a]Adult members only (age is 16 and older).

Table 10. Employment of adult household members.

Occupation	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
% of adult members[a]	72	68	71	64	69
Primary occupation (%)					
Farming activities	80	89	82	80	84
Small-scale business	14	1	5	3	5
Shopkeeper	–	3	2	2	2
Driver	–	–	1	3	1
Furniture maker	–	–	2	2	1
Tailoring	–	–	–	4	1
Others[b]	6	7	8	6	6

[a]Only household members whose age is 16 to 64.
[b]Other occupation includes nonfarm labor service and salaried jobs.

Farm land characteristics

Landholdings. Table 11 shows the general attributes of the households' landholdings. The average farm size of the sample household is 0.7 ha. Generally, farms are further subdivided into 2 to 4 parcels or plots based on agroecological characteristics. The average area of a parcel ranges from 0.2 to 0.4 ha.

Farm size distribution of selected households in different stress-prone environments is given in Figure 3. The distribution shows that farm size is positively skewed, meaning that most households have small farms. Some 66% to 86% of the farm sizes of the sample households at selected sites are less than 1.0 ha. Land fragmentation is higher in North 24 Parganas, where more than 65% of the farms are below 0.5 ha.

Land tenure. Table 11 also shows the proportion of farm area by tenurial arrangement. Most of the households interviewed own their lands. On average, more than 70% of the total area of the sample households is owned. In Purulia, all farms are owned by the sample farmers, whereas, in North 24 Parganas, around 8% of the total area is rented-in while 5% to 20% of the total area is rented out to other farmers.

Land type and soil type. The type of abiotic stress affecting an area may depend on its land type. In Nadia and North 24 Parganas, the proportion of land under upland conditions is only 16% and 2%, respectively, while the share of upland in Purulia is 48%. This is consistent with the conventional wisdom that lands that are in the uplands are prone to drought while those in relatively lower areas are prone to submergence or salinity intrusion.

Some variations in soil types are observed across sites. In Nadia and North 24 Parganas, a majority of the farms have clay to loam soil type while calcareous and loam soil types are the major types in Purulia. On the other hand, all farms in representative saline and nonsaline areas in North 24 Parganas have clay and clay-loam soil types, respectively.

Table 11. General characteristics of the farm.

Characteristics	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Av. farm size (ha)	0.8	0.7	0.6	0.5	0.7
Av. no. of parcels per household	2	4	3	2	3
Av. parcel area (ha)	0.4	0.2	0.2	0.2	0.2
Farm area by tenure (%)					
Owned	95	100	88	72	93
Rented-in	5	–	5	20	5
Rented-out	–	–	7	8	2
Farm area by land type (%)					
Upland	16	48	2	9	24
Medium land	47	25	48	70	42
Lowland	36	27	50	21	34

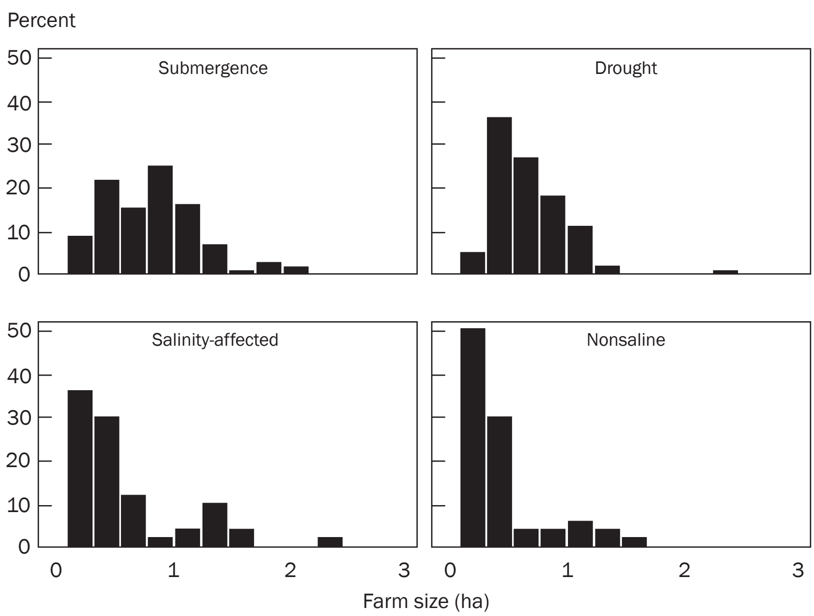


Fig. 3. Farm size distribution of sample households by different stress environments.

Irrigation and land use. Crop cultivation during the boro season is made possible by the availability of irrigation facilities such as low-lift pumps, deep tube wells, and shallow tube wells. Electric pumps, shallow/deep tube wells, and water from ponds are the common sources of irrigation in Bangladesh. Table 12 shows that sample farmers in submergence-prone areas are able to provide irrigation to most of their farms during the dry season while irrigation is not available in Purulia, making boro/rabi cultivation uncommon.

In North 24 Parganas, irrigation is provided to 56% of the area in nonsaline areas during the dry season while only 30% of the total area receives irrigation at the representative saline site.

Table 13 shows the total cropped area by season. On average, more than 90% of the farm is planted during aman while only half is planted during the boro season. In Nadia, sample farmers are able to plant during both seasons because irrigation during the boro season is available. However, in Purulia and North 24 Parganas, the percentage of area irrigated is low (Table 12). As a result, cultivation during the boro season is limited and more lands are kept fallow.

Table 12. General characteristics of the farm.

Percent irrigated area	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Farm area irrigated (%)					
Wet season	45	–	12	0.3	20
Dry season	97	–	30	56	50

Table 13. Proportion of cropped area by season.

Percent irrigated area	Submergence	Drought	Salinity		All
	Nadia[a]	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Total cropped area (%)					
Aman	94	100	78	77	92
Boro	91	–	30	60	48

[a]Area sown during aus in Nadia is included in the aman season. A small area (5%) is also reported to be cropped throughout the year.

Characteristics of the rice-based cropping system

The farm land is cultivated to different rice and nonrice crops. The predominant cropping pattern in Nadia is rice-rice while rice-fallow is commonly practiced in North 24 Parganas and Purulia. Other cropping sequences observed in submergence-prone areas include rice-rice-jute, rice-rice-sesame, rice-mustard, and rice-wheat while rice is the sole crop cultivated by the sample farmers in saline and drought areas.

The cropping intensity (CI) index is given by the proportion of gross cropped area to total net cropped area. Gross cropped area is the total area planted to crops in all seasons while net cropped area is the total operational area. Results show that the degree of intensification in submergence-prone areas in Nadia is highest, with a value of 185%, which implies that most areas are cropped twice a year (Table 14). On the other hand, CI index at saline and drought sites shows that most areas are grown only once a year. In addition to the areas in Purulia being monocropped, rice is the sole crop reported by sample farmers.

On average, 80% of the gross cropped area is planted to rice. The major nonrice crops such as jute and mustard occupy 43% of the gross cropped area in selected submergence-prone areas in Nadia. In addition, sample households in nonsaline areas cultivate nonrice crops such as groundnut, mustard, potato, and vegetables.

Patterns of rice varietal adoption

Rice is the main crop in the representative districts in West Bengal. On average, rice is grown on at least 84% of the area during aman and on more than 64% during the boro season at the survey sites.

Combination of rice types grown. Farmers may grow a combination of rice types such as a modern rice variety (MV) in one parcel and a traditional variety (TV) in another parcel. Table 15 shows the combination of rice types grown in the stress-prone districts. Results show a clear dominance of MV rice regardless of season. In Purulia and North 24 Parganas (saline areas), around 10% and 14% of the sample households, respectively, reported growing a combination of MV and TV during aman. A small number of households in saline areas reported growing a TV only.

Rice area by season and land type. In Nadia, around 44% of the gross rice area is planted to aman (wet-season) rice while 56% is grown to boro (dry-season) rice (Table 16). In saline areas, aman rice consists of more than 70% of the gross rice area

Table 14. Cropping intensity index in selected areas in West Bengal.

Area	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Gross cropped area					
Share of rice (%)	57	100	100	91	83
Share of nonrice (%)	43	–	–	9	17
Cropping intensity	185	100	116	149	142

Table 15. Combination of TV and MV rice grown during aman and boro seasons.

Percent of households	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Season and rice type					
Aman (wet) season					
MV only	100	86	86	100	92
TV only	–	–	4	–	1
MV and TV	–	14	10	–	7
Boro (dry) season					
MV only	100	–	100	100	100

Table 16. Proportion of rice area to total cropped area by season in selected areas in West Bengal.

Rice area	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Percent rice area					
Aman	44	100	72	60	67
Boro	56	–	28	40	33

Table 17. Proportion of rice area by type and season.

Percent rice area	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Aman (wet) season					
MV	93	92	90	100	93
TV	7	8	10	–	7
Boro (dry) season					
MV	100	100	100	100	100

while only 28% is planted to boro rice. On the other hand, 100% of the gross rice area is planted to aman rice in Purulia. Cultivation of rice in each season strongly depends on the availability of water for irrigation. Farmers in Nadia are able to grow rice in both seasons because enough irrigation water is available. In contrast, rice monocropping is common in Purulia and saline areas in North 24 Parganas due to the limited supply of irrigation water.

The type of rice varieties grown is presented in Table 17. Modern rice varieties dominate the total rice area during aman and boro seasons for all selected districts.

Only 7% of the total rice area is grown to traditional rice varieties during aman and none during the boro season. The type of rice varieties does not vary much across land types. Most lands, regardless of the type, are grown to MV rice.

Area under modern rice varieties. To further describe the patterns of adoption, the generation of MVs was identified to determine how old the rice varieties adopted were. For simplicity purposes, MVs were classified into two groups based on the year of release. "Old"-generation MVs are those varieties released before 1990 while "new"-generation MVs are those released in 1990 and subsequent years.

Table 18 summarizes the generation of MVs grown in selected districts in West Bengal. Findings show a strong correlation between rice cropping season and the generation of MVs grown. Old-generation MVs are grown mainly during the aman season while new-generation MVs dominate during the boro season. However, this pattern of adoption is not observed in Nadia District, where rice areas of sample farmers are grown mostly to new-generation MVs. In Nadia, more than 40% of the rice area during aman is grown to Ranjit, a variety released in 1994 with a duration similar to that of Swarna.

Major rice varieties. According to an ICAR report (2010), a total of 946 modern rice varieties were released all over India. Specifically, 47 rice varieties were released for West Bengal. Tables 19 and 20 show the percentage area sown to different modern rice varieties during aman and boro seasons in West Bengal. Results show that around 20 different MVs were grown during the aman season and only 9 MVs during the boro season.

In Purulia and North 24 Parganas, results show that old-generation MVs dominate the rice fields during aman. In Purulia, the dominant varieties are Swarna and Lalat, which were released in 1982 and 1989, respectively. In selected saline areas, sample farmers reported Patnai, Swarna, and Pankaj as the major rice varieties while Masuri, Patnai, and Pankaj are the common rice varieties among sample farmers in the nonsaline areas.

On the other hand, sample farmers in Nadia reported that 61% of the rice area is grown to new-generation MVs during the aman season. Among the MVs, Ranjit,

Table 18. Percent of MV rice areas by generation and season.

Percent rice area	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
MV generation					
Aman (wet) season					
Old	39	96	88	88	77
New	61	4	12	12	23
Boro (dry) season					
Old	–	–	9	–	1
New	100	–	91	100	99

released in 1994, occupies 43% of the total MV area of the sample farmers. Other new-generation MVs reported are Banstara, IET-17904, M. Sankar, Nayanmoni, Satabdi, and Sonamukhi. Sample farmers also reported large areas grown to Swarna (39%), an old-generation MV.

The major boro rice varieties cultivated are presented in Table 20. During the boro season, new-generation MVs dominate the rice areas of sample farmers, particularly Satabdi, Sankar, and Nayanmoni in submergence-prone areas and IR1444 and WGL-20471 in North 24 Parganas. These rice varieties are new generation MVs released after 1990.

Table 19. Percent area under new- and old-generation rice varieties in aman season.

Percent rice area	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Aman (wet) season					
Old generation					
Annapurna	0	1	0	0	0
BR23	0	0	0	4	0
Lalat	0	43	0	0	19
Mahsuri	0	0	6	42	6
Pankaj	0	0	17	27	6
Patnai	0	0	37	15	7
Swarna	39	52	28	0	38
All	39	96	88	88	77
New generation					
Bullet	0	2	0	0	1
CR-1009	0	0	0	2	0
Gotra-1	0	0	0	2	0
IET 17904	0	0	0	0	0
IR1444	0	0	1	6	1
Khandagiri	0	2	0	0	1
M. Sankar	10	0	0	0	3
Mahananda	0	0	0	0	0
Nayanmoni	2	0	0	0	1
Ranjit	43	0	11	0	14
Satabdi	5	0	0	0	2
Sonamukhi	0	0	0	0	0
WGL-20471	0	0	0	1	0
All	61	4	12	12	23

Table 20. Percent area under new- and old-generation rice varieties in boro season.

Percent rice area	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Boro (dry) season					
Old generation					
Annada	0	0	7.3	0	1
Swarna	0	0	1.4	0	0
All	0	0	8.7	0	1
New generation					
Gotra	4	0	3	0	4
IET 17904	7	0	0	0	5
IR1444	–	0	45	25	9
Sankar	15	0	0	0	11
Nayanmoni	15	0	0	0	11
Satabdi	59	0	10	9	46
WGL-20471	0	0	33	66	14
All	100	0	91	100	99

Yield effects by type and generation

Yield rates of the different types of rice are presented in Table 21. Generally, rice yields during the boro season are higher than yields in the aman season. High yield of boro rice may be explained by various factors such as irrigation provision, absence of abiotic stresses, and rice varieties grown.

In areas where sample farmers reported the use of modern and traditional rice varieties, rice yield obtained from MVs is higher by about 0.55 t/ha on average. In North 24 Parganas, sample farmers in nonsaline areas obtained higher yields than those sample farmers in saline areas. Results show a 0.3 t/ha and 0.4 t/ha yield difference between saline and nonsaline areas during aman and boro season, respectively.

The high yields at saline sites during the boro season may imply farmers' active selection of areas that are not affected by salinity. Only 30% of the gross rice area of sample farmers is planted during the boro season. Farmers may have planted boro rice only in areas where there is no or minimal salt-water intrusion. This implies that the effect of salinity is not just a decrease in yield but also a substantial reduction in area.

Rice yields by generation of MV are shown in Table 22. Based on the results, yield rates of new-generation MVs surpassed those of old-generation MVs during aman and boro seasons. Yield differences between old- and new-generation MVs can

Table 21. Average rice yield (t/ha) by type and season.

Rice yield	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Aman (wet) season					
MV	3.85	2.92	2.77	3.07	3.07
	(0.51)	(0.39)	(0.42)	(0.50)	(0.55)
TV	3.33	2.61	2.39		2.70
	(0.83)	(0.4)	(0.34)		(0.60)
Difference	0.52	0.31**	0.38***	–	0.37**
Boro (dry) season					
MV	5.69	–	4.64	5.06	5.32
	(0.32)	–	(0.22)	(0.53)	(0.57)

*** and ** indicate statistical significance at the 1% and 5% levels, respectively. Standard deviation is in parentheses.

Table 22. Rice yield (t/ha) of MVs by generation and season.[a]

Rice yield	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Aman (wet) season					
Old	3.67	2.94	2.70	3.05	2.98
	(0.71)	(0.36)	(0.40)	(0.50)	(0.48)
New	3.96	2.35	3.24	3.13	3.51
	(0.28)	(0.40)	(0.25)	(0.52)	(0.68)
Difference	0.29	−0.59***	0.54***	0.08	0.53*
Boro (dry) season					
Old	–	–	4.48	–	4.48
	–	–	(0.13)	–	(0.13)
New	5.69	–	4.67	5.06	5.34
	(0.32)	–	(0.22)	(0.53)	(0.56)
Difference	–	–	0.19*	–	0.86**

[a] ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard deviation is in parentheses.

be attributed not only to the seed being new or old but also to other factors such as farmers' practices, land characteristics, and climate. Similarly, the yield differences found by this study between MVs and TVs are not solely attributed to seed performance itself but also to other factors inherent to the farmers and the environment.

However, aman rice yield was found to be 20% lower for new-generation MVs in Purulia. The low yield is attributed to the very short duration rice varieties grown such as Khandagiri and Bullet. On average, yields from areas grown to Khandagiri and Bullet were 2.2 and 2.4 t/ha, respectively, during the aman season.

Reasons for growing the dominant rice varieties

The major rice varieties grown vary by season and location. The dominant rice varieties are Lalat, Masuri, Pankaj, Patnai, Ranjit, and Swarna during the aman season while IR1444, Sankar, Nayanmani, Satabdi, and WGL-20471 are the major rice varieties grown in the boro season. The characteristics of these major rice varieties as perceived by farmers are summarized in Tables 23 and 24.

Based on the results, high yield, good taste, and high grain quality are the characteristics most farmers like about these aman rice varieties. For Patnai, a major rice variety in saline areas, only a few farmers recognized its high yield quality while 59% cited its low yield as undesirable.

Similarly, 97%, 88%, and 86% of the sample farmers growing the major boro rice varieties indicated high yield, good grain, and good taste as the varieties' good attributes. In addition, the high market price of IR1444, Satabdi, and WGL-20471 during the boro season is desired by the farmers.

Low tolerance of pests and diseases and the poor ability of a variety to withstand lodging are the undesirable characteristics cited by farmers. Lodging is more common in Nadia during aman because of frequent flooding. On the other hand, poor pest tolerance is the major undesirable attribute of the popular boro and aman rice varieties in the representative areas in West Bengal.

Adoption of new-generation MVs—econometric analysis

According to previous results, old-generation MVs dominate during the aman season while most rice areas are grown to new-generation MVs during the boro season. Tobit analysis was done for Nadia District only because the adoption rates of old-generation MVs were very high in Purulia (96%) and North 24 Parganas (88%). This resulted in a highly unbalanced data set with little variation in the dependent variables for Purulia and North 24 Parganas. In Nadia, 39% of the aman rice area is grown to old-generation MVs while the remaining 61% is grown to new-generation MVs. Using cross-sectional data with 82 observations, the probability and intensity of adoption of new-generation MVs during the wet season are analyzed using a censored regression model or tobit model, which is discussed in Chapter 2 (see Chapter 2 for details) while summary statistics are presented in Table 25. Independent variables such as awareness of stress-tolerant varieties and women's participation in decision making on what rice variety to grow were omitted due to a lack of variation in the data.

Table 23. Farmers' perceptions regarding preferred traits of the major improved varieties.[a]

Rice varieties	MV generation	Ecosystem	High yield	Pest-tolerant	Good taste	Good grain	High market price
					(% of households)		
Aman season							
Lalat	Old	Drought	97	–	84	30	2
Masuri	Old	Nonsaline	85	8	92	42	4
Pankaj	Old	Saline, nonsaline	97	–	90	32	–
Patnai	Old	Saline, nonsaline	29	10	88	78	27
Ranjit	New	Submergence	100	8	95	83	–
Swarna							
	Old	Submergence, drought, saline	96	1	84	46	1
Boro season							
IR1444	New	Saline, nonsaline	97	–	80	69	37
Nayanmoni	New	Submergence	100	4	84	96	–
Sankar	New	Submergence	100	–	100	100	–
Satabdi	New	Submergence	97	–	99	99	97
WGL-20471	New	Saline, nonsaline	92	4	58	69	62

[a]Households were allowed to provide multiple answers. Each value represents the percentage of households reporting each characteristic.

Table 24. Farmers' perceptions regarding undesirable traits of the major improved varieties.[a]

Rice varieties	MV generation	Ecosystem	Low yield	Lodging	Not tolerant of pests
Aman (wet) season					
Lalat	Old	Drought	–	8	94
Masuri	Old	Nonsaline	4	12	81
Pankaj	Old	Saline, nonsaline	–	26	97
Patnai	Old	Saline	59	29	56
Ranjit	New	Submergence	–	70	80
Swarna	Old	Submergence, drought, saline	–	38	97
Boro (dry) season					
IR1444	New	Saline, nonsaline	–	37	94
Nayanmoni	New	Submergence	–	12	84
Sankar	New	Submergence	–	–	100
Satabdi	New	Submergence	–	3	51
WGL-20471	New	Saline, nonsaline	–	23	92

[a]Households were allowed to provide multiple answers. Each value represents the percentage of households reporting each characteristic.

Table 25. Summary statistics.[a]

Variables	Mean	Std. dev.	Minimum	Maximum
Dependent variable				
Share of new MVs	57	46.77	0	100
Explanatory variables				
Age (in years)	48	10.66	23	79
Education (in years)	6	3.18	0	15
Adult household size (number)	4	1.47	2	9
Farm size (in ha)	0.9	0.43	0.2	2.1
Share of lowland rice area (%)	35	44.60	0	100
Distance from market (in km)	4	1.80	2	6
Participation in training/organization (1 = yes, 0 = no)	0.12	0.33	0	1

[a]No. of observations is 82.

Results from tobit model. Adoption of new-generation MVs is estimated using censored regression (tobit) for the aman season only[2] as this is the only season in which both new and old MVs co-exist. In the boro season, farmers grow mainly new-generation MVs. Empirical results are presented in Table 26. Surprisingly, the socioeconomic variables were found to be not correlated with the adoption of new MVs. Among the variables used to explain adoption, only the share of lowland rice area in total rice area is found significant. The negative correlation means that a high share of lowland rice area is associated with low adoption of new MVs. The results show that the biophysical characteristics of the farm influence farmers to adopt new-generation MVs. Land type is a critical factor that needs to be considered for targeting new rice varieties in rainfed environments.

Economics of MV production

Seed and fertilizer use of the sample farmers in MV rice production is presented in Table 27. Seed use per unit area varies by location, with the average ranging from 61 to 72 kg per ha during aman and boro seasons. Transplanting is the major crop establishment practice.

Farmers use various chemical fertilizers and micronutrients. In general, fertilizer and labor use during the boro season is higher than in the aman season. According to the results, N-fertilizer use is higher by an average of 40 kg/ha. The fertilizer rates for P and K are also higher by 7 and 17 kg/ha, respectively, during the boro season.

However, it is important to note that fertilizer use reported by the sample farmers is much lower than the average fertilizer use in India. As cited by Gregory et al (2010), the mean fertilizer use on rice in India was 100 kg/ha for N, 33 kg/ha for P_2O_5 (or 14 kg/ha P), and 21 kg/ha for K_2O (or 17 kg/ha K) in 2007. This indicates that farmers in stress-prone rice environments use less N fertilizer, especially during the aman season. The low adoption level of fertilizer is caused by the high production risk in

Table 26. Results from tobit model with robust standard errors.

Independent variables	Tobit	
	Marginal effects	Elasticity
Distance from market	–5.07	–0.32
Farm size	–12.58	–0.19
Adult household size	0.85	0.07
Education	–2.56	–0.27
Age	0.16	0.13
Participation in training/organization (1 = yes, 0 = no)	0.73	0.001
Share of lowland rice area (%)	–0.49***[a]	–0.29

[a]*** indicates statistical significance at the 1% level.

[2]Most rice area is grown to new-generation MVs during the boro season.

Table 27. Input use in MV rice production.

Inputs	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Aman					
Seeds (kg/ha)	61	72	70	69	67
Fertilizer (kg/ha)					
N	59	25	25	26	35
P	11	7	5	4	7
K	26	5	4	9	11
Labor (person-days/ha)	172	151	137	145	153
Boro					
Seeds (kg/ha)	74		76	73	74
Fertilizer (kg/ha)					
N	91		58	44	75
P	13		18	9	14
K	32		21	24	28
Labor (person-days/ha)	178		180	161	174

these areas where farmers tend to underuse fertilizer because of the high probability of flood or drought damage.

Aside from higher fertilizer rates during the boro season, labor use is also higher. On average, boro rice cultivation requires an additional 21 person-days/ha. The additional labor is required for irrigating crops and weeding during the boro season (Tables 28 and 29).

Costs and returns analysis of rice production

Rice production is the main source of livelihood in selected stress-prone districts. Table 30 presents the costs and returns of MV rice production during boro and aman seasons. On average, labor costs during the aman season comprise about 60% of the total costs while power cost comprises only about 16% of the total costs (Appendix 2). Family labor plays an important role in rice production as it shares more than 60% of the labor cost.

Net returns from MV rice production vary by season and across sites. In general, net income from rice during the boro season is significantly higher than that of the aman season. This is often attributed to the more favorable climate during the boro season. The variations in net income across sites may also be explained by various factors such as crop management practices, the performance of a rice variety, severity of stress, and others.

Table 28. Labor use in MV rice production during aman season, 2008.

Labor use (person-days/ha)	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Land preparation	11.2	13.5	3.3	3.5	9.2
Crop establishment	37.7	32.1	34.3	32.3	34.1
Application of fertilizer	1.7	0.4	0.8	0.9	0.9
Application of herbicide	0.0	0.0	0.0	0.0	0.0
Application of insecticide	0.5	1.1	3.1	1.8	1.4
Application of organic fertilizer	0.5	3.9	0.0	0.0	1.5
Irrigation	0.2	0.0	0.0	0.0	0.1
Weeding	47.1	36.2	27.6	32.8	37.1
Harvesting	36.5	32.0	30.2	31.2	32.8
Threshing	22.5	19.6	23.4	25.7	22.2
Postharvest activity	14.3	11.8	14.0	16.4	13.8
Total	172.2	150.6	136.7	144.6	153.1

Table 29. Labor use in MV rice production during boro season, 2008.

Labor use (person-days/ha)	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Land preparation	7.9	–	5.8	5.2	6.9
Crop establishment	38.3	–	37.5	34.3	37.2
Application of fertilizer	2.0	–	1.6	1.4	1.8
Application of herbicide	0.2	–	0.0	0.0	0.1
Application of insecticide	0.9	–	6.6	4.4	2.7
Application of organic fertilizer	0.3	–	0.0	0.0	0.2
Irrigation	10.5	–	12.2	5.3	9.6
Weeding	46.9	–	40.0	36.0	43.2
Harvesting	35.7	–	32.5	32.1	34.3
Threshing	22.1	–	25.4	25.8	23.5
Postharvest activity	13.2	–	18.0	16.0	14.7
Total	178.0	–	179.6	160.5	174.2

Table 30. Costs and returns (in US$/ha) from MV rice production during aman and boro seasons.[a]

Items	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Aman season					
Total returns	689	448	455	527	532
Costs					
Total material input cost	86	89	46	60	75
Total labor cost	259	130	192	187	188
Total power cost	63	50	41	40	50
Total cash cost	314	222	130	173	222
Total noncash cost	94	47	149	115	91
Total costs	408	269	279	288	313
Returns above total costs	281	179	176	240	219
Returns above cash cost	375	226	325	354	310
Boro season					
Total returns	1,139	–	878	944	1,047
Costs					
Total material input cost	281	–	354	352	310
Total labor cost	267	–	262	212	254
Total power cost	70	–	43	-	49
Total cash cost	503	–	429	429	472
Total noncash cost	115	–	230	135	141
Total costs	618	–	559	564	613
Returns above total costs	521	–	219	380	434
Returns above cash cost	636	–	449	515	575

[a]Exchange rate used is US$1 = Rs 46.6.

Rice production using modern varieties is found profitable among sample households in selected rainfed areas. The incremental benefit from growing MVs relative to TVs is around $90 or 40%. In addition, a comparison of the profitability of old- and new-generation MVs is presented in Tables 31 and 32.

According to Tables 31 and 32, rice production under new-generation MVs during the aman season is more profitable than that of old-generation MVs. On average, net returns from new MVs are higher by 9% to 66%, depending on location. However, more areas are cultivated to old-generation MVs during aman despite this result. The choice to adopt old-generation MVs during the aman season can also be attributed to other factors such as farmers' preferences in rice varieties as indicated in Table 23. Input uses by generation of MVs are presented in Appendix 3 and 4.

Crop production and disposal

More than 50% of the sample households in stress-prone areas sell a portion of their rice output in the market. On average, 44% of the total rice output is sold in Nadia and 24% and 23% is sold in Purulia and saline areas in North 24 Parganas, respectively. In Purulia, the relatively low rice allocation to the market can be attributed to the low cropping intensity as most farmers can grow rice during the aman season only. In effect, more than 70% of the rice production is secured by the household for food consumption. A similar pattern is observed in North 24 Parganas, where boro cultivation can be problematic due to high salinity (Table 33).

Different sources of income

Table 34 summarizes the different sources of income[3] of the sample households. Income from crop production is 18% to 58% of the total income. In Nadia, 34% of the income from crop production comes from nonrice crops such as jute, banana, cabbage, and mustard while rice is the only crop grown by the sample farmers in Purulia. Similarly, rice is the only crop grown by the sample farmers in saline areas of North 24 Parganas while, in nonsaline areas, sample farmers are able to grow nonrice crops. On average, 19% of the total income from crop production is derived from nonrice crops such as vegetables, mustard, and sesame in selected nonsaline areas.

Aside from crop production, households derive income from various activities. Other income sources include farm and nonfarm income-generating activities. In Nadia, a portion of the income of the sample households is derived from other farm activities such as selling of animals and animal by-products (2.5%), fish production (0.6%), and farm labor services (2.6%) while nonfarm income also comprises 36% of the total income of the sample households. More than 90% of the income from nonfarm activities is derived mostly from small-scale businesses and salaried jobs.

On the other hand, farm labor services are important sources of income in Purulia District. On average, 31% of the total income of the sample households comes from farm labor services. Sample farmers are able to render labor services during the boro

[3]Income is defined as the gross income derived from crop production (including the value of produce consumed at home), animal sales, and other farm and nonfarm activities.

Table 31. Costs and returns (in US$/ha) of MV rice production by generation during aman season.[a]

Items	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
New generation					
Total returns	709	350	552	568	663
Costs					
Total material input cost	79	87	69	65	77
Total labor cost	257	110	156	205	237
Total power cost	62	48	47	42	57
Total cash cost	303	244	196	170	272
Total noncash cost	96	1	76	141	99
Total costs	398	245	272	311	371
Returns above total costs	311	105	280	256	292
Returns above cash cost	406	106	356	398	391
Old generation					
Total returns	662	450	448	517	495
Costs					
Total material input cost	95	89	44	59	75
Total labor cost	262	130	194	182	174
Total power cost	63	50	41	40	48
Total cash cost	328	221	125	174	209
Total noncash cost	92	48	154	108	89
Total costs	420	269	279	281	297
Returns above total costs	242	181	169	236	198
Returns above cash cost	334	229	323	343	286

[a]Exchange rate used is US$1 = Rs 46.6.

Table 32. Costs and returns (in US$/ha) of MV rice production by generation during boro season.[a]

Items	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
New generation					
Total returns	1,139	–	885	944	1,051
Costs					
Total material input cost	281	–	351	352	309
Total labor cost	267	–	258	212	253
Total power cost	70	–	44	–	49
Total cash cost	503	–	430	429	473
Total noncash cost	115	–	223	135	138
Total costs	618	–	653	564	611
Returns above total costs	521	–	232	380	440
Returns above cash cost	636	–	455	515	578
Old generation					
Total returns	–	–	817	–	817
Costs					
Total material input cost	–	–	379	–	379
Total labor cost	–	–	302	–	302
Total power cost	–	–	38	–	38
Total cash cost	–	–	421	–	421
Total noncash cost	–	–	298	–	298
Total costs	–	–	719	–	719
Returns above total costs	–	–	98	–	98
Returns above cash cost	–	–	396	–	396

[a]Exchange rate used is US$1 = Rs 46.6.

Table 33. Rice output and disposal.

Crop disposal	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Percent of households that sold	85	58	52	38	63
Uses (%)					
Food	55	73	75	67	62
Sold	44	24	23	31	36
Seed	1	3	1	2	2
Payment	0	0	1	0	0
Others	0	0	0	0	0

Table 34. Share (%) of different sources of income.[a]

Income sources	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Farm income					
Crop production	58.0	24.4	26.1	18.2	38.3
Rice	38.1	24.4	26.1	14.9	28.7
Nonrice crops	19.9	0.0	0.0	3.4	9.6
Other farm income	5.8	34.8	21.5	27.1	18.7
Farm labor	2.6	31.2	10.5	5.9	10.7
Sale of animals and by-products	2.5	3.2	0.8	0.2	2.0
Aquaculture/fish production	0.6	0.0	10.3	21.0	5.9
Fruits and forest products	0.0	0.4	0.0	0.0	0.1
Nonfarm income	36.2	40.8	52.4	54.7	43.0
Small-scale business	25.4	5.6	15.6	27.9	20.3
Salary	9.0	23.6	10.3	14.9	13.7
Renting out of assets	0.0	1.2	3.9	0.4	0.8
Remittance	0.1	0.0	0.0	0.2	0.1
Nonfarm labor	1.6	10.5	22.6	11.3	8.0
Total income (Rs/household/year)	109,785	54,460	58,576	107,811	82,479
Income per capita per day (US$)	1.38	0.71	0.69	1.31	1.03

[a]Exchange rate used is $1 = Rs 46.6.

season when none of the farmers in the sample area are able to grow rice. Aside from farm labor, nonfarm labor activities and salaried jobs are other important sources of income in Purulia.

Rice farming accounts for 26% of the total income in saline areas of North 24 Parganas. In addition, households derive income from fishing or aquaculture, which represents 10% of the total income while more than 50% of the income is derived from various nonfarm activities such as operating small-scale businesses, rendering nonfarm labor services, and working in salaried jobs.

Income per capita ranges from Rs 11,700 to 23,000 per year or \$0.70–\$1.40 per day. Per capita income in submergence-prone and nonsaline areas averages at least \$1.30 per day while sample households in drought-prone and saline areas earn less (\$0.70 per capita per day). Income is low in drought and saline areas because most farmers practice monocropping.

Household coping strategies

Households exposed to abiotic stresses make necessary adjustments to cope with stress. Adjustments vary by households depending on the options available to them. Poor households with limited assets are expected to be the most vulnerable group in the event of submergence or drought. Most adjustments reported in the survey are ex post coping mechanisms, which include a decrease in food consumption and an increase in borrowing.

Rice sufficiency. Most households at the study sites grow rice or keep a portion of rice harvest for home consumption. Table 35 shows rice sufficiency of households during normal and stress years. During normal years, 86% of the households are rice sufficient for 12 months at selected sites. However, during stress years, the percentage of households that are rice sufficient for 12 months declines to 47%. The decrease in rice sufficiency is more prominent in Purulia than in Nadia. This is because a majority of the farmers is Purulia grow rice crops only in the aman season while farmers in Nadia can grow two rice crops per year. In terms of rice sufficiency, households in drought-prone areas are considered more vulnerable in the event of abiotic shocks.

Table 35. Rice sufficiency of households (%).

Rice sufficiency (no. of months)	Submergence	Drought	All	Submergence	Drought	All
	Nadia	Purulia		Nadia	Purulia	
	Normal year			Stress year		
0 to 3	0	0	0	0	12	6
4 to 6	1	6	4	5	44	25
7 to 9	3	12	8	6	28	17
10	0	5	3	2	7	5
11	0	0	0	0	1	1
12	96	76	86	87	7	47

The decrease in rice supply among households during stress years has an effect on the frequency of meals eaten by the households per day. Table 36 shows the frequency of meal consumption of households during normal and stress years. Similar to the pattern of rice sufficiency, the change in the number of meals eaten per day is more in Purulia. During normal years, sample households eat 3 meals a day. In the event of drought, 47% of the sample households reduce the frequency of meals to 2 per day. On the other hand, the change in meal consumption of the sample households in Nadia did not vary much.

During stress years, households may opt to decrease food consumption by skipping meals and/or eating less in order to prolong the household's food supply. This kind of adjustment may have an adverse effect on the health and nutrition of the household.

Consumption patterns. Consumption patterns of households between normal and stress years are given in Table 37. According to the results, the percentage of households consuming rice on a regular basis did not change much between normal and stress years while a slight change in fish, meat, and milk consumption was reported during stress years by sample households in Purulia.

Changes in borrowing. Borrowing, in the form of cash or kind, plays an important role in meeting households' consumption deficit. Households borrow cash from formal and informal institutions such as relatives or other social networks. On average, 89% of the sample households reported an increase in cash borrowing during stress years (Table 38). On the other hand, borrowing in the form of food and seed did not change much.

In addition, deferred loan payments were reported by some households at the study sites. In Purulia, 90% of the households claimed to defer on loan payments during stress years while only 42% deferred on loan payments in Nadia.

The incidence of borrowing in the form of cash is high during stress years. Farmers borrow money to meet immediate consumption needs of the household and to purchase inputs for crop production. Reliance on borrowing through banks and informal money lenders during stress years creates the need for a well-developed credit market in these areas.

Aside from borrowing, households reported the use of savings during stress years. The use of savings was reported by 47% of the sample households. Other adjustments made by sample households in Purulia were consumption of seed reserves (81%) and selling of assets (69%).

Other adjustments. Farmers interviewed during the FGD reported that there is no major adjustment in areas devoted to rice in the event of flood or drought. However, the time of occurrence of such a stress is important in farmers' decision on how much rice area to plant. Generally, if drought comes early, farmers delay transplanting or reduce their rice area until enough water becomes available to grow rice crops. Similarly, if flood comes early, farmers may reduce area devoted to rice or delay transplanting if possible. In addition, farmers reported the application of more urea to help rice crops recover after suffering from a stress.

Table 36. Number of meals eaten per day by the household.

No. of meals	Submergence		Drought		All	
	Nadia		Purulia			
	Normal	Stress	Normal	Stress	Normal	Stress
2	0	2	0	47	0	25
3	100	98	100	53	100	75

Table 37. Daily consumption (% of households) of major food items.

Item	Submergence		Drought		All	
	Nadia		Purulia			
	Normal	Stress	Normal	Stress	Normal	Stress
Egg	1	0	1	1	1	1
Fish	0	0	6	1	3	1
Meat	0	0	13	2	7	1
Milk	8	5	9	1	9	3
Pulses	98	100	7	7	53	54
Rice	98	98	100	100	99	99
Vegetables	97	95	100	98	99	97
Wheat	52	58	0	0	26	29

Table 38. Other adjustments in borrowing made by farmers to cope with flood and drought.

Adjustments	Submergence	Drought	All
	Nadia	Purulia	
Change in cash borrowing			
Decreased	–	1	1
Increased	89	90	89
No change	11	9	10
Deferred loan payment			
No	58	10	36
Yes	42	90	64

In addition, various drought mitigation programs are available in the state depending on the severity of drought. Short-term mitigation measures are development programs such as a food for work program, tube-well construction, high priority of water storage projects, transportation of drinking water from other areas, and high priority for drought-resistant crops. On the other hand, medium-term measures include rainwater harvesting and watershed management, early completion of irrigation and water supply projects, regional planning for better use of water, developing early-maturing crop varieties, dry-land farming techniques, and the introduction of water-saving crops.

Awareness of stress-tolerant varieties

Sample households were asked about their awareness of stress-tolerant rice varieties. All sample households have not heard of or planted stress-tolerant rice varieties. However, all respondents are willing to grow these varieties.

Gender division of responsibility and decision-making

Women make up 46% of the total household members of the sample. Men and women are involved in different farm and nonfarm activities and the degree of participation of women in decision-making varies depending on the activity. Table 39 shows the labor participation of women in rice production. Labor participation of men and women varies across sites. In selected submergence-prone areas in Nadia, women's participation in farming activities is very low and close to zero. Nadia is located along the border of Bangladesh, where most women are involved in homestead activities and participation in farming activities is rare. On the other hand, the reverse is observed in selected areas in Purulia and North 24 Parganas (saline area), where more than 60% of the hired labor is provided by women.

Table 40 presents the degree of participation of men and women in various activities. An index is computed to measure the level of empowerment among women in decision-making related to both farm and nonfarm activities. A high index implies high empowerment among women.

According to the results, men dominate in most decision-making pertaining to farming activities. More than 90% of the decisions about what varieties to grow, adoption of new technology, hiring farm labor, marketing of harvested crops, purchasing of farm implements, allocation of income, and borrowing are made by men. Women participate in decisions regarding which food to consume in times of crisis, children's education, and the number of children to raise. On average, more than 60% of the decisions regarding food to consume and children's education are equally participated in by men and women. Moreover, 92% of the decisions about the number of children to raise are made jointly by men and women.

Variations in the degree of women's participation in decision-making are also observed. In nonsaline areas, sample respondents reported the dominance of men in decision-making with regard to food items to consume (72% by men only), children's education (63% by men only), and the number of children to raise (71% by men

Table 39. Labor participation of males and females in rice production.

Labor	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Wet season					
Total labor (person-days per ha)	173	152	140	149	156
% Male labor	99.7	49.7	58.5	78.9	72.1
% Female labor	0.3	50.3	41.5	21.1	27.9
Hired labor (person-days per ha)	90	57	43	70	66
% Male labor	99.6	25	37	58	62
% Female labor	0.4	75	63	42	38
Family labor (person-days per ha)	83	95	97	79	89
% Male labor	99.9	65	68	98	80
% Female labor	0.1	35	32	2	20
Dry season					
Total labor (person-days per ha)	179		183	164	177
% Male labor	99.9		56	84	88
% Female labor	0.1		44	16	12
Hired labor (person-days per ha)	87		43	71	75
% Male labor	100		29	65	85
% Female labor	0		71	35	15
Family labor (person-days per ha)	94		140	92	101
% Male labor	99.8		64	99	90
% Female labor	0.2		36	1	10

Table 40. Division of responsibilities, decision making (%), and Women's Empowerment Index in various agricultural and other livelihood activities.

Decisions	Husband only	Wife only	Both			WEI
			Husband more influential	Both equally influential	Wife more influential	
What rice variety(ies) to grow	95	2	–	–	3	1.16
Who and number of farm laborers to hire	96	2	1	–	1	1.16
Whether to sell/consume harvested crop	94	2	1	–	3	1.31
Quantity of output to sell and consume	95	2	–	–	3	1.28
When and where to sell the harvested crop	97	2	–	–	1	1.35
At what price to sell the output	97	2	–	–	1	1.31
What farm implements to purchase	98	2	–	–	–	1.15
Whether to slaughter and sell animals	78	2	–	–	20	1.57
Adoption of technology in rice production	97	2	–	–	1	1.17
Allocation of farm income	97	2	–	–	1	1.23
Allocation of household income	94	2	–	1	3	1.22
What types of food to consume in times of stress	36	2	–	1	61	2.33
Children's education	32	2	–	1	65	2.48
Where to borrow	92	1	–	–	7	1.35
Participation in voting/politics	69	2	–	–	29	2.28
Number of children to raise	8	–	–	–	92	4.45
Overall						1.67

only). In Nadia, 92% of the sample households reported equal participation of men and women in voting/politics.

Overall, women's participation is found visible only on decisions regarding the type of food to consume, children's education, and the number of children to raise. The general WEI of the sample households is 1.67, which indicates very low empowerment among women in decision-making.

Summary of the findings

- Farming is the main occupation of the households in selected areas in West Bengal. At least 80% of the total number of adults who are employed cited farming as their primary occupation.
- Cropping intensity is lowest in Purulia (100%) due to a lack of irrigation water, causing farmers to practice monocropping. On the other hand, cropping intensity is highest in Nadia, where farmers are able to cultivate crops twice a year.
- In North 24 Parganas, the saline site (116%) has lower cropping intensity than nonsaline areas (149%). This is due to the high salinity, which limits crop production during the boro season.
- MV adoption is very high at the selected survey sites. Most lands regardless of type and season are grown to MVs. During the boro season, the total rice area of the sample households is planted to MVs while 7% to 10% of the rice area is planted to TVs during the aman season.
- Old-generation MVs dominate during the aman season while new-generation MVs occupy most rice areas during the boro season in North 24 Parganas (saline and nonsaline areas). However, new-generation MVs are predominant in Nadia regardless of season.
- The major rice varieties at the submergence site (Nadia) are Ranjit (new) and Swarna (old) during aman and Nayanmoni, Sankar, and Satabdi (new MVs) during boro season. At the drought-prone site (Purulia), old-generation MVs such as Lalat and Swarna are the major aman rice varieties. In selected saline areas in North 24 Parganas, old-generation MVs such as Patnai, Pankaj, and Swarna are the major aman rice varieties. At nonsaline sites, Pankaj and Mahsuri dominate. During the boro season, IR1444 (new) and WGL-20471 (new) are the major rice varieties in both saline and nonsaline areas. The varietal attributes desired by sample farmers include high yield, good taste, and good quality of grains.
- Overall, the yield of MVs (3.07 t/ha) is higher than that of traditional varieties (2.70 t/ha) during the aman season. Similarly, the yield of new-generation MVs is significantly higher than that of old-generation MVs during the aman season, except in Purulia, where very short duration new-generation MVs are grown.
- The yield of MV rice is higher at submergence sites (3.85 t/ha) than at drought sites (2.92 t/ha) during the aman season. In North 24 Parganas, the yield in areas that are nonsaline is higher by 9–11%.
- The effect of salinity is not just a decrease in yield but also a reduction in area. During the boro season, when salinity is higher, the effect on area is greater than the effect on yield.

- Fertilizer rate during the boro season is relatively higher than in the aman season. On average, N-fertilizer use is higher by 40 kg/ha, P-fertilizer is higher by 7 kg/ha, and K-fertilizer is higher by 17 kg/ha during the boro season. However, fertilizer rates in the selected stress-prone environments are very low when compared with the national average.
- MV rice production is profitable even after taking into account noncash costs such as family-owned resources. Among the stress-prone areas, profit is highest in Nadia (submergence) and lowest in Purulia (drought). In general, net returns from boro rice cultivation are higher than in aman rice cultivation due to more favorable climatic conditions coupled with irrigation provision to rice crops during the boro season.
- During aman, the incremental benefit from growing MVs instead of TVs is $90 or 40% while the incremental gains from growing new-generation MVs in place of old-generation MVs is $100 or 37% on average.
- In drought and saline areas, more than 70% of the rice output is consumed while 44% of the rice is sold in Nadia (submergence). In Nadia, 85% of the sample households are rice sellers. Households are able to sell rice because of higher production.
- Rice production contributes 38%, 24%, and 26% to total household income in Nadia, Purulia, and North 24 Parganas, respectively. In Nadia, production of nonrice crops (20%) and operation of a small-scale business (25%) are the other major sources of income. In Purulia, rendering farm labor (31%), nonfarm labor services (11%), and salaried jobs (24%) are the other major sources of income. In North 24 Parganas, sources of income of the household are relatively more diverse.
- The effect on rice sufficiency of abiotic stress is substantial in Purulia. During normal years, 76% of the households claimed to be rice sufficient for the whole year. However, during stress years, the percentage of households declines to 7%. In addition, the number of meals eaten per day by the household decreased in Purulia during stress years.
- Farmers have low awareness of stress-tolerant rice varieties but most households are willing to try these rice varieties.
- In Purulia and North 24 Parganas (saline area), more than 60% of the total hired labor is provided by women while the involvement of women in selected areas in Nadia is very rare.
- Men dominate in most decision-making. Women's participation is visible only on decisions regarding the type of food to consume, children's education, and the number of children to raise. Women's Empowerment Index in decision-making among sample households was low (1.67).

References

Gregory DJ, Haefele SM, RJ Buresh, Singh U. 2010. Fertilizer use, markets and management. In: Pandey S, Byerlee D, Dawe D, Dobermann A, Mohanty S, Rozelle S, Hardy B, editors. Rice in the global economy: strategic research and policy issues for food security. Los Baños (Philippines): International Rice Research Institute. p 231-264.

Ministry of Statistics and Program Implementation. www.mospi.gov.in/.

Statistical Handbook West Bengal. 2007. http://wbplan.gov.in/htm/ReportPub/wbhandbook2007.pdf.

Statistical Handbook West Bengal., 2009. http://wbplan.gov.in/htm/ReportPub/EcoRev09-10/Econ_Review_2009-10.pdf.

Notes

Authors' addresses: B. Bagchi, Nadia Zilla Farmers Development Organization (NZFDO); M. Bool-Emerick, Social Sciences Division, International Rice Research Institute, Los Baños, Philippines.

Appendix 1. History of flood and drought years of West Bengal, India.[a]

Year	Flood	Drought
1971	1	0
1972	0	1
1973	0	0
1974	0	1
1975	0	0
1976	0	0
1977	0	0
1978	1	0
1979	1	1
1980	1	0
1981	1	0
1982	1	1
1983	1	0
1984	1	0
1985	1	0
1986	1	1
1987	1	1
1988	1	0
1989	1	0
1990	1	0
1991	1	0
1992	1	0
1993	1	0
1994	1	0
1995	1	0
1996	1	0
1997	1	0
1998	1	0
1999	1	0
2000	1	0
2001	0	0
2002	1	1
2003	1	0
2004	1	1
2005	1	0
2006	1	0
2007	1	0
2008	1	0
2009	0	1

[a]Flood year or drought year is indicated by 1.
Source: Personal communication with Dr. B. Bagchi.

Appendix 2. Percentage of cost under MV rice production during aman and boro seasons.

Cost	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
Aman season					
Total material input cost	21	33	16	21	24
Total labor cost	64	48	69	65	60
Total power cost	15	19	15	14	16
Total cash cost	77	82	47	60	71
Total noncash cost	23	18	53	40	29
Total costs	100	100	100	100	100
Boro season					
Total material input cost	45		54	62	51
Total labor cost	43		40	38	41
Total power cost	11		7	0	8
Total cash cost	81		65	76	77
Total noncash cost	19		35	24	23
Total costs	100		100	100	100

Appendix 3. Input use in rice production by generation of MV during aman season.

Input use	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
New generation					
Seeds (kg/ha)	61	71	64	69	63
Fertilizer (kg/ha)					
N	60	17	46	31	53
P	21	15	19	9	19
K	15	0	3	6	12
Labor (days/ha)	171	128	137	151	164
Old generation					
Seeds (kg/ha)	61	72	71	69	68
Fertilizer (kg/ha)					
N	59	25	24	25	30
P	22	13	9	8	13
K	12	3	2	5	4
Labor (days/ha)	173	151	137	143	150

Appendix 4. Input use in rice production by generation of MV during boro season.

Input use	Submergence	Drought	Salinity		All
	Nadia	Purulia	North 24 Parganas		
			Saline	Nonsaline	
New generation					
Seeds (kg/ha)	74		76	73	74
Fertilizer (kg/ha)					
N	91		61	44	75
P	27		35	17	26
K	17		12	13	15
Labor (days/ha)	178		178	161	174
Old generation					
Seeds (kg/ha)			74		74
Fertilizer (kg/ha)					
N			37		37
P			39		39
K			8		8
Labor (days/ha)			192		192

Source: STRASA baseline survey, 2008.

Chapter 7

Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas of Chhattisgarh and Orissa

Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas of Chhattisgarh and Orissa

D. Behura, A. Koshta, D. Naik, P. Samal, and M. Malabayabas

Introduction

State background

Orissa and Chhattisgarh are two of the six states in eastern India. Orissa has a total land area of 15.5 million ha and is considered the ninth-largest state in India, with an estimated population of 42 million according to the 2011 Census of India. It is bounded to the north by Jharkhand, to the northeast by West Bengal, to the south by Andhra Pradesh, to the west by Chhattisgarh, and to the east by the coast of the Bay of Bengal. Chhattisgarh, on the other hand, borders Orissa and is one of the youngest states in India. It has a total land area of 13.7 million ha and a population of 26 million according to the 2011 Census of India.[1] Of the total land area, 55% is considered to be cultivated and the rest is forest area (Koshta 2010).

Rice is the major crop in Orissa and Chhattisgarh, accounting for 35% of the gross cropped rice area and 28% of the total rice produced in eastern India.[2] Rainfed rice is also very prominent in these states, with approximately 70% of the estimated rice area under rainfed farming (www.irri.org). These areas are characterized by vulnerability to abiotic stresses such as drought, flood, and salinity, which result in a substantial reduction in rice production and adversely affect the livelihoods of poor farmers. For example, Bhandari et al (2007) estimated that the 2002 drought in India caused a 22% drop in rice production and an overall decrease in agricultural GDP by 5.3%. These abiotic stresses not only affect productivity per se but also induce costly coping mechanisms such as asset sales and even distress migration.

Objectives

This report is an outcome of the baseline socioeconomic survey under Objective 7 (Impact assessment and targeting) of the STRASA project. The objectives of the study are the following:

- To analyze farmers' livelihood systems in the selected drought-prone, submergence-prone, and salinity-affected environments in Orissa and Chhattisgarh.

---

[1]Below the poverty line/level in India and poverty population statistics. India statistics—statistical analysis, data information, and facts about India. www.indiastat.com/table/economy/8/ incidence of poverty/221/348040/data.aspx. Accessed on 14 July 2010.

[2]Eastern India consists of the following states: Assam, West Bengal, Bihar, Jharkand, eastern Uttar Pradesh, Orissa, and Chhattisgarh.

- To analyze the patterns of varietal adoption and the factors that determine the adoption of modern rice varieties.
- To analyze the economics of rice production.
- To document farmers' strategies for coping with different stress situations (drought, submergence, and salinity).
- To understand gender roles in rice production and women's participation in decision-making.
- To serve as a baseline for future impact assessment and for technology targeting.

Organization of the report

This report is organized into six major sections. The first section gives the background of the states and the objectives of the study. This is followed by a short description of the research design and data generation. The third section provides a brief description of the trends in rice production. The fourth section provides a general description of the survey sites and abiotic stresses such as drought, submergence, and salinity using information gathered from focus group discussions and key informant surveys. The fifth section presents a detailed analysis of the farm-level data describing the livelihood of the farmers, the adoption of new-generation modern varieties, economics of rice production, consumption patterns, coping strategies, and gender analysis. The final section summarizes the findings.

Research design and data generation

This research was implemented in partnership with Orissa University of Agriculture and Technology (OUAT), the Central Rice Research Institute (CRRI), and Indira Gandhi Agricultural University (IGAU). Data for this study were collected by combining rapid rural appraisal methods, secondary sources, and specifically designed household surveys.

A survey was carried out for the 2008 rice cropping season under the STRASA project. The prevalence of stress (drought, submergence, and salinity) and the proportion of rainfed rice area were the two major criteria used for the selection of districts and study villages. Household surveys included 608 households covering the representative rainfed districts in Orissa and Chhattisgarh (Table 1). In Orissa, the districts that were included were Jajpur (submergence), Dhenkanal and Bolangir (drought), and Bhadrak and Kendrapara (salinity). Raipur (drought) District was included for Chhattisgarh. Within each district, at least two villages were selected for the detailed household survey covering 50 randomly selected households from each village. Some of these selected surveyed villages were also the sites for "on-farm participatory varietal selection" (PVS). The survey sites and stress situations were characterized by using focus group discussions (FGDs) and key informant surveys (KIS). Detailed information on farmers' livelihoods, socioeconomic features, rice production systems, variety adoption patterns, input use, costs and returns, income structure, farmers' cop-

Table 1. Selected survey sites representing stress-prone rice areas in Chhattisgarh and Orissa.

State	District	Stress	Village	Sample size	Institution
Chhattisgarh	Raipur	Drought	Khairkunt, Saguni, San-kara, Tarpongi	100	IGAU
Orissa	Jajpur	Submergence	Nuagaon Sakuntalapur	100	CRRI
	Dhenkanal	Drought	Kalanga Kankadapal	100	OUAT
Telenpali	Bolangir	Drought	Solbondh	100	OUAT
	Bhadrak	Salinity	Tilanchi	50	OUAT
		Nonsalinity	Bahu[a]	49	OUAT
	Kendrapara	Salinity	Kharnasi	59	OUAT
		Nonsalinity	Sikhar[a]	50	OUAT
	6 Districts		14 villages	608	

[a]Salinity is prevalent year-round. The rice production practices in salinity-affected villages were compared with those in nearby villages that are not affected by salinity. This survey design provides a limited "with" and "without" comparison to assess the effect of salinity.

ing strategies, and gender-disaggregated data on rice farming was collected from the household surveys.

Econometric analyses were carried out using censored regression (tobit) and probit models to identify the major factors determining the probability and the rate of adoption of MVs and new-generation MVs. The basic analytical approach is described in detail in Chapter 2.

Agriculture and trends in rice production

Agriculture is one of the important sectors in the economy of Orissa and Chhattisgarh. It accounts for 15–20% of the total state gross domestic product (SGDP) and employs more than a quarter of its population.[3] For example, in the case of Orissa, agriculture employs 32% of the economically active labor force, which mostly consisted of cultivators and agricultural laborers in 2001 (OAS 2006-07). In addition, during 1993-2008, the SGDP in Orissa and Chhattisgarh grew at 7% and 8% per annum, respectively

[3]Human development, poverty, and public programs. India statistics, statistical analysis, data information, and facts about India.www.indiastat.com/Economy/8/10.HumanDevelopmentPovertyandPublicProgrammes/460549/460551/data.aspx

(www.indiastat.com).[4] The rice sector accounted for 32% to 47% of the total value in agriculture in both states in 2005-06 (www.indiastat.com).

Trends in rice production

Rice is the most dominant crop in Orissa and Chhattisgarh. Figures 1 and 2 show the trends in production, area, and productivity of rough rice in Orissa and Chhattisgarh from 1970 to 2009. A detailed discussion of rice production systems in both states is presented in the following section.

Orissa. Rice in Orissa is grown in winter, autumn, and summer seasons. Winter rice or kharif rice is the dominant crop, accounting for 77% of the total rice produced in the state. In this season, the planting period usually starts in June-August and harvest occurs in December-January. On the other hand, autumn rice, which is also known as prekharif rice, is grown during May-June to September-October. This crop accounts for 11% of the total rice production in the state and is usually grown in rainfed upland areas. The share of autumn rice in the total rice area is highest (above 30%) in the western region comprising Bolangir, Kalahandi, Sambalpur, and Sundargarh. Autumn rice accounts for the lowest share of rice area (less than 10%) in the coastal belt, comprising Balasore, Cuttack, Ganjam, and Puri. In the remaining districts of the central belt, the share of autumn rice in the total rice area is between 10% and 30%. Summer rice, which is also known as rabi rice, accounts for 12% of the total rice produced in the state, with a total area of 0.3 million ha in 2008. The usual planting occurs in December-January and harvest in May-June. This crop is grown mostly in the irrigated areas of Balasore, Bolangir, Puri, Cuttack, Kalahandi, Koraput, and Sambalpur.

Overall, rice in Orissa accounted for 11% and 8% of the total rice area and rough rice production in India during 2009-10, respectively. In 2009-10, rice area in the state reached 4.4 million ha and production of 10.4 million tons of rough rice with an average yield of 2.3 t/ha (www.indiastat.com).[5] Table 2 shows the growth rates of rice area, production, and yield in Orissa from 1974 to 2009. The period 1981-90 showed a significant growth in area, production, and yield. Yield growth was the main source of productivity growth in 1981-90 but was not sustained in the succeeding periods (Pandey et al 2003). In general, the long-term growth rates in yield and production during 1974-2009 were about 1.3% per annum, with the contribution of area growth being negligible.

Figure 3 shows the 10-year moving growth rates of rice area, production, and yield. It shows that yield and production growth rates increased over time until the 10-year period ending in 1991. After this point, growth rates, particularly those of yield and production, started to decline. This decrease was partly caused by consecutive major drought events that were experienced in Orissa during the period (Pandey

---

[4]India statistics—statistical analysis, data information, and facts about India. www.indiastat.com/table/economy/8/byproducts/29938/413517/data.aspx. Accessed on 15 July 2010.

[5]India Statistics—statistical analysis, data information, and facts about India. www.indiastat.com/table/economy/8/orissa/ 12850/385004/data.aspx. Accessed on 12 July 2010.

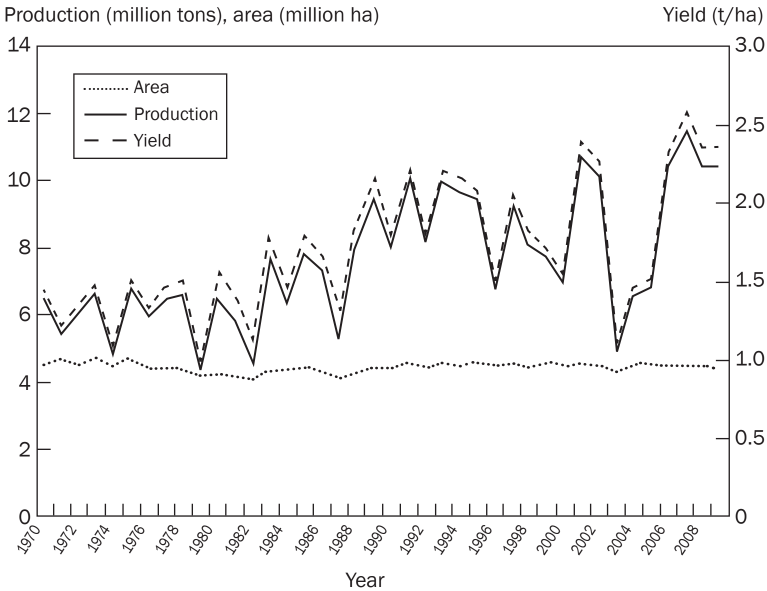


Fig. 1. Trend in area, production, and yield of rough rice in Orissa, 1970-2009. Data source: www.indiastat.com.

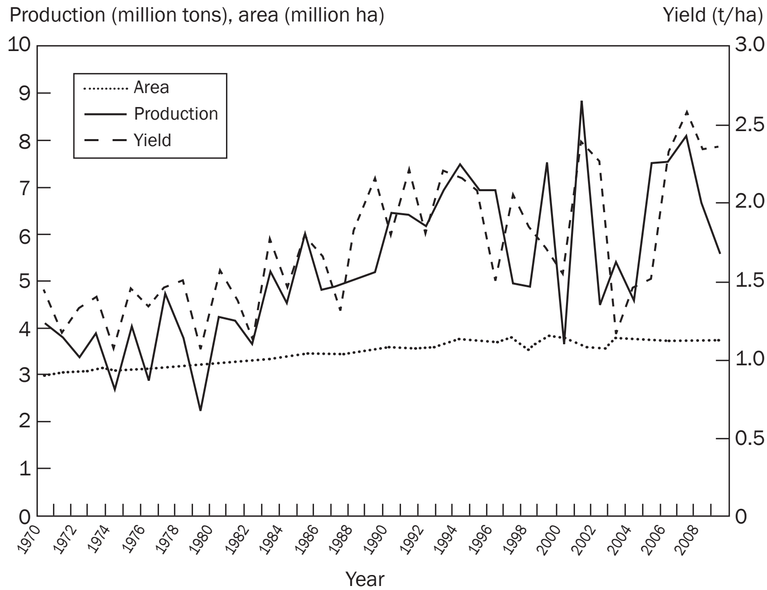


Fig. 2. Trend in area, production, and yield of rough rice in Chhattisgarh, 1970-2009. Data source: www.indiastat.com

Table 2. Growth rates (% per year) of area, yield, and production of rice in Chhattisgarh and Orissa, 1974-2009.[a]

Period	Chhattisgarh			Orissa		
	Area	Yield	Production	Area	Yield	Production
1974-80	0.7***	−0.5	0.2	−1.0***	1.4***	0.4
1981-90	0.8***	3.9***	4.7***	0.3**	3.1***	3.4***
1991-2000	0.7***	−0.4	0.3	0.3**	−1.0	−0.7
2001-09	0.1*	2.2*	2.3**	−0.1*	1.2	1.1
1974-2009	0.6***	1.4***	2.0***	0.06	1.3**	1.3**

[a]***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively.
Data were adjusted using 5-year moving averages of the end point. Growth rates were computed using a semi-log trend equation.
Data source: www.indiastat.com.

et al 2003). The growth rates of yield and production have increased after that, with production growth in the recent decade being about 3% per year.

Chhattisgarh. Rice is mainly produced during the kharif season. The rice area in this state increased slightly from 3.2 million ha in 1981 to 3.7 million ha in 2009 (www.indiastat.com).[6] The main source of irrigation is the Gangrel Dam (through its canals), making it possible for farmers to produce rice more than once a year. However, only 8% of the total rice area is under double cropping (Koshta 2010).

In general, rice in Chhattisgarh accounted for 9% and 4% of the total rice area and rough rice production in India during 2009, respectively. Rice area in the state has reached 3.7 million ha with production of 5.6 million tons of rough rice (www.indiastat.com).[7] Long-term growth rates from 1974 to 2009 show significant growth in area, production, and yield of rice of 0.62%, 1.4%, and 2.0% per annum, respectively (Table 2, Fig. 2). The positive rate of growth in rice in this state may be due to an increase in the use of high-yielding varieties (HYVs) and an expansion of irrigation facilities. It was estimated that the area under HYVs increased substantially from 35% in 1981-83 to 75% in 2005-07 (Koshta 2010). The same is true with irrigated areas, which increased from 21% in 1981-83 to 35% in 2005-07 (Koshta 2010).

Figure 4 shows the 10-year moving growth rates in area, production, and yield during 1970-2009. Results show that growth rates in yield and production increased over time until the 10-year period ending in 1991, after which they started to decline. Although yield and production growth rates were increasing toward the latter part, growth rates are still low and unstable.

[6]India statistics—statistical analysis, data information, and facts about India. www.indiastat.com/table/economy/8/chhatisgarh/332874/332875/data.aspx. Accessed on 12 July 2010.

[7]Chhattisgarh growth statistics details figures. www.chhattisgarhstat.com/table/agriculture/2/hyvp-crops/28982/72700/data.aspx. Accessed on 15 July 2010.

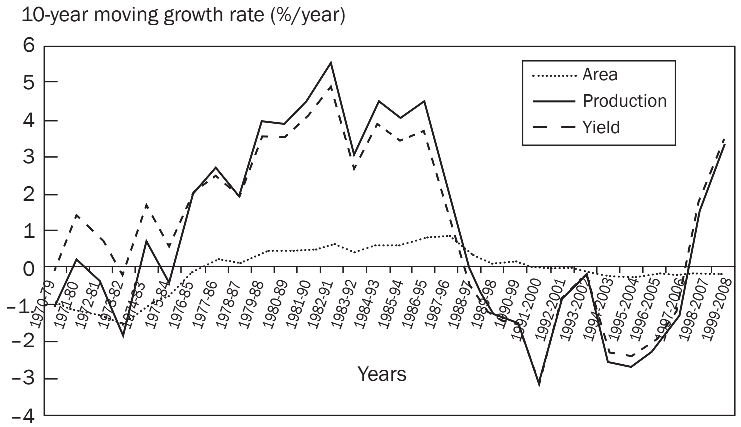


Fig. 3. Ten-year moving growth rates of area, production, and yield of rice in Orissa, 1970-2009.
Data source: www.indiastat.com. (Growth rates for each time segment are based on the original data without smoothing.)

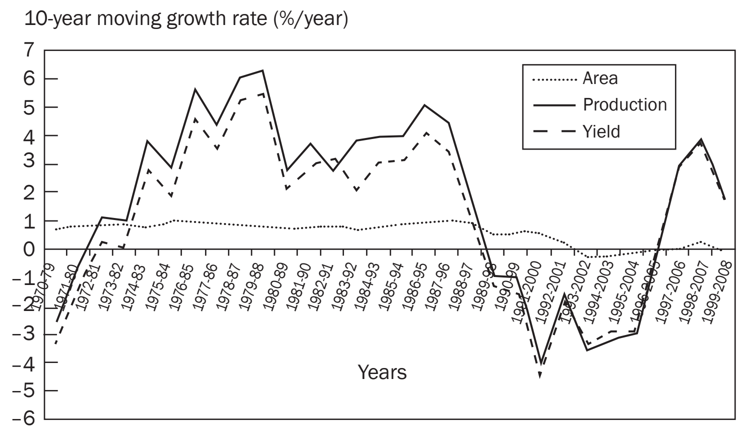


Fig. 4. Ten-year moving growth rates of area, production, and yield of rice in Chhattisgarh, 1970-2009.
Data source: www.indiastat.com. (Growth rates for each time segment are based on the original data without smoothing.)

Rice variety development and releases in Orissa and Chhattisgarh

Modern rice varieties have been released in India since the 1960s. A total of 940 improved varieties were released in India during 1970-2010. A combined total of 157 varieties have been released for Orissa and Chhattisgarh. A substantial majority of these varieties are targeted to rainfed ecosystems.

Site and stress characterization

Description of the survey site

Orissa. The study included five representative villages in Orissa where a prevalence of abiotic stresses such as drought, submergence, and salinity can be observed. These include the following: Jajpur, Bolangir, Dhenkanal, Bhadrak, and Kendrapara.

Bolangir and Dhenkanal districts were selected as representative of drought areas. According to statistics of the Agricultural Department of the government of Orissa, these districts had a total rice area of 0.8 million ha in 2008, with only about one-third of this rice area being under irrigated conditions during the kharif season. Among the rice varieties, Swarna, Lalat, MTU-1001, and Parijat are the popular ones. Also, traditional rice varieties such as Bernagali, Baikani, and Mayurkantha are grown in limited areas. Aside from rice, farmers in Dhenkanal and Bolangir districts grow nonrice crops such as groundnut, sesamum, pigeon pea, green gram, and black gram (in normal years) during kharif (May-December).

Jajpur was selected as representative of a submergence-prone district in Orissa (Fig. 5). The total rice area in this district reached 0.13 million ha during 2008 (Statistics of the Agriculture Department of the government of Orissa). Two representative villages of this district were surveyed for the study: Nuagaon and Sakuntulapur. These villages are considered to be submergence-prone areas and both are situated on the bank of the river sana-Genuti. Average rainfall in these villages is 1,500 mm. The cropping patterns consist of rice-urdbean-mungbean. Modern rice varieties such as Swarna, Parijat, Lalat, and Pooja are commonly grown in these villages. In addition, traditional varieties such as Sarchuna, Banki Sarua, and Betanasia are popular in these areas.

For the salinity area, the districts of Bhadrak and Kendrapara were selected out of seven coastal districts in Orissa. These districts were considered due to the large proportion of rice area affected by coastal salinity (Fig. 5). In Bhadrak District, the villages of Tilanchi and Bahu were included in the survey and represent saline-prone and non-saline-prone environments (control), respectively. These villages are situated within 20°47′N latitude and 86°46′E longitude. On the other hand, in Kendrapara District, the saline village of Kharnasi and non-saline-prone village (control) of Sikhar were selected for the study. These villages are situated within 20°30′N latitude and 86°25′E longitude with an average rainfall of 1,556 mm. Rice is mostly grown in the area during the kharif season that lasts from mid-June up to mid-January. Traditional rice varieties such as Pateni, Raspanjar, and Sula are commonly grown in the area. Yield of these varieties ranges from 2.5 to 3.5 t/ha during a normal season and can drop to 1.2–1.5 t/ha when salinity is very high.

Chhattisgarh. Raipur[8] was selected as a representative drought-prone district in Chhattisgarh (Fig. 6). A total of four villages (Khairkut, Saguni, Sankara, and Tarpongi)

[8]This district serves as an example of a district that is less drought-affected than the selected districts in Orissa. Expansion of irrigation in Raipur in recent years has reduced the impact of drought relative to earlier periods.

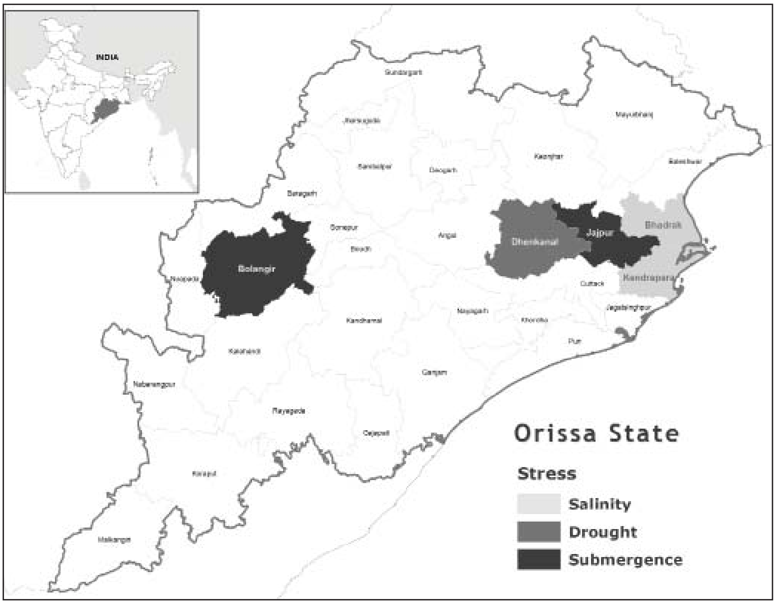


Fig. 5. Location of selected stress-prone districts in Orissa. Map source: GIS, IRRI.

Fig. 6. Location of selected stress-prone districts in Chhattisgarh. Map source: GIS, IRRI.

of Tarpongi block were included in the survey. All of these villages have an average rainfall of 1,000 to 1,100 mm.

Farmers usually grow crops in two seasons: kharif (June-November) and rabi (January-May). Rice is the major crop during the kharif season while wheat, arhar, vegetables, and soybean are grown during the rabi season. A similar cropping pattern was observed during drought years but with relatively fewer crops planted during the rabi season. In all of the villages, modern rice varieties such as MTU-1010, Mahamaya, Tapashwini, and Swarna are commonly grown.

Description of the major abiotic stresses

Flood. During the last ten years, flood occurred six times in the villages of Nuagon and Sakuntalapur, with 2008 being the most recent flood year (Table 3). July to September were the months when the recent flood occurred and it lasted for 11 days, with flood depth reaching 210–215 cm. This high flood depth affected almost all rice-farming households.

Flood usually occurs during both the vegetative and reproductive stages of rice. During normal years, rice is grown during May and harvested in December. However, during a severe flood year, it is not possible to plant rice since flood prevents successful crop establishment. In such situations, farmers forego the rice crop completely and plant crops such as urdbean and mungbean in September-December and January-March, respectively.

Salinity. Coastal salinity is one of the major problems affecting rice production in the coastal parts of India. In Orissa, Bhadrak and Kendrapara are two of the seven districts that are severely affected by coastal salinity (Behura 2010). Salinity usually occurs during the kharif season due to tidal water intrusion that goes directly to rice fields. The saline water infiltrates through creeks, surface channels, and rivers during high tide and cyclonic storms and becomes worse during the dry season. Salinity is a continuous phenomenon at the study sites (Table 3). However, in the last 10 years, Kharnasi (Kendrapara) experienced five major salinity years due to sea-water intrusion, with 2008 being the most severe. On the other hand, Bhadrak District experienced severe salinity problems in 2002. Compared with Kendrapara (which has high incidence of salinity during June to September), Bhadrak experiences salinity during March to June. In 2008, it damaged most of the rice area, affecting more than 1,000 households.

Drought. Drought is a recurrent stress that affects the districts of Raipur and Orissa (Bolangir and Dhenkanal). In the last 20 years, drought occurred 6 to 7 times in these areas. The most recent droughts were in 2005 and 2006 in Orissa and Raipur, respectively (Table 3). Late-season drought is usually experienced in Orissa, and it normally occurs during September and October and lasts for at least 30 days. However, in Chhattisgarh, both early and terminal droughts are common, which usually occur during the early stage and during the maturity stage of crop growth. In the recent stress year, it was estimated that more than 70% of the total rice area and 7–100% of the households were affected in the sample villages. In addition, these districts normally face terminal droughts that affect a long-duration paddy crop, particularly during its

Table 3. Occurrence and characteristics of stress in Chhattisgarh and Orissa, 2008.

Item	Drought			Submergence	Saline	
	Chhattisgarh	Orissa		Orissa	Orissa	
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara
Recent major stress year	2006	2005	2005	2008	2002[a]	2008[a]
Months when stress often occurs	June-October	September-October	September-October	July-September	March-June	April-June, September
Duration (days)	35–45	30	30	11	[a]	[a]
Depth of water (cm)	–	–	–	210–215	–	–
Rice area affected (%)	29–61	82–83	71–92	100	88	81
Households affected (%)	7–90	81–91	95–99	90–99	76	80
Stage of crop growth when stress often occurs	Early (sowing), maturing	Tillering, panicle initiation	Tillering, panicle initiation	Vegetative, reproductive, panicle initiation	Seedling, tillering, panicle initiation	Tillering, panicle initiation

[a]Coastal salinity prevails every year (continuously). However, the years reported here in the table were considered to be the most severe years due to sea-water intrusion. Information of this table is based on focus group discussions and key informant surveys.

flowering stage. The expansion of irrigation in Raipur in recent years, however, has reduced the impact of drought relative to the earlier years.

Farm-level analysis

Socio-demographic characteristics

The characteristics of the farmers interviewed are summarized in Table 4. The average household size ranges from 6 to 7 across locations. Most of the respondents are males and had at least 4 years of schooling. Agriculture is regarded as the major occupation by most of the households. Aside from agriculture, employment in a nonagricultural sector such as company work, service, business, and skilled labor also exists in the districts under study.

Farm characteristics

Landholdings. Raipur has an average farm size of 2.8 ha, which is higher than Orissa's average farm size of only 1.5 ha (Table 5). Saline-affected areas, particularly in Kendrapara (Kharnasi), have an average of two parcels per household, which is smaller than in other villages in the study that range from three to six parcels.

Farm size distribution across locations is positively skewed as shown in Figure 7. Most of the farms are very small (less than 1.5 ha). In addition, farms can be categorized as marginal (less than 1 ha), small (1–2 ha), medium (2–10 ha), and large (more than 10 ha) according to the Ministry of Agriculture in India (www.indiastat.com).[9] Marginal farms are dominant in Jajpur, Dhenkanal, and Kendrapara (Fig. 8). The average farm size under this category ranges from 0.57 ha to 0.72 ha. On the other hand, medium farms are considered to be common in Raipur, with an average of 4.10 ha, while small farms are common in Bolangir and Bhadrak, with an average farm size of 1.46 ha.

Land tenure. Most of the farmers are owner-operators (Table 5). However, in the salinity-affected areas of Bhadrak, renting of land is a common practice and accounts for 42% of the total land. Scarcity of labor is one of the problems in the area, causing most of the large farmers to rent out their land to tenants in adjacent villages. This practice is also common in Raipur, wherein farmers rent out their land in two types of tenurial arrangement: land rented out on a fixed-rent basis (called locally *regha*) and sharecropping (Koshta 2010).

Area irrigated. The proportion of the gross cropped area irrigated in the kharif season is higher than in the rabi season in all of the districts (Table 5). The proportion of irrigated area (51% of the gross cropped area) is higher in the saline-prone areas of Bhadrak. Water from creeks is the main source of irrigation in these areas. However, these creeks are also one of the major sources of salinity in the areas. But, during kharif, rainwater serves as the major source of fresh water in the area, offsetting the effect of saline water. Raipur also has a relatively higher proportion of irrigated area (36%

[9]Operational landholding category. www.indiastat.com/table/agriculture/2/agricultural landholdings/153/496067/data.aspx. Accessed on 14 February 2011.

Table 4. General characteristics of the households in Chhattisgarh and Orissa, 2008.

Household characteristics	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Total number of households	100	100	100	100	50	59	49	50	508
Average household size	7	6	5	6	6	7	7	5	6
Average age of respondents (years)	53	52	45	52	46	48	47	50	49
Years of education of respondents (average)	6	4	5	7	4	5	6	8	5
Gender of respondents (%)									
Female	3	2	2	0	0	5	0	0	1
Male	97	98	98	100	100	95	100	100	99
Primary occupation (%)									
Agriculture	84	70	90	67	85	67	62	54	74
Nonagriculture[a]	16	30	10	33	15	33	38	46	26

[a]Nonagricultural occupations include company work, business, government, house construction, service jobs, and skilled labor.

Table 5. Farm characteristics in Chhattisgarh and Orissa, 2008.

Farm characteristics	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Average farm size (ha)	2.8	1.5	2.1	1.2	2.2	1.3	1.7	1.0	1.5
Average number of parcels per household	3	5	4	5	4	2	5	6	4
Average area of a parcel (ha)	1.1	0.4	0.9	0.4	0.5	0.7	0.3	0.2	0.5
Total area (ha) by tenure									
Owned	95	80	97	84	57	79	54	52	77
Rented-in	5	20	3	13	42	17	41	34	20
Rented-out	0	0	0	3	1	3	5	14	2
Sharecrop	0	0	0	0	0	1	0	0	1
Total	100	100	100	100	100	100	100	100	100
Farm area by land type (%)									
Upland	4	24	43	9	1	0	0	13	18
Medium land	90	35	37	46	11	2	48	48	33
Lowland	7	41	20	45	88	98	52	39	49
Total	100	100	100	100	100	100	100	100	100
Area irrigated by season (%)									
Wet season	36	3	0	19	51	5	68	60	22
Dry season	21	0	0	14	1	1	1	33	5

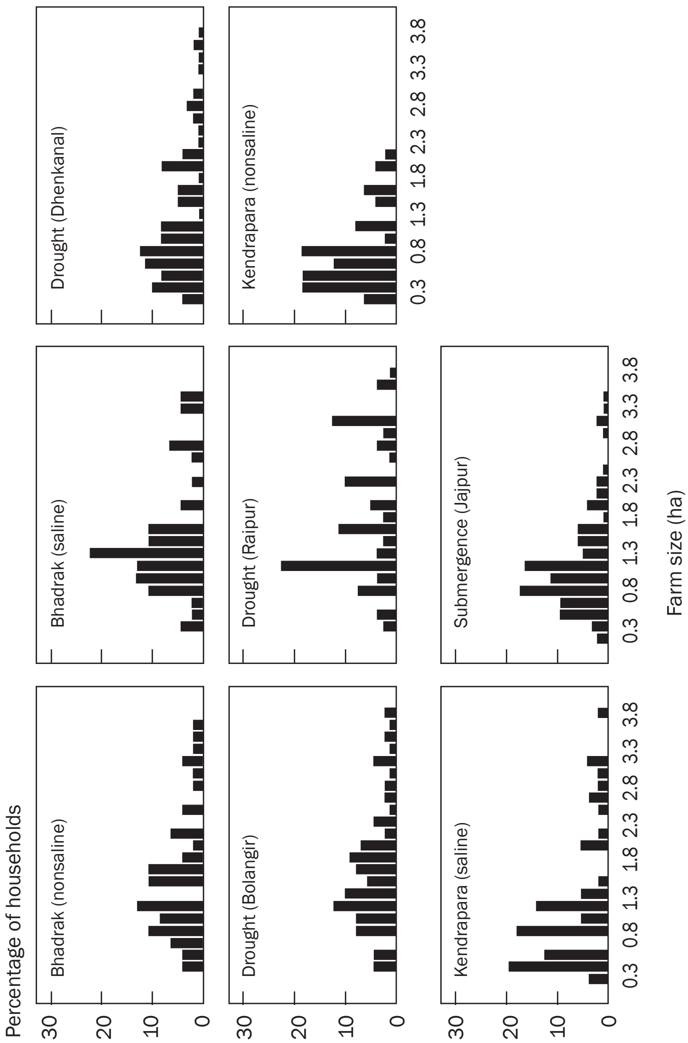


Fig. 7. Farm size distribution in the districts of Chhattisgarh and Orissa, 2008.

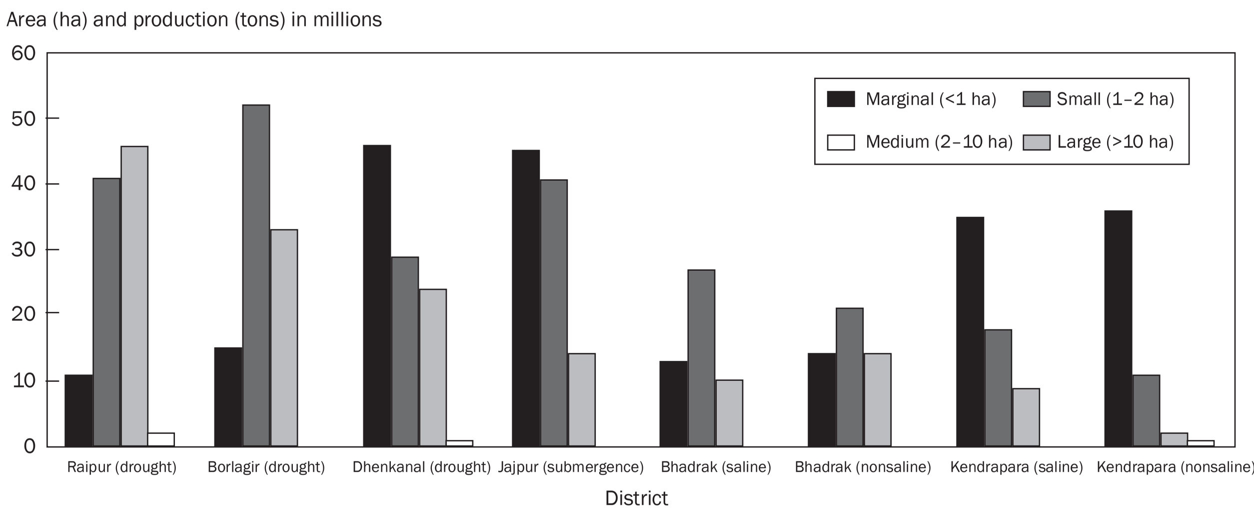


Fig. 8. Operational size of landholdings of farmers (%) in Chhattisgarh and Orissa, 2008.

and 21% of the total area during kharif and rabi seasons, respectively). Tube wells are the major source of supplemental irrigation in most of the villages. In Bolangir, rice production is mainly rainfed, with irrigated area being very small.

Characteristics of the rice-based cropping system

Cropping system. Rice is the major crop that accounts for the lion's share of the gross cropped area during kharif (Table 6). The major cropping pattern consists of rice-pulses except in nonsaline areas of Bhadrak, in which farmers grow rice only in kharif. Rice is also planted during rabi in Raipur and Kendrapara but only in small areas.

Cropping intensity. A cropping intensity index measures the intensity of land use and this can be measured as the ratio of gross cropped area to net cropped area. Cropping intensity in most of the villages ranges from 100% to 160% except in saline areas of Kendrapara, which have a cropping intensity of 95% (Table 6). This low crop intensity in the area can be explained by the fact that farmers in saline areas mostly plant rice during the kharif season, when there is an abundant supply of water. Lands are usually kept fallow while only small areas are planted to rice and some pulses during the rabi season due to a lack of fresh water for irrigation.

Patterns of rice varietal adoption

Adoption of modern varieties (MVs). Farmers can be classified as growers of MVs only, growers of TVs only, or growers of both types of varieties (or partial adopters of MVs). A high proportion of farmers in the study adopted MVs only in drought-prone areas of Raipur and Bolangir (Table 7). Farmers in the saline areas mostly grow TVs only due to constraints of salinity. However, many farmers grow both MVs and TVs, particularly in submergence-prone areas of Jajpur. Stress-tolerant varieties, particularly flood-tolerant varieties, just started to spread in 2008 and are not yet widely available to farmers.

Rice area by variety type. Modern rice varieties cover almost all of the rice areas in all districts except in saline-prone areas and drought-prone areas of Dhenkanal in Orissa, wherein TVs covered 90–97% and 59% of the total rice area, respectively (Table 8). In the case of saline areas, particularly in parcels that are affected by salinity, farmers mostly grow TVs because the MVs that are available are not adapted to the amount of salinity in the area. In addition, these areas consist mostly of lowland fields that are very vulnerable to salt-water intrusion (Table 9). On the other hand, in the drought-prone areas of Dhenkanal, the dominance of TVs can be associated with their crop duration and the timing of the monsoon season. This district is basically characterized by a large lowland rice area and dependence on monsoon.

Method of establishment. Transplanting (TPR) and direct seeding (DSR) for rice are both practiced in the study area (Table 10). DSR is the common practice in drought- and submergence-prone areas while TPR is common in salinity-affected areas. TPR is common in saline areas since seedlings at the germination stage are very sensitive to salinity.

On the other hand, DSR is practiced in submergence-prone areas of Jajpur and drought-prone areas of Dhenkanal and Raipur. In drought-prone areas of Dhenkanal,

Table 6. Share of rice and nonrice crop area in the gross cropped area by season and overall cropping intensity in Chhattisgarh and Orissa, 2008.

Season and crop	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Kharif									
Rice	100	90	66	98	100	100	100	100	89
Nonrice crops[a]	0	10	34	2	0	0	0	0	11
Total	100	100	100	100	100	100	100	100	100
Rabi									
Rice	33	0	0	0	0	100	0	4	1
Nonrice crops	67	100	100	100	100	0	0	96	99
Total	100	100	100	100	100	100	0	100	100
Cropping intensity (%)	140	114	113	160	100	95	97	138	117

[a]Major nonrice crops include cotton, chili, black gram, bengal gram, green gram, groundnut, horse gram, lathyrus, and vegetables.

Table 7. Types of rice grown by sample farmers (% of farmers) in Chhattisgarh and Orissa, 2008.

Type of rice	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Modern varieties only	99	26	66	13	0	0	14	98	32
Traditional varieties only	0	2	4	7	68	92	10	0	21
Both varieties	1	72	30	80	32	8	76	2	47
Total	100	100	100	100	100	100	100	100	100

Table 8. Percentage of rice area by variety type (%) in Chhattisgarh and Orissa, 2008.

Variety type	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Modern	99	41	89	51	10	3	47	100	48
Traditional	1	59	11	49	90	97	53	0	52
Total	100	100	100	100	100	100	100	100	100

Table 9. Percentage of rice area by land type (%) in Chhattisgarh and Orissa, 2008.

Item	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
By land type									
Upland	3	6	9	7	0	0	0	16	5
Medium land	91	42	60	47	11	2	52	51	39
Lowland	6	52	31	46	89	98	48	33	56

Table 10. Percentage rice area by crop establishment method in Chhattisgarh and Orissa, 2008.

Crop establishment method	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Dry direct seeding	62	65	48	85	1	0	23	7	40
Transplanting	38	35	52	15	99	100	77	93	60
Total	100	100	100	100	100	100	100	100	100

farmers usually begin direct seeding by taking advantage of the moisture brought by the early rains. In Jajpur, farmers practice DSR ahead of the rains to prevent damage due to possible early submergence. Another reason why farmers practice DSR particularly in Raipur is the limited availability of labor and higher wage rate in the area since DSR requires less labor than TPR.

Major rice varieties. A total of 103 rice varieties were recorded during the survey. A majority (63%) of the total number of varieties consisted of traditional varieties (TVs). The popular TVs are the following: Pateni and Raspanjar (saline); Bergahali and Sarchunamali (drought-prone Orissa); Jangalijhata and Rajmali (submergence-prone Orissa); and Safri (drought-prone Chhattisgarh).

In terms of MVs, farmers allocate a large proportion of MV area to old-generation varieties[10] (varieties released before 1990) in Chhattisgarh and Orissa during kharif (Table 11). These constitute 45% to 88% of the total MV area. This finding is similar to that of Janaiah et al (2006) that MVs that were released in the early 1980s are still popular among farmers in India, which indicates slow varietal replacement. Among the old-generation MVs, Swarna, which was released in 1982, occupies 15% to 59% of the total MV rice area. There are also other old-generation MVs in drought-prone areas of Dhenkanal and Bolangir, where Lalat is the second most popular old-generation variety.

In terms of new-generation MVs (varieties released after 1990), Mahamaya occupies 25% of the total MV area in Raipur. On the other hand, Khandagiri was mainly adopted in Jajpur. This short-duration variety was released in 1992 and is suited for the rainfed upland ecosystem. In the drought-prone areas of Bolangir and Dhenkanal, MTU-1010 is a popular new-generation MV.

The extent of adoption of MVs by generation varies depending on the land type (Table 12). Generally, old-generation MVs are dominant in lowland and medium land, with the new-generations MVs being dominant in uplands. The exception is in saline-prone areas, where new-generation MVs are equally as important as old-generation MVs. However, the adoption of MVs in general (old- plus new-generation MVs combined) is very low in saline-prone areas.

The major characteristics of the dominant new- and old-generation MVs are presented in Table 13. Swarna is the most adopted old-generation MV that was released in 1982 in the state of Andhra Pradesh. This variety is recommended for the rainfed shallow lowland ecosystem and is adapted to the rainfed areas of Orissa and Chhattisgarh. Popular new-generation MVs that were adopted by farmers include Mahamaya, MTU-1010, and MTU-1001, which mostly also originated in Andhra Pradesh. These varieties are of shorter to medium duration. However, most of these new-generation MVs are recommended only for the irrigated ecosystem and are not grown widely under purely rainfed conditions.

[10]In the analysis, varieties released before 1990 were considered as old-generation MVs while those released after 1990 were considered as new-generation MVs. For details of this classification, see Chapter 2.

Table 11. Adoption of modern rice varieties (% total MV area) during kharif in Chhattisgarh and Orissa, 2008.

Varieties	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Old-generation MVs[a]	61	88	79	61	54		45	47	68
Swarna	59	49	57	37	48		45	15	45
Parijat								17	0
Gayatri				18				14	6
Lalat		28	20		6				12
Sona Masuri	2								
Others		11	2	6				1	5
New-generation MVs[a]	39	12	21	39	46	100	55	53	32
Jarawa						67			0
Khandagiri		2	4	12					4
Lunishree (SR-26B)						33			0
MTU-1001					36		55		8
MTU-1010	12	6	7						4
Pooja				8				35	7
Sarala								17	2
Saria			4						2
Mahamaya	25								0
Durga				11					2
Swarna-Sub1				4					1
Mahalakshmi		4	6	4	10				0
Others	2							1	2

[a]Varieties released before 1990 are considered here as old-generation MVs and those released during 1990 and onward are considered as new-generation MVs.

Table 12. Adoption of modern rice varieties (% total MV area) by generation and land type during kharif in Chhattisgarh and Orissa, 2008.

Varieties	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Upland									
New generation	71	54	97	91	0	0	0	0	65
Old generation	29	46	3	9	0	0	0	100	35
Total	100	100	100	100	0	0	0	100	100
Medium land									
New generation	37	5	18	24	43	100	55	68	30
Old generation	63	95	82	76	57	0	45	32	70
Total	100	100	100	100	100	100	100	100	100
Lowland									
New generation	58	18	9	40	62	100	50	57	28
Old generation	42	82	91	60	38	0	50	43	72
Total	100	100	100	100	100	100	100	100	100

Table 13. Information on the major modern rice varieties in Orissa and Chhattisgarh, 2008.

Rice variety	Year of release	Ecosystem	State/committee release	Duration (days)	Grain type
Old-generation MVs					
Swarna	1982	Rainfed shallow lowland	Andhra Pradesh	125	Medium slender
Gayatri	1988	Rainfed shallow lowland	Orissa	125	Small bold
Lalat	1988	Irrigated medium land	Orissa	95	Long slender
Parijat	1976	Rainfed upland	Orissa	70	Medium slender
New-generation MVs					
Khandagiri	1992	Rainfed upland	Orissa	70	Medium slender
Mahamaya	1995	Irrigated medium land	Central Variety Release Committee (CRVC)	101	Long bold
MTU-1001	1995	Irrigated medium land	Andhra Pradesh	110	Medium slender
Pooja	1999	Rainfed shallow lowland	Central Variety Release Committee (CRVC)	115	Medium slender
MTU-1010	2000	Irrigated medium land	Andhra Pradesh	90	Long slender
Sarala	2000	Waterlogged situation	Orissa	135	Medium slender

Sources: http://dacnet.nic.in/rice/Rice%20Varieties%20-%2009.htm and Rhani et al (2010).

Yield effects

Rice yield by land type and season. The average yield across the districts varies from 1.0 to 4.0 t/ha during kharif (Table 14). Among the districts, Raipur has average yield of 3.2 t/ha, which is higher than the state (Chhattisgarh) average of 1.7 t/ha (www.indiastat.com). Overall, the difference between the yields of MVs and TVs in Chhattisgarh and Orissa is 0.4 t/ha and 0.6 t/ha, respectively.

Yields of MVs and TVs differ significantly in all land types in Orissa, particularly in medium lands, wherein the estimated average yield of MVs is 1.3 t/ha higher than that of TVs (Table 15). Among the varieties, Swarna covers a majority of the medium land, reaching 49% of the total MV area (Appendix 1).

Yield effects of MVs by generation. New-generation MVs are performing well, particularly on medium lands of Orissa. New-generation MVs on medium land showed a significantly higher yield than old MVs by 1.3 t/ha (Table 16). The common new-generation MVs that can be found on medium lands are MTU-1010, MTU-1001, and Pooja (Table 17). These varieties recorded an average yield of 1.5 to 3.9 t/ha.

In general, Swarna is the major rice variety in all of the areas covering most of the total area under modern varieties (Table 17). However, aside from Swarna, there are other important MVs, which vary depending on the location. In Raipur District, Mahamaya is widely grown, having an average yield of 3.0 t/ha. On the other hand, Khandagari, Gayatri, and Durga are considered to be important MVs in submergence areas, covering 41% of the total MV area. In drought-prone areas of Orissa, Lalat is an important MV that has an average yield of 0.9 to 1.4 t/ha.

Reasons for growing dominant rice variety Swarna

A large area is being allocated to Swarna in most of the drought and submergence areas. Table 18 shows the reasons why farmers prefer this variety. In all of the districts, farmers highly preferred this variety for the following reasons: high yield, resistance to lodging, good taste of the cooked rice, bold grains, and good market price. In addition, farmers in Dhenkanal found Swarna to have a high market demand.

On the other hand, farmers also enumerated the following major undesirable traits of Swarna: susceptible to lodging, susceptible to pests, and poor grain quality. In addition, farmers considered this variety to not be flood resistant in submergence-prone areas.

Adoption of varieties: an econometric analysis

Descriptive summary statistics. The factors determining cross-sectional variations in the incidence and intensity of adoption of improved varieties were analyzed using probit and tobit models. Two types of comparison were made. The first analysis involved the identification of the factors that determine the adoption of improved varieties relative to traditional varieties. The second analysis involved the identification of the factors that determine the adoption of new-generation improved varieties relative to old-generation improved varieties. Chapter 2 (methodology) provides a full discussion of the approaches used.

Table 14. Rice yield (t/ha) by land type and by variety type during kharif in Chhattisgarh and Orissa, 2008.[a]

	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Overall	3.2	1.7	1.1	1.0	2.1	1.5	3.4	4.0	2.0
	(0.7)	(0.8)	(0.6)	(0.8)	(0.7)	(0.5)	(1.1)	(1.2)	(1.4)
By land type									
Upland	3.1	0.7	0.6	1.2	0	0	0	3.0	1.1
	(0.6)	(0.6)	(0.4)	(1.1)				(1.2)	(1.1)
Medium land	3.2	1.3	1.1	1.1	2.7	1.6	3.9	4.1	2.2
	(0.7)	(0.6)	(0.6)	(0.8)	(1.3)	(0.6)	(1.0)	(1.1)	(1.6)
Lowland	3.1	2.1	1.4	0.9	2.0	1.5	2.6	3.9	2.0
	(0.7)	(0.7)	(0.7)	(0.7)	(0.5)	(0.5)	(0.7)	(1.2)	(1.1)
By variety type									
MVs	3.2	1.6	1.1	1.0	3.4	2.8	4.1	4.0	2.3
	(0.7)	(0.7)	(0.6)	(0.9)	(0.8)	(1.1)	(0.9)	(1.2)	(1.6)
TVs	2.8	1.8	0.8	1.0	2.0	1.5	2.6		1.7
	(0.4)	(0.9)	(0.4)	(0.7)	(0.5)	(0.4)	(0.7)		(0.8)
Difference	0.4**	−0.2	0.3	0	1.4	1.3	1.5	4.0	0.6**

[a]** indicates statistical significance at 5%.
Standard deviation is in parentheses. Uplands refer to upper fields.

Table 15. Rice yield (t/ha) by variety for each land type during kharif in Chhattisgarh and Orissa, 2008.[a]

	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Upland									
MVs	3.1	1.0	0.6	1.2	0	0	0	3.0	1.3
	(0.6)	(0.7)	(0.4)	(1.1)				(1.2)	(1.2)
TVs	0	0.4	0.5	0	0	0	0	0	0.4
		(0.3)	(0.4)						(0.3)
Difference	–	0.6	0.1	–	0	0	0	–	0.9
Medium land									
MVs	3.2	1.5	1.1	1.1	3.5	2.0	4.1	4.1	2.5
	(0.7)	(0.7)	(0.6)	(0.9)	(0.8)		(0.8)	(1.1)	(1.7)
TVs	3.0	1.0	0.8	1.0	1.3	1.1	2.5	0	1.2
		(0.4)	(0.3)	(0.8)	(0.6)		(0.8)		(0.8)
Difference	0.2	0.5**	0.3**	0.1	2.2	0.9	1.6***	–	1.3**
Lowland									
MVs	3.1	1.8	1.4	0.7	2.7	3.5	3.1	4.0	2.2
	(0.7)	(0.7)	(0.7)	(0.7)	(0.8)		(1.5)	(1.2)	(1.6)
TVs	2.5	2.2	1.2	1.0	2.0	1.5	2.6	0	1.9
		(0.6)	(0.4)	(0.6)	(0.5)	(0.4)	(0.6)		(0.8)
Difference	0.6	−0.4*	0.2	-0.3	0.7	2.0	0.5		0.3

[a]***, **, and * indicate statistical significance at 1%, 5%, and, 10%, respectively.
Standard deviation is in parentheses. Uplands refer to upper fields.

Table 16. Rice yield (t/ha) by generation for each land type during kharif in Chhattisgarh and Orissa, 2008.[a]

Factor	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Upland									
New generation	3.1	1.3	0.6	1.3	0	0	0	0	1.0
	(0.7)	(0.5)	(0.4)	(1.2)					(1.0)
Old generation	3.2	0.7	0.9	0.6	0	0	0	3.0	1.8
	(0.03)	(0.7)	(0.2)	(0.3)				(1.2)	(1.5)
Difference	−0.1	0.6	−0.3	0.7	0	0	0	–	−0.8
Medium land									
New generation	3.0	1.1	1.2	1.1	3.2	2.0	4.0	4.1	3.4
	(0.7)	(0.7)	(0.5)	(1.0)	(0.8)		(0.8)	(1.1)	(1.5)
Old generation	3.4	1.5	1.1	1.1	3.6		4.3	4.0	2.1
	(0.7)	(0.7)	(0.6)	(0.9)	(0.8)		(0.8)	(1.2)	(1.5)
Difference	−0.4	−0.4	0.1	0	−0.4		-0.3	0.1	1.3**
Lowland									
New generation	3.2	2.0	1.2	0.6	2.5	3.5	3.8	3.9	2.4
	(0.8)	(0.7)	(0.6)	(0.8)	(1.0)	(1.2)	(2.7)	(1.3)	(1.8)
Old generation	3.2	1.7	1.5	0.8	3.2		2.8	4.1	2.0
	(0.5)	(0.7)	(0.7)	(0.7)			(1.2)	(1.1)	(1.4)
Difference	0	0.3	−0.3	−0.2	−0.7		1.0	−0.2	0.4

[a]** indicates statistical significance at 5%.
Standard deviation is in parentheses. Uplands refer to upper fields.

Table 17. Percentage of MV area and yield of major MVs by generation during kharif in Chhattisgarh and Orissa, 2008.

Varieties	Drought						Submergence		Saline				Nonsaline				All Orissa	
	Chhattisgarh		Orissa				Orissa		Orissa				Orissa					
	Raipur		Dhenkanal		Bolangir		Jajpur		Bhadrak		Kendrapara		Bhadrak		Kendrapara			
	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield
Old-generation MVs																		
Gayatri							18	0.8	6	3.2					14	4.1	6	2.6
Lalat			28	1.4	20	0.9											12	1.2
Swarna	59	3.4	49	1.7	57	1.4	37	1.1	48	3.6			45	4.2	15	4.1	44	2.3
Parijat															17	3.0	3	2.0
New-generation MVs																		
Durga							11	0.6									2	0.6
Jarawa											67	2.0					0	2.0
Mahamaya	25	3.0																
Khandagiri			2	1.6	4	0.8	12	1.2									4	1.1
MTU-1001									36	3.2							8	3.9
MTU-1010	12	2.9	6	1.8	7	1.3							55	4.0			4	1.5
Sarala															17	4.1	2	4.0
Pooja							8	0.7							35	4.0	7	3.6

Table 18. Farmer preferences (% of households) and reasons for growing Swarna in Orissa and Chhattisgarh, 2008.[a]

Traits	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Desirable traits									
High yield	88	49	57	76	68		69	54	50
Resistance to lodging		28	37	76	62		63	50	40
Good taste	88	49	55	76	22		69	52	49
Good grain type	88	19	19	74	22		65	50	35
Good market price	88	36	35	76	17		65	52	42
Others									
Good tillering		12							2
High market demand		32							7
Good for perched rice					4				0.3
Undesirable traits									
Low yield									
Susceptible to lodging	88								
Susceptible to pests and diseases	88	44	53	76	22		69	52	48
Poor grain		1		2					
Others									
Not resistant to flood				74					
Not resistant to drought		24	17						8
High fertilizer requirement		14	8						6
Short straw		21	32						6

[a]Households were allowed to provide multiple answers. Each value represents the percentage of households reporting each characteristic.

The descriptive statistics of some of the major variables are presented in Tables 19 and 20. Information in Table 19 pertains to the analysis of the adoption of MVs in general relative to TVs. On the other hand, information in Table 20 pertains to the analysis of new-generation MVs relative to old-generation MVs. Slight differences in the mean values of the explanatory variables between these tables are due to the differences in the number of observations used in each of the analyses.

Results. The results of the probit and tobit estimations (Table 21) for modern varieties indicate that land type (lowland), presence of saline areas, and years of education are the major factors affecting the adoption of MVs. The coefficients associated with lowlands were found to be negative and statistically significant in both analyses. This suggests that the probability (as indicated in the probit results) of adopting MVs in lowland fields is lower than in other field types. Similarly, the intensity of adoption of MVs is lower for farmers who have proportionately larger area under lowlands. These results from probit and tobit models are consistent with each other. Traditional varieties (TVs) are planted in the lowlands of Orissa due to their adaptability to lowland conditions while MVs are planted mainly in upper portions of the fields. The same is true with salinity, suggesting that the probability and the extent of adoption of MVs are relatively lower in saline fields.

In terms of the household-level variables, education was found to significantly affect the adoption of MVs. This is expected since most of the earlier studies on adoption have shown that education helps farmers to learn and acquire new technologies faster. The effect of farm size was found to be negative (and weakly significant in the probit) but the coefficient was not significant in the tobit model. Overall, the effect of farm size on the adoption of MVs seems inconclusive. The district dummies also showed significant coefficients, indicating that location effects are strong.

In terms of the choice between new-generation and old-generation MVs, the results again show the importance of land type. The negative coefficients associated with lowland and medium land types in the probit model imply that new-generation MVs are grown mostly in upper fields (Table 22). Most old-generation MVs are of long duration and are more suited to lowland (or medium land) types. On the other hand, several newer generation varieties are of medium duration, making them more suited to upper field types. Thus, the adoption of new-generation MVs is also governed mainly by field type. In addition, the coefficients associated with location dummies are statistically significant, indicating the importance of location-specific factors in determining the adoption of new-generation MVs.

Economics of rice production and household economy

Input use in rice production.

- Rice seed

  The average use of seeds in Raipur is 120 kg/ha, which is relatively higher than in other districts (Table 23). High seed use per hectare can be attributed partly

Table 19. Definitions of variables and summary statistics for MV/TV adoption analysis.

Variable name	Variable definition	Modern/traditional varieties (MVs/TVs)	
		Mean	Standard deviation
Total number of plots (plot level N = 1,988)			
Number of plots with MVs (plot level N = 1,074)	Grow MV at the plot level (yes = 1; otherwise = 0)	54[a]	
Percentage area under MVs (%) (N = 508)	Share of MV area in the total rice area	52	40
Explanatory variables			
Farm size	Cultivated area of the farm (in ha)	1.6	1.4
Adult household size	Household members above 15 years old (number)	4	2
Age	Age of household head (in years)	49	11
Education	Education of household head (in years)	5	4
Share of lowland	Proportion of rice area under lowland (%)	53	36
Share of saline area	Proportion of rice area under saline conditions (%)	20	39
Dummy variables[a]			
Lowland	Lowland land type (lowland = 1, 0 otherwise)	48	
Medium land	Medium land type (medium land = 1, 0 otherwise)	35	
Bolangir	Bolangir District (Bolangir = 1, 0 otherwise)	12	
Dhenkanal	Dhenkanal District (Dhenkanal = 1, 0 otherwise)	22	
Jajpur	Jajpur District (Jajpur = 1, 0 otherwise)	22	
Bhadrak	Bhadrak District (Bhadrak = 1, 0 otherwise)	23	
Kendrapara	Kendrapara District (Kendrapara = 1, 0 otherwise)	20	
Saline	Saline parcel (saline = 1, 0 otherwise)	14	

[a] Mean (proportion) of the variables, during kharif season.

Table 20. Definitions of variables and summary statistics for new-/old-generation MV adoption analysis.

Variable name	Variable definition	New-/old-generation varieties (new/old)	
		Mean	Standard deviation
Total number of plots (plot-level N = 1,353)			
Number of plots with new MVs (plot-level N = 541)	Grow new MVs at the plot level (yes = 1; otherwise = 0)	40[a]	
Percentage area under new MVs (%) (N = 492)	Share of new MV area in total MV area	34	35
Explanatory variables			
Farm size	Cultivated area of the farm (in ha)	1.8	1.7
Adult household size	Household members above 15 years old (number)	4	2
Age	Age of the household head (in years)	50	12
Education	Education of the household head (in years)	6	4
Share of lowland	Proportion of rice area under lowland (%)	35	32
Share of saline area	Proportion of rice area under saline conditions (%)	3	14
Dummy variables[a]			
Lowland	Lowland land type (lowland = 1, 0 otherwise)	23	
Medium land	Medium land type (medium land = 1, 0 otherwise)	61	
Bolangir	Bolangir District (Bolangir = 1, 0 otherwise)	15	
Dhenkanal	Dhenkanal District (Dhenkanal = 1, 0 otherwise)	15	
Jajpur	Jajpur District (Jajpur = 1, 0 otherwise)	17	
Bhadrak	Bhadrak District (Bhadrak = 1, 0 otherwise)	12	
Kendrapara	Kendrapara District (Kendrapara = 1, 0 otherwise)	20	
Saline	Saline parcel (saline = 1, 0 otherwise)	0.14	

[a]Mean (proportion) of the variables, during kharif season.

Table 21. Factors determining the adoption of modern varieties using probit and tobit in Orissa, 2008.

Factor	Probit[h]		Tobit[i]	
	Coefficient	Marginal probability	Coefficient	Elasticity
Intercept	0.016		59.63	
Age (years)	−0.002	−0.0007	−0.03	−0.02
Education (years)	0.04***	0.02	2.27***	0.18
Adult household size (number of members)	0.02	0.01	0.23	0.01
Farm size (ha)	−0.05*	−0.02	−0.35	−0.008
Share of lowland (%)			−0.48***	−0.38
Share of saline area (%)			−1.36***	−0.41
Dummy for lowland[a]	−0.51***	−0.20		
Dummy for medium land[b]	0.69***	0.27		
Dummy for Bolangir[c]	0.86***	0.32	66.90***	0.20
Dummy for Dhenkanal[d]	−0.32***	−0.13	1.61	−0.004
Dummy for Bhadrak[e]	−0.35***	−0.14	23.31***	0.07
Dummy for Kendrapara[f]	1.94***	0.60	74.75***	0.24
Dummy salinity[g]	−3.91***	−0.70		
Likelihood ratio $\chi 2$	−831.38***			
Log pseudolikelihood			−1,333.91***	

*** and * indicate statistical significance at 1% and 10%, respectively. [a]1 if lowland and 0 otherwise. [b]1 if medium land and 0 otherwise. [c]1 if Bolangir and 0 otherwise. [d]1 if Dhenkanal and 0 otherwise. [e]1 if Bhadrak and 0 otherwise. [f]1 Kendrapara and 0 otherwise. [g]1 if the parcel is saline and 0 otherwise. [h]1 if MV and 0 otherwise. [i]Share of MV area in total rice area.
Raipur is not included since all parcels were planted with MVs.

Table 22. Factors determining the adoption of new-generation modern varieties using probit and tobit models in Chhattisgarh and Orissa, 2008.

Factor	Probit[h]		Tobit[i]	
	Coefficient	Marginal probability	Coefficient	Elasticity
Intercept	0.21		16.48	
Age (years)	0.003	0.001	0.35	0.31
Education (years)	−0.004	−0.002	0.03	0.003
Adult household size (number of members)	−0.02	−0.007	−0.72	−0.05
Farm size (ha)	0.01	0.006	1.37	0.05
Share of lowland (%)			−0.17	−0.11
Share of saline area (%)			−0.13	−0.006
Dummy for lowland[a]	−0.32**	−0.12		
Dummy for medium land[b]	−0.52***	−0.20		
Dummy for Bolangir[c]	−0.59***	−0.21	−32.84***	−0.11
Dummy for Dhenkanal[d]	−1.13***	−0.34	−59.32***	−0.19
Dummy for Jajpur[e]	−0.37**	−0.13	−0.005	−0.00001
Dummy for Bhadrak[f]	0.31**	0.12	33.01***	0.07
Dummy for Kendrapara[g]	0.32***	0.13	47.60***	0.09
Likelihood ratio $\chi 2$	−824.64***			
Log pseudolikelihood			−1,495.58***	

*** and ** indicate statistical significance at 1% and 5%, respectively. [a]1 if lowland and 0 otherwise. [b]1 if medium land and 0 otherwise. [c]1 if Bolangir and 0 otherwise. [d]1 if Dhenkanal and 0 otherwise. [e]1 if Jajpur and 0 otherwise. [f]1 if Bhadrak and 0 otherwise. [g]1 Kendrapara and 0 otherwise. [h]1 if new MV and 0 otherwise. [i]Share of new MV area in total MV area.

to the practice of direct seeding. The sources of seeds for farmers were Agricultural Offices, the Primary Agriculture Cooperative Society (PACS), neighbors/other farmers, and from their own farm-saved seeds. However, farmer-to-farmer exchange is a major source of seeds. The mode of payment for purchased seeds is a combination of cash and credit.

- Inorganic and organic fertilizer
  NPK use varies considerably across locations. It is high in Raipur, with combined NPK use of 133 kg/ha. In stress-prone areas, use varies from 19 to 54 kg/ha (Table 23). The high use of NPK in Raipur can be explained by the availability of irrigation and the high adoption of MVs. Low use of fertilizer can be observed in saline areas of Kendrapara since farmers grow mainly traditional taller varieties, which are not responsive to a higher use of chemical fertilizers. Also, rice is usually planted in knee-deep water, making it impossible to apply fertilizer. Aside from inorganic fertilizers, organic fertilizers such as farm manure and compost were also widely used.
- Labor use
  Labor use for rice production ranges from 91 to 126 person-days/ha (Table 24). Labor use for weeding is high in areas where rice is mainly direct seeded as weed infestation is generally high in direct-seeded fields. The use of herbicides is minimal in the survey locations. Transplanting and harvesting are the other two most labor-intensive activities.
- Input use
  Table 25 compares input use between MVs and TVs. It is clear that farmers apply more inputs to MVs than to TVs. However, input use is similar between the two classes of MVs (Table 26).

Costs and returns analysis. The overall incremental returns above cash costs associated with a switch from traditional to improved varieties were found to be $65/ha in Orissa (Table 27). This represents a gain of about 52% in terms of the returns above cash costs when farmers have made a switch from TVs to MVs. Noncash cost comprises most of the total cost in MV and TV production (Appendix 2).

When making a similar comparison between old- and new-generation improved varieties, results differ between Orissa and Chattisgarh (Table 28). For Chhattisgarh, old-generation MVs have a 30% higher return than new-generation MVs. For Orissa, the opposite holds, with new-generation MVs providing 65% higher returns than old-generation MVs. This result is driven mainly by the difference in yield between these two categories of varieties as the costs of production are similar (Appendix 3). In both locations, the dominant old-generation variety is Swarna. However, there are differences in new-generation varieties adopted, with a greater range of new-generation improved varieties being grown in Orissa relative to Chhattisgarh, where Mahamaya is the dominant new-generation variety (see Table 11). The adoption of a wider range of new-generation improved varieties in Orissa could have provided a greater opportunity to better match the field types and varietal characteristics, resulting in a higher average yield.

Table 23. Major inputs used in rice production (kg/ha) during kharif in Chhattisgarh and Orissa, 2008.[a]

Inputs	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Fertilizer									
N	76	17	23	32	34	16	47	65	30
P	44	12	9	17	18	3	35	44	17
K	13	3	2	5	0	0	5	14	4
(combined NPK)	133	32	34	54	52	19	86	123	51
Organic fertilizer	2,400	2,200	1,200	1,800	–	9	2,146	2,100	1,300
Seed	120	105	107	75	59	74	63	79	85

[a]On the basis of the largest parcel.

Table 24. Labor use (person-days/ha) in rice production during kharif in Chhattisgarh and Orissa, 2008.

Labor activity	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Land preparation	9	22	16	6	7	8	9	8	12
Crop establishment	17	25	32	19	27	36	27	35	28
Application of chemicals	7	11	7	6	1	1	2	5	5
Weeding	28	40	33	22	10	18	9	14	24
Harvesting	19	17	16	19	29	33	35	36	24
Threshing	11	9	7	8	12	11	15	17	10
Others[a]	9	2	1	16	5	2	8	7	6
Total labor	100	126	112	96	91	109	105	122	109

[a]Others includes labor for transporting grains and irrigation. On the basis of the largest parcel.

Table 25. Input use in rice production using MVs and TVs during kharif in Chhattisgarh and Orissa, 2008.[a]

Item	Drought						Submergence		Saline				Nonsaline				All Orissa	
	Chhattisgarh		Orissa				Orissa		Orissa				Orissa					
	Raipur		Dhenkanal		Bolangir		Jajpur		Bhadrak		Kendrapara		Bhadrak		Kendrapara			
	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TVs
Fertilizer (kg/ha)																		
N	76	–	19	14	24	16	37	27	–	34	–	16	56	35	62	–	36	24
P	44	–	15	8	9	7	19	16	–	18	–	3	41	27	42	–	22	12
K	13	–	4	1	2	0	6	4	–	0	–	0	7	1	13	–	6	1
NPK total	133	–	38	23	35	23	62	47	–	52	–	19	104	63	117	–	64	37
Organic fertilizer (kg/ha)	2,400	–	2,200	2,200	1,200	800	1,300	2,400	–	0	–	8	300	130	2,100	–	1,500	900

Table 26. Input use using new- and old-generation MVs during kharif in Chhattisgarh and Orissa, 2008.[a]

Inputs	Drought						Submergence		Saline				Nonsaline				All Orissa	
	Chhattisgarh		Orissa				Orissa		Orissa				Orissa					
	Raipur		Dhenkanal		Bolangir		Jajpur		Bhadrak		Kendrapara		Bhadrak		Kendrapara			
	New	Old	New	Old	New	Old	New	Old	New	Old	New	Old	New	Old	New	Old	New	Old
Fertilizer (kg/ha)																		
N	74	77	22	19	21	25	46	33					53	64	65	66	47	30
P	22	24	7	8	4	5	11	9					22	22	23	23	16	9
K	23	25	4	8	2	4	15	9					13	13	28	23	17	9
NPK total	119	126	33	35	27	34	72	51					88	99	116	112	80	48
Organic fertilizer (kg/ha)	2,000	2,600	2,300	2,100	1,000	1,300	775	1,500	–	–	–	–	271	508	2,300	1,800	1,400	1,600
Seed (kg/ha)	113	123	97	102	111	104	73	75	–	–	–	–	63	55	79	78	83	93
Labor use (person-days/ha)	104	98	119	127	106	114	98	93	–	–	–	–	114	125	128	107	115	113

[a]On the basis of the largest parcel.

Table 27. Costs and returns (in US$) per hectare in rice production using MVs and TVs during kharif in Chhattisgarh and Orissa, 2008.[a]

Item	Drought						Submergence		Saline				Nonsaline				All Orissa	
	Chhattisgarh		Orissa				Orissa		Orissa				Orissa					
	Raipur		Dhenkanal		Bolangir		Jajpur		Kendrapara		Bhadrak		Bhadrak		Kendrapara			
	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TVs	MVs	TVs
Number of households	100	–	58	42	86	14	53	47	–	50	–	59	27	22	50	–	274	234
Returns																		
Value of grain	768	–	145	137	144	99	279	215	–	315	–	254	596	413	617	–	301	244
Value of straw	5	–	23	28	18	17	90	87	–	28	–	26	34	38	53	–	41	40
Total returns	773	–	168	165	162	116	369	302	–	343	–	280	630	451	670	–	342	284
Costs																		
Paid-out cost																		
Material cost	73	–	25	20	14	8	38	32	–	113	–	34	128	98	165	–	60	53
Labor	89	–	49	38	42	16	57	49	–	72	–	142	99	54	131	–	68	74
Hired power	43	–	14	12	15	6	20	27	–	29	–	63	44	26	50	–	25	32
Total paid-out cost	205	–	88	70	71	30	115	108	–	214	–	239	271	178	346	–	153	159
Imputed cost																		
Material cost	39	–	35	36	30	27	21	28	–	14	–	12	10	14	25	–	26	21
Labor	105	–	107	120	95	121	91	101	–	202	–	132	152	137	165	–	115	138
Own power	42	–	38	45	27	36	43	40	–	7	–	1	9	9	0	–	26	21
Total imputed cost	186	–	180	201	152	184	155	169	–	223	–	145	171	160	190	–	167	180
Total costs	391	–	269	272	223	213	270	278	–	437	–	384	442	338	536	–	321	339
Returns above cash costs	568	–	80	95	91	86	254	193	–	129	–	40	358	273	324	–	189	125
Net returns	382	–	(101)	(107)	(61)	(97)	99	24	–	(94)	–	(104)	187	113	134	–	22	(55)

[a]The exchange rate used was US$1 = Rs 46.60. The estimates are all on the basis of the largest parcel.

Table 28. Costs and returns (in US$) per hectare in rice production using new- and old-generation MVs during kharif in Chhattisgarh and Orissa, 2008.[a]

Item	Drought						Submergence		Nonsaline				All Orissa	
	Chhattisgarh		Orissa				Orissa		Orissa					
	Raipur		Dhenkanal		Bolangir		Jajpur		Bhadrak		Kendrapara			
	New	Old	New	Old	New	Old	New	Old	New	Old	New	Old	New	Old
Number of households	31	69	6	52	21	65	16	36	19	8	35	15	97	176
Returns														
Value of grain	672	811	131	147	129	149	331	250	583	626	636	571	435	227
Value of straw	4	5	21	23	16	19	78	92	35	30	55	49	44	38
Total returns	676	816	152	170	145	168	409	342	618	656	691	620	479	265
Costs														
Paid-out cost														
Material cost	86	68	34	24	11	15	43	37	129	125	180	128	102	36
Labor	79	94	48	49	29	46	72	51	111	73	135	123	91	56
Hired power	41	43	23	13	11	16	29	17	44	44	49	53	35	20
Total paid-out cost	206	205	105	86	51	77	144	105	284	242	364	304	228	112
Imputed cost														
Material cost	35	41	36	35	28	30	17	22	10	8	27	22	23	29
Labor	104	105	101	108	103	93	79	93	135	195	178	134	132	105
Own power	40	43	23	40	35	25	44	42	9	8	0	0	18	30
Total imputed cost	179	189	160	183	166	148	140	157	154	211	205	156	173	164
Total costs	385	394	265	269	217	225	284	262	438	453	569	460	401	276
Returns above cash costs	470	612	47	84	94	91	265	237	335	414	327	316	251	152
Net returns	291	423	(113)	(99)	(72)	(58)	125	80	180	203	123	160	78	(11)

[a]The exchange rate used was US$1 = Rs 46.60. The estimates are all on the basis of the largest parcel.

Crop disposal

Most of the rice produced is used for home consumption in Orissa while quite a large proportion is sold in Raipur (Table 29). The price of grain can be one of the factors why farmers opt to sell a high proportion of their produce, particularly in the case of Raipur. In 2008, the recorded price of grain in Raipur reached Rs 11/kg ($0.24/kg), which is higher than in other areas due to the additional price support given by the state government of Chhattisgarh (e.g., Rs 1.70/kg or $0.07/kg) in addition to the normal minimum support provided by the central government.

Sources of income

The total income of a household is defined here as the gross income earned by the household in a year. It is composed of the following: total value of crop production (irrespective of whether it is marketed or home consumed), off-farm income, nonfarm income, and income from sales of animals/animal products. Off-farm income is defined as the income of households working in other farmers' fields as hired labor. Nonfarm income is defined as the income derived from nonagricultural employment.

Table 30 shows the sources of income among the households. Raipur District has the highest gross income per capita of Rs 27,000, which is more than twice the value in Orissa. A larger average farm size in Chhattisgarh and a higher support price for rice contributed to higher incomes from crops in Chhattisgarh than in Orissa. The share of crop income in total income is substantially higher (72%) in Chhattisgarh than in Orissa (39%). For Orissa, income from nonfarm employment is considered to be the main source of income (Table 30). Thus, the overall income structure is quite different between these two states. There does not seem to be any obvious correlation between the income structure and the nature of stress in rice production, however.

Credit use can be important for farmers, particularly during stress years when crop production declines. The data show that all of the households borrow mostly cash during stress years. The borrowed cash capital is high in Jajpur and reached Rs 8,700/hh ($187/hh) (Table 31). This high borrowing in Jajpur can be associated with the flood experienced during the time of the survey. The common formal sources of credit are the following: Primary Agricultural Cooperative Society, Indian Overseas Bank, self-help groups, Grameen, and Kalinga Gramya Bank. On the other hand, money lenders are the common informal source of credit in all of the villages.

The interest rates vary across the lending sources. Generally, nonformal sources charge much higher interest rates than formal sources. The reported interest rates vary widely, from 8% to 35%. Among the formal sources, self-help groups have the highest interest rates, which range from 24% to 28%. This is followed by the Indian Overseas Bank and Kalinga Gramya Bank, which have an interest rate of 12%. The lowest interest rate can be observed in the Primary Agricultural Cooperative Society (PACS), which ranges from 6% to 7%. In borrowing cash, most of the households used their farm as collateral.

Table 29. Cropping disposal of rice (% of the total rice production) in Chhattisgarh and Orissa, 2008.

Item	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Consumed	26	78	69	81	41	74	40	47	60
Sold	65	12	22	4	35	10	42	33	25
Seed	7	6	9	6	3	5	3	3	5
Other uses	2	4	0	9	21	11	15	17	10
Total	100	100	100	100	100	100	100	100	100

Table 30. Percentage income and per capita income in Chhattisgarh and Orissa, 2008.[a]

Item	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Income from crop production (%)	72	31	56	24	60	27	44	36	39
Rice (%)	67	23	31	10	59	27	44	29	29
Nonrice (%)	5	8	25	14	1	0	0	7	10
Off-farm income (%)	2	9	15	6	6	29	0	3	7
Nonfarm income (%)	26	50	27	66	27	44	54	57	49
Sale of animals (%)	0	10	2	4	7	0	2	4	5
Total income (Rs/hh)	180,000	60,000	43,000	74,000	56,000	50,000	81,000	81,000	59,000
Income per capita (Rs)	27,000	10,000	8,000	12,000	9,000	7,000	12,000	15,000	9,000
(in $)	(579)	(215)	(172)	(258)	(193)	(150)	(258)	(322)	(193)

[a]Currency: www.oanda.com/currency/converter/. Values in US$ are in parentheses. Exchange rate: US$1 = Rs 46.60.

Table 31. Cash borrowings among households in Chhattisgarh and Orissa, 2008.

Item	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Average amount borrowed (Rs)	7,500	3,700	8,600	8,700	3,200	6,800	9,900	2,900	6,500
In US$ (US$1= Rs 46.60)	161	79	185	187	69	146	212	62	139
Collateral used for borrowing cash (%)									
Land record	90	86	63	100	48	21	36	40	61
Membership in society	–	14	37	–	–	–	–	–	1
None	10	–	–	–	52	79	64	60	38
Total	100	100	100	100	100	100	100	100	100
Interest rates of cash (%)	9	9	7	8	17	35	22	16	16
Purpose of borrowing among households (%)									
Agriculture	4	94	67	89	78	50	77	70	75
Food	20	0	8	–	–	5	5	10	0
Purchase of tractor/ bullock/cow	–	6	–	–	–	–	–	–	0
House repair and construction	4	0	6	5	–	–	5	–	0
Business	6	–	6	–	–	12	–	10	5
Wage payment	59	–	–	–	–	–	–	–	0
Others	7	–	–	6	22	33	13	–	20
No answer	0	–	13	–	–	–	–	10	0
Total	100	100	100	100	100	100	100	100	100

Household coping strategies

Households that are usually exposed to stresses such as drought and flood do have inherent coping strategies. In this section, information on how households dealt with these stresses is presented. The common coping strategies that were identified are the following: consumption adjustments, crop management adjustments, and credit and expenditure adjustments.

Consumption adjustments. Households adjust not only their farm management strategies but also their consumption during stress years to cope with the adverse effects of stress since production is greatly affected. Table 32 shows the adjustments made by households in Orissa and Raipur districts. During normal years, more than 60% of the households are considered to be rice-sufficient throughout the year, whereas, in stress years, only 8–32% of the households reported being self-sufficient. Households reported having reduced both the number of meals in a day and the quantity of food consumed per meal to manage the shortage. During normal years, more than 80% of the households consumed three meals a day. However, the proportion of households that consumed three meals a day was lower.

Household livelihood adjustments. Livelihood adjustments of households appear in Table 33, which shows that most of the households do resort to using their savings as an immediate response to stress. Increasing cash borrowing during stress years is also widely practiced. Food and seed borrowings were also done in most of the areas. Most of the households also sell or mortgage assets such as land, jewelry, and home appliances. All of the households reduced their expenses for clothing, festivals, and social ceremonies.

Crop management adjustments. Table 34 shows the major crop management adjustments of farmers during stress years. The adjustments reported in this section were all based on the focus group discussions done in each village. Most of the respondents interviewed decreased their area planted to rice. For example, in Chhattisgarh, they decreased the area planted due to limited water availability and also to reduce input costs.

Some adjustments were made in crop establishment methods also during stress years. Farmers in Jajpur reported a change in their method of rice establishment from direct sowing to transplanting. This is because direct seeding is not possible when fields are submerged. In saline areas such as Bhadrak and Kendrapara, farmers practice late transplanting. This is done in order to make sure that the salinity is fully washed out. In the case of drought-prone areas of Raipur, farmers changed from the usual transplanting to DSR due to a lack of water. On the other hand, increasing the seeding rate to more than 60% was done by farmers during stress years, believing that planting additional seeds can compensate for the crop loss.

Replanting/resowing is usually done depending on the extent of damage caused by flood/drought and the availability of money and labor. Farmers keep additional quantities of seeds for such use and those who don't have extra seeds purchase them from neighboring farms. Farmers reported growing alternative crops when rice failed. In Jajpur, the farmers plant urdbean and mungbean in fields that were intended for rice

Table 32. Rice food sufficiency and food intake among households during normal and stress years in Orissa and Chhattisgarh, 2008.

Item	Drought			Submergence
	Chhattisgarh	Orissa		Orissa
	Raipur	Dhenkanal	Bolangir	Jajpur
Percent of households that are self-sufficient in a year				
Normal years	95	71	64	91
Stress years	9	31	32	8
Percent of households that are consuming 3 meals/day				
Normal years	100	90	89	98
Stress years	12	36	43	91
Percent of households eating less food during stress years	88	50	54	21

Table 33. Other adjustments by households (%) during stress years in Chhattisgarh and Orissa, 2008.

Adjustments	Drought			Submergence
	Chhattisgarh	Orissa		Orissa
	Raipur	Dhenkanal	Bolangir	Jajpur
Using savings	100	82	91	13
Deferring loan payments	85	71	91	–
Selling more harvested crop	99	–	–	–
Increasing cash borrowing	65	64	97	78
Increasing food borrowing	6	69	49	–
Increasing seed borrowing	2	44	67	–
Selling/mortgaging assets	2	58	61	–

Table 34. Major crop management adjustments of farmers during stress years in Chhattisgarh and Orissa, 2008.

Coping strategies	Drought			Submergence	Saline	
	Chhattisgarh	Orissa		Orissa	Orissa	
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara
Area planted	*[a]	–	–	*		
Change in crop establishment						
DSR to TPR				*	*	*
Late transplanting						
TPR to DSR	*					
Seed rate	*	*	*	*	*	*
Replanting/resowing	*	*	*	*		
Storing seeds	*	*	*	*	–	–

[a]* means there is a change and (–) = no change.
Based on results of focus group discussions.

production. Farmers also practice some preventive measures to minimize the effect of a particular stress. In saline areas of Bhadrak and Kendrapara, farmers constructed an embankment beside the creek to prevent salt water from entering into the field. Farmers in Chhattisgarh similarly adjust water distribution and use from tanks and canals.

Relief programs. Most of the relief programs come from the government. In Jajpur, the government provides direct relief in the form of various food items, including rice. On the other hand, relief programs in Chhattisgarh consisted of payment for public works such as constructing roads and deepening village ponds under various employment guarantee schemes. These programs employ people in the affected areas and payment is made in both cash and kind. Generally, the scope of these programs is limited due to budgetary constraints and targeting of the programs is often poor. Farmers expressed these concerns during the FGDs.

Awareness of stress-tolerant varieties (STVs)

The introduction of a specific variety is one way of helping farmers adjust to stress. Table 35 shows the awareness of farmers of stress-tolerant varieties introduced in the area. In Dhenkanal and Bolangir, all of the households that were interviewed had not heard of any STVs. On the other hand, 95% of the households interviewed in Raipur were already aware of the STVs. Information usually came from Rural Agricultural Extension Officers and other farmers. In terms of willingness to plant STVs, all farmers who were interviewed were willing to plant such varieties if they were demonstrated to perform well in stress-prone environments.

Table 35. Awareness to stress-tolerant varieties (STVs) among households (%) in Chhattisgarh and Orissa, 2008.

Item	Drought			Submergence
	Chhattisgarh	Orissa		Orissa
	Raipur	Dhenkanal	Bolangir	Jajpur
Percent of households that heard about STVs	95	0	0	8
Percent of households that planted STVs	–	0	0	6
Percent of households that are willing to plant STVs	100	100	100	100
Sources of information about STVs				
Rural Agricultural Extension Officers	69	–	–	–
Farmers	15	–	–	–
Institutions (CRRI)	–	–	–	8

Gender division of responsibility and decision-making

The division on decisions and responsibilities between the husband and wife in all districts is presented in Table 36. Results show that most of the decisions with regard to farming are made mainly by men. On the other hand, household decisions are made by women, although men also contribute substantially to such decisions.

In terms of labor participation, Table 37 shows that, on average, 82% of the farm labor activities were done by males in Orissa. On the other hand, the result is reversed in Raipur, where more than half of the activities are done by females, particularly weeding, land preparation, and crop establishment, and harvesting and threshing.

In order to identify the participation of women in the decision process in farming as well as in household matters, the Women's Empowerment Index (WEI), which was developed by Hossain, was adopted in the study (Paris et al 2008). Table 38 shows the computed WEI across locations. Results show that husbands mainly make farming decisions in most cases, particularly in Orissa. However, some indicators require a joint decision, which usually pertains to household matters such as farm/household income, type of food to consume, and children's education (Raipur, Dhenkanal, and Bolangir). On the other hand, joint decision making was done on issues such as identifying from which institution to borrow, political decisions, and number of children to raise in Jajpur. Alternatively, the only decision that is solely made by the wife even if the husband is around is the type of food to consume in Bhadrak and Kendrapara, and identifying which institution to borrow money from in Raipur. The findings suggest that, in the areas under study, women still have a limited role not only in rice farming but also in household management.

Summary of findings

- Raipur has a larger average farm size of 2.8 ha than Orissa, where farms range from only 1.0 to 2.1 ha.
- Farmers mostly own their farm land. However, some farmers in Bhadrak and Raipur are involved in rice farming by renting-in land from larger farmers due to a scarcity of labor.
- Cropping intensity in most of the villages ranges from 100% to 160% except in saline areas of Kendrapara, which has an intensity of 95% since rice is planted only in kharif when salinity is washed out by rain.
- A high proportion of farmers adopt only TVs in saline areas because of salinity. However, farmers use both MVs and TVs in submergence-prone areas of Jajpur. On the other hand, most of the areas are covered by MVs except for the coastal areas of Bhadrak and Kendrapara, where TVs cover 90% and 97%, respectively.
- Old-generation varieties (varieties released before 1990) dominate most of the areas. These old varieties include Swarna, Lalat, and Gayatri. On the other hand, the major new-generation varieties (varieties released after 1990) are Mahamaya, Khandagiri, and MTU-1010.

Table 36. Division of responsibilities and decision-making between husband and wife (%) in Chhattisgarh and Orissa, 2008.

Decisions	Husband only		Wife only		Both					
					Husband more influential		Wife more influential		Both equally influential	
	Chhattisgarh	Orissa	Chhattisgarh	Orissa	Chhattisgarh	Orissa	Chhattisgarh	Orissa	Chhattisgarh	Orissa
What varieties to grow	65	91	3	1	–	7	–	–	31	2
Who and number of farm laborers to hire	66	91	4	1	1	7	–	–	28	2
Whether to sell or consume the harvested crop	35	91	5	1	–	7	3	–	56	2
Quantity of output to sell or consume	32	91	5	1	–	7	1	–	60	2
When and where to sell the harvested crop	63	91	5	1	1	7	1	–	30	2
At what price to sell	79	91	2	1	1	7	–	–	18	2
What farm implement to purchase	82	91	4	1	1	7	1	–	12	2
Whether to slaughter or sell animals	73	91	6	1	1	7	–	–	19	2
Adoption of technology in rice	79	91	2	1	2	7	–	–	17	2
Allocation of farm income	25	91	6	1	1	7	–	–	68	2
Allocation of household income	10	91	7	1	–	7	–	–	82	2
What types of food to consume	9	91	10	1	–	7	3	–	77	2
Children's education	32	91	5	1	–	7	–	–	61	2
Where to borrow	69	91	3	1	2	7	–	–	25	2
Participation in voting/politics	68	91	4	1	2	7	–	–	23	2
Number of children to raise	6	91	4	1	–	7	1	–	84	2

[a] – = no response.
District-level information is not available in this table but is available upon request.

Table 37. Percentage of labor activities by gender during kharif in Chhattisgarh and Orissa, 2008.

Activity	Chhattisgarh		Orissa	
	Total labor share (%)	Labor share of women (%)	Total labor share (%)	Labor share of women (%)
Land preparation and crop establishment	26	62	37	20
Application of chemicals	7	14	5	0
Weeding	28	71	22	21
Harvesting and threshing	30	60	31	18
Others[a]	9	33	5	0
Total	100	58	100	18

[a]Others includes postharvest activities, labor for transportation, and irrigation.

Table 38. Women's Empowerment Index (WEI) in Chhattisgarh and Orissa, 2008.

Decisions	Chhattisgarh		Orissa			All Orissa
	Raipur	Dhenkanal and Bolangir	Jajpur	Bhandrak and Kendarapara		
	Drought	Drought	Submergence	Saline	Nonsaline	
What varieties to grow	2	1	1	1	1	1
Who and number of farm laborers to hire	2	1	1	1	1	1
Whether to sell or consume the harvested crop	2	2	1	1	1	2
Quantity of output to sell or consume	2	3	1	1	1	2
When and where to sell the harvested crop	2	2	1	1	1	1
At what price to sell	2	1	1	1	1	1
What farm implement to purchase	1	1	1	1	1	1
Whether to slaughter or sell animals	2	2	1	1	1	1
Adoption of technology in rice	1	1	1	1	1	1
Allocation of farm income	3	2	2	1	1	2
Allocation of household income	3	3	2	1	1	2
What types of food to consume	3	3	2	4	4	3
Children's education	2	3	2	2	1	2
Where to borrow	4	2	3	1	1	2
Participation in voting/politics	2	1	3	2	2	2
Number of children to raise	3	3	3	1	1	2
Overall	2	2	2	1	1	2

- The yield of MVs is significantly higher by 0.4 t/ha and 0.6 t/ha than that of TVs in Raipur and Orissa, respectively. In terms of land type, MV yield is significantly higher than TV yield in the medium land type by 1.3 t/ha.
- Probit and tobit analyses indicated that the presence of lowland and saline-affected areas significantly affects the adoption of MVs and new MVs. In addition, farm size was found to significantly affect only the probability of adopting MVs but not the intensity of adopting them.
- Cultivation of MVs is significantly profitable (in terms of net returns above cash costs) relative to TVs in Orissa by $65/ha. This represents a 50% gain if the farmers decide to switch from TVs to MVs. Old-generation MVs were found to be more profitable by 30% than the new-generation MVs in Raipur, while new-generation MVs were more profitable in Orissa by 65%. The result is driven mainly by the difference in yields between these two categories of varieties as the production costs are similar.
- Crop production is the main source of income in Chhattisgarh while nonfarm employment in Orissa is the main income source.
- Households borrow mostly cash during stress years. The amount borrowed is highest in Jajpur—Rs 8,700/hh ($187/hh).
- Few households that were included in the study are aware of stress-tolerant varieties. However, they are willing to plant these STVs as long as they will give high yield, exhibit stress tolerance, and be readily available with proper demonstrations.
- Regarding gender participation, decisions related to farming are mainly made by the principal male members (husbands). However, decisions about the allocation of farm and household income, types of food to consume, and education for the children are jointly made by men and women. Women generally have a limited role in farm decision-making at all of the sites.

References

Behura D. 2010. Socio-economic baseline report of coastal belts of Orissa under STRASA program. Unpublished paper. Department of Agricultural Economics, Orissa University of Agriculture and Technology, Bhubaneshwar, India.

Bhandari H, Pandey S, Hardy B, editors. 2007. Economic costs of drought and rice farmers' drought coping mechanisms in eastern India. Los Baños (Philippines): International Rice Research Institute. p 43-113.

Food and Agricultural Policy Research Institute (FAPRI) Projections Macro database 1980-2009.

Gauchan D, Smale M. 2007. Comparing the choices of farmers and breeders: the value of rice landraces in Nepal. In: Jarvis D, Padoch C, Cooper HD, editors. Managing biodiversity in agricultural ecosystems. CABI, Columbia University Press. 512 p.

Janaiah A, Hossain M, Otsuka K. 2006. Productivity impact of the modern varieties of rice in India. Dev. Economies 44(2):190-207.

Koshta AK. 2010. Rice stress tolerance of poor farmers in South Asia and Africa with special reference to Chhattisgarh. Unpublished paper.

Naik D. 2010. Socio-economic analysis on rice production system in stress situations of Orissa (India). Unpublished paper. Department of Agricultural Economics, Orissa University of Agriculture and Technology, Bhubaneshwar.

OAS (Orissa Agricultural Statistics). 2004-2005, 2005-2006, 2006-2007, and 2007-2008. Directoriate of Agriculture and Food Production, Bhubaneshwar, Orissa.

Pandey S, Barah BC, Velasco L. 2003. Patterns of rice productivity growth in eastern India: implications for research and policy. Unpublished manuscript. International Rice Research Institute, Laguna, Philippines.

Pandey S, Barah BC, Velasco L. 2007. Rice technologies for rainfed environment of Asia. In: Ballabh V, editor. Institutional alternatives and governance of agriculture. Academic Foundation, New Delhi.

Paris T, Singh A, Cueno A, Singh VN. 2008. Assessing the impact of participatory research in rice breeding of women farmers: a case study in eastern Uttar Pradesh, India. Exp. Agric. 44:97-112.

Rhani NS, et al. 2010. High yielding rice varieties of India. Directorate of Rice Research (Indian Council of Agricultural Research), Hyderabad, India.

Notes

Authors' addresses: D. Behura and D. Naik, Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, Orissa, India; A. Koshta, Department of Agroforestry, College of Agriculture, Indira Gandhi Agricultural University, Raipur, Chhattisgarh; P. Samal, Agricultural Economics, Central Rice Research Institute, Cuttack, Orissa; M. Malabayabas, Social Sciences Division, International Rice Research Institute, Los Baños, Philippines.

Appendix 1. Percentage area of modern rice varieties by land type during kharif in Chhattisgarh and Orissa, 2008.

Varieties	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
In upper fields									
Parijat			3	9				100	30
Khandagiri		39	48	88					47
Naveen				3					0
Ananda		5							1
Kharvel		15							2
Lalat		5							0
Pathara		36							4
Saria			49						16
Mahamaya	32								
MTU-1010	39								
Swarna	29								
Total	100	100	100	100				100	100
On medium land									
Jarawa						100			0
Chandan (CRM)								1	0
MTU-1001					43		55	0	11
Pooja				13				65	9
Pratikshya								3	0
Swarna	61	48	47	73	57		45	31	49
Konark		0	4						1
Lalat		42	33						19
MTU-1010	11	4	10						4

Continued on next page

Appendix 1 continued

Varieties	Drought			Submergence	Saline		Nonsaline		All Orissa
	Chhattisgarh	Orissa		Orissa	Orissa		Orissa		
	Raipur	Dhenkanal	Bolangir	Jajpur	Bhadrak	Kendrapara	Bhadrak	Kendrapara	
Mahamaya	24								
Swarna-Sub1				9					1
Others	4	6	6	5					7
Total	100	100	100	100	100	100	100	100	100
Lowland									
Khandagiri									1
Lunishree						100			0
Durga				29					7
Gayatri				51	37			42	19
Pooja			3	4				8	3
Swarna	32	61	90	1			50		47
Tulasi				6					1
Varshadhan				5					1
Jajati		3							0
Lalat		3							0
MTU-1001		3					50		2
MTU-1010	19	12	3						3
Ramchandi		3							0
Savitri		9							2
Utkal Prava		6							1
Mahamaya	41								0
Sona Masuri	8								0
Malakshmi					63				1
Sarala								50	8
Others			4	4					4
Total	100	100	100	100	100	100	100	100	100

Appendix 2. Percentage (%) of cost in the total cost in rice production during kharif using MVs and TVs in Chhattisgarh and Orissa, 2008.

Costs	Drought						Submergence		Saline				Nonsaline				All Orissa	
	Chhattisgarh		Orissa				Orissa		Orissa				Orissa					
	Raipur		Dhenkanal		Bolangir		Jajpur		Bhadrak		Kendrapara		Bhadrak		Kendrapara			
	MV	TV	MV	TV	MV	TV	MV	TV	MV	TV	MV	TV	MV	TV	MV	TV	MV	TV
Paid-out costs																		
Material cost	19	–	9	8	6	4	14	12	–	26	–	9	29	29	31	–	19	16
Labor	23	–	18	14	19	8	21	18	–	16	–	27	22	16	24	–	21	22
Hired power	11	–	5	4	7	3	8	10	–	7	–	16	10	8	9	–	8	10
Total paid-out costs	53	–	33	26	32	14	43	39	–	49	–	62	61	53	65	–	48	47
Imputed costs																		
Material cost	10	–	13	13	13	13	8	10	–	3	–	3	2	4	5	–	8	6
Labor	27	–	40	44	43	57	34	36	–	46	–	34	34	41	31	–	36	41
Owned power	11	–	14	17	12	17	16	14	–	2	–	0	2	3	0	–	8	6
Total imputed costs	47	–	67	74	68	86	57	61	–	51	–	38	39	47	35	–	52	53
Total costs	100	–	100	100	100	100	100	100	–	100	–	100	100	100	100	–	100	100

Appendix 3. Percentage (%) of cost in total cost in rice production using new- and old-generation MVs during kharif in Chhattisgarh and Orissa, 2008.

Costs	Drought						Submergence		Saline				Nonsaline				All Orissa	
	Chhattisgarh		Orissa				Orissa		Orissa				Orissa					
	Raipur		Dhenkanal		Bolangir		Jajpur		Bhadrak		Kendrapara		Bhadrak		Kendrapara			
	New	Old	New	Old	New	Old	New	Old	New	Old	New	Old	New	Old	New	Old	New	Old
Paid-out costs																		
Material cost	22	17	13	9	5	7	15	14	–	–	–	–	29	28	32	28	25	13
Labor	20	24	18	18	13	20	26	20	–	–	–	–	25	16	24	27	23	20
Hired power	11	11	9	5	5	7	10	6	–	–	–	–	10	10	9	11	9	8
Total paid-out costs	54	52	40	32	24	34	51	40	–	–	–	–	65	53	64	66	57	41
Imputed costs																		
Material cost	9	10	14	13	13	13	6	9	–	–	–	–	2	2	5	5	6	10
Labor	27	27	38	40	47	41	28	35	–	–	–	–	31	43	31	29	33	38
Owned power	10	11	9	15	16	11	15	16	–	–	–	–	2	2	0	0	5	11
Total imputed costs	46	48	60	68	76	66	49	60	–	–	–	–	35	47	36	34	43	59
Total costs	100	100	100	100	100	100	100	100	–	–	–	–	100	100	100	100	100	100