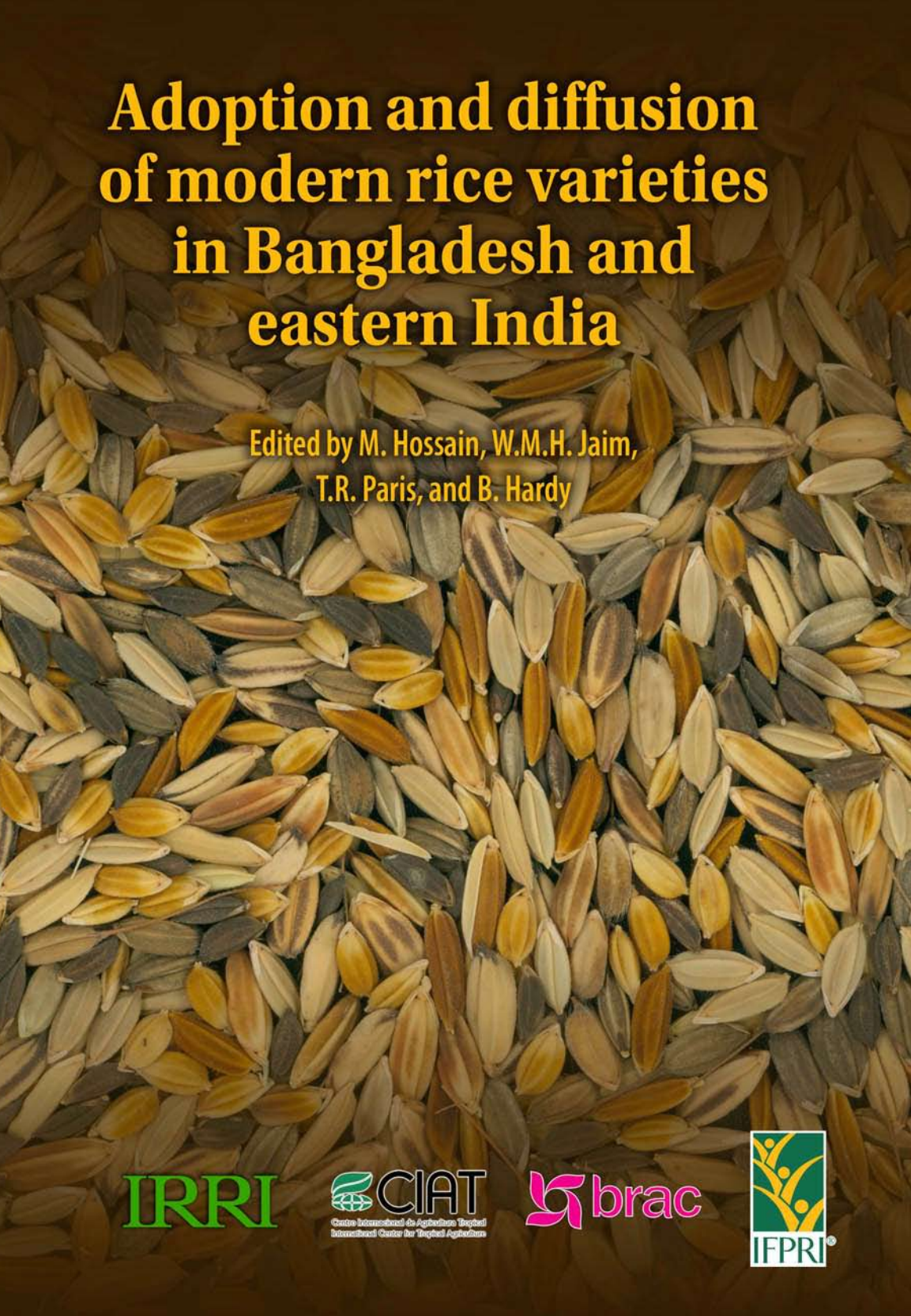
Adoption and diffusion of modern rice varieties in Bangladesh and eastern India

Edited by M. Hossain, W.M.H. Jaim, T.R. Paris, and B. Hardy



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2012
IRRI
International Rice Research Institute

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Foreword

Ensuring household and national food security is the goal of agricultural programs. Demand is growing for grains for staple food because of increasing population growth and crop loss and a decline in crop productivity brought about by climatic change. Thus, greater attention is needed to crop diversity for mitigating the negative effects of extreme climate change such as drought and floods. Aside from food insecurity, malnutrition is a major problem that affects millions of poor farming households in Asia that depend on rice as their staple food. About half of the people in Bangladesh and about a quarter of the people in India are malnourished because of poor calorie intake and low intake of vitamins, minerals, and proteins. However, the intake of micronutrients from rice grain largely depends on methods of rice processing/milling and cooking practices as well as consumer preferences. Incorporating micronutrients in popular rice varieties on the one hand and reducing losses in milling and cooking practices on the other hand may help to reduce malnutrition of low-income people in both Bangladesh and eastern India. Unfortunately, national statistics on the adoption of specific rice varieties by agroecosystems are not available. There is also a general lack of information on milling and cooking practices that affect nutritional intake from rice as well as farmers' perceptions on the potential of biofortified rice to overcome malnutrition.

With this background, the International Rice Research Institute (IRRI) and International Food Policy Research Institute (IFPRI), under the Harvest Plus project of the International Center for Tropical Agriculture (CIAT), carried out a pioneering project on "Adoption and diffusion of rice varieties in Bangladesh and eastern India" from 2004 to 2008. This project was organized by Dr. Mahabub Hossain, agricultural economist and former head of the Social Sciences Division of IRRI, and now executive director of the Bangladesh Rural Advancement Committee (BRAC) in Bangladesh. Dr. Thelma Paris, deputy head of IRRI's Social Sciences Division, took over the coordination of this project after Dr. Hossain moved to BRAC. This project was conducted in collaboration with different institutes/research organizations in Bangladesh and three neighboring states of India (West Bengal, Orissa, and Jharkhand). The collaborators in India were Birsa Agricultural University (BA) in Jharkhand, Nadia Zilla Farmer's Development Office (NZFDO) in West Bengal, and SAMRDI in Orissa; in Bangladesh

they were the Department of Agricultural Extension and Bangladesh Agricultural University, Mymensingh. The results of this study were presented at a workshop held on 3-4 October 2010 at BRAC in Dhaka, Bangladesh.

The study covered almost all the districts of Bangladesh (62 out of 64) and three states of eastern India—West Bengal, Orissa, and Jharkhand (20 out of 24 districts)—representing diverse agro-climatic zones. Multistage random sampling was adopted in choosing 31,527 farm households from the selected villages of Bangladesh and the three states of eastern India. Data entry and analysis were done by Socioconsult Limited in Bangladesh.

We would like to thank J.V. Meenakshi, coordinator of the Harvest Plus project (IFPRI-CIAT), Mahabub Hossain, Waeza M.H. Jaim, Thelma Paris, Debdutt Behura, S.K. Bardhan Roy, Banudeb D. Bagchi, Dipti Jena, Valeria Lakra, Ratan P. Singh, Zenaida Sumalde, Mafus Rahman, Alamgir Chowdhury, Josie Narciso, Robert Hijmans, and Mirla Domingo for the successful implementation of this pioneering research.

Robert Zeigler
Director General
IRRI

Preface

Rice is the most important food crop, particularly for India and Bangladesh, which rank second and fourth, respectively, among the rice-producing countries in the world. The Green Revolution, through the introduction of modern varieties (accompanied by fertilizer and irrigation), helped to substantially increase rice productivity starting in the late 1960s. However, the adoption of modern varieties has displaced a large number of traditional varieties and contributed to an erosion of biodiversity. Many traditional rice varieties have completely disappeared; yet, despite the allegedly inferior yield of traditional varieties, farmers still grow many of them. Heterogeneous agroecological conditions (soils, elevation, and climate), access to seed markets, farmers'/consumers' preference for special traits of certain varieties, etc., largely explain the diversity as well as concentration of rice varieties in different regions.

Rice scientists, extension agents, as well as planners for various reasons need to know about existing rice varieties (both modern and traditional ones) with their percentage share in area and their respective yields. Identifying the most popular rice varieties is particularly important for rice breeders who are trying to develop new varieties with higher yield and varieties suitable for unfavorable areas/climatic conditions. Identification of the most popular varieties is also important for rice breeders for incorporating micronutrients in rice grain to overcome nutritional deficiencies. It is also important to know the diffusion process of modern varieties, identifying the traits for the popularity of some varieties and investigating the reasons for the discontinuation of growing some popular varieties (both traditional and high-yielding varieties). The sources of seed supply and sources of information about new rice technology, the role of private and government organizations in supplying seed, etc., are also important aspects for enhancing rice production for food security.

Information on rice milling and cooking practices in relation to the loss of micronutrients from rice grain and consumers' preferences for a particular type/quality of rice are also some of the important aspects from the viewpoint of nutrition. Finally, assessing both farmers' and consumers' attitude for the acceptance of biofortified rice is also important under the current context of meeting micronutrient deficiency through biofortified rice. The existing literature lacks information with respect to these aspects. The purpose of this book is to fill the information gaps. The book is based on findings

from extensive surveys of 31,527 households in Bangladesh and three neighboring states of India (West Bengal, Orissa, and Jharkhand).

We are heavily indebted to many institutions and individuals for the support and cooperation received in conducting the study on which this book is based. The study was financed by the International Rice Research Institute (IRRI) and International Food Policy Research Institute (IFPRI) under the HarvestPlus Project of the International Center for Tropical Agriculture (CIAT).

Rice varietal diversity, milling, and cooking practices in Bangladesh and eastern India: a synthesis

M. Hossain

Introduction

About half of the people in Bangladesh and about a quarter of the people in India are malnourished because of poor calorie intake and low intake of vitamins, minerals, and proteins. Further, the prevalence of malnutrition among children under age 5 was more than half (55%) in Bangladesh and a little less than half (46%) in India compared with 39% in Vietnam, 32% in the Philippines, and only 13% in Thailand and 14% in China. Cereals are the most important source of nutrients in Bangladesh and eastern India. Except for wheat, rice is the cheapest source of supply of calories and carbohydrates in Bangladesh and eastern India. It is also one of the cheapest sources of protein and fat.

However, the intake of micronutrients from rice grain largely depends on methods of rice processing/milling and cooking practices as well as consumer preferences. Incorporating micronutrients in popular rice varieties on the one hand and reducing losses in milling and cooking practices on the other hand may help to reduce malnutrition of low-income people in both Bangladesh and eastern India. In order to identify varieties for biofortification, one of the main targets of this study was to investigate varietal diversification of rice and identify the most popular rice varieties with specific traits and adoption processes. And, to retain micronutrients in rice grain, the second most important objective of this study was to investigate milling and cooking practices that affect nutritional intake from rice. With this background, the International Rice Research Institute (IRRI) in collaboration with different institutes/organizations in Bangladesh and three neighboring states of India (West Bengal, Orissa, and Jharkhand) carried out a study to answer the following questions:

- Can a large proportion of rice consumers be targeted through biofortification of a few varieties?
- What traits do farmers want in a new variety?
- What is the process of deployment and diffusion of a new variety? Can large and enterprising farmers with better extension contacts validate a new variety?
- To what extent can farmers keep their own rice production for self-consumption?

- Is rice overmilled such that micronutrients in the outer layer are not available to consumers?
- Do cooking practices contribute to further washing away of micronutrients?
- What are the reasons behind the erosion of rice biodiversity?

Methodology

The study covered almost all the districts of Bangladesh (62 out of 64) and three states of eastern India—West Bengal, Orissa, and Jharkhand (20 out of 24 districts)—representing diverse agro-climatic zones. Multistage random sampling was adopted in choosing farm households from the selected villages of Bangladesh and the three states of eastern India. The number of sample households for Bangladesh, West Bengal, Orissa, and Jharkhand was 14,095, 7,684, 6,529, and 3,219, respectively.

Key questions and findings

Can a large proportion of rice consumers be targeted through biofortification of a few varieties?

The answer to this question is yes.

Despite the gradual erosion of biodiversity with the spread of modern varieties, farmers still grow a large number of varieties. The number of varieties grown in different seasons in Bangladesh and the three states of eastern India is as follows:

Bangladesh: aman 535, boro 261, aus 295
West Bengal: aman 166, boro 60
Orissa: kharif 723, summer 29
Jharkhand: kharif 145

However, a few varieties cover a large proportion of area (Fig. 1). The major varieties according to area coverage in Bangladesh and eastern India are as follows:

Bangladesh:
Dry season: BRRI dhan29, 37%; BRRI dhan28, 23%
Wet season: BR11, 27%; Swarna, 12%

West Bengal:
Wet season: Lal Swarna, 45%,
Dry season: IR36, 27%; Satabdi, 18%

Orissa:
Swarna, 29%; Lalat, 7%

Jharkhand:
Swarna, 28%; IR36, 8%

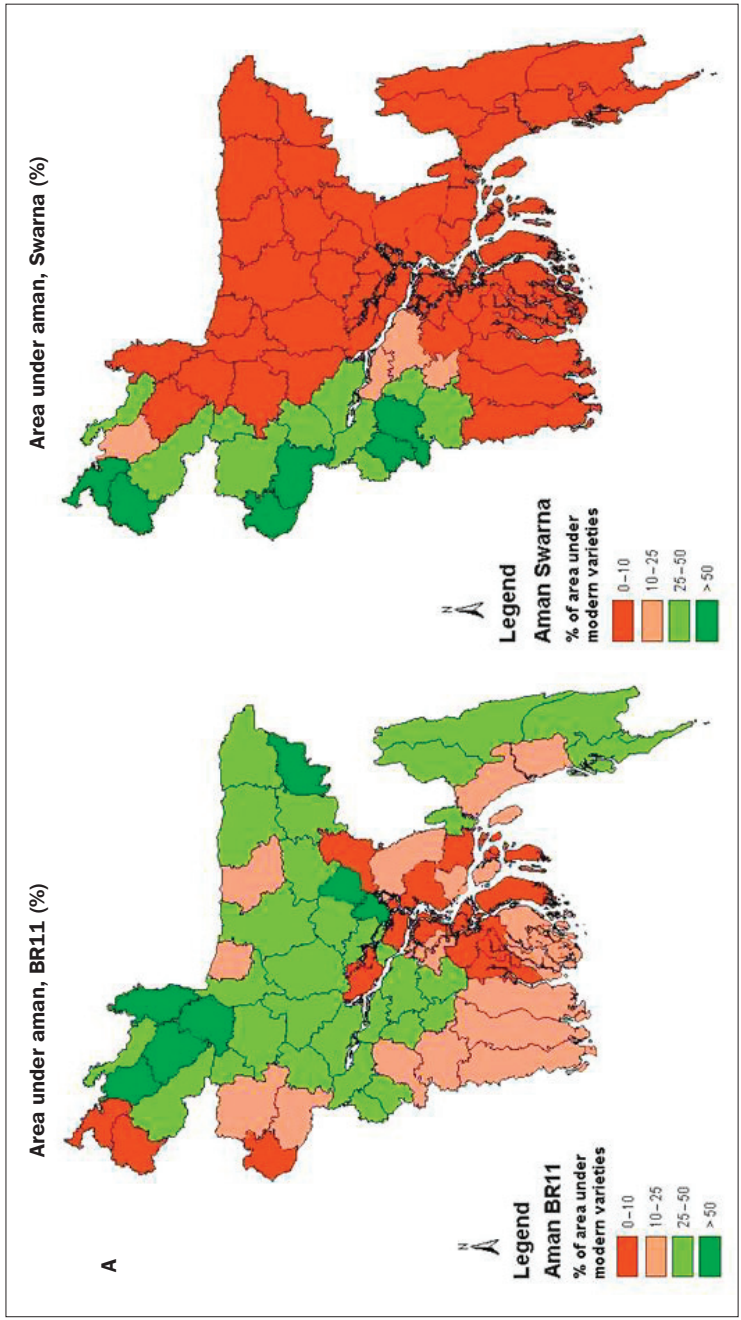
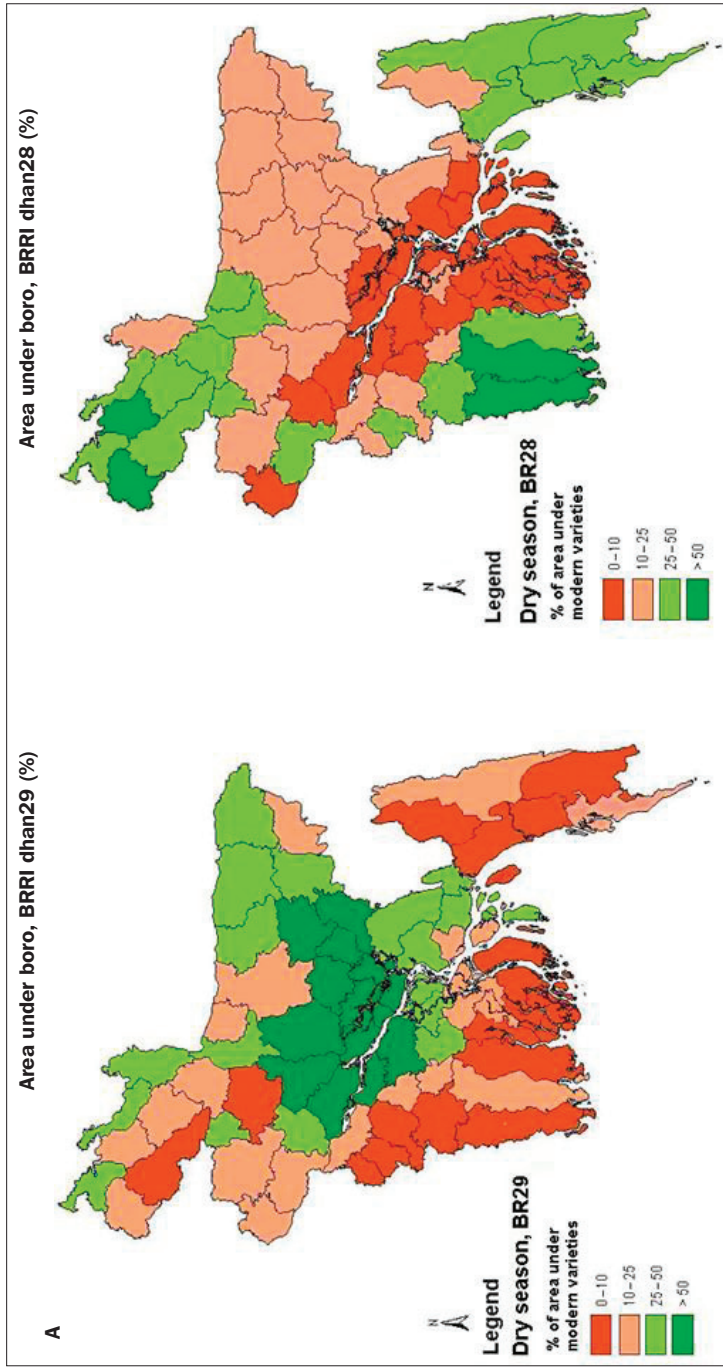


Fig. 1. Coverage of major rice varieties by districts in (A) Bangladesh, (B) Jharkhand, and (C) Orissa.

Fig. 1 continued.



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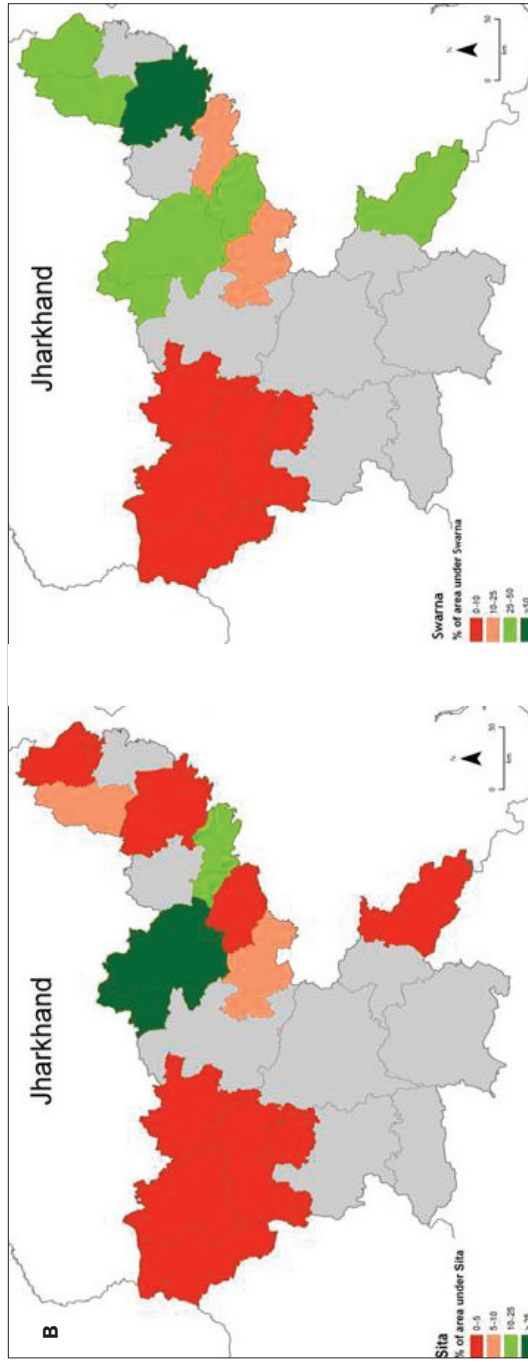

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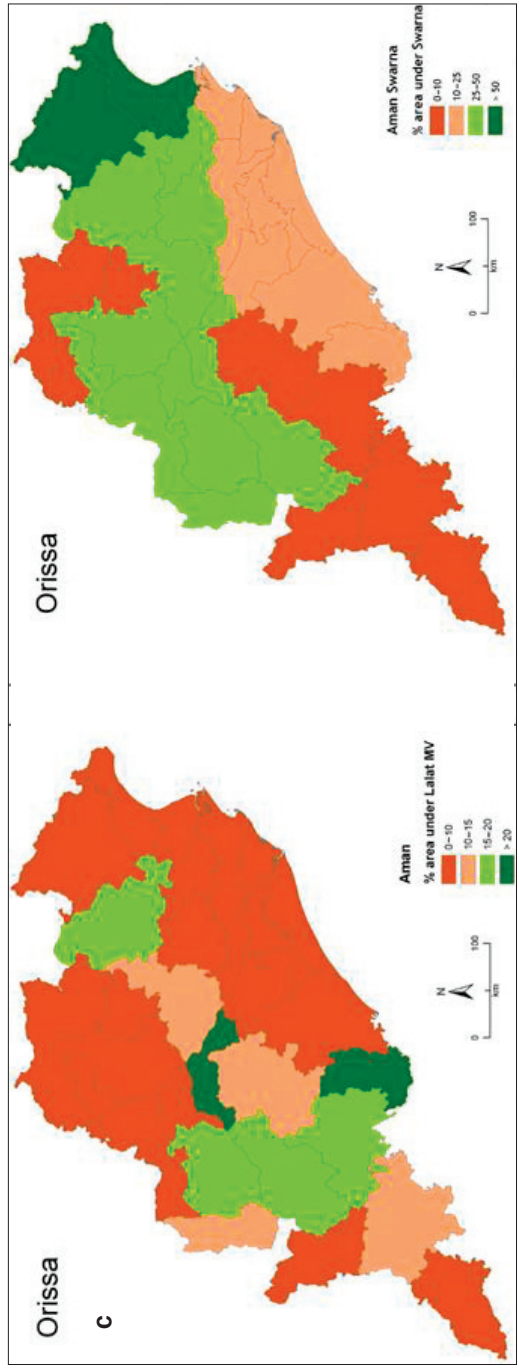

What traits do farmers want in a new variety?

Farmers seek the following primary traits:

High yield for more grains from limited farm size is the primary or most important trait that farmers want in a new variety. The responses from the farmers (in %) with respect to this trait were as follows:
Bangladesh 96%, West Bengal 100%, Orissa 100%, Jharkhand 73%.

Farmers look for the following secondary traits:

Grain quality for a premium price in the market with growing demand for better quality rice from the market.
Shorter maturity for flexibility of growing additional crops from the same piece of land during the year, and for fitting nonrice crops into the cropping pattern.
Lodging resistance
Higher milling recovery
Insect and disease resistance are not emphasized because of a lack of experience with host-plant resistance.

What is the process of deployment and diffusion of a new variety? Can large and enterprising farmers with better extension contacts validate a new variety?

The survey revealed the following findings in relation to the above questions:

- If varietal performance is substantially better than that of existing varieties, farmers adopt and small and medium farmers follow; otherwise, the variety is eliminated.
- Availability of seed of improved varieties is a major constraint to fast-tracking diffusion (70% to 80% of the seeds are from farmers' own harvest or are exchanged with or purchased from neighbors).
- Once farmers in a village are convinced of the superiority of a new variety, it takes 3 to 5 years to reach areas suitable for the variety.
- However, it may take a longer time to reach a substantial portion of area because of information lag (extension system is not highly effective, radio/television is a minor source of information, input dealers are not targeted as information bearers).
- Once a variety is established, it is difficult to dislodge it unless improved varieties have traits that are substantially superior. BR11, IR36, and Swarna are still mega-varieties despite being released more than two decades ago.

To what extent do farmers keep their own rice production for self-consumption?

- Small and marginal farmers who are either subsistence farmers or deficit farmers dominate the agrarian structure as revealed from the following findings (Table 1) in relation to farm size distribution in Bangladesh (Table 2) and the three selected states of eastern India.

Table 1. Distribution of farm size.

Region	% of farms with less than 1 hectare	% of farms with more than 2 hectares
Bangladesh	75	4
West Bengal	59	14
Orissa	52	16
Jharkhand	47	21

Table 2. Marketed surplus of rice by farm size in Bangladesh in 2004.

Farm size (ha)	Farm households selling rice (%)	Output marketed (%)	Net surplus (tons/household)
Nonfarm	–	–	−1.46
Up to 0.40	32	15	−0.90
0.41–1.00	66	27	0.53
1.01–2.00	87	56	2.71
2.01 and over	94	78	9.61
Total	52	41	−0.35

- A large proportion of households can be targeted for biofortified rice with production on their own farms.

Is rice overmilled such that micronutrients in the outer layer are not available to consumers?

The findings in relation to this question follow:

- The practice of parboiling for binding of micronutrients is widespread.
- Households that do not parboil paddy before milling:
  Bangladesh 4%
  Orissa 14%
  Jharkhand 11%
- Households that parboil twice:
  Bangladesh 18%
  Orissa 46%
  Jharkhand 28%
- However, urban consumers reached through markets may get fewer benefits because mills have a tendency to overpolish to get a better price.

Mills that polish rice more than once

Bangladesh	21%
Orissa	64%
Jharkhand	3%

Consumers' preference for the type of milling

Type of milling	Percentage
• Rice husked by *Dheki*	27
• Less polished milled rice	59
• More polished milled rice	14

Consumers' perceptions about good-quality rice:

Perceptions	Percentage of cases reporting
• Slender grain	43
• Good eating quality/palatability	24
• Clean rice	17
• Few broken grains	4.0
• Expands after cooking	3.5
• Has good smell	1.9
• Has nutritious quality	1.8

Do cooking practices contribute to further washing away of micronutrients?

The findings in relation to this question follow:

- Rice is washed intensively before cooking.
- Incidence of washing twice or more:

Bangladesh	90%
West Bengal	71%
Orissa	93%
Jharkhand	78%

- Rice is cooked with excess water that is drained after cooking.
- Incidence of draining out of excess water after cooking:

Bangladesh	62%
West Bengal	97%
Orissa	89%
Jharkhand	60%

Only in Jharkhand, 19% of consumers reported using an electric cooker and 21% an exact amount of water that does not require draining after cooking.

Reasons for washing rice more than once

Reason	Percentage
• To remove dust and other small particles	66
• For making cooked rice white/nice looking	28
• To reduce bad smell	3

- To get rid of paddy husk 2
- To keep all water in cooked rice 1

Excess water in rice cooking

	Percentage of respondents
• Awareness of nutritional quality of drained water:	
— Aware of nutritional quality	94
— Not aware	6
• Reasons for draining excess water despite knowledge of its benefit:	
— For feeding domestic animals	28
— Not accustomed to drinking drained water	25
— Not accustomed to using proper amount of water for cooking	21

Use of excess water after cooking

Response	Percentage of respondents
• No need to throw away excess water	38
• Use as animal feed	51
• Just throw away	9
• Drink excess water with salt	2

What are the reasons behind the erosion of rice biodiversity?

The findings in relation to this question follow:

- Biodiversity is eroding, with many traditional varieties that were popular earlier being dropped with the adoption of improved varieties.
- Many farmers use more than one rice variety because of diversity in land elevation and demand for quality rice for special purposes.
- Traits of many traditional varieties such as pest resistance and tolerance of abiotic stresses have been incorporated into modern varieties.
- The main reason for stopping the cultivation of traditional varieties is substantially lower yield/profitability than modern varieties:
  - — Yield of improved varieties 3–5 t/ha
  - — Yield of traditional landraces 1–2.5 t/ha
- The other factor is a lack of market for seeds of landraces. Farmers keep seed from their own harvest. So, once they stop producing the seed, it becomes unavailable and the variety disappears.
- With the use of seed from own harvest, genetic degeneration takes place, leading to a further reduction in yield.

Pure-line selection of key landraces by research organizations and marketing of quality seeds to farmers can help raise the yield of traditional landraces and help them compete with improved varieties.

Conclusions

The following conclusions emerged from the study:

- If Swarna, BR11, BRRI dhan29, and BRRI dhan28 were targeted for biofortification, more than half of the rice consumers in Bangladesh and eastern India could be reached with nutrient-dense rice.
- Farmers will accept varieties with nutritional traits only if there is no yield penalty. They might be attracted to these varieties if these could mature earlier and have better eating quality.
- Consumers are aware of the nutritional value of rice as they do parboil in order to bind the bran with the endosperm before milling, and there is in general a preference for less-polished rice.
- Millers, however, go for more polishing for targeting high-income consumers and the urban market that pay premium prices for polished rice.
- Nutritional values of rice further erode due to the practice of washing rice before cooking, and the use of excess water that is drained after cooking.
- Nutritional traits must be put into the endosperm in order for the nutrients to reach consumers.
- Information campaigns must be strengthened and the seed distribution system must be improved for fast-tracking the diffusion of nutrient-dense rice.

Policy recommendations

- It is easy to spread a new trait such as micronutrients by focusing on a few dominant varieties. But, rice breeders should also consider other traits that farmers and consumers (both men and women) look for. Moreover, farmers and consumers should be involved in the participatory varietal selection (PVS) process, which includes nutrient-rich rice lines.
- The potential yield of rice varieties should be increased focusing on environment stress, particularly with the threat of climate change to rice farming.
- There is a need to focus on pure-line selection of popular traditional varieties to keep them competitive with improved varieties.
- Government organizations should play an active role in on-farm conservation of popular traditional varieties as well as developing varieties suitable for growing under stress conditions or unfavorable ecological conditions.
- Expansion of irrigation facilities can also contribute to the adoption/expansion of improved varieties as well as significantly increase the yield of traditional varieties.

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Notes

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Diversity, Spatial Distribution, and Adoption of Varieties

Diversity, spatial distribution, and the process of adoption of improved rice varieties in Bangladesh

M. Hossain and W.M.H. Jaim

Introduction

In order to meet the growing demand for food grain emanating from population growth, high-yielding varieties (HYVs) as well as modern hybrid rice varieties have been introduced in Bangladesh and in many other rice-producing countries since the late 1960s. Researchers have documented genetic erosion or the loss of crop genetic resources due to the introduction of these modern varieties. Many traditional rice varieties have completely disappeared, yet farmers' conservation of rice genetic diversity has continued managing landraces in the agroecosystems and communities where they have evolved historically. Hossain and Jaim (2009) reported that farmers in Bangladesh still cultivate more than 1,000 traditional varieties/landraces. These landraces have evolved in response to wide variations in local conditions, combined with the careful seed selection and management practices of farmers. In the same context, recent studies focus on competition between modern and traditional varieties of the principal staple crops (wheat, rice, maize, potato) to explore why traditional varieties persevere, de facto, in certain areas without being completely displaced despite their allegedly inferior yields (Brush et al 1992, Bellon et al 1998, Widawsky et al 1998, Meng et al 1998, Bellon and Taylor 1993, Louette et al 1997, Louette and Smale 2000, Perales Rivera et al 2003).

Case studies have consistently identified two major generic or conceptual factors that characterize regions and predict variation in the levels of crop diversity maintained by communities and households located within their boundaries (Benin et al 2003). These factors can also be considered for explaining diversity as well as the concentration of rice varieties in different regions. The first generic factor concerns agroecological conditions (soils, elevation, and climate). Ethno-botanical research has suggested that farmers choose varieties based on varietal adaptation to soils and other environmental factors (Zimmerer and Douches 1991). That is, the more heterogeneous the conditions in which farmers cultivate the crop, the higher the expected levels of infraspecific diversity and the varieties differ in the extent to which they provide agronomic (adaptation to soils, maturity, disease resistance, fodder and grain yield) and consumption (taste, appearance) attributes (Benin 2003). Again, several studies

conducted in the Peruvian Andes, Turkey, and Mexico demonstrated a positive relation between marginal growing conditions for the crop and the choice to continue growing landraces (Brush 1995). In Bangladesh also, landraces/traditional varieties are mostly grown on marginal land or in unfavorable ecosystems: the rainfed uplands, deepwater areas, and saline-affected coastal areas. However, the relationship of environmental heterogeneity to crop infraspecific diversity has perhaps a stronger basis in the genetics and ecology literature than does the relative marginality of the production environment (Benin et al 2003).

The second generic factor that operates at a regional or community scale and is hypothesized to explain variation in levels of crop inter- and infraspecific diversity is opportunities for trade in markets. This implies that the more physically isolated a community or household is, the less specialized its production activities. Hence, an area relatively isolated from markets would lead us to predict that modern varieties are less likely to be found or are found to a lesser extent. Applying the microeconomic theory of the household farm predicts that the higher the transaction costs faced by individual households within communities as a function of their specific social and economic characteristics, the more we would expect them to rely on the diversity of their crop and variety choice to provide the goods they consume (Benin et al 2003). Consistent with this hypothesis, Van Dusen (2000) found that the more distant the market, the greater the number of maize, bean, and squash varieties grown by farmers. Meng (1997) also found that cultivation of wheat landraces was positively associated with their relative isolation from markets in Turkey.

When farmers cannot rely on the market to provide them with the seed that meets their demand for attributes, they may grow a more diverse set of varieties to ensure their needs. At the same time, access to seed markets also enables farmers to combine the attributes of purchased seed types with those selected and maintained by farmers in their own community.

Greater numbers of plots and farm fragmentation have also been associated with crop and variety specificity. Brush (1995) reported that land fragmentation promoted conservation by enabling farmers to conserve landraces in one plot, while planting modern varieties in the majority of cultivated area. Further, farmers may seek temporal smoothing in crop and variety requirements through growing combinations with different planting, weeding, and harvesting dates, which leads to the cultivation of different varieties.

Farmers may cease growing landraces if changes in the production or marketing environment cause them to lose their relative value (Gauchan et al 2005). The total number of landraces as well as the area planted to landraces in Bangladesh and many other countries such as India and Nepal appears to be declining over time (Hossain and Jaim 2009, Gauchan et al 2005). However, several traditional varieties are still popular among farmers/consumers due to their special traits despite their low yield compared with modern varieties. Decades ago, Harlan (1972) and Frankel (1970) warned against the extensive displacement of landraces they observed during the early years of the Green Revolution, particularly in the more favorable agronomic environments where high-yielding varieties were adopted first.

Modern varieties may possess traits not found in local varieties (Louette et al 1997) or have more uniform grain quality, enabling cash to be earned to satisfy other consumption needs of households (Zimmerer 1996). In this context, it can be mentioned that, with the efforts of scientists of the Bangladesh Rice Research Institute (BRRI), 50 HYVs and two hybrid varieties have so far been released. In addition to these, some Indian high-yielding varieties as well as hybrid rice varieties are also in farmers' fields, particularly in the border areas of Bangladesh. However, a few of these modern varieties have proved to be very popular due to their well-accepted traits and diffusion of these varieties took place in a shorter period compared with other varieties.

With this background, this study specifically aims at investigating the following:

1. Diversity and concentration of varieties
2. Spatial distribution of varieties
3. Traits demanded in improved varieties
4. Process of diffusion of improved varieties
5. Varieties on the way to extinction and the reasons

Methdology

For this study, using the multistage random sampling method, primary data were collected through a sample survey with assistance from Department of Agricultural Extension (DAE) field staff. In order to cover all of Bangladesh under the study, at first, a list of all the blocks of the DAE was collected from each of the upazilas. Thus, a list of about 15,000 blocks (covering all 64 districts of Bangladesh) was prepared for the six regions, which were Dhaka, Rajshahi, Comilla, Jessore, Barisal, and Chittagong. Then, for each of the six regions, 100 blocks were selected using systematic random sampling. Again, from each block, three villages were selected randomly and, from each village, eight farmers were selected using stratified random sampling to include farmers with different farm sizes and tenancy status. Thus, covering all six regions, 14,400 farmers from the selected 600 blocks (24 farmers from each block) were targeted to be interviewed for the survey. However, the number of samples/farmers ultimately covered by the survey was 14,095. Data were collected from November 2004 to January 2005, which covered information related to rice during the period from the aman season of 2004 to the aus/boro season of 2005.

Results and discussion

Physical, environmental, and socioeconomic characteristics

About 59% of the selected villages were located in favorable areas (favorable environment for crop production) while the villages located in unfavorable areas such as flood-prone, drought-prone, and saline were 29%, 9%, and 4%, respectively (Table 1). Therefore, most of the areas had favorable environmental conditions for crop production. Again, on the basis of flood depth, about three-fourths of the area was of medium land, in which the crop is not normally damaged by flood. Occasionally,

Table 1. Environmental, physical, and socioeconomic characteristics.

Characteristics	% of area	
Environmental characteristics of farms		
Flood-prone area	28.8	
Drought-prone area	8.8	
Saline area (coastal)	3.8	
Favorable area	58.6	
All	100.0	
Physical characteristics of farms		
Highland	5.1	
Medium land	74.9	
Lowland	18.9	
Very low land	1.1	
All	100.0	
Socioeconomic characteristics of farms		
Farm size (ha)	2005 IRRI survey (%)	1996 Agricultural Census (%)
Up to 0.2	5	28
0.2 to 0.4	18	21
0.4 to 1.0	37	31
1.0 to 2.0	27	13
2.0 to 3.0	10	4
3.0 and over	3	3
All	100	100
Tenancy	% of farms	
Pure owner	44	
Pure tenant	27	
Owner-cum-tenant	29	
All	100	
Level of education	% of farms	
No formal schooling	15.8	
Primary	43.2	
Secondary	30.3	
Secondary school certificate and above	10.7	
All	100.0	

crop damage occurs in lowland, which was about 19% of the total area covered in the survey, while never-flooded highland was about 5.1%.

Farm size distribution of the sample farmers compared with that of the Agricultural Census in 1996 showed that marginal farms were underrepresented while large farms were overrepresented (Table 1). The main reason for the underrepresentation of marginal farms in this study (IRRI 2005 survey) was that it considered only farm households while the Agricultural Census (1996) considered all households, the vast majority of which belonged to the landless category. It was also found that a majority

Table 2. Number of varieties at the farm level: IRRI 2005 survey and 1996 DAE survey.

Season	Share of area (%)		Share of production (%)		No. of rice varieties	
	1996	2005	1996	2005	1996	2005
Aus	24	10	16	6	440	295
Aman	46	50	45	49	519	535
Boro	30	40	39	55	143	261
All seasons	100	100	100	100	1,102	1,091

of the selected farmers (56%) were either pure tenants or owner-cum-tenants. Further, a majority of the farmers (59%) were either illiterate (16%) or had a primary level of education (43%).

Diversity and concentration of rice varieties

Rice diversity. Bangladesh has three rice seasons: aus, aman, and boro. Among these, boro rice has grown in importance over time. Findings of the IRRI 2005 survey compared with the 1996 DAE survey show that, within a decade, boro rice area increased from 30% to 40% and its share of production increased from 39% to 55% (Table 2). Boro has largely displaced aus rice and, by 2005, it had become a marginal rice variety in terms of both area and production. In the case of aman, although its share of rice area increased slightly over a decade, its share of production was less than boro in 2005. Findings of both IRRI and the DAE survey showed that there is considerable diversity of rice varieties in all the seasons. The IRRI 2005 survey identified the existence of 515 rice varieties in aman, 261 varieties in boro, and 295 varieties in the aus season. Table 2 shows that, over a decade (1996 to 2005), the number of rice varieties declined for aus, but increased for boro. It also shows that rice diversity is very high for the aman season. The findings suggest that considerable diversity of rice varieties exists: farmers still grow more than 1,000 varieties. However, most of these varieties are traditional local varieties and their area coverage is very low. A complete list of all the rice varieties with their respective area share and yield can be seen in the rice diversity report of Bangladesh (Hossain and Jaim 2009).

Concentration of rice varieties. Although farmers still grow more than 1,000 varieties in the three rice seasons, only some of these varieties gained popularity, covering a major share of the rice area. Many of the rest of the varieties covered considerably less area, with lower yield than that of the popular varieties (Hossain and Jaim 2009). Table 3 shows the top three most popular aman, boro, and aus varieties grown in 2004-05. In the aman season, BR11 was the most popular variety, followed by Swarna, covering about 27% and 12% of the area, respectively. In the boro season, the most popular variety was BRRI dhan29 (BR29), followed by BRRI dhan28 (BR28), and these two varieties covered about 60% of the boro area. In the case of aus, no single variety was found to be largely dominating as with aman and boro varieties. In

Table 3. The top three most popular aman, boro, and aus varieties in Bangladesh, 2004-05.

Season	Variety	% of farmers	% of area	Yield (t/ha)	SE of mean
Aman 2004	BR11	22.44	26.53	3.92	0.013
	Swarna	9.76	11.56	3.79	0.020
	Paizam	7.97	7.45	3.29	0.018
Boro 2005	BR29	30.29	36.23	6.13	0.017
	BR28	25.16	23.15	5.11	0.016
	BR16	3.61	3.07	5.20	0.043
Aus 2004	BR28	9.78	9.03	3.87	0.042
	Haitta	8.66	8.28	2.03	0.023
	BR2	6.38	6.90	3.13	0.047

this case, the most popular variety was BR28, followed by Haitta, covering only 9% and 8% of the aus area. The findings showed that, although BR28 is basically a boro variety, it is also grown as a popular variety in the aus season. However, the yield of BR28 in the aus season was considerably lower than in the boro season (Table 3).

Diversity and concentration of varieties by region. Diversity of rice varieties was found in different regions, particularly with respect to traditional varieties. However, there were similarities in adopting most popular varieties in all the regions, with some exceptions. BR11 was found to be the most popular aman variety in all the regions except Khulna and Barisal. In the Khulna region, Indian variety Swarna was found to be a bit more popular than BR11 (Table 4). It can be mentioned that some Indian popular varieties are widely grown in Bangladesh, particularly in the border districts. Again, in the Barisal region, a local variety called Sada Mota, although it had comparatively less yield, was found to be an equally preferred variety like BR11. Again, in the case of the boro/aus season, BR29 and BR28 were found to be the most popular varieties in all the regions except Khulna and Barisal. In addition to BR29 and BR28, two Indian varieties, Ratna in Khulna and Bhajon in Barisal, were popular (Table 4).

Spatial distribution of varieties. Regional diversity of rice varieties in the previous section showed that although there were wide variations in varieties across different regions, the most popular varieties were BR11 and Swarna in the aman season and BR29 and BR28 in the boro season. However, there were distinct variations in the concentration of these varieties in different districts/regions. In terms of percentage of area covered by BR11 and Swarna in different districts/regions, it can be observed from Figure 1A and 1B that the concentration pattern in different regions/districts of these two varieties was somewhat opposite. The Indian aman variety Swarna is heavily concentrated in the border districts located in the eastern part of West Bengal, India, while BR11 is concentrated in other regions/districts with some area overlapping with Swarna, particularly in the northwestern region of Bangladesh. Again, the

Table 4. Concentration of rice varieties at the regional level in aman and boro/aus seasons.

Region	Varieties in aman season[a]	Varieties in boro/aus season
Rajshahi	BR11 (39%), Swarna (31%), Paijam (11%), Chini Ataop (1.3%)	BRRI dhan29 (29%), BRRI dhan28 (28%), BR1 (8.3%), Parija (5.6%)
Dhaka	BR11 (33%), Paijam (19%), BRRI dhan32 (3.8%), Swarna (2.9%)	BRRI dhan29 (56%), BRRI dhan28 (18%), BR14 (5.9%), Paijam (3.9%), BR26 (2.6%), BR3 (2.3%)
Sylhet	BR11 (27%), BR22 (13%), BRRI dhan32 (7.7%), Paijam (4.6%), Khama (2.4%), Til Bajal (1.9%)	BRRI dhan29 (53%), BRRI dhan28 (16%), BR16 (6.9%), BR3 (5.1%), BR14 (3.2%), BR19 (2.4%)
Khulna	Swarna (25.12%), BR11 (22.77%), BR30 (8.56%), BR10 (7.10%), BR23 (5.95%), Sada Mota (4.45%)	BRRI dhan28 (39%), Ratna (19%), BRRI dhan29 (9.3%), Mota, Minikit (7.0%), Heera (4.5%), Nayanmoni (3.8%), GS1 (2.7%)
Barisal	Sada Mota (10%), BR11 (10%), Chikon (5.4%), Madumala(5.4%), BR10 (4.8%), BR3 (4.5%), BR23 (4.5%), Nizershail (2.4%)	BRRI dhan29 (41%), Bhajan (25%), BRRI dhan28 (6.4%), BR8 (2.5%), Belobori (2.8%), Heera (1.8%)
Chittagong	BR11 (28%), Paijam (11%), BR22 (5.8%), BR10 (5.8%), BR30 (5.0%), BR32 (4.3%), Kala Shail (3.6%), BR41 (2.2%)	BRRI dhan28 (32%), BRRI dhan29 (19%), BR16 (9.1%), BR14 (3.5%)

[a]The numbers in parentheses indicate the percentage of rice area.

concentration pattern of BRRI dhan29 and BRRI dhan28 was also a bit opposite (Fig. 1C and 1D). BRRI dhan29 is heavily concentrated in the middle part of Bangladesh, which is a relatively low-lying area. On the other hand, BRRI dhan28 is concentrated in relatively highland areas, particularly in the northwestern region and the hilly area in the southeastern region. Concentration of this variety was also observed in coastal districts located in the southwestern part of Bangladesh.

Demand for traits in improved varieties

The survey investigated the reasons for the preference of the most popular boro varieties such as BRRI dhan29 and BRRI dhan28. For BRRI dhan29, as the first response, almost all the farmers (96%) reported that high yield (6.1 t/ha) was the main reason for preferring this variety. From multiple responses, along with high yield other important reasons reported by the farmers were eating quality (66%), lodging resistance (62%), and pest resistance (32%) of the rice plants (Table 5).

Again, in the case of BR28, high yield (5.1 t/ha) was also found to be an important reason for preferring this variety as revealed from the first response (64%) and multiple responses (68%). However, from multiple responses, eating quality (77%) and shorter maturity (69%) were found to be very important reasons for preferring this variety.

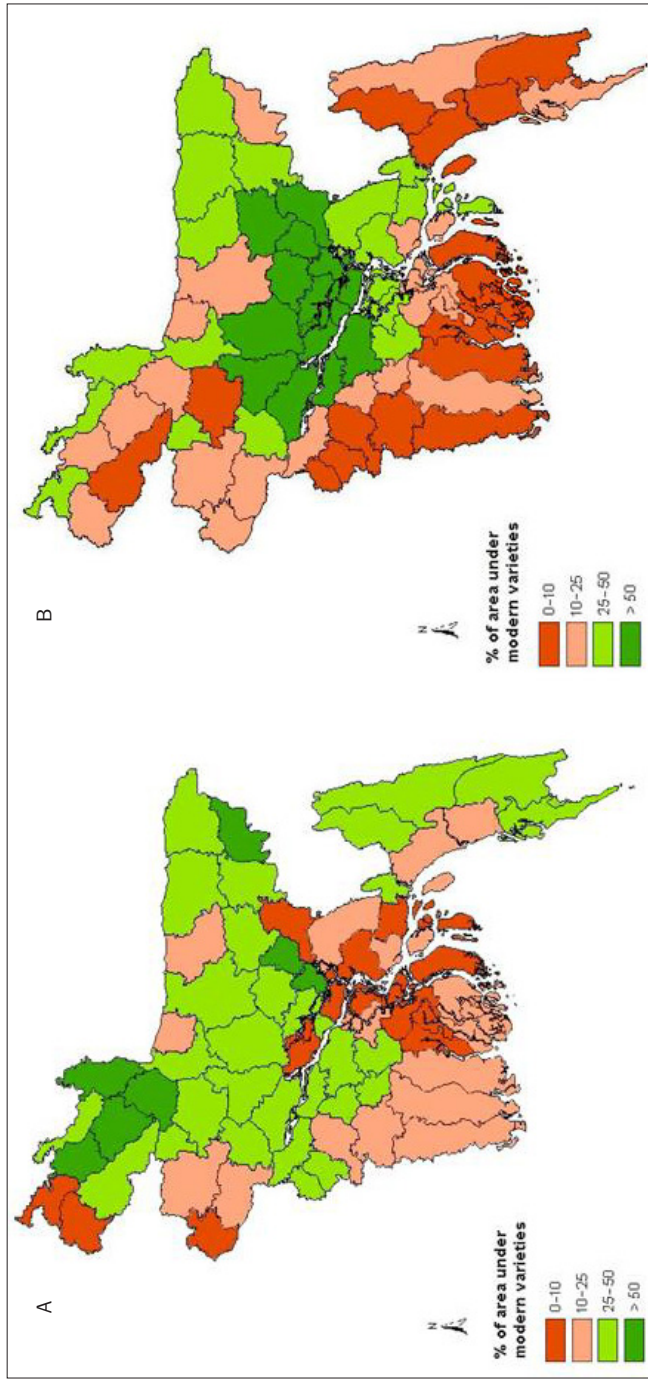

Fig. 1. Rice variety diversity by district, Bangladesh.

Fig. 1 continued.

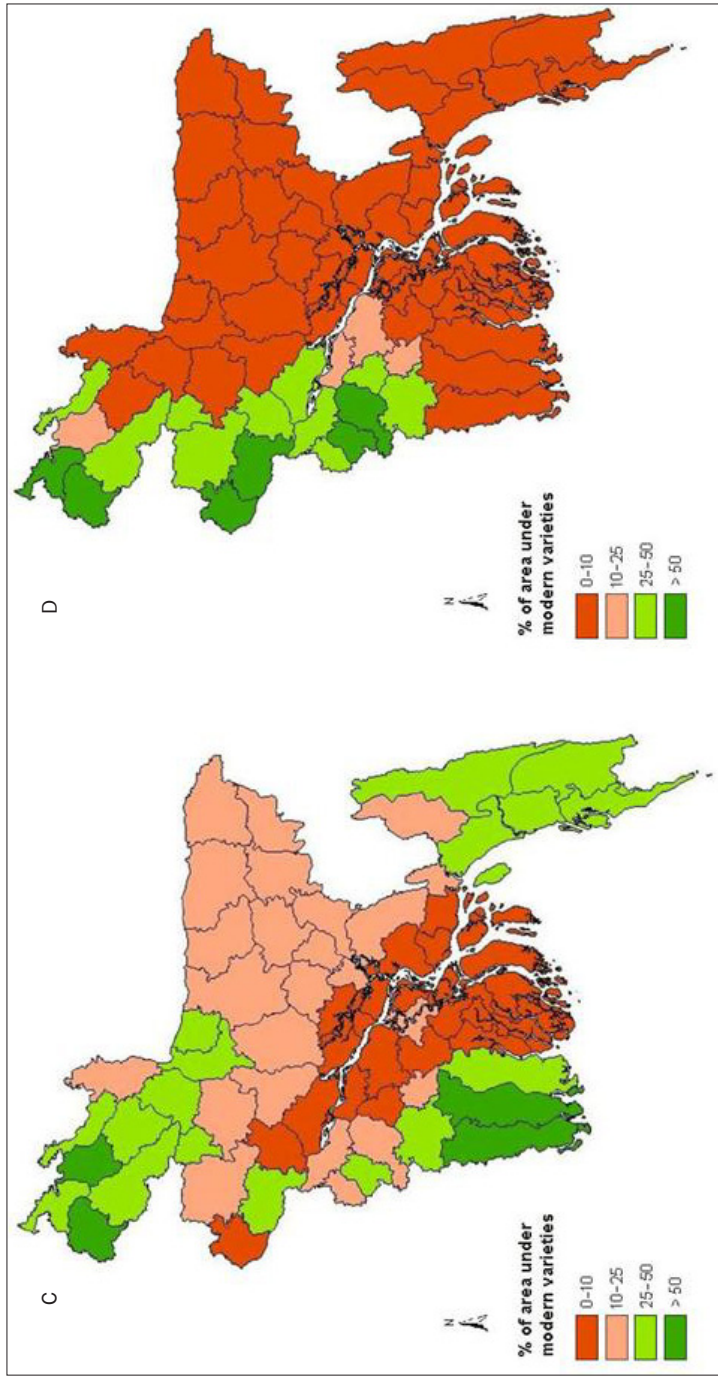

Table 5. Reasons for preference of popular varieties.

Variety	Reason for preference	First response (%)	Multiple responses (%)
BRRI dhan29	High yield	96	98
	Eating quality	2	66
	Lodging resistance	0.5	62
	Pest resistance	0.6	32
BRRI dhan28	High yield	64	68
	Eating quality	22	77
	Shorter maturity	8	69
	Pest resistance	5	20
	Lodging resistance	3	23

Process of diffusion of improved varieties

Sources of first information about new varieties. For introducing any rice variety at the farmers' level, getting information to farmers is very important. The survey revealed that field-level staff of the DAE are the main source of first information about a new variety (Table 6). The extension contact, however, is biased in favor of large farmers. On the other hand, enterprising neighbors who first experiment with a new variety are often a source of information on the performance of a new variety for small and marginal farmers. Findings of the survey also showed that fertilizer traders are still not a good source of information about new varieties. Further, the role of radio and TV for spreading information about a new variety remains limited (Table 6).

Sources of seed for expansion of area. Rice seeds used by farmers can be broadly classified into four groups: modern varieties (MVs) of Bangladeshi origin, MVs of Indian origin, hybrid varieties, and traditional varieties (TVs). Findings from the field survey revealed that 64% of the farmers used Bangladeshi MVs while Indian MVs were used by about 10% of the farmers and hybrid seed was used by less than 2% of the farmers (1.67%). On the other hand, rice seed of TVs was used by about a quarter of the farmers (24.4%).

The analysis showed that the main source of seed is the farmers' own harvest (Table 7) while the Bangladesh Agricultural Development Corporation (BADC) accounts for a small fraction of the seed market for improved varieties. It also showed that Indian varieties are spreading through neighbors and fertilizer dealers and hybrids are spreading mostly through fertilizer traders. However, about 23% of the farmers mentioned their own harvest and neighbors as the source of hybrid seeds. This indicates the use of F_2 seeds by farmers due to ignorance about hybrid seeds. The survey also revealed that traditional varieties are maintained mostly through the use of own harvest and procuring seeds from neighbors.

Time taken for full adoption since introduction. The process of adoption of the two most popular boro varieties, BRRI dhan29 and BRRI dhan28, was found to be

Table 6. Sources (%) of first information about a new variety.

Information source	Small farmer	Large farmer	All cases
DAE staff	48	70	58
Other farmers	38	17	28
Radio	1.9	1.2	1.6
Television	2.0	2.0	2.0
Fertilizer dealer	2.5	3.2	3.2
Relatives and friends	5.7	5.6	6.2
Others	1.8	1.8	1.6

Table 7. Sources (%) of seed for expansion of area.

Source of seed	Bangladeshi MVs	Indian MVs	Hybrids	Traditional varieties
Own harvest	52	72	18	82
Neighbor	13	21	5	15
Fertilizer trader	9	6	60	0
BADC	25	0	0	0
BRRI	0.2	0	0	0
NGOs	0.8	1.0	17	3
Total	100	100	100	100

more or less the same. Therefore, in the following sections, the adoption process of only BRRI dhan29 is discussed. The survey showed that it took about 3 years for full adoption of this variety. However, small and marginal farmers as well as tenant farmers were faster adopters than larger farmers although the DAE had better contacts with large farmers than with small and marginal farmers in disseminating information about new varieties.

Time pattern of adoption of BR29. The time pattern of adoption of the most popular boro variety, BR29, by ecological factors showed that, since its inception (1995), adoption was the highest in flood-prone areas, followed by favorable, drought-prone, and salt-affected areas, respectively (Fig. 2). In terms of land type (according to flood depth), it was found that the adoption of this variety was the highest in very low land followed by lowland, medium land, and highland (Fig. 2B). Again, in terms of farm size, it was found that adoption of this variety was positively related to farm size (Fig. 2C), whereas year-wise allocation of land as a percentage of total land was inversely related to farm size (Table 8). This implies that, in adopting BR29, although the percentage of large farmers was higher than small/medium farmers over time, the large farmers allocated proportionally less land than others with small farm sizes.

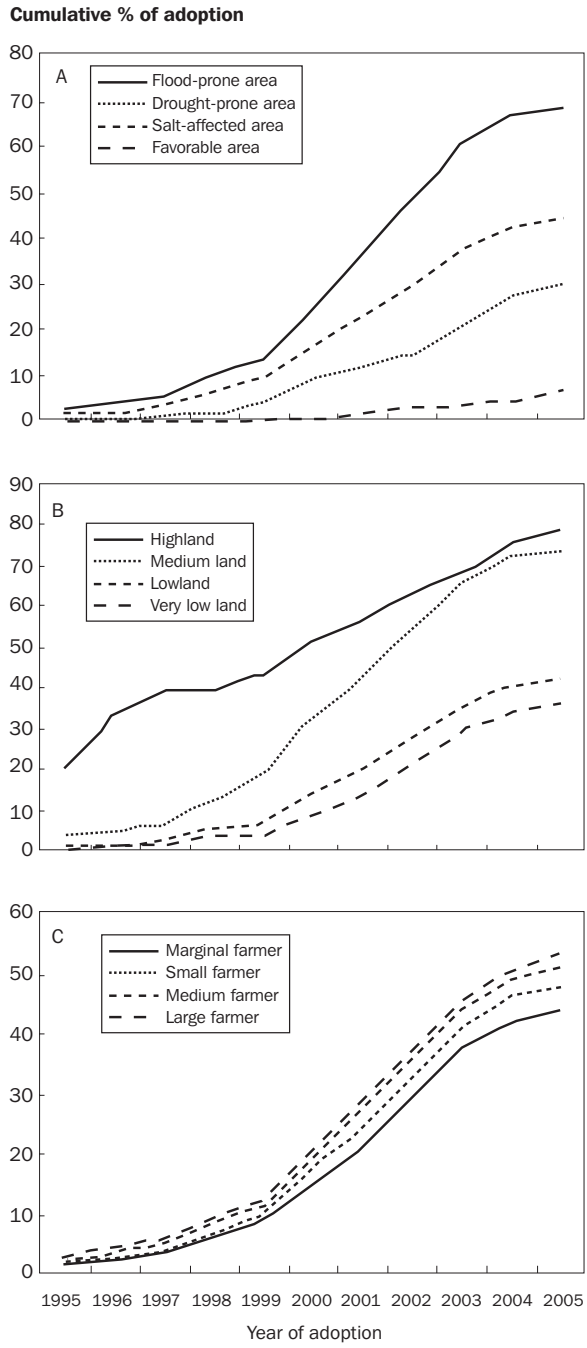

Fig. 2. Time pattern of adoption of BR29 by (A) ecological condition, (B) topography, and (C) farm size.

Table 8. Time taken for full adoption of BRRI dhan29 since introduction.

Farm size	Area covered in first year (%)	Area covered in second year (%)	Full adoption (years)
Marginal	56	77	2.7
Small	31	47	3.0
Large	14	25	3.5

Table 9. Major reasons for the extinction of varieties.

Reason	First reason		Multiple reasons	
	No of cases	% of cases	No of cases	% of cases
Low yield	8,031	77.1	8,039	73.0
Long maturity	469	4.5	672	6.4
Lodging problems	360	3.5	608	5.8
Low milling recovery	61	0.6	92	0.9
More pest incidence	256	2.5	310	3.0
Others	1,242	11.9	1,296	12.4

Varieties at risk of extinction and reasons

The 2005 IRRI survey showed that a lot of traditional aman and aus varieties were popular earlier but are now on the way to extinction. Farmers mentioned the names of 572 rice varieties in the aman season and 426 varieties in the boro season that they stopped growing or that are on the way to extinction. A complete list of all the extinct varieties can be seen elsewhere (Hossain and Jaim 2009). The important extinct aman varieties are Nazir Shail, Loti Shail, Raja Shail, Balam, Binni, Digha, Kartik Shail, etc., while the most important extinct aus varieties are Haitta, Kotoktara, Goria, Porangi, Kala Manik, Hasi Kalmi, Balam, Vaduri, Agali, etc. However, there were variations in extinct popular varieties in different regions of Bangladesh. The main reason farmers stopped growing some traditional varieties that were popular earlier is low yield, as reported by more than 70% of the farmers. The other reasons are long maturity, lodging problems, more pest incidence, etc. (Table 9).

Major findings and conclusions

Findings of the 2005 IRRI survey showed that considerable diversity still exists for rice varieties at the farm level in Bangladesh. However, the diversity is higher in the aman and aus seasons than in the boro season. The survey also showed that a few varieties dominate the landscape; often, three to five varieties account for over half of the total land area.

Many farmers keep traditional varieties of their choice for the special traits that they value in that variety. The survey also indicated that there is large regional variation in the choice and concentration of improved varieties. Some Indian varieties with special traits are popular in areas near the Indian border. It was found that high yield is the predominant trait that farmers want in a new variety. However, they also prefer shorter maturity for more intensive land use and good quality for premium prices. The findings also showed that hybrids are becoming popular despite the high seed cost because of their 1.0 to 1.5 t/ha yield advantage.

Findings in relation to the process of adoption and diffusion of new varieties showed that extension officials are the dominant source of first information about a new variety, but the extension contact is biased in favor of large farmers. For small and marginal farmers, enterprising farmers are the major source of information about an improved variety.

A new variety spreads very fast once farmers are convinced about its good traits of their liking. It takes about 3 years to diffuse a variety to its potential area in a village after its introduction. The area covered, however, does not go beyond half to two-thirds of the area. The survey also revealed that many traditional popular varieties are on the way to extinction because of low yield and lower profitability than improved varieties.

The findings of the study have the following policy implications:

1. It is easy to spread a new trait such as micronutrients by focusing on a few dominant varieties.
2. The potential yield of aman and aus varieties should be increased and focus on environmental stresses.
3. There is a need to focus on pure-line selection of popular traditional varieties to keep them competitive with improved varieties.
4. Government organizations should take an active role in on-farm conservation of popular traditional varieties.

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Notes

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Diversity, spatial distribution, and the process of adoption of improved rice varieties in West Bengal

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With the main objectives of investigating diversity and the adoption process of improved rice varieties in the state of West Bengal, 7,684 farm households were selected using multistage random sampling, which covered all the districts of the state. The survey identified 226 rice varieties in West Bengal, a large proportion of which are traditional varieties mostly grown in the aman season. The most popular variety in the aman season was found to be Lal Swarna, which alone covered 45% of the rice area, whereas in the boro season it was IR36 covering 27% of the area. The most important trait for the popularity/wide adoption of a variety was found to be high yield, accompanied by good eating quality and short maturity. The number of years taken for full adoption for the popular varieties in the boro season was 3.5 years, with 4 years for aman. The main source of seed for aman varieties was own seed, whereas, in the case of improved boro varieties, it was seed traders. The role of government in supplying seed or information was found to be negligible. Farmers stopped growing some popular varieties. The main reasons were low yield in the case of traditional varieties and long maturity period for improved varieties. The study identified the dominant varieties in which a new trait such as micronutrients can be incorporated and also recommended pure-line selection of popular traditional varieties to keep them competitive with improved varieties.

Introduction

The state of West Bengal is situated in the eastern part of India. It has 8% of the total population of the country, 72% of whom live in rural areas. Agriculture plays an important role in the economy of West Bengal. Agriculture contributed 21% of the net domestic product of the state, providing employment to 25% of the state's active work force in 2005-06. The state has 5.9 million farm holdings covering an area of 5.3 million ha. The average holding size is 0.82 ha, which is highly fragmented. Eighty-two percent of the farm holdings are within 1 ha of land and per capita availability of land was 0.065 ha in 2001 (GOI Agricultural Census 2000-01).

The state has diverse agro-climatic regions, with average rainfall varying from 796 mm to 2,264 mm in different districts. Based on soil, topography, and climate, the

state is delineated into six agro-climatic zones: hill, *terai*, new alluvial, old alluvial, red and laterite, and coastal and saline zones. Out of these six zones, the new alluvial zone and old alluvial zone are very fertile, with higher percentages of irrigated area. These two zones are recognized as the granary of West Bengal.

West Bengal, an agriculturally developed state of India, contributes 16% of the country's total rice production. West Bengal has two growing seasons, which are termed the wet season and dry season or, in local words, aman and boro seasons. Traditionally, large numbers of rice varieties were cultivated by farmers in these two seasons. However, with the introduction of high-yielding varieties (HYVs) as well as hybrid varieties during the last few decades, many traditional rice varieties have completely disappeared, which has contributed to an erosion of biodiversity. However, many traditional varieties still exist in farmers' fields.

Studies in other countries have also shown that, although competition between modern and traditional varieties of principal staple crops (wheat, rice, maize, potato) has displaced a large number of traditional varieties, many traditional varieties exist in certain areas without being completely displaced despite their allegedly inferior yields (Brush et al 1992, Bellon et al 1998, Widawsky et al 1998, Meng et al 1998, Bellon and Taylor 1993, Louette et al 1997, Louette and Smale 2000, Perales et al 2003, Hossain and Jaim 2009). In fact, farmers choose varieties based on varietal adaptation to soils and other environmental factors. Unfavorable physical and environmental conditions, a lack of irrigation facilities, nonavailability of improved seed, etc., are the major reasons that explain the existence of traditional varieties. Access to markets also explains farmers' maintenance of traditional varieties. This implies that the more physically isolated a community or household is, the less specialized its production activities (Benin et al 2003). Hence, we can expect that modern varieties are less adopted in remote areas due to farmers' lack of access to seeds. Meng (1997) also found that the cultivation of wheat landraces was positively associated with their relative isolation from markets in Turkey.

Again, the major reasons for the diversity and concentration of different rice varieties in different regions have been explained as variations in agroecological conditions (soil, elevation, and climate), that is, the more heterogeneous the conditions in which farms cultivate the crop, the higher the expected varietal diversity (Benin et al 2003). Greater numbers of plots and farm fragmentation have also been associated with crop and variety specificity (Brush 1995).

Farmers may cease growing landraces if changes in the production or marketing environment cause them to lose their relative value (Gauchan et al 2005). On the other hand, although several improved varieties have been released by research stations, a few of these varieties have become popular due to their well-accepted traits. The diffusion of these varieties also took place in a relatively shorter period than for other varieties.

With this background, the specific objectives of this study were to investigate four aspects of the diversity and concentration of varieties:

1. Spatial distribution of varieties
2. Traits demanded in improved varieties

3. Process of diffusion of improved varieties
4. Varieties on the way to extinction and the reasons

Methodology

The survey was conducted in all the 17 districts (Midnapur was taken as one district in lieu of East Midnapur and West Midnapur) of West Bengal representing six agro-climatic zones. To select farmers, at first 85 blocks (25% of all 341 blocks) were selected by using systematic random sampling. Then, from each block, two village *panchayats* were selected: one from the southern area and the other from the northern area of the block. Again, from each village *panchayat,* two villages were selected randomly.

To conduct the survey, it was decided to select 15% of the farmers randomly from the selected villages using the list of all the households kept in the village *panchayat* office. Because of the larger size of some selected villages and Maoist insurgency in some areas, the sample size of the villages was reduced to 331 instead of 340. As a result, ultimately, the total sample size stood at 7,684. Rice-related information for the wet season of 2006 and summer season of 2006-07 was collected from the sample farmers during April to October 2007.

Results and discussion

Characteristics of farms

Farm size distribution. Farming in West Bengal was found to be dominated by small/marginal farmers in terms of both number of farms and area cultivated. About three-fourths of the farmers had a small farm size, having up to 1.0 hectare of land (Table 1). This group of farmers possessed about half of the cultivated land. Average landholdings of the sample farmers was 0.77 ha, which was very close to the findings of the Agricultural Census of West Bengal (0.82 ha) (GOI, Agricultural Census 2000-01).

Physical and environmental characteristics. Distribution of land considering flood depth showed that most of the cultivable land (about 73%) was medium type while only about 11% was highland and about 13% was located in low-lying areas (Table 2). More than half of the study area (about 54%) had favorable environment for rice production while the rest (46%) had unfavorable conditions located in coastal saline (16%), drought-prone (19%), and flood-prone (11%) areas. In terms of irrigation facilities, it was found that only about 31% of the rice land had access to irrigation.

Diversity and concentration of varieties

The study identified 226 distinct rice varieties, of which 166 were grown in the wet/aman season and 60 were grown in the dry/boro season during 2006-07. A detailed list of all the varieties with share of area and respective yield can be seen elsewhere (Hossain and Jaim 2009). The maximum number of rice varieties grown by a single farmer was 10. However, about 78% of the sample farmers cultivated a single variety

Table 1. Distribution of landholdings of the sample farmers.

Farm size	No. of samples	% of farms	% of land area
Up to 0.5 ha	3,065	39.9	17.6
0.5–1 ha	2,654	34.5	31.2
1–2 ha	1,627	21.2	36.8
2–4 ha	317	4.1	12.8
4 ha and above	21	0.3	1.6
Total	7,684	100.0	100.0

Source: 2007 household surveys.

Table 2. Distribution of farms by land type and environmental characteristics.

Particulars	No. of farms	% of farms
Land type		
Highland	797	10.5
Medium land	5,548	72.8
Lowland	899	11.8
Very low land	54	0.7
Mixed land	321	4.2
Total	7,619	100.0
Environmental characteristics		
Flood prone	808	10.8
Drought prone	1,387	18.6
Coastal nonsaline	77	1.0
Coastal saline	1,189	15.9
Favorable environment	3,995	53.6
Total	7,456	100.0

Source: 2007 households surveys.

or two varieties while the rest cultivated more than four varieties. These were cultivated mostly in medium land under favorable environments.

Out of 166 rice varieties grown in the wet season, the number of varieties that covered more than 1% of the rice area was only 18. Again, among all the varieties grown in the wet season, the most popular variety was Lal Swarna (MTU 7029), which covered 45% of the rice area (Table 3). The other popular rice varieties according to importance were White Swarna (6.3%), Ranjit (4.6%), Swarna Masuri (3.9%), Lalat (3.7%), etc. Thus, the five most popular varieties covered 63.4% of the wet-season rice area. Yield of these popular varieties ranged from 3.4 to 3.6 t/ha.

Table 3. Varietal diversification and share of area of the most popular varieties in the wet and dry seasons.

Season	Total no. of varieties	Popular varieties	% of farms	% of area	Yield (t/ha)
Wet season/aman	166	Lal Swarna	38.0	44.9	3.6
		White Swarna	6.8	6.3	3.5
Dry season/boro	60	IR36	23.8	26.6	5.2
		Satabdi	20.6	18.4	5.0

Source: 2007 household surveys.

Irrigation is one of the most important inputs for dry-season/boro rice production. As only 31% of the rice area was found to have access to irrigation, only 23% of the rice area was covered by boro rice during 2006-07. The number of rice varieties planted by the sample farmers during the dry season was also limited (only 60) compared with the wet season (166). The most popular dry-season rice was found to be IR36, covering 27% of the boro rice area. The other popular varieties according to importance were Satabdi (18.4%), Khitish (8.7%), CR-1010 (7.1%), Sankar (6.8%), etc. These top five varieties covered about 68% of the total dry-season rice area.

The grain yield of IR36, Satabdi, Khitish, and CR-1010 was almost the same (about 5 t/ha). It can be mentioned that yield of some other varieties was also close to that of these varieties or even higher but coverage was less (less than 1%). The low adoption of these varieties may be due to other reasons besides yield.

Spatial distribution of varieties

The findings showed that in the aman season improved rice varieties occupied about 87% of the area while the remaining 13% was occupied by traditional varieties. Again, district-wise area under traditional rice varieties was found to be highest in 24 Parganas (South), followed by Jalpaiguri, Howrah, Coochbehar, 24 Parganas (North), and Midnapur. A recent published document by the West Bengal Biodiversity Board (2007) revealed that the highest number of landraces can be found in 24 Parganas, followed by Midnapur and Coochbehar. Larger areas under traditional rice varieties are because these districts suffer from moderate to severe salinity and inundation as well as a lack of suitable modern varieties for the ecosystem.

The distribution of aman rice area by districts of West Bengal showed wide variations in terms of percentage share of area in different districts, ranging from 1.9% in Darjiling and Dakshin Dinajpur to 14.7% in Midnapur, followed by Burdwan (11%). Further, varietal distribution of area by districts in aman showed dominance of Lal Swarna (ranging from 37% of rice area in Nadia to 79% in Burdwan) in all the districts except in two, 24 Parganas North and South (Table 4). It can be noted that, although medium land type is predominant in West Bengal, farmers plant late-duration (140–145 days) varieties such as Lal Swarna, Ranjit, and White Swarna instead of medium-duration (125–130 days) varieties. The popularity/dominance of

Table 4. Spatial distribution of aman area with the most popular variety by districts.

District	% share of aman rice area	Most popular aman variety	% of area covered by variety	Yield (t/ha)
Darjiling	1.9	L. Swarna	63.8	3.2
Jalpaiguri	4.9	L. Swarna	40.5	3.0
Coochbehar	3.12	L. Swarna	56.9	3.1
Uttar Dinajpur	2.5	L. Swarna	69.8	3.5
Dakshin Dinajpur	1.9	L. Swarna	57.5	3.5
Maldah	3.6	L. Swarna	39.3	3.8
Mursidabad	6.5	L. Swarna	53.0	3.5
Birbhum	6.7	L. Swarna	56.0	3.9
Burdwan	11.0	L. Swarna	79.0	4.0
Nadia	3.6	L. Swarna	37.0	3.6
North 24 Parganas	4.9	W. Swarna	15.9	3.5
Hoogly	7.3	L. Swarna	41.9	3.6
Bankura	7.3	L. Swarna	69.6	3.7
Midnapur	14.7	L. Swarna	22.3	3.3
Howra	3.2	L. Swarna	26.7	3.5
South 24 Parganas	9.8	Pankaj	15.0	3.6
Purulia	7.0	L. Swarna	64.0	3.3
Total	100	–	–	–

Source: 2007 household surveys.

Lal Swarna is also noticeable in crop-intensive districts such as Hooghly, Burdwan, and Murshidabad, which have more irrigation facilities.

The share of boro area by districts also showed wide variations, ranging from only 0.1% in Purulia to 12.9% in Midnapur. Diversity of rice varieties by districts in boro was visible since environmental conditions for boro rice vary between the northern and southern districts of West Bengal. China boro was found to be the most popular variety in Jalpaiguri and Coochbehar in the northern districts, while IR36 and Satabdi were the most popular varieties in the southern districts covering a major share of boro cultivated area (Table 5). However, IR36 outyielded China boro and Satabdi (Table 5).

Traits demanded in improved varieties

The first preference trait for the most popular improved rice varieties and their adoption in both the wet and dry seasons was high yield as revealed from the responses of almost all the farmers (Table 6). The second most important trait was eating quality (good taste) of the variety. The other important traits for variety preference were

Table 5. Spatial distribution of boro area with the most popular variety by districts.

District	% share of boro area	Most popular boro season variety	% of area covered by variety	Yield (t/ha)
Darjiling	0.2	Satabdi	59.6	4.3
Jalpaiguri	1.3	China Boro	47.7	4.0
Coochbehar	2.1	China Boro	68.3	4.2
Uttar Dinajpur	2.8	Khitish	59.3	4.6
Dakshin Dinajpur	3.5	Khitish	47.0	4.7
Maldah	5.4	IR36	31.0	5.0
Mursidabad	8.5	IR36	38.4	5.3
Birbhum	6.5	IR36	57.2	5.4
Burdwan	2.2	IR36	48.7	5.3
Nadia	6.9	Satabdi	63.1	4.8
North 24 Parganas	7.7	Satabdi	60.4	4.8
Hoogly	11.3	IR36	27.9	5.4
Bankura	3.2	IR36	69.8	4.9
Midnapur	12.9	Sankar	52.6	4.7
Howra	1.5	Khitish	5.8	4.8
South 24 Parganas	4.1	Satabdi	34.5	5.1
Purulia	0.1	IR36	100.0	4.5
Total	100	–	–	–

Source: 2007 household surveys.

shorter maturity period for some popular varieties (i.e., Lal Swarna, White Swarna, Lalat, IR36, Ratna, CR1010, Bullet, etc.), which allows an opportunity for intensive cropping. Good for water rice (Panta Bhat) and higher milling recovery were also important traits in the cases of Lal Swarna and White Swarna. Further, some special traits are considered by farmers for preferring a variety. For example, variety MTU-7029 contributes higher grain yield with acceptable taste and high milling recovery. It also has good quality for making puffed rice (Muri), which is prepared by women. Because of these traits, this variety has been adopted on a large scale across the state, in spite of its susceptibility to pests and diseases.

Process of diffusion of improved varieties

Sources of first information about new varieties. To introduce any rice variety at the farmers' level with its cultural practices, getting information to farmers is very important. The survey revealed that, in the aman season, the main source of first information about new varieties was other farmers of the village (40% of the respondents), followed by fertilizer dealers (30%) and farmers/relatives from other villages (24%).

Table 6. Traits that farmers look for in selecting varieties in the aman and boro seasons.

Trait	Popular aman varieties				Popular boro varieties			
	Lal Swarna		White Swarna		IR36		Satabdi	
	1st trait	2nd trait	1st trait	2nd trait	1st trait	2nd trait	1st trait	2nd trait
High yield	99.8		99.8		100.0		99.4	
Good taste	0.1	51.2		47.8		82.9		89.5
Shorter maturity		23.3		22.9		11.2		8.0
Good for water rice		11.5		9.2		0.7		
Higher milling recovery		10.7		9.2		0.8		0.6
Insect resistant	0.2	1.4	0.2	2.4		1.6	0.6	0.6
Disease resistant		1.3		6.0		2.8		1.3
Weed competitive		0.1						
Lodging resistant		0.5		2.6				
Total	100	100	100	100	100	100	100	100

For boro rice varieties, the main source of first information was also other farmers of the village (92% of the respondents). Fertilizer dealers also had some role in this respect (7%). Surprisingly, the media such as radio and television as well as the Agricultural Extension Department had a negligible role in providing first information to farmers about new varieties (Table 7).

Sources of seed for expansion of area. The survey revealed that most farmers used improved variety seed. Only 16% of the farmers used traditional seed varieties in the aman season while almost all the farmers (99.5%) used improved varieties for boro production. The main sources of seed in the aman season (Table 8) were farmers' own seed (61% of the farmers), followed by neighbors (28%) and seed traders (11%). The survey revealed that, for the most popular aman variety, Lal Swarna, the source of seed for 71% of the farmers was own seed and this was 60% for another popular rice variety, White Swarna.

In the boro *s*eason, seed traders were the main source of seed supply (42%), followed by own harvest (34%) and neighbors (24%). The short-duration varieties are mainly grown in the boro season, whose seed does not possess dormancy. As such, viability declines rapidly before planting in the next season. Rains and storms during the harvesting of boro rice also affect the quality of the seed. Hence, for shorter duration popular varieties such as IR36 and Satabdi, most of the farmers purchase seed from seed traders. The survey also revealed that the role of the government and other organizations in supplying seed was very negligible (Table 8).

Time pattern for adoption of popular varieties. In general, it took about 5 years for full adoption of improved aman and boro varieties. However, for popular boro varieties, it took less time than for popular aman varieties. The number of years taken

Table 7. Source of first information about new varieties.

Source of information	Aman season		Boro season	
	Number of farms	% of total	Number of farms	% of total
Radio	13	0.4	12	0.2
TV	1	0.0	12	0.2
Other farmers of the village	1,338	40.4	7,030	92.2
Fertilizer dealer	994	30.0	538	7.1
Farmers/relatives from other villages	788	23.8	28	0.4
Agricultural extension	172	5.2	5	0.1
Other	2	0.0	–	–
Total	3,308	100.0	7,625	100.0

Source: 2007 household surveys.

Table 8. Sources (%) of seed for expansion of area.

Source of seed	Traditional variety		Improved variety		Total	
	No. of farms	% of total	No. of farms	% of total	No. of farms	% of total
Aman season						
Own harvest	1,182	66.9	5,539	59.9	6,721	61.1
Purchase from neighbors	440	24.9	2,624	28.4	3,064	27.8
Seed traders	143	8.1	1,068	11.6	1,211	11.0
Government	2	0.1	6	0.1	8	0.1
Others	0	0.0	4	0.0	4	0.0
Total	1,767	100.0	9,241	100.0	11,008	100.0
Boro season						
Own harvest	6	30.0	1,243	34.0	1,249	33.9
Purchase from neighbors	4	20.0	888	24.3	892	24.2
Seed traders	10	50.0	1,523	41.6	1,533	41.6
Government	0	0.0	5	0.1	5	0.1
Others	0	0.0	2	0.1	2	0.1
Total	20	100.0	3,661	100.0	3,681	100.0

Source: 2007 household surveys.

Table 9. Time taken for full adoption of the most popular varieties since introduction.

Aman season		Boro season	
Popular varieties	Years taken for full adoption	Popular varieties	Years taken for full adoption
Lal Swarna	4.0	IR36	3.6
White Swarna	3.8	Satabdi	3.2
Ranjit	3.5	Khitish	3.8
Swarna Masuri	4.1	CR-1010	3.3
Lalat	3.7	Sankar	3.6
All	4.0	All	3.5

Source: 2007 household surveys.

for full adoption of popular rice varieties in the aman season varied from 3.5 to 4 years (Table 9). The most popular aman rice variety, Lal Swarna, took 4 years for its full adoption. Other popular varieties such as White Swarna, Ranjit, Swarna Masuri, and Lalat took 3.5 to 4.1 years for full adoption.

For boro, the most popular variety, IR36, took 3.6 years for its full adoption. Other popular varieties such as Satabdi, Khitish, CR-1010, and Sankar took 3.2 to 3.8 years. The long-duration rice varieties, specifically aman varieties, can be multiplied only once in a year, as a result of which adoption of aman-season rice is relatively slow. On the other hand, most of the popular boro rice are short-duration varieties that have the advantage of being multiplied throughout the year, leading to quicker adoption. The time pattern of adoption of popular varieties in aman and boro seasons can be seen in Figure 1.

Varieties at risk of extinction and reasons

Farmers stopped cultivating some traditional varieties mainly because of low yield. The second reason as identified from farmers' responses was a longer maturity period. For improved varieties also, almost all the farmers (99.2%) stopped cultivating some of the varieties after growing them one or two times. The popular extinct improved varieties are Pankaj, Jaya, IR50, Ratna, etc. The first most important reason for this as revealed from the farmers responses (Table 10) was longer maturity period of the variety (77% of responses), followed by less yield (13%) and lodging problems (8%). The second most important reason was susceptibility to pests (76% of responses), followed by lodging problems (12%) and less milling recovery (6%). The third most important reason as reported was unsuitability of paddy straw for cattle feed (32% of responses), followed by paddy not good for making popped rice such as *Chira, Muri*, etc. (31%).

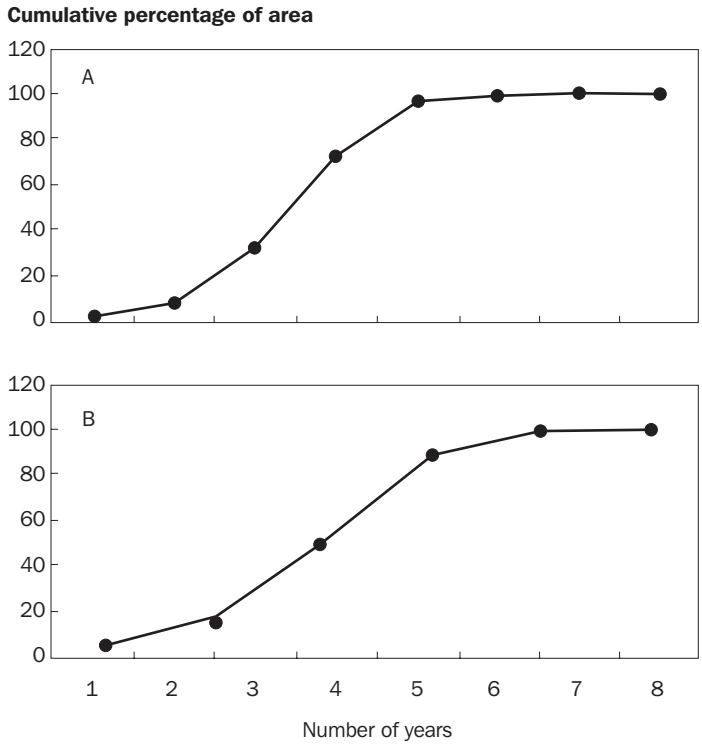

Fig. 1. Number of years taken for full adoption of rice varieties in the aman season (A) and boro season (B).

Major findings and conclusions

Major findings

This study revealed that farming in West Bengal is dominated by small/marginal farmers. Rice is cultivated mostly on medium land (73% of the rice area) having a favorable environment for rice production in about half of the area (54% of the rice area). Irrigation facilities in West Bengal were found to be inadequate; only about 31% of the rice area had access to irrigation.

The study identified 226 distinct rice varieties grown by the sample farmers of the selected blocks during 2006-07. The number of varieties grown in the wet/aman season of 2006 was 166. Although large numbers of varieties were grown in the aman season, only 18 were grown on more than 1% of the rice area. Among all the varieties grown in the aman season, the most popular variety was Lal Swarna (MTU 7029), which alone covered 45% of the rice area.

The number of rice varieties planted by the sample farmers during the dry/boro season was limited (60 varieties) compared with the aman season. The most popular dry-season rice was IR36, covering 26% of the dry-season rice area. Other popular

Table 10. Reasons for stopping growing some popular improved varieties.

Reasons	First reason		Second reason		Third reason	
	No. of responses	% of responses	No. of responses	% of responses	No. of responses	% of responses
Less yield	1,000	13.2	2	0.0	1	0.0
Longer maturity period	5,816	76.6	164	2.2	6	0.1
Lodging problems	584	7.7	871	11.5	39	0.5
Less milling recovery	30	0.4	480	6.3	29	0.4
Susceptible to pests	148	1.9	5,794	76.3	1,152	15.2
Not good for water rice	6	0.1	157	2.1	270	3.6
Not good for popped/thatched rice (*Chira*/*Muri*)	5	0.1	87	1.1	2,311	30.5
Easily shatters when drying in the field	1	0.0	23	0.3	1,169	15.4
Straw not suitable for cattle			9	0.1	174	2.3
Others	2	0.0	6	0.1	2,429	32.0
Total	7,592	100.0	7,593	100.0	7,580	100.0

Source: 2007 household surveys.

varieties according to importance were Satabdi, Khitish, CR-1010, Sankar, etc., and the top five varieties covered about 68% of the total dry-season rice area.

The most important trait that farmers looked for in selecting varieties in the aman season was high yield (93% of the responses), followed by good taste and high milling recovery. For boro varieties, the important traits were slender grains, high yield, good taste, and shorter duration.

Farmers' own seed was the major source of rice varieties in the aman season, whereas seed traders were the main source in the boro season. Other farmers in the village and friends/relatives were the main sources of first information for new seeds while the Agricultural Extension Department and the media (radio, TV, etc.) had an insignificant role in providing information.

The number of years taken for full adoption of popular rice varieties in the aman season varied from 3.5 to 4 years. For boro, the most popular variety, IR36, took 3.6 years for its full adoption.

The survey also revealed that farmers stopped cultivating some of the popular varieties. The main reason for stopping growing some popular traditional varieties was low yield, whereas, in the case of improved varieties, the most important reason was longer maturity period (77% of responses) followed by less yield (13%) and lodging problems (8%).

Policy recommendations

It will be easier to disseminate varieties with new traits such as micronutrients by focusing on a few dominant varieties such as Lal Swarna and White Swarna in the aman season and IR36 and Satabdi in the boro season.

The potential yield of aman and boro varieties can be reached by developing more varieties that can tolerate environmental stresses.

Expansion of irrigation facilities can also contribute to the adoption/expansion of improved varieties as well as a significant increase in the yield of traditional varieties. There is a need to focus on pure-line selection of popular traditional varieties to keep them competitive with improved varieties.

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Diversity, spatial distribution, and the process of adoption of improved rice varieties in Orissa State of India

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With the objectives of investigating varietal diversification of rice, the adoption process of improved varieties, and related issues in the state of Orissa, India, a survey was conducted in 2008. Using multistage stratified random sampling, 6,529 households were selected that represented all 30 districts of the state. The number of varieties as identified from the survey was 723 in the wet season, most of which were traditional varieties. On the other hand, the number of varieties in the summer season was 29, all of which were improved varieties grown under irrigated conditions. Varietal diversity of rice was found at the household level in different districts as well as under different agroecological conditions (particularly with variations in land elevation). Variety Swarna was the most popular variety in the wet season whereas in summer it was Lalat. Farmers' most important reason for preferring a variety was high yield accompanied by other traits such as good taste of cooked rice, lodging resistance, shorter duration, etc. The survey showed that the main source of first information about a new variety was other farmers and the source of seed was mainly their own harvest. It took about 4 years for full adoption of popular varieties. The survey also identified extinction of a considerable number of both traditional and modern varieties. Low yield was the main reason for rejecting traditional varieties, whereas, for modern varieties, pest susceptibility and relatively low yield were the two dominant reasons. Potential yield of both traditional and modern varieties should be increased by focusing on environmental stresses and new traits (such as micronutrients) that could be incorporated in the identified popular varieties.

Introduction

The state of Orissa lies in the subtropical belt in the eastern region of India. The state occupies 4.7% of India's landmass with a share of 4% of the total population. Nearly 84% of its 37 million people live in rural areas and depend mostly on agriculture and allied activities for their livelihood. Again, more than 45% of the state's population lives in the coastal belts that constitute only 25% of the land area of the state. Orissa is one of the poorest states in India, with a high incidence of poverty, particularly among the scheduled tribes and scheduled castes, which constitute nearly 39% of

the population of the state. Frequent droughts, floods, and other natural calamities contribute to the impoverishment of the people.

The state has diverse agro-climatic situations. Based on the land formation, topography, soil, climate, and crop adaptability, it has been divided into 10 agro-climatic zones and 61 farming situations. However, the state is broadly divided into four physiographic divisions: the Northern Plateau, the Central Table Land, the Eastern Ghats, and the Coastal Region. Regions in the coastal areas have highly fertile alluvial soils. The rest of the regions are plateau and hill terrains, mostly having red, red and yellow, and laterite soils of low fertility. Annual average rainfall of the state is 1,451 mm, which varies widely among the districts. Rainfed farming is the dominant feature of the state's agriculture. Out of the total land area of 5.1 million hectares, upland constitutes 42%, medium land 32%, and lowland 26%. Only about 33% of the cropped area is irrigated, mostly from canals, covering the medium land and lowland areas. However, a canal as a source of irrigation is not reliable as the canals have inadequate water during drought periods.

Agriculture is the mainstay of the state's economy and subsistence for the life of the people. In 2005-06, agriculture, including livestock, contributed 23% of the net domestic product of the state, but provided employment to 73% of the economically active labor force, indicating the very low productivity of labor in agriculture. According to the Agricultural Census of 2000-01, 4.07 million farm holdings in the state covered an area of 5.08 million hectares. Scheduled tribes and scheduled castes accounted for 30% and 14% of the farm holdings, respectively. The average landholding is 1.25 hectares, which is highly fragmented, mostly located in the coastal region. The per capita availability of cultivated land has declined significantly over time from 0.39 ha in 1950-51 to 0.14 ha in 2004-05 (Government of India 2001).

Rice is the predominant crop in Orissa. The Jeypore tract in the Eastern Ghat region accounts for more than 90% of the total area under cereals and contributes about 93% of the total cereal production. Out of the total kharif cropped area of 6.14 million hectares in 2006-07, rice was grown on 4.14 million hectares, which constituted more than 67% of the total cropped area. In 2006-07, rice yielded about 1.5 t/ha (milled rice), which was one of the lowest among the rice-producing states in India. The yield of rice fluctuates highly from year to year because of the high frequency of droughts, floods, and cyclones.

Rice is grown in Orissa in autumn, winter, and summer seasons. Autumn rice is grown with premonsoon rains in the upland areas and is mostly direct seeded. Winter rice grown during the monsoon season (harvested in December-January) is the dominant crop. Summer rice is grown mostly in the irrigated areas of Balasore, Bolangir, Puri, Cuttack, Kalahandi, Koraput, and Sambalpur. These three seasons account for 17%, 76%, and 7%, respectively, of the total rice area and contribute to about 11%, 78%, and 11% of rice production. The share of autumn rice in the total area and production has decreased over the years while that of summer rice has increased.

The area under modern varieties has spread rapidly from 4% in 1970 to about 80% in 2005-06, but yield has remained low. However, large numbers of traditional varieties still exist in the state despite the rapid expansion of modern varieties. Recent

studies focus on competition between modern and traditional varieties of the principal staple crops (wheat, rice, maize, potato) to explore why traditional varieties persevere, de facto, in certain areas without being completely displaced despite their allegedly inferior yields (Brush et al 1992, Bellon et al 1998, Widawsky et al 1998, Meng et al 1998, Bellon and Taylor 1993, Louette et al 1997, Louette and Smale 2000, Perales Rivera et al 2003).

The first genetic factor concerns agroecological conditions (soil, elevation, and climate). Farmers choose varieties based on the varieties' adaptation to soils and other environmental factors (Zimmerer and Douches 1991), that is, the more heterogeneous the conditions in which farms cultivate the crop, the higher the expected amounts of infraspecific diversity. The diverse agroecological conditions of Orissa mainly explain the reasons for the existence of a large number of traditional rice varieties. The second generic factor that operates at a regional or community scale is opportunities for trade on markets. This indicates that, when farmers cannot rely on the market to provide them with the seed that meets their demand for attributes, they may grow a more diverse set of varieties to ensure their needs. Greater numbers of plots and farm fragmentation have also been associated with crop and variety specificity, which is also true for Orissa. Brush (1995) reported that land fragmentation promoted conservation by enabling farmers to conserve landraces in one plot, while planting modern varieties in the majority of cultivated area.

Farmers may cease growing landraces if changes in the production or marketing environment cause them to lose their relative value (Gauchan et al 2005). Decades ago, Harlan (1972) and Frankel (1970) warned against the extensive displacement of landraces they observed during the early years of the Green Revolution, particularly in the more favorable agronomic environments where high-yielding varieties were adopted first. The total number of landraces as well as the area planted to landraces in India and many other countries such as Bangladesh and Nepal appear to be declining over time (Hossain and Jaim 2009, Gauchan et al 2005). However, a number of traditional varieties are still popular among farmers/consumers because of their special traits despite their low yield compared with that of modern varieties.

Modern varieties may possess traits not found in local varieties (Louette et al 1997) or have more uniform grain quality, enabling cash to be earned to satisfy other consumption needs of households (Zimmerer 1996). However, a few of these modern varieties have been proved very popular due to their well-accepted traits and diffusion of them took place in a shorter period than with other varieties.

With this background, this study specifically aims at investigating

1. Diversity and concentration of varieties
2. Spatial distribution of varieties
3. Traits demanded in improved varieties
4. Process of diffusion of improved varieties
5. Varieties on the way to extinction and the reasons

Methodology

Orissa has 30 districts consisting of 314 community development blocks, 6,234 *gram panchayats,* and 51,551 revenue villages. The household survey in relation to this study was conducted in all 30 districts of Orissa representing 10 different agro-climatic zones of the state. The sample size consisted of 20–25% of the blocks of each district, 3–5% of the villages under each district, and 10–15% of the farm households under each village. To select farmers, at first 119 blocks were selected from all 30 districts using systematic random sampling and then, from these blocks, 287 villages were again selected randomly.

To conduct the survey, it was initially decided to select 15% of the farm households randomly from the list of all farm households kept with the ward members of the village. However, for large villages (more than 200 households), 10% of the households were selected randomly. A smaller proportion of sample households was selected from a few villages located in Malkangiri, Deogarh, and Gajapati districts, where, because of Maoist insurgency and threats, it was difficult for the investigators to stay overnight. However, because of the larger size of some of the selected villages, the total number of the sample ultimately stood at 6,529 instead of 6,000 as designed earlier. Rice-related data for the kharif/wet season of 2007 and summer season of 2007-08 were collected from the sample households during June to September 2008.

Results and discussion

Farm characteristics

Socioeconomic characteristics. Farm size distribution according to this study showed close similarities with that of findings of the Agricultural Census of 2000-01 for Orissa (Table 1). According to landholdings, farmers were categorized into four groups: marginal farmers (up to 1 ha), small farmers (1 to 2 ha), medium farmers (2 to 4 ha), and

Table 1. Distribution of landholdings according to this study (2008) and the Agricultural Census, 2000-01, for Orissa.

Farm size	Present survey (2008)		Agricultural Census of 2000-01	
	% of farms	% of area	% of farms	% of area
Up to 0.5 ha	21.2	5.8	28.1	6.6
0.5–1 ha	31.0	18.3	28.4	16.1
Up to 1 ha	52.2	24.1	56.5	22.7
1–2 ha	31.8	34.5	27.4	30.4
2–4 ha	12.7	25.7	12.3	26.5
Above 4 ha	3.3	15.8	3.9	20.4
Total	100.0	100.0	100.0	100.0

large farmers (above 4 ha). Marginal farmers constituted 52% of all farm households, with a share of 24% of total land. Small farmers accounted for another one-third of the farms, with a share of one-third of total land. On the other hand, large farms comprised only 3.3% of the households but controlled 16% of the land area. Thus, the agrarian structure of the state was dominated by marginal and small farmers who constituted more than 80% of the farm households. Some 78% were owner-farmers while only 5% were pure tenants and 17% were owner-cum-tenants. About 33% of the farmers did not have any formal education whereas 30% had a primary education. About 19% completed secondary education and the percentage of those who had above secondary education was 18%.

Physical and environmental characteristics. In terms of land elevation, it was found that 45% of the paddy land was medium type while the corresponding percentages for lowland, very low land, and highland were 40%, 7%, and 9%, respectively. According to environmental characteristics in relation to crop production, about 59% of the selected villages were located in drought-prone areas. Ecosystems having both flood-prone and drought-prone characteristics covered about 9% of the area whereas flood-prone area alone covered about 8%. Further, coastal saline-drought and flood-prone constituted about 3% of the rice area. Only about 21% of the area was irrigated and canals were the major source of irrigation, accounting for 74% of the land area, followed by rivers (7%), shallow tube wells (6%), ponds (4.4%), and dug wells (4%).

As a result of erratic monsoon and uneven distribution of rainfall, canals as a source of irrigation have become useless during drought years due to poor storage capacity of the reservoirs. Therefore, environmental characteristics as well as irrigation facilities in Orissa do not seem to be at all favorable for rice production in general, particularly for modern rice varieties for which reliable irrigation facilities are indispensable.

Diversity and concentration of rice varieties by season

Wet season. The study identified 723 distinct rice varieties that were grown by the sample farmers during the 2007 wet/kharif season. A complete list of all the varieties with the percentage of area covered and yield can be seen elsewhere (Hossain and Jaim 2009). The survey showed that much rice diversity still exists in the state. Diversity is also considerable at the household level. The largest number of rice varieties grown by a single farmer was 14. However, about 30% of the farmers cultivated only one variety while 33% cultivated two varieties and 21% cultivated three varieties. The percentage of farmers who cultivated more than three varieties was 16.

Most of the varieties identified were traditional; however, modern varieties were found to be more popular. In the wet season, the most popularly variety was Swarna, covering 29% of the rice area (Table 2). The other popular varieties according to share of wet-season rice area were Lalat (7.3%), Pooja (6.8%), MTU-1001 (5%), CR1018 (3.2%), etc. These five popular varieties (including Swarna) covered about 54% of the rice area in the wet season.

Among the modern varieties, varieties released by the Central Rice Research Institute, Cuttack, had the highest yield, but the performance across different locations

Table 2. Varietal diversity and concentration of the most popular varieties by season, 2007-08.

Season	Number of varieties	Popular varieties	% of farmers	% of area	Yield (t/ha)
Wet season, 2007	723	Swarna	21.3	29.3	3.0
		Lalat	8.3	7.3	2.1
		Pooja	5.8	6.8	3.2
Summer season, 2007-08	29	Lalat	48.6	47.0	4.0
		MTU-1001	8.4	15.2	4.2
		MTU-1010	7.1	9.5	5.1

Source: Household survey 2008.

was not stable as indicated by the high value of the standard error of yield. On the other hand, the yield of the most popular variety in Orissa, Swarna, was about 3 t/ha, which was lower than CR varieties and some other varieties such as Tiki Mahsuri (3.53 t/ha), Sarala (3.47 t/ha), Jagabandhu (3.22 t/ha), Pooja (3.21 t/ha), etc. But, Swarna has a stable yield as indicated by the low value of standard error (0.018).

Among the low-yielding traditional varieties that are still cultivated in a significant proportion of land are Raspanjar (1.49 t/ha), Mugudhi (1.5 t/ha), Bankei (1.27 t/ha), Jhalka (1.83 t/ha), Baula (1.31 t/ha), Sapuri (1.77 t/ha), Kakudimanji (1.52 t/ha), etc. These varieties are grown because of their very special traits such as short maturity, superior grain quality, and resistance to drought, submergence, salinity, etc.

Summer season. Only about 14.5% of the farmers having assured irrigation in the state cultivated summer rice. Only 29 summer rice varieties were identified from the survey (Hossain and Jaim 2009), all of which were modern varieties. The most popular variety was Lalat, which was cultivated by about 49% of the farmers, covering 47% of the summer rice crop area, with an average yield of 4 t/ha. This was followed by MTU-1001, covering an area of 15% and yielding 4.2 t/ha. Other varieties having considerable area under summer rice were MTU-1010 (9.5%), Parijat (6.7%), Konark (5.3%), Khandagiri (5.6%), etc., with an average yield from 3.6 to 5.1 t/ha. The state average summer rice yield was 4.3 t/ha.

Diversity and concentration of varieties by land elevation

Diversity of varieties was observed depending on the land elevation of rice fields. The survey identified 143 upland rice varieties in the state during the 2007 wet season. More than half (52%) of the upland rice area was covered by the popular modern varieties such as Khandagiri, Arnapurna, and Lalat. Khandagiri alone covered about 34% of the total upland paddy area. The yield of modern varieties in uplands varied from 0.36 t/ha for Nilagiri to 2.94 t/ha for Swarna. But, very few farmers (0.82%) adopted Swarna in the uplands.

In the medium land of Orissa, 332 varieties were grown and almost half (49%) of the land was covered by Swarna, followed by Lalat (14.7%), MTU-1001 (10%), etc. Medium land having the most stable environment for rice farming experienced

Table 3. Varietal diversity and concentration of the most popular varieties in the wet season by land type.

Land type by elevation	No. of varieties	Popular variety	% of farms	% of area	Yield (t/ha)
Upland	143	Khandagiri (MV)	32.0	34.0	1.97
		Arnapurna (MV)	11.0	11.0	1.63
Medium land	332	Swarna (MV)	38.5	49.0	3.14
		Lalat (MV)	17.5	15.0	2.07
Medium-lowland	411	Swarna (MV)	13.0	18.0	2.71
		Pooja (MV)	13.0	16.0	3.20
Lowland	109	Raspanjar (TV)	11.5	18.0	1.49
		Mugudhi (TV)	6.0	11.0	1.46

Source: Household survey 2008.

lower varietal diversity than medium-lowlands. Among the recently released varieties for irrigated medium lands, MTU-1001 was found to be the most promising, with a yield of 2.8 t/ha. Swarna's performance was highest (3.14 t/ha) in medium land against all other land types. Other medium-land rice varieties with higher yield were Pooja (3.25 t/ha), Surendra (2.95 t/ha), Keshari (2.82 t/ha), and Moti (2.66 t/ha). However, coverage of these varieties in area was small. The average mean yield of paddy in medium land was 2.59 t/ha.

Varietal diversity in the medium-lowlands showed that 411 rice varieties (mostly traditional) were grown by farmers and the average yield was 2.66 t/ha. In the medium-lowlands too, Swarna continued to share a higher percentage of area (18.33%), with a yield of 2.71 t/ha. However, in the medium-lowlands of Orissa, Pooja, a newly released variety from CRRI, Cuttack, was found to be gaining popularity among farmers. This variety covered about 16% of the medium-lowlands of the state, with a promising yield of 3.2 t/ha.

The number of varieties grown in lowland was 109 during the wet season of 2007. More than 90% of the area under such land was under traditional varieties. The popular varieties were Raspanjar (18% of rice area), Mugudhi (10.67%), Baula (9.83%), Putia (7%), etc. For modern varieties, only three varieties, Sarala (3% of rice area), Durga (2.41%), and Kanchan (0.58%), had some degree of acceptability and the most promising was Sarala, having yield of 3.56 t/ha.

Spatial distribution of rice varieties

District-wise distribution of area and yield showed that Swarna was the most popular variety in 18 districts out of a total of 30 districts, with yield variability ranging from 2.2 t/ha in Nuapada District to 3.66 t/ha in Sambalpur District. In the southern districts of Koraput, Malkangiri, and Nawarangpur, MTU-1001 was the most popular variety, whereas in Gajapati and Rayagada districts it was Lalat. Local varieties still predominate in Sundergarh District, having the highest percentage of area in upland

Table 4. Distribution of the most popular varieties by districts.

Variety	Districts along with respective coverage (%)[a]
Swarna	Bhadrak (61), Balasore (60), Mayurbhanj (51), Kalahandi (46), Jajpur (45), Baragarh (42), Nuapada (42), Jharsuguda (40), Balangir (37), Sambalpur (37), Boudh (33), Keonjhar (31), Dhenkanal (28), Angul (26), Puri (22), Nayagarh (21), Khurda (21), Cuttack (17)
MTU-1001	Malkangiri (36), Sonepur (32), Koraput (17), Nawarangpur (15)
Lalat	Gajapati (26), Rayagada (16.5)
Pooja	Ganjam (30)
CR-1018	Jagatsinghpur (23)
Moti	Deogarh (14)

[a]Numbers in parentheses represent percentages of rice area.
Source: Household survey 2008.

paddy. In the tribal-dominated district of Kandhmal also, traditional varieties constituted about 50% of the total rice area. During the recent years, Pooja (a CRRI variety released in 1999) has been gaining importance among the farmers in almost all the districts of the state.

Traits that farmers look for in selecting improved varieties

High yield was the most important trait in preferring a rice variety as reported by all of the respondents who adopted popular modern rice varieties such as Swarna, Pooja, CR-1018, etc. For the most popular variety, Swarna, the second important trait was good taste of the cooked rice, followed by lodging resistance, shorter duration, quality grain, higher milling recovery, etc. (Table 5). For another popular variety, Pooja, the second most important trait for preferring it was good eating quality of the rice, followed by higher milling recovery, lodging resistance, etc. Further, farmers' choice of a variety also depends on some other traits such as good for water rice (*Panta*) and suitable for making puffed rice such as *Chira-Muri-Khoi,* etc. (Table 5).

Process of diffusion of improved varieties

Sources of first information about new varieties. About 71% of the farmers got their first information about new varieties from fellow farmers of the village while about 19% got the information from agricultural extension officials. Again, about 9% of the farmers received information from relatives/farmers from other villages. Mostly medium (41%) and large farmers (69%) got information from the agricultural department about new varieties and from them it was disseminated to other farmers of the village. Among the social caste groups, scheduled castes and tribes are the most underprivileged ones as they got little attention from extension officials regarding information about new varieties. The role of radio, television, seed companies, KVK officials, and NGOs in disseminating first-time information about modern varieties was negligible.

Sources of seed for expansion of area. The study showed that, for modern varieties, farmers used their own seeds in about 88% of the cases. Only about 8% of the

Table 5. Traits that farmers look for when selecting modern varieties (numbers represent % of responses).

Traits	Swarna			Pooja			CR-1018		
	1st trait	2nd trait	Multiple responses	1st trait	2nd trait	Multiple responses	1st trait	2nd trait	Multiple responses
High yield	100.0	–	100.0	100.0	–	100.0	99.6	–	99.6
Lodging resistance	–	53.5	56.4	–	16.5	23.0	–	7.4	13.2
Shorter maturity	–	20.4	21.0	–	2.6	2.6	–	–	0.0
Good eating quality	–	12.4	71.6	–	57.4	88.5	0.4	2.1	22.6
High milling recovery	–	7.6	18.1	–	20.3	30.6	–	86.8	90.9
Good for water rice (*Panta*)	–	1.2	9.3	–	–	26.8	–	1.2	42.4
Insect/disease resistance	–	–	0.1	–	0.9	9.6	–	0.8	25.5
Good grain quality	–	4.7	20.3	–	1.9	16.5	–	1.2	2.9
Good for puffed rice	–	0.1	3.0	–	–	0.2	–	0.4	2.5
Others	–		0.1	–	0.2	1.2	–	–	0.0
Total	100.0	100.0	300.0	100.0	100.0	300.0	100.0	100.0	300.0

Source: Household survey, 2008.

Table 6. Source of first information about new seed varieties.

Source of information	No. of farms	% of farms
Other farmers of the village	4,056	71.3
Agricultural extension officials	1,077	18.9
Farmers or relatives from other villages	505	8.9
Seed company/trader	27	0.5
KVK officials	11	0.2
Radio	9	0.2
Television	2	0.0
NGOs	3	0.1
Total	5,690	100.0

Source: Household survey 2008.

Table 7. Distribution of farmers by sources of seed.

Source of seed	No. of farms	% of farms
Own harvest	13,534	88.0
Government seed sale center	1,199	7.8
Farmer-to-farmer exchange	391	2.5
Neighbors	99	0.6
Seed traders	85	0.6
Seed purchased from private seed growers	34	0.2
Others	30	0.2
Total	15,372	100.0

Source: Household survey 2008.

farmers bought seed from a government seed sale center and about 3% procured seed through exchange with other farmers. For traditional varieties, almost all the farmers used their own seed.

Time taken for full adoption of modern varieties. On average, it took 4–5 years for full adoption of most of the popular modern varieties in Orissa. However, by the fourth year, most of the popular modern varieties were fully adopted in area suitable for a particular land type in the state. The time pattern for adoption of popular varieties such as Swarna, Pooja, CR-1018, and MTU-1001 can be observed in Figure 1.

Varieties at risk of extinction and reasons

The survey found that about 54% of the farmers in the state abandoned a particular modern variety for some specific reasons. It was invariably found that pest susceptibility and low yield were the two dominant reasons for rejecting a specific modern

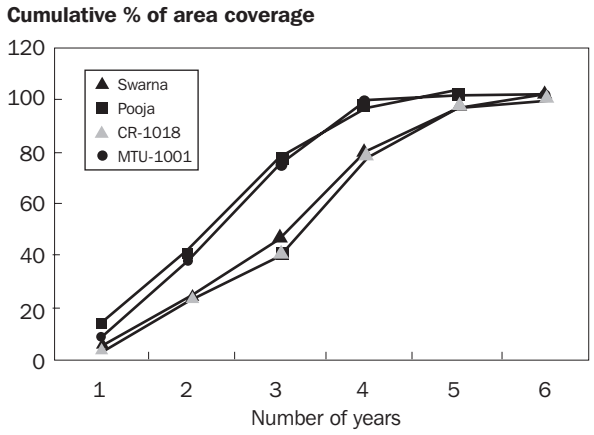

Fig. 1. Time pattern for full adoption of popular varieties.

variety. Poor grain quality and poor taste also had some bearing on the sample farmers for rejecting the varieties.

In the case of traditional varieties**,** irrespective of the farm size groups, 100% of the farmers as the first reason mentioned that they stopped cultivating some varieties due to their low yield. The other reasons as revealed from their responses were seed degeneration (more than 85% of responses), nonavailability of seed (42%), and susceptibility to lodging (more than 40%).

Summary and conclusions

This survey covering all the districts of Orissa identified poor landholding status of the farmers as having adverse environmental characteristics, which do not seem to be at all favorable for rice production in general. Ecosystems having characteristics of either flood-prone or drought-prone or both covered about 76% of the study area. Only about 24% of the rice area had access to irrigation and canals were the major source of irrigation, which became useless during drought years due to poor storage capacity of the reservoirs.

The study identified 723 distinct rice varieties that were grown by the sample farmers during the 2007 wet season. Most of the varieties identified in this study were traditional; however, modern varieties were more popular than traditional varieties. In the wet season, the most popular variety was Swarna, covering 29% of the rice area. The number of summer rice varieties as identified from the survey was only 29, all of which were modern varieties. In this case, the most popular variety was Lalat, which was cultivated by about 49% of the farmers, covering 47% of the summer rice area.

The study revealed that the number of rice varieties varies considerably depending on land type. The number of varieties grown in upland was considerably low (143 varieties) compared with medium land (332 varieties) and lowland (520 varieties).

Table 8. Main reasons for stopping growing some specific popular modern varieties (numbers represent % of responses).

Reason	Popular modern varieties				
	CR-1009	Jajati	Swarna	CR-1030	Jagannath
Susceptibility to pests	57.5	78.1	83.9	80.6	85.6
Low yield	0.9	19.2	0.0	2.5	11.9
Poor grain quality	26.3	0.0	0.0	3.6	0.0
Longer maturity	2.8	1.3	0.3	7.9	1.0
Less resistant to waterlogging	5.7	0.2	4.4	2.9	0.0
Poor taste	4.9	0.0	0.0	0.0	0.0
Variety not suitable for land type	0.7	0.2	7.6	1.4	0.0
Others	1.0	1.0	3.7	1.1	1.5
Total	100.0	100.0	100.0	100.0	100.0

Source: Household survey 2008.

Varietal diversification was also observed across different districts; however, Swarna was the most popular variety in 18 districts out of 30 total districts. In the southern districts of Koraput, Malkangiri, and Nawarangpur, MTU-1001 was the most popular variety, whereas, in Gajapati and Rayagada, it was Lalat.

High yield was the most important trait in selecting a rice variety. The second most important trait in selecting the most popular variety (such as Swarna) was good taste of the cooked rice, followed by lodging resistance, shorter duration, high-quality grain, higher milling recovery, etc.

About 71% of the farmers got their first information about modern varieties from fellow farmers while only about 19% got information from agricultural extension officials. The role of radio, television, seed companies, and NGOs in disseminating first-time information about modern varieties was negligible. The survey revealed that, for modern varieties, farmers used their own seeds in about 88% of the cases**,** whereas only about 8% of the farmers bought seed from government seed sale centers.

On average, it took 4–5 years for full adoption of most of the popular modern varieties in Orissa. However, by the fourth year, most of the popular modern varieties were fully adopted.

The survey found that about 54% of the farmers in the state abandoned a particular modern variety for some specific reasons. It was invariably found that pest susceptibility and low yield were the two dominant reasons for rejecting a specific modern variety. For traditional varieties**,** low yield was the main reason.

The overall findings of the survey revealed that a large number of traditional varieties still exist in Orissa and the adoption of modern varieties is seriously constrained by reliable sources of irrigation, an adequate supply of quality seeds, information about new technologies, etc. Potential yield of both traditional and modern varieties should be increased by focusing on environmental stresses. Therefore, more attention/

support is needed from government and nongovernment organizations in developing rice varieties suitable for growing under stress conditions or in unfavorable ecological conditions. The study also identified a few popular rice varieties in which a new trait such as micronutrients can be incorporated.

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Diversity, spatial distribution, and the process of adoption of improved rice varieties in Jharkhand, India

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In order to assess the varietal diversity of rice and the process of adoption of improved varieties, a survey was conducted in 20 districts out of 24 districts of Jharkhand, which included 3,219 farm households selected by using stratified random sampling. The survey showed wide variations in diversity and concentration of rice varieties grown in upland, medium land, and lowland. Altogether, 145 varieties were identified and the highest number was for medium land (71), followed by lowland (55) and highland (19). In the highland, traditional variety Gora Dhan was found to be the most popular, while in the medium land and highland improved varieties IR36 and Swarna, respectively, were the most popular varieties. However, Swarna was the most popular variety in 10 out of 20 districts. High yield was the most important trait for selecting a variety. It took about 3 years for full adoption of the most popular improved varieties. The most important reason for stopping growing some traditional varieties was the long growing period, followed by low yield. The development of environmentally stress-tolerant varieties and incorporating new traits (i.e., micronutrients) in the popular varieties identified as well as expanding irrigation facilities are suggested to improve the quality and quantity of rice production in the state.

Introduction

At the end of 2000, the state of Jharkhand was carved out of the southern part of Bihar State. Jharkhand is situated in eastern India at an elevation of about 1,100 m, with an area of 74,677 km^2 and a population of 26.93 million. Average population density is 274 persons per km^2, which varies considerably from as low as 148 persons in Gumla District to as high as 1,167 people per km^2 in Dhanbad District. Jharkhand was formed with 18 districts, which were formerly part of southern Bihar. Some of these districts were reorganized to form 6 new districts and the state now has 24 districts.

Most of the state lies on the Chota Nagpur Plateau. The Damodar, Brahmani, Kharkai, and Subarnarekha rivers flow in the state, whose upper watersheds lie within Jharkhand. Much of the state is still covered by forest. The soil of Jharkhand mainly consists of soil formed from the disintegration of rocks and stones.

Jharkhand is predominantly an agricultural state, where 71% of the population depends on agriculture. However, the net sown area of the state is only 22.7% of the total landmass. Large tracts of land are left barren in almost all the areas that are highly fertile for the cultivation of vegetables and fruits. Only 40% of the land is fertile, with very scanty irrigation facilities. Obviously, most of the cultivable land is dependent on rainfall and Jharkhand receives a good share of rainfall, which provides high potential for agriculture and horticulture.

Most of the farmers cultivate only one crop in a year and paddy dominates the present cropping pattern. Although modern varieties (both improved and hybrid) have been introduced in the state, many traditional varieties still exist. Studies in some other countries show that varieties differ in the extent to which they provide agronomic (adaptation to soils, maturity, disease resistance, fodder and grain yield) and consumption (taste, appearance) attributes (Benin et al 2003). Varietal diversity in Jharkhand could also be explained by heterogeneous agroecological conditions (soils, elevation, and climate), greater numbers of plots and farm fragmentation (Rana et al 2000), inadequate access to a seed market (Brush et al 1992), access to reliable irrigation facilities, etc.

The total number of landraces as well as the area planted to landraces appears to be declining over time in Jharkhand as in other states of eastern India, Bangladesh, and Nepal (Hossain et al 2009, Bagchi et al 2009, Behura et al 2009, Chaudhary et al 2004). This is mainly due to competition between landraces and modern varieties (Brush et al 1992, Meng et al 1998) or choices among landraces (Van Dusen 2000, Smale et al 2001). Farmers have also ceased growing some popular varieties due to changes in the production or marketing environment (Gauchan et al 2005). In this context, decades ago, Harlan (1972) and Frankel (1970) warned against the extensive displacement of landraces they observed during the early years of the Green Revolution, particularly in the more favorable agronomic environments where high-yielding varieties were adopted first.

In Jharkhand, besides high-yielding varieties (HYVs), farmers have adopted a few hybrid varieties. These modern varieties possess traits not found in local varieties (Louette et al 1997) or they have more uniform grain quality, enabling cash to be earned to satisfy other consumption needs of households (Zimmerer 1996). Among these modern varieties, a few have been proved popular and their diffusion has taken place in a relatively short period. However, there are variations in these varieties as well as in popular varieties across different regions/districts with different land types and ecological environments.

With this background, this study specifically aims at investigating

1. Diversity and concentration of varieties
2. Spatial distribution of varieties
3. Traits demanded in improved varieties

4. Process of diffusion of improved varieties
5. Varieties on the way to extinction and the reasons

Methodology

Twenty out of 24 districts of Jharkhand were selected for the study. In each district, 20% to 25% of the blocks, 3% to 5% of the villages under each block, and 10% to 15% of the farm households under the selected villages were included in the study. A total of 53 blocks and 203 villages were selected, in which 3,219 farmers were selected for the surveys. Systematic random sampling was used to select the blocks, villages, and farm households.

Surveys were conducted in Jharkhand from May 2007 to December 2007. In collecting data on rice variety, the investigators sometimes faced the problem of the names of some rice varieties. In some areas, these names were reported using the local dialect. In such cases, the researchers could not differentiate whether a variety was the same or a different one as reported by the farmers in some other areas.

Results and discussion

Farm characteristics

Socioeconomic characteristics. The distribution of farms according to farm size showed that 47% of the sample farmers were marginal farmers having cultivable land below 1.0 hectare (Table 1). The corresponding percentages for small, medium, and large farmers were 32%, 17%, and 4%, respectively. According to social class/caste, 41% belonged to the scheduled tribe group, followed by backward class (21%), scheduled caste (17%), etc. The surveys also revealed that about a quarter of the farmers were illiterate and 30% of the interviewed farmers had a primary education while 9% had a secondary education. Farming was the main occupation of 87% of the farmers. Both male (57%) and female (43%) members were reported as earning members in the households.

Table 1. Distribution of selected households according to farm size.

Farm size (ha)	Farm size category	No. of households	% of all
Below 1.0	Marginal	1,509	46.9
1.0–2.0	Small	1,038	32.3
2.1–4.0	Medium	537	16.7
4.1 and above	Large	135	4.2
All	–	3,219	100.0

Source: Household survey 2007.

Table 2. Diversity of rice varieties by land type in the wet season.

Land type	Varieties grown (no.)		
	Total	Traditional varieties	Improved varieties
Upland	19	14	5
Medium land	71	50	21
Lowland	55	46	9
Total	145	110	35

Source: Household survey 2007.

Some 58% of the respondents from all social groups classified themselves as moderately poor, while 18% reported that they were very poor. On the other hand, about 17% and 7% of the respondents reported that they belonged to the solvent group and rich group, respectively. Regarding changes in economic conditions over the last 10 years, about 24% of the respondents reported that their economic conditions improved while 70% reported that their conditions did not change. The remaining 6% of the respondents felt that the economic conditions of their families had deteriorated over the last 10 years.

Land type and access to irrigation. The distribution of rice area by land elevation showed that rice occupied 48%, 29%, and 24% in medium land, lowland, and upland, respectively. Only 10% of the rice area had access to irrigation and the main source of irrigation was dug wells (25%), followed by river (24%), pond (21%), and canal (18%). Groundwater irrigation provided by tube wells covered only 12% of the irrigated area. This implies that the state suffers from unreliable sources of irrigation, which is a serious constraint to the expansion of modern rice varieties.

Diversity and concentration of rice varieties. This study revealed that 145 rice varieties were grown during the wet season (kharif season) in Jharkhand (Table 2). A complete list of all the rice varieties grown by the farmers with percentage of area covered and yield can be seen elsewhere (Lakra and Singh 2009). According to topography, three types of rice varieties are grown in Jharkhand: upland rice, medium-land rice, and lowland rice.

Nineteen rice varieties were grown in the uplands (Table 3). Among these 19 varieties, 14 were traditional (74%) and 5 were improved varieties (26%). In the case of medium land, 71 varieties were grown, of which 50 were traditional (70%) and 21 were improved varieties (30%). In lowland, 55 varieties were grown and among these varieties 46 were traditional (84%) and 9 were improved varieties (16%). Thus, rice farming in Jharkhand in the rainy season is largely dominated by traditional varieties.

Varietal diversification and concentration in uplands. Among the 19 upland rice varieties, the most popular variety was Gora Dhan, a traditional variety grown by 65.1% of the respondents. This variety covered about 69% of the upland rice area and 79% of the area under traditional varieties. The average yield of Gora Dhan was

Table 3. Distribution of rice area and yield of the most popular varieties in upland.

Upland rice	Farmers		Area		Average yield (t/ha)	SE of mean
	No.	% of total	Hectares	% of total		
Improved varieties						
Vandana	41	36.9	12.63	43.5	3.0	0.0313
Anjali	37	33.3	12.70	43.8	3.0	0.0191
Birsa Dhan 108	30	27.0	3.16	10.9	2.2	0.0120
Other varieties	3	2.7	0.52	1.8		
Total	111	100.0	29.01	100.0	–	–
Traditional varieties						
Gora Dhan/Goda	598	74.1	159.83	78.7	1.9	0.0347
Jhuli	39	4.8	7.50	3.7	1.9	0.0228
Baid	35	4.3	7.90	3.9	2.0	0.0260
Other varieties	135	16.7	27.94	13.8		
Total	807	100.0	203.17	100.0	1.9	0.0264

Source: Household survey 2007. Other improved varieties include Birsa Vikas (IV) and Sadabar (IV); other traditional varieties include Budhadhan, Soreya, Sathi, Bala Bora, Bhadai, Jarki, Asmi, Saro Salar, Rohini and Dhani Gora.

1.9 t/ha. On the other hand, improved varieties such as Anjali and Vandana had the highest yield of 3.0 t/ha each. Although there was a wide gap between the yield of improved varieties and traditional varieties of upland rice, most farmers preferred to grow traditional varieties for several reasons other than yield. Among the improved varieties, Vandana, Anjali, and Birsa Dhan 108 covered 98% of the upland rice area under improved varieties.

Varietal diversification and concentration in medium land. Out of 71 varieties grown on medium land, seven were hybrid rice. Among these, Pioneer was the most popular and covered 43% of the hybrid area. Advanta was the next popular hybrid variety, which covered 32% of the hybrid area in medium lands. Yields of Pioneer and Advanta were 6.6 and 6.5 t/ha, respectively. However, another hybrid, PA-6444, had the highest yield (6.8 t/ha).

Fourteen improved varieties were grown in medium lands. IR36 was the most popular variety, which covered the highest area (28%) under medium lands, followed by Lalat (23%) (Table 4). The popular varieties IR36, Lalat, Sita, and IR64 covered 87% of medium lands. Average yields of these varieties varied from 3.9 to 4.5 t/ha.

Fifty traditional varieties were grown in medium lands. The most popular varieties, Jarli, Balibhojna, and Aarababa, covered 8–12% of the medium lands. These varieties showed average yields of 2.6 t/ha.

Varietal diversification and concentration in lowland. Out of 55 rice varieties grown in the lowlands, nine were improved varieties. Again, Swarna was the most popular variety among these varieties. Swarna was preferred by 58.3% of the re-

Table 4. Distribution of rice area and yield of the most popular varieties in medium land.

Rice varieties	Farmers		Area		Average yield (t/ha)	SE of mean
	No.	% of farmers	Hectares	% of total		
Hybrid						
Pioneer	157	41.8	52.35	42.9	6.6	0.1165
Advanta	107	28.5	38.51	31.5	6.5	0.0240
PA 6444	40	10.6	14.35	11.8	6.8	0.0835
Other varieties	72	19.2	16.89	13.8		
Total	376	100.0	122.10	100.0		
Improved varieties						
IR36	528	27.0	170.09	28.3	4.3	0.0638
Lalat	502	25.7	136.89	22.8	4.1	0.1135
Sita	364	18.7	102.44	17.0	3.9	0.0063
IR64	321	16.4	114.24	19.0	4.5	0.0510
Other varieties	237	12.2	77.35	12.9		
Total	1,952	100.0	601.01	100.0	4.8	–
Traditional varieties						
Jarli	61	9.8	16.92	7.9	2.6	0.0418
Balibhojna	55	8.8	25.12	11.8	2.6	0.0353
Aara Baba	47	7.5	21.22	9.9	2.6	0.0923
Other varieties	461	73.8	150.03	70.3		
Total	624	100.0	213.49	100.0	–	–

Source: Household survey 2007. Other hybrid varieties include Suruchi, NK Sahadri, and PAC 801; other improved varieties include Pusa Basmati, Saryu 52, Sonam, Kaveri, MTU 100, Birsa 2002, MTU 1006, Rana, Parmal, and MTU 1012; other traditional varieties include Rash, Bakra, karhaini, Jonga, China Gora, Pichawi, Pandri, Siki Nanhia, Ludua, Parijat, Jeera, Noyan, Kasowa, Makram, Maina Thor, Sahjeera, Kobiphul, Kakrubaba Garibsal, Chintamuni, Supersita, Satbui, Raghu raj, Parbati, Pandula, Lohan, Koya, Hira Dhan, Dudh Kalmi, Bali, Bakudha, Neta, Gutika, Thilasar, Takiya, Sona, Padman, Laldei, Surbhi, Sakti, Raghusal, Lunchi, Kasiphul, Karticsak, Chauki Dhan, Sanipa, and Lakhansal.

spondents and it covered 60.7% of the total lowland area and 89% of the area under improved varieties (Table 5). Swarna had the highest yield (5.1 t/ha), followed by MTU-1017 (4.8 t/ha).

In the lowlands, 46 traditional rice varieties were identified by the respondents. Among the traditional varieties, the most popular variety was Bhojna, followed by Kalam Dani. Bhojna had the largest area covered, followed by Kalam Dani. However, Kalam Dani had the highest yield (3.6 t/ha).

Table 5. Distribution of rice area and yield of the most popular varieties in lowland.

Rice varieties	Farmers		Area		Average yield (t/ha)	SE of mean
	No.	% of total	Hectares	% of area		
Improved varieties						
Swarna	1,583	87.6	590.54	88.9	5.1	0.0316
MTU-1001	101	5.6	32.04	4.8	4.7	0.2068
Pant 4	54	3.0	19.38	2.9	4.7	0.0803
Other varieties	69	3.8	22.33	3.4		
Total	1,807	100.0	664.29	100.0		
Traditional varieties						
Bhojna	134	14.8	50.22	16.3	2.9	0.0901
Kalam Dani	114	12.6	38.79	12.6	3.5	0.2119
Malti	83	9.1	31.85	10.3	2.2	0.1107
Other varieties	577	63.5	188.11	60.9		
Total	908	100.0	308.97	100.0	–	–

Source: Household survey 2007.

Spatial distribution of varieties

Diversity of rice varieties was observed in different districts. The number of varieties in different districts varied from 10 in Deoghar District to a maximum of 44 in Gumla (Table 6). The number of traditional varieties was also highest (44) in Gumla. A good number of improved varieties (maximum 12) as well as hybrid varieties (maximum 6) were also grown by the farmers in different districts. Both the number of improved and hybrid varieties varied considerably in different districts (Table 6).

The study revealed that, out of 20 districts, a majority of the respondents from 10 districts reported Swarna as the most popular rice variety, followed by IR36 in three other districts. A traditional variety, Gora Dhan, was also found to be the most popular variety in another three districts. However, Swarna had the highest share in rice area, followed by IR36.

Traits that farmers look for in selecting improved varieties

Farmers mentioned seven important traits that they look for in selecting improved varieties (Table 7). High yield was the most important trait in selecting a rice variety, which was reported by more than 70% of the respondents. On the other hand, farmers mentioned "short duration" as the second most important trait. The third important trait mentioned was "resistance to lodging." Similarly, "high yield" was the most important trait for the adoption of Swarna, Lalat, IR64, and Sita, while "short duration" was the most important trait for the adoption of IR36.

Table 6. Diversity of varieties by district.

District	Number of varieties grown			
	Total varieties	Traditional varieties	Improved varieties	Hybrid varieties
Bokaro	22	11	11	–
Chatra	29	11	12	6
Deoghar	10	3	7	–
Dhanbad	34	21	9	4
Dumka	15	8	5	2
East Singhbhum	30	19	11	–
Garhwa	17	6	8	3
Giridih	18	9	3	6
Godda	19	10	5	4
Gumla	44	32	9	3
Hazaribagh	32	16	11	5
Jamtara	11	2	9	–
Koderma	18	10	7	1
Latehar	11	7	2	2
Loharda ga	13	3	6	4
Pakur	13	12	1	–
Palamu	23	9	10	4
Ranchi	36	22	11	3
Saraikela-Kharsawan	30	18	10	2
West Singhbhum	40	28	12	–

Source: Household survey 2007.

Process of diffusion of improved varieties

Sources of seeds and information on new rice varieties. About half (47%) of the farmers reported that they used their own harvested seeds for the next season (Table 8). Thirty percent of the farmers bought seeds from traders. The source of seed was found to vary by seed variety. A majority of the respondents purchased hybrid seeds from seed traders/shops. Seed traders were the main source of improved varieties, followed by own harvested seed. The majority of the respondents who used traditional varieties used their own seeds for the next season.

A majority of the respondents reported that they obtained information about popular improved varieties such as Swarna, Lalat, IR64, and Sita from other farmers (Table 9). Fifteen percent of the farmers interviewed reported that they obtained information on new varieties from other farmers and relatives from other neighboring

Table 7. Traits that farmers look for in selecting improved varieties.

Traits	First trait		Second trait		Third trait	
	Number of respondents	% of respondents	Number of respondents	% of respondents	Number of respondents	% of respondents
High yield	2,338	72.6	136	4.2	–	–
Insect/disease resistance	156	4.9	324	10.1	975	30.3
Short duration	603	18.7	1,821	56.6	795	24.7
Good grain quality	122	3.8	–	–	231	7.2
Does not lodge easily	–	–	938	29.1	422	13.1
Good taste for eating	–	–	–	–	560	17.4
More straw for livestock	–	–	–	–	236	7.3
Total	3,219	100.0	3,219	100.0	3,219	100.0

Source: Household survey 2007.

villages. In the case of IR36, other farmers of the village were the main source of information, followed by "seed company/traders."

Number of years taken for full adoption of popular improved varieties. A majority (72%) of the farmers reported that it took 3 years for full adoption of IR36. On the other hand, it took a little more than 3 years for full adoption of Swarna, Lalat, IR64, and Sita. IR36 was the only variety that was adopted by the farmers before 1980 by less than 10% of the respondents. During 1980 to 2000, a majority of the respondents adopted IR36 and Sita. Again, after 2000, a majority of the respondents adopted

Table 8. Source of seeds for the farmers.

Source of seed	No. of respondents	% of total
Own harvested	3,105	47.5
Seed traders	1,944	29.8
Neighbors	816	12.5
Relatives	350	5.4
Government Mini-kit Program	155	2.4
Other government program	151	2.3
NGO	13	0.2
Total	6,534	100.0

Source: Household survey 2007.

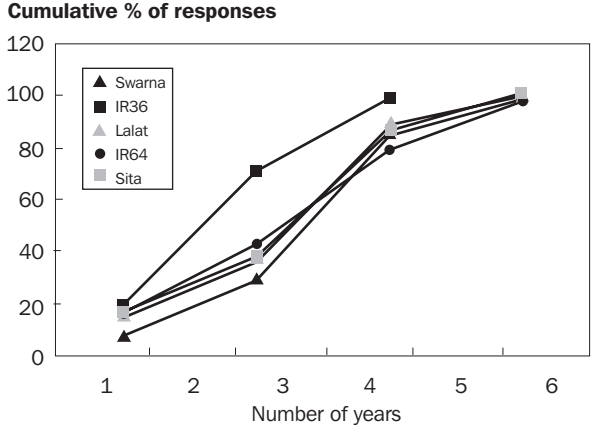

Fig. 1. Number of years taken for full adoption of some popular varieties.

Swarna, Lalat, and IR64. Although IR36 and Sita are very old varieties, farmers have continuously grown them until recently.

Varieties on the way to extinction and reasons

The most important reason why farmers stopped growing some local/traditional rice varieties was long duration/growing period, followed by low yield. Less grain weight/husked rice after milling, lodging of rice plants, degeneration of seeds, and susceptible to insects/diseases were also important reasons why farmers stopped growing some popular local rice varieties (Table 10).

Table 9. Sources of information about the technology for the most popular improved rice varieties.

Sources	Swarna		IR36		Lalat		IR64		Sita	
	N[a]	%	N	%	N	%	N	%	N	%
Listening to radio + watching TV	33	2.1	18	3.4	–	–	15	4.7	24	6.6
Other farmers of the village	1,094	69.1	211	40.0	302	60.2	165	51.4	181	49.7
Farmers or relatives from other villages	220	13.9	40	7.6	61	12.2	45	14.0	49	13.5
Seed company/traders	101	6.4	133	25.2	57	11.4	40	12.5	–	–
Agricultural extension officials	92	5.8	101	19.1	59	11.8	25	7.8	110	30.2
NGOs	16	1.0	11	2.1	23	4.6	22	6.9	–	–
KVK officials	27	1.7	14	2.7	–	–	9	2.8	–	–
Total	1,583	100.0	528	100.0	502	100.0	321	100.0	364	100.0

[a]N = number of respondents.
Source: Household survey 2007.

Table 10. Reasons why farmers stopped growing some popular traditional varieties.

Reasons	First		Second		Second	
	No. of respondents	% of all responses	No. of respondents	% of all responses	No. of respondents	% of all responses
Long duration	2,136	31	214	14	9	2
Low yield	2,057	30	74	5	–	–
Less grain weight	1,063	16	182	12	100	22
Lodges easily	670	10	270	18	277	61
Degeneration of seeds; seed not available	580	8	453	31	35	8
Susceptible to insects/diseases	333	5	288	20	33	7
All	6,839	100	1,481	100	454	100

Source: Household survey 2007.

Summary and conclusions

For this study, 3,219 farmers were selected randomly from 20 out of 24 districts of Jharkhand. The distribution of farms according to farm size showed that farming in Jharkhand was dominated by marginal (47%) and small farmers (32%). According to social class/caste, a majority of them belonged to the scheduled tribe group (41%), followed by backward class (21%). The survey also revealed that about a quarter of the farmers were illiterate and 30% of the interviewed farmers had a primary education. Farmers did not have favorable conditions for adopting modern varieties as only 10% of the rice area had access to irrigation and the main source of irrigation was surface water, which was an unreliable source.

This study revealed that 145 rice varieties were grown during the wet season. Most of these were traditional varieties and the area covered by each variety was very low. The number of rice varieties varied with land type. In the upland, 19 varieties were grown. Among these, the most popular variety was Gora Dhan (traditional variety), which covered about 69% of the upland area. Again, out of these 19 varieties, only five were improved varieties. Among these improved varieties, Vandana and Anjali were the most popular varieties, each covering about 44% of the rice area under improved varieties.

The survey identified 71 varieties of rice grown in medium lands during the wet season. The study revealed seven types of hybrid rice. Among these hybrids, Pioneer was the most popular and it covered 43% of the hybrid area. Fourteen improved varieties were grown in medium lands and IR36 was the most popular variety, which covered the highest area (28%), followed by Lalat (23%). Fifty traditional varieties were grown in medium lands. The most popular varieties, Jarli, Balibhojna, and Aarababa, covered 8–12% of the medium lands.

Respondents reported that they grew 55 rice varieties in the lowlands. Of these varieties, nine were improved rice varieties and Swarna alone covered about 89% of the rice area in the lowlands. The respondents identified 46 traditional rice varieties. Among the traditional varieties, the most popular was Bhojna, followed by Kalam Dani. However, the study revealed that, out of 20 districts, a majority of the respondents from 10 districts reported Swarna as the most popular rice variety.

High yield was the most important trait in selecting a rice variety, which was reported by more than 70% of the respondents. On the other hand, farmers mentioned "short duration" as the second most important trait. The third important trait mentioned was "resistance to lodging."

About half (47%) of the farmers reported that they used their own harvested seeds for the next season. Thirty percent of the farmers bought seeds from traders. Seed traders were the main source of improved varieties. A majority of the respondents reported that they obtained information about popular improved varieties from other farmers.

About 72% of the farmers reported that it took 2 years for full adoption of IR36. On the other hand, it took 3 years or a little more for full adoption of Swarna, Lalat, IR64, and Sita.

The most important reason why farmers stopped growing some local/traditional rice varieties was "low yield," followed by less grain weight/husked rice after milling. Lodging of rice plants, degeneration of seeds, susceptibility to insects/diseases, and long duration/growing period of the variety were other important reasons why farmers stopped growing some popular local rice varieties.

On the basis of the findings of the study, it can be concluded that Gora Dhan for upland, IR36 for medium land, and Swarna for lowland were the most popular varieties in Jharkhand. Farmers preferred Swarna for its high yield while Gora Dhan and IR36 were preferred for their short duration. Therefore, these varieties can be targeted to incorporate new traits such as micronutrients. The development of new varieties to cope with environmental stress and expansion of irrigation facilities for more adoption of modern varieties are suggested to increase rice production substantially in the state.

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Consumer Preferences, Milling, and Cooking Practices

Rice milling processes, consumers' preferences, and cooking practices in Bangladesh: implications for nutritional value

W.M.H. Jaim and M. Hossain

The main aim of this paper is to explore various milling and cooking practices of rice as well as consumers' preferences for rice quality, which have important implications from the nutritional point of view. The study covered 31 randomly selected districts out of 64 districts of Bangladesh. Using stratified random sampling, 30 traditional rice mills, 15 mobile rice mills, as well as 1,007 households were selected. The study showed that, due to the ignorance of traditional millers/farmers, paddy for milling is not processed properly (i.e., cleaning, parboiling, soaking, steaming, drying, etc.) and this affects the quality of rice grain as well as nutrient content of the milled rice. Further, a considerable portion of nutrients from rice are lost due to excess polishing of rice as well as cooking practices (i.e., washing rice several times for cooking, draining out excess water from cooked rice, etc.). Minimizing loss due to rice milling/processing and cooking practices can go a long way in overcoming the deficiencies of some important micronutrients in Bangladesh.

Introduction

Poor calorie intake as well as low intake of vitamins, minerals, and proteins result in malnutrition, which in fact is a consequence of poverty or vice versa. About half of the population in Bangladesh is malnourished because of low income and poor food distribution. The percentage of the population undernourished is very high (38%), particularly when compared with China (11%). The corresponding percentages in other Asian countries such as India, the Philippines, Thailand, and Vietnam are also much lower (21% to 22%) than in Bangladesh. Further, the prevalence of malnutrition among children under five years old is 55% in Bangladesh compared with 46% in India, 39% in Vietnam, 32% in the Philippines, and only 13% in Thailand and 14% in China (Jaim 2002).

Poor nutritional status is by far the largest single risk factor for disease in the World Health Organization's (WHO's) calculations of the total burden of disease, leading to 1.1 billion days of illness a year worldwide (World Bank 2002). Carbohydrates, protein, and fat are the important nutrients required by human beings for living healthy

lives. The Bangladesh Medical Association and other specialized medical organizations published alarming reports on widespread incidence of vitamin A deficiency among children leading to blindness, iron and calcium deficiency among pregnant mothers, a high infant mortality rate, babies with low birth weight, and so on.

Cereals are the most important source of nutrients in Bangladesh, accounting for 80% of all calories consumed (mostly from rice). Cereals also account for 62.82% of protein, 86.23% of carbohydrate, 50.08% of iron, and 12.35% of calcium (Bangladesh National Nutrition Survey 1995-96). Except for wheat, rice is the cheapest source of supply of calories and carbohydrates in Bangladesh. It is also one of the cheapest sources of protein and fat. However, the extent of nutrient content in rice largely depends on the methods of rice processing/milling as well as cooking practices.

Paddy processing includes parboiling (soaking and steaming), drying, etc., in order to get milled rice. In some places, parboiling practices are not followed. People get milled rice by milling raw paddy. Milling is the final step in postharvest processing of paddy. The types of rice mills and processing operations significantly affect the recovery and quality of rice.

A *Dheki* made by a wooden plank was the traditional method of dehusking paddy in Bangladesh. Now, the Engleberg system of hulling and milling has replaced the *Dheki*. The classification of rice mills varies in different studies depending on the coverage of various aspects. In this study, according to different methods of rice processing and milling practices, rice mills have been classified into the following four categories: (1) traditional rice mills, (2) semi-automatic rice mills, (3) automatic rice mills, and (4) mobile rice mills.

According to the methods of paddy processing and milling processes, traditional rice mills can be categorized into two types: husking rice mills and major rice mills. In husking rice mills, milling operations are done to provide custom service for farmers or small businessmen. Other processing operations such as parboiling and drying are done by the farmers themselves. Major rice mills are used to process rough rice needed for parboiled rice. In addition to custom services, the millers procure paddy from the local market, process paddy to produce parboiled rice, and then sell it to local markets, distant markets, or distant customers/businessmen. Hull and bran are separated manually in the case of traditional rice mills and milling capacity is about 1 ton per hour. This has declined, however, with the introduction of small-sized traditional mills in recent years.

Semi-automatic rice mills are those that perform processing operations using either an improved or modern boiler, dryer, and milling devices. The operations consist of steaming the paddy before sacking, soaking the paddy in concrete tanks, parboiling by using a standard steam broiler with a meter for measuring steam pressure, and artificial drying. However, in some cases, parboiling and drying of paddy are done like in traditional major mills. Hull and bran are separated mechanically and the capacity of these mills ranges from 1 to 2 tons per hour (Baqui et al 1994). Rice produced in semi-automatic rice mills is well polished and has less broken.

Automatic rice mills use modern techniques for paddy processing and almost all operations such as cleaning of paddy, soaking, parboiling, drying, dehusking, paddy

separation, polishing, and cleaning are mechanized. The paddy is precleaned before soaking in water at high temperature and is parboiled under pressure by steaming. Then, paddy is dried in a dryer and husked by a rubber roll huller. Milled rice is graded according to head rice, large broken, and small broken, and about 5 tons of paddy per hour are processed (Baqui et al 1994). Automatic rice mills equipped with a rubber roll huller in Bangladesh have been processing mostly locally available short-grain (3–4 mm) aromatic rice in nonparboiled conditions.

Mobile rice mills are technically just like a small rice husking mill. The difference is, in the case of traditional husking mills, the huller is installed in milling rooms with a good concrete foundation while in the case of a mobile mill it is moveable. Villagers, particularly small farmers, like mobile rice mills/hullers because they provide home services that save their time and cost of carrying a small quantity of paddy to the mill premises. The milling capacity of a mobile rice mill is 0.30–0.40 tons of paddy per hour.

About 95% of the milling is done by an Engelberg-type steel huller in Bangladesh (Farouk and Zaman 2002). Traditional rice mills of different capacities are available all over the country, although the exact number of these mills is not known. However, on the basis of estimates from different sources, it may be said that now there are a bit more than 100,000 traditional rice mills, about 500 semi-automatic rice mills, and about 50 automatic rice mills in Bangladesh. The traditional *Dheki* for rice dehusking has gradually disappeared and mobile rice mills/hullers are gaining popularity in rural areas. The number of mobile rice mills may be a few thousand now.

Paddy processing (parboiling, drying, etc.) and milling practices using different types of mills as well as perceptions of the millers about good quality of rice/nutrient content in rice grain have important implications from a nutritional point of view. On the other hand, from the consumers' point of view, consumer perceptions about the good quality of rice, preference for less/more polished rice, rice cooking practices, etc., are important in relation to the intake of nutrients from rice. Keeping these aspects in mind, in this study two types of surveys were conducted among rice millers and rice consumers with the specific objectives of exploring the impact of rice milling and cooking practices on nutritional intake from rice.

Methodology

In selecting millers and rice consumers from villages all over Bangladesh, this study targeted covering all 64 districts of the country; however, ultimately, 62 districts were covered as two districts in the Chittagong Hill Tracts were excluded due to problems in collecting data. From each of the 62 districts, one thana/upazila, one union, and one village were selected randomly. Thus, 62 villages were selected initially. Again, 50% of the villages were selected randomly. Thus, 31 villages were selected from 31 districts that were considered for selecting rice millers and rice consumers' households for this study.

Three types of rice mills were found in the study areas: the traditional rice mill, semi-automatic rice mill, and mobile rice mill. From each village, one traditional

rice mill was selected randomly where there was more than one mill. However, in the selected villages where there was no traditional mill, the adjacent mill of the neighboring village where the villagers went for husking rice was selected. Thus, 30 traditional mills and one semi-automatic rice mill were selected. As the number of recently introduced mobile mills was much less than traditional rice mills, it was targeted to select 15 mobile mills from the randomly selected 15 villages. One mobile rice mill was selected randomly from those villages where there was more than one mobile mill.

In selecting households for the rice consumers' survey, depending on the size of the 31 selected villages, 30–35 households were selected using stratified random sampling to include all types of households. Thus, 1,007 households were selected for the rice consumers' survey. The data for this study were collected during December 2005 to February 2006. The findings of the rice millers and rice consumers' surveys have been presented separately in two different sections of this chapter.

Results and discussion

Rice milling processes

Among the four types of rice mills (as mentioned above), since most of the milling is done by using traditional mills, particularly for rural consumers, this section mainly focuses on rice processing and milling practices by traditional mills and their implications from the nutritional point of view. Perceptions of millers about good-quality rice and about nutrition with respect to milling practices have also been assessed in this section.

Paddy processing for milling. Processing of paddy for milling has several steps: cleaning, parboiling, soaking, steaming, and drying. These processes have important implications for the nutrient content of milled rice.

Cleaning of paddy before processing is an important step for the production of good-quality rice, but, in general, this step is ignored by most traditional millers as it is a labor-consuming job. Cleaning, however, is partially done during soaking. But, cleaning of paddy during soaking is not adequate because dust penetrates into the grains in soaking, resulting in poor-quality rice. Moreover, during soaking, fine dust particles may stick to the grains and cause severe wear of the milling machine. The presence of metallic substances, stones, and dust in the paddy causes rapid wear of huller machine parts (Farouk and Zaman 2002).

The traditional parboiling process involves soaking rough rice/paddy overnight or longer in water at ambient temperature, followed by boiling or steaming the rice at 100 °C. The parboiled rice is then cooled and sun-dried before storage or milling. Parboiling results in inward diffusion of water-soluble vitamins, in addition to partial degradation of thiamine, during heat treatment (Padua and Juliano 1974). Despite the degradation of thiamine, parboiled milled rice has higher vitamin content than raw milled rice (Padua and Juliano 1974). Thus, parboiled rice has a positive effect on nutrition. Further, parboiled cooked rice grains are less sticky, do not clump, and are resistant to disintegration; the grains are also harder. Although soaking, steaming,

and their duration are important parameters that determine the quality of rice, it was observed that most rice millers and their technicians are not aware of the optimum conditions for soaking and steaming. They also do not bother much about the quality of rice. The reasons behind this are that (1) traditional methods and procedures are followed by the rice millers, (2) they think that the methods and procedures they follow are correct, (3) nobody tells them about the optimum conditions, and (4) no books or pamphlets on rice milling technology are available to them (Farouk and Zaman 2002). It was found that, for 37% of the traditional mills, paddy was parboiled for milling. Among those who parboiled paddy, 27% parboiled paddy once while 73% parboiled twice. The reasons for parboiling once or twice were explored from the millers' point of view. Among those who parboiled once, the reasons were reported as the nutritional value in rice grain is maintained, rice becomes tasty, good color of rice is maintained, and rice grain remains unbroken. This indicated that the millers who parboiled once have some misconceptions about the impact of parboiling once or twice.

On the other hand, millers who parboiled paddy twice reported that the most important reason was less broken rice grain (as reported by 39% of the millers). The second most important reason was the amount of rice increases (as reported by 33% of the millers). The other reasons for parboiling twice were rice becomes hard (as reported by 16% of the millers), good market price (6%), and rice becomes tasty (6%). In the case of mobile mills, rice recovery (after husking of paddy and removing bran) was found to be slightly higher than that of traditional mills. Less recovery of rice from husking the same amount of paddy by traditional mills implies that rice husked by traditional mills is more polished than that of mobile mills. This also implies more nutrient loss from husked rice by traditional mills compared with mobile mills. However, the rice milled by mobile mills contains more broken rice than that milled by traditional mills.

Millers' perceptions about quality of rice and milling practices. With the term "good quality of rice," 39% of the millers think that rice should be clean, 35% think that rice should not be broken, and 26% think that rice should have slender grain. To get good quality of rice, 79% of the millers polish rice once, which is the minimum requirement to make rice eatable. However, for making the grains whiter and slender, 21% of the millers polish rice more than once. In the cases of semi-automatic or automatic rice mills, the desired level of polishing is achieved automatically by fixing different degrees of polishing desired. The responses from the millers revealed that, to achieve good quality of rice, some millers give importance to making it whiter and slender, ignoring its nutritional value.

The most important reason for polishing rice more as revealed from the responses of the millers was to get clean rice (45% of responses), followed by high market demand/better price for more polished rice (33%), rice looking nice (14%), and to make rice slender (8%). The term "rice looking nice" has been used here to mean a combination of characteristics such as clean, bright, and slender rice. This is a subjective assessment of rice quality by millers/consumers, made by just looking at the rice grains.

It was reported that about 82% of rice business people requested polishing one time whereas 18% requested polishing twice. This implies that, to get a higher price, some (18%) business people ignore the loss of nutrient value in rice that is polished twice. However, 100% of the farmers in the case of husking paddy for own consumption asked for polishing rice once.

In the case of traditional mills, polishing more than once does not make a significant difference in the brightness of rice; so, the price increases of polished rich are not that much. It was observed that minor differences exist in single-polished and double-polished rice; however, close observation reveals that single-polished rice contains some unhusked rice as well as more bran and small broken rice compared with double-polished rice.

On the other hand, for semi-automatic and automatic rice mills, significant changes in brightness as well as changes in shape/size of rice grains can be observed, which leads to a considerable increase in the price of polished rice. In this case, the extent of rice polishing depends on fixing the degree of polishing desired by the miller. To get an abnormally high price from customers, sometimes highly polished rice is sold in the name of another better variety of rice. For example, highly polished Paijam is converted to look like Nizershail (a slender-grain variety) and is sold in the name of Nizershail. Similarly, highly polished BRRI dhan28 is sold as Paijam. Needless to say, polishing of rice to such an extent causes a considerable loss of micronutrients from the upper layer of the rice grains.

From the viewpoint of the semi-automatic rice miller, good quality of rice means clean, less broken, and slender grain. In this case, paddy is parboiled twice and the most important reason is less breakage of rice grain, followed by good recovery from husked paddy, rice looking nice, and good taste of the cooked rice. Again, the main reason for polishing rice is to make it whiter, and its market demand as well as price are high. Rice is less broken and more polished in the case of semi-automatic rice mills than for traditional/mobile rice mills, which implies a loss of more micronutrients from the rice grain although a higher price of rice is achieved.

Consumers' preferences for milled rice

Socioeconomic characteristics of consumers. On the basis of land ownership, 41.6% of the consumers included in the sample were landless, whereas, on the basis of total cultivated land (own + rented-in land), about 26% were landless (Table 1). The Household Income and Expenditure Survey (HIES 2000) at the national level showed that, on the basis of own landholding, the percentage of rural households having no land or land up to 1 hectare was 90.6% (BBS 2003). In the case of this study, the corresponding percentage was 91.1%, which is very close to the national figure. Again considering total cultivated land, the HIES 2000 showed that, including the landless, the farming households having land up to 1 hectare were 89.6%. The corresponding figure for this study was 87.7%, which was also very close to the HIES 2000 (BBS 2003). All these figures indicate that the sample households selected for the rice consumers' survey for this study well represented rural households nationally.

Table 1. Landholding of consumers' households on the basis of own land and cultivated land.

Landholding groups	Own land		Cultivated land	
	No. of consumers	% of consumers	No. of consumers	% of consumers
Landless	416	41.6	263	26.1
Up to 0.40 ha	330	32.8	384	38.1
0.41–1 ha	168	16.7	236	23.6
1.01–2 ha	74	7.3	104	10.3
Above 2 ha	16	1.6	20	2.0
All	1,004	100.0	1,007	100.0

Source: Household survey 2005-06.

About 45% of the household heads were practically illiterate and about 55% of them had some education. This survey found that the main occupation of 43.3% of the household heads was farming. The Household Income and Expenditure Survey for 2000 showed that, nationally, the main occupation of 49.2% of the household heads was farming; however, the corresponding percentage for rural areas was 59.1% (BBS 2003). Again, labor selling was 15.3% in this study while the corresponding figure nationally was 10.3% for the rural areas of Bangladesh in 2000 (HIES 2000).

Sources of rice for consumption and rice buying and milling activities. Three sources of rice for consumption were identified from the survey: (1) from own production, (2) buying from the market, and (3) both from own production and buying from the market. About 40% of the rice consumers consumed rice from their own production while about 26% bought rice from the market. Further, the source of rice for consumption for about 34% of the consumers was both from own production and buying from the market.

Rice buying activities. About 61% of the rice consumers bought rice from the market for consumption. Households depend on the market for purchasing rice and this was found to vary widely with cultivated land. The percentage of consumers that purchased rice from the market was inversely related to farm size as can be seen in Table 2. Almost 100% of the consumers of landless households purchased rice from the market while only 14% of medium farmers (1.01–2.00 ha) and 16% of large farmers (above 2.00 ha) bought rice from the market for consumption. Further, 68% of the marginal farmers (up to 0.40 ha) purchased rice from the market. Some 31% of the households that cultivated 0.41 to 1.0 ha of land bought rice from the market.

Again, the landless households purchased rice year-round while the marginal farmers bought rice for about half of the year (6.54 months). Other farming households with a larger size of cultivated land bought rice for 4 to 5 months (Table 2). On average, considering all the households, purchasing of rice continues for 8.59 months (Table 2) in a year.

Table 2. Rice purchases by consumers by farm size.

Farm size (ha)	Consumers that bought rice from the market					No. of months rice was bought for consumption
	No. of consumers		% of rice consumers			
	Yes	No	Yes	No	Total	
Landless	258	2	99.2	0.8	100	11.99
Up to 0.40 ha	261	123	68.0	32.0	100	6.54
0.41–1 ha	71	160	30.7	69.3	100	4.01
1.01–2 ha	15	88	14.5	85.4	100	4.71
Above 2 ha	3	16	15.8	84.2	100	4.00
All	608	389	61.0	39.0	100	8.59

Of the consumers that purchased rice from the market, 51.2% of them purchased it on a weekly basis while 25.3% of them purchased it on a daily basis. Further, about 21% of the consumers purchased rice on a monthly basis and only about 2% of them purchased it on more than a monthly basis.

However, the mode of purchase varied widely with farm size. As expected, the percentage of households purchasing rice on a daily basis was highest for the landless group. Again, more than half of the landholding households purchased rice on a weekly basis; the corresponding percentage for landless households was about 42%. Some of the landless households also bought rice on a monthly basis (18%) as well as on more than a monthly basis (3%). Again, about a quarter of the small farmers and a few medium farmers (7%) purchased rice on a monthly basis. Rice-purchasing households in the large farmer group were only 3, among whom 2 purchased on a weekly basis and 1 on a monthly basis. The percentage of rice-purchasing households for more than a monthly basis was very small (about 2%). Further, rice purchased on more than a 1-month basis was about 3% for landless households, about 2% for marginal farmers' households, and about 7% for medium farmers' households.

About 96% of the consumers bought parboiled rice from the market whereas only about 4% of them purchased nonparboiled (*Atap*) rice. The most important reason for preferring parboiled rice as revealed from the responses of 57% of the consumers was their habit of eating parboiled rice (Table 3). This was also the most important reason from multiple responses (39.8% of the responses). The other reasons for eating parboiled rice as revealed from multiple responses were parboiled rice is not sticky (15.7%), it is easily digestible (15.2%), the rice is tasty (13.2%), it remains in good condition for a longer time (12.2%), and cooked rice increases in quantity (3.8%). Therefore, consumption habit as well as some other considerations are the main reasons for consuming parboiled rice rather than considering nutritional value.

Rice milling activities. For rice consumption from own production, about 61% of the consumers husked paddy using traditional mills while about 12% of them used

Table 3. Reasons for eating parboiled rice.

Reasons	Responses for most important reason		Multiple choices of reasons (compiled for all)	
	No.	% of total	No.	% of total
Accustomed to eating parboiled rice	344	57.4	476	39.8
Parboiled rice is easily digestible	69	11.5	182	15.2
Parboiled cooked rice remains good for a longer time	61	10.2	146	12.2
Parboiled cooked rice is not sticky	53	8.8	188	15.7
Parboiled rice is tasty	49	8.2	158	13.2
Cooked parboiled rice increases in amount	23	3.8	46	3.8
All	599	100.0	1,196	100.0

Source: Household survey 2005-06.

mobile mills and the rest (27%) used both traditional and mobile mills. In response to a question as to whether there is any quality difference in rice if paddy is husked by traditional mills and by mobile mills, about 24% of the consumers said yes, 14% said no, and 62% said that they had no idea about a difference in quality. In fact, the husking quality (fineness) of rice depends on the size of the mills (Baqui et al 1994). With an increase in the size of the mills (engine horsepower), the fineness of rice increases. Since most of the traditional mills recently established in rural areas are of a small size (very close to mobile mills), it is difficult for the majority of consumers to distinguish the milling quality of traditional mills from that of mobile mills.

However, those who reported that there is a quality difference, in specifying the differences, about 78% of the respondents said that rice is cleaner if husked by traditional mills instead of by mobile mills. Other differences as mentioned by consumers were less broken rice grain (about 16% of respondents) and finer/slender rice (about 6% of respondents).

In the case of own production, the paddy husked by consumers was of different varieties. However, the most common varieties were BRRI dhan29 and BRRI dhan28 as reported by 26.5% and 25.3% of consumers, respectively (Table 4). The other important varieties were BR11 and Swarna, as reported by 22.3% and 20.1% of respondents. Hybrid varieties as well as varieties such as Lal Swarna and Rotna were of minor importance as can be seen from Table 4. Therefore, four varieties (BR11, BRRI dhan29, BRRI dhan28, and Swarna) accounted for 95% of rice consumption. Therefore, breeding for nutritional improvement should target these four varieties.

The survey revealed that, in about 82% of the cases, paddy was parboiled once. Only about 18% of the respondents parboiled twice for husking paddy. Further, in 97% of the cases, paddy was parboiled at home and 3% did parboiling at the mill.

Table 4. Varieties of paddy husked from own production.

Name of variety	Number of responses[a]	% of total
BR11	273	22.3
BRRI dhan29	324	26.5
BRRI dhan28	310	25.3
Swarna	246	20.1
Hybrid	45	3.8
Lal Swarna	3	0.2
Rotna	23	1.8
All	1,224	100.0

[a]The number of responses is more than the number of respondents as the same respondents husked different varieties of paddy.

Consumers' perceptions about good quality of rice. Consumers' perceptions about the good quality of rice for consumption were assessed by considering their opinions about important characteristics of rice. They were asked to mention the three most important characteristics. Accordingly, the first most important quality to consider for good quality of rice was slender rice (42.7% of the responses), followed by tasty for eating (24.4%) and clean rice (17.0%) (Table 5). Again, considering all three most important characteristics, it was revealed that tasty for eating ranked first (30.2% of the responses), followed by slender rice (23.2%), clean rice (13.5%), and less broken rice (10.2%).

Consumers' preference for rice according to type of mill. Consumers' preference for rice according to the process of rice milling was assessed by asking them about the type of rice they prefer and the reasons for that. It was found that 58.8% of consumers prefer milled rice with less polishing (Table 6). Next to this, the preference was given for rice husked by the traditional method (*Dheki*), as reported by 26.9% of respondents. Further, 14.2% of consumers reported that they preferred milled rice with more polishing. Again, it was found that almost all of them (about 99%) knew that rice husked by mills was more polished than that husked by the *Dheki*. The findings indicated that most rice consumers are concerned about nutrient content in rice grain related to milling practices.

Consumers' preference for polished rice. About 82% of rice consumers who husked paddy from their own production reported that polishing was requested of millers after husking paddy. However, only one polishing was requested in almost all cases (99.7%) for own consumption. About 87% of the customers knew that they get less rice after polishing. The rest (13%) were not aware of this. Again, it was found that about 89% of the customers (who polished rice) knew that, when polishing rice, vitamins and nutrition are lost. The rest (11%) had no idea about the loss of vitamins and nutrition when polishing rice.

Table 5. Perceptions of consumers about good quality of rice for consumption.

Consumers' perceptions about what is meant by good quality of rice	Responses for the most important quality		Responses for the second most important quality		Responses for the third most important quality		Responses for all	
	No.	% of total	No.	% of total	No.	% of total	No.	% of total
Thin rice	430	42.7	149	15.2	1	0.2	580	23.2
No bad smell	14	1.4	106	10.8	43	8.3	163	6.5
Rice that has a good smell	19	1.9	45	4.6	46	8.9	110	4.4
Clean rice	171	17.0	149	15.2	17	3.3	337	13.5
Tasty for eating	245	24.4	195	19.9	69	13.4	754	30.2
Less broken rice grain	40	4.0	131	13.4	85	16.5	256	10.2
Less black/dead rice	9	0.9	19	1.9	54	10.5	82	3.3
Hard rice	15	1.5	36	3.7	17	3.3	83	3.3
Rice that increases after cooking	35	3.5	56	5.7	52	10.1	143	5.7
Old rice	4	0.4	28	2.9	66	12.8	98	3.9
Nutritious	18	1.8	41	4.2	49	9.5	108	4.3
Cooked rice remains good for a long time	2	0.2	20	2.0	12	2.3	34	1.4
Insect-free rice	1	0.1	1	0.1	1	0.2	3	0.1
Rice that is boiled quickly	3	0.3	2	0.2	3	0.6	8	0.3
Total	1,006	100.0	978	100.0	515	100.0	2,499	100.0

Table 6. Type of rice preferred by consumers according to milling practices.

Particulars of milling practices	Consumers' preference according to milling practices	
	No. of responses by consumers	% of responses
Rice husked by *Dheki*	271	26.9
Less polished milled rice	593	58.9
More polished milled rice	143	14.2
All	1,007	100.0

Source: Household survey 2005-06.

Table 7. Reasons consumers preferred more polished rice.

Reasons for preference	Responses for most important reason		Multiple responses for reasons (compiled for all)	
	No.	% of total	No.	% of total
For getting bright/nice-looking rice	91	63.6	107	30.0
For consuming slender rice	20	14.0	44	12.3
Cooked rice is good	17	11.9	74	20.7
Rice is tasty	15	10.5	85	23.8
More demand in the market	–	–	37	10.4
Higher price is received from the market	–	–	10	2.8
All	143	100.0	357	100.0

Source: Household survey 2005-06.

In the case of a preference for milled rice, there were two choices: one with less polished rice and the other with more polished rice. The reasons for choosing more polished or less polished rice were further explored by asking consumers the reasons for their choices. In the case of a preference for more polished rice, the most important reason as identified from their responses was to get bright/nice-looking rice, as reported by about 64% of the consumers (Table 7). From multiple responses also, this was the most important reason for more polishing of rice (30%). The other reasons according to relative importance were that rice becomes tasty (23.8%), cooked rice is good (20.7%), etc.

On the other hand, the most important reason for preferring less polished rice was consumers' awareness about nutritional value as reported by about 59% of the respondents (Table 8). From multiple responses, awareness of nutritional value (43.1% of responses) was again the main reason for preferring less polished rice, followed

Table 8. Reasons consumers preferred less polished rice.

Reasons for preference	Responses for most important reason		Multiple responses of reasons (compiled for all)	
	No.	% of total	No.	% of total
Much nutritional value	351	58.9	493	43.1
More rice is recovered from paddy	135	22.7	362	31.6
Tasty for eating	48	8.0	98	8.6
Less breakage of rice	35	5.9	133	11.6
Rice can be purchased at lower price	16	2.7	29	2.5
Good cooked rice	9	1.5	15	1.3
Less husking cost	2	0.3	14	1.2
All	596	100.0	1,144	100.0

Source: Household survey 2005-06.

Table 9. Reasons for washing rice more than once.

Reasons for washing more than once	Responses for most important reason		Multiple responses for reasons (compiled for all)	
	No. of responses	% of total	No. of responses	% of total
For more cleaning	873	96.6	884	66.4
For making cooked rice white/nice looking	9	1.0	368	27.7
To reduce bad smell	9	1.0	35	2.6
To get rid of paddy husk	13	1.4	27	2.0
Others	–	–	17	1.3
All	904	100.0	1,331	100.0

Source: Household survey 2005-06.

by more recovery of rice from paddy (31.6% of responses). However, for those who consumed less polished rice, it was clear from their responses that they were well aware of the nutritional value in rice grain related to rice polishing.

Rice cooking practices in relation to nutrient intake

For cooking rice, it is generally washed twice or thrice as reported by 45.9% and 42.3% of the respondents, respectively. Further, 9.7% of the respondents reported that rice was washed once and in a very few cases (2.1%) it was washed four times. It can be mentioned here that more washing leads to a loss of micronutrients from the rice grain. The most important reason for washing rice more than once was found to be for more cleaning as reported by about 97% of the respondents (Table 9). Compiling multiple

Table 10. Use of excess drained-out water after cooking.

Use of excess water after cooking rice	No. of responses	% of responses
Used for drinking purposes	12	2
Used as animal feed	516	83
Just thrown away	93	15
All	621	100

Source: Household survey 2005-06.

Table 11. Reasons for draining out excess water from cooked rice knowing its benefit.

Reasons for draining out excess water from cooked rice	Responses for most important reason		Multiple responses for reasons (compiled for all)	
	No.	% of total	No.	% of total
For feeding domestic animals	160	27.5	275	25.7
Not accustomed to using proper amount of water for cooking	136	23.4	228	21.3
Not accustomed to drinking excess water of cooked rice	145	24.9	218	20.4
To make cooked rice nonsticky	82	14.1	212	19.9
Feels shame if others know	34	5.8	65	6.1
Excess water of cooked rice is not tasty	23	4.0	63	5.9
Because of bad smell, excess water of cooked rice is not drinkable	2	0.3	7	0.6
All	582	100.0	1,068	100.0

Source: Household survey 2005-06.

responses, the most important reason was also for more cleaning of rice (66.4% of responses), which was followed by making cooked rice white/nice looking (27.7%).

For cooking rice, the proper amount of water was used in 38% of the households for which there was no need to throw away excess water after cooking. Thus, water-soluble micronutrients in cooked rice are retained for 38% of the rural households. However, for 62% of the households, excess water was drained out after cooking. The excess drained-out water after cooking rice was mostly used as animal feed as reported by 83% of the respondents (Table 10). Only 2% of the households used it for drinking purposes. Further, for 15% of the households, this water just thrown away.

Rice consumers were also asked whether they were aware about nutritional value in the excess water of cooked rice. About 94% of them reported that they knew about nutrition in the excess water of cooked rice. However, the rest (6%) did not have any idea about nutritional value in the excess water of cooked rice.

The most important reason for draining out excess water from cooked rice knowing its benefits was for feeding domestic cattle, as reported by 27.5% of the respondents (Table 11). The other most important reasons were that they were not accustomed to drinking excess water (24.9% of responses) and they were not accustomed to using the proper amount of water for rice cooking (23.4%). When compiling multiple responses, it was also found that feeding domestic cattle was the most important reason for draining out excess water from cooked rice (25.7% of responses), followed by other reasons such as not accustomed to using the proper amount of water for rice cooking (21.3%), not accustomed to drinking excess water of cooked rice (20.4%), making cooked rice nonsticky (19.9%), etc.

Summary and conclusions

Methods of rice processing by traditional mills have important implications for the quality of rice and nutrient content of milled rice. However, most millers do not bother much about the quality of rice. For example, although soaking, steaming, and their duration are important parameters that determine the quality of rice, most rice millers and their technicians are not aware of the optimum conditions for soaking and steaming. In most cases when consumers husk paddy from their own production, the paddy is parboiled once, which means that most consumers are not aware of the positive effects of parboiling twice, particularly in relation to the inward diffusion of water-soluble vitamins in the rice grain. However, in the case of millers who purchase paddy for doing business by selling husked rice, it was found that most millers parboiled paddy twice, particularly because this makes rice grain harder and as a result there is less breakage of rice grain.

The millers, when they do business by purchasing paddy and selling it as husked rice, in some cases polish rice more than once to make it slender and whiter to get a higher price. However, through polishing, nutrition is lost from rice grain; at the same time, the amount of husked rice also decreases, which is largely compensated for by the increased price of the polished rice. In the case of semi-automatic rice mills, rice is less broken and more polished than in traditional/mobile rice mills; however, this also implies a loss of more micronutrients from the rice grain.

With the term "good quality of rice," most consumers understand slender rice, which has a better taste and is cleaner. All this means more polished rice with less content of micronutrients, although most consumers reported that they prefer less polished rice on nutritional grounds.

A majority of the consumers washed rice two or three times before cooking. However, more washing results in a loss of water-soluble vitamins from the rice grains. Further, slightly more than one-third of the consumers used a proper amount of water for cooking rice, and, as a result, there was no need to drain out water from cooked rice; thus, nutrients were retained in cooked rice. On the other hand, a majority of the consumers drained out water from cooked rice instead of drinking it or retaining it in cooked rice; thus, the benefits of micronutrients in excess water of cooked rice were lost. However, most of them used it to feed domestic animals.

A considerable portion of nutrients from rice is lost due to rice processing/milling as well as cooking practices in Bangladesh. Minimizing losses due to rice milling/processing and cooking practices can go a long way toward overcoming the deficiencies of some important micronutrients in Bangladesh as the per capita daily intake of rice in rural areas is 478.8 grams (HIES 2000).

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Consumers' preferences for grain quality and rice milling and cooking practices for eastern India: implications for nutrition

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The main objective of this chapter is to explore rice milling and cooking practices as well as consumers' preferences in relation to the intake of micronutrients from rice grain. The study was conducted in three states of eastern India, West Bengal, Orissa, and Jharkhand, which covered all the districts of West Bengal and Orissa, and 20 out of 24 districts of Jharkhand. Using stratified random sampling, 7,684, 6,529, and 3,219 households were interviewed in West Bengal, Orissa, and Jharkhand, respectively. The findings indicated that, although a majority of the households in West Bengal and Orissa preferred bold short grain with less polished milled rice, a considerable proportion of the households preferred well-polished slender grain. In contrast, 87.42% of the households in Jharkhand did not like polished rice and the traditional method of husking rice with a *Dheki* still played a strong role. Almost all the households in West Bengal (97%) and Orissa (89%) drain out excess water from cooked rice, but only 60% of the households in Jharkhand. Further, retaining micronutrients in cooked rice seems to be higher in Jharkhand as about 19% of the households used an electric rice cooker and 21% used the proper amount of water, for which there was no need to drain excess water. Awareness of the rural households about the loss of micronutrients in milling and cooking practices may help to increase the intake of more micronutrients from the consumption of rice.

Introduction

In India, about 22% of the population is undernourished, which is considerably high, particularly when compared with China (only 11%). Further, the prevalence of malnutrition among children under 5 years old was also very high in India (46%) compared with Vietnam (39%), the Philippines (32%), Thailand (13%), and China (14%) (Jaim 2002). Poor nutritional status is by far the largest single risk factor for disease in the WHO's calculations of the total burden of disease, leading to 1.1 billion days of illness a year worldwide (World Bank 2002). Carbohydrates, protein, and fat are some of the important nutrients required by human beings for living healthy lives.

Cereals are the most important source of nutrients in eastern India. Except for wheat, rice is the cheapest source of calories and carbohydrates in eastern India. It is also one of the cheapest sources of protein and fat. However, the extent of nutrient content in rice largely depends on the methods of rice processing/milling as well as cooking practices (Jaim and Hossain 2009). From the consumers' point of view, consumers' perceptions about the good quality of rice, preference for less/more polished rice, rice cooking practices, etc., are important in relation to the intake of nutrients from rice. Keeping these aspects in mind, the specific objective of this chapter is to explore the impact of nutritional intake from rice in relation to preference for grain quality of consumers, and rice milling and cooking practices in eastern India (i.e., West Bengal, Orissa, and Jharkhand).

This study was conducted independently in West Bengal, Orissa, and Jharkhand, and the survey related to this study was also conducted at different periods. Therefore, this is not a comparative study of the three states of eastern India; rather, it depicts the independent nature of milling and cooking practices as well as consumers' preference for rice grain quality in these states. It can be mentioned here that the survey questionnaire did not include any question related to milling practices in West Bengal; as such, there is no analysis/findings in relation to milling practices there. Since it was an independent study in these three states, the methodologies as well as findings were different and have been presented in three separate sections of this paper.

Section 1: West Bengal

Methodology

The survey was conducted in all 17 districts (Midnapur was taken as one district in lieu of East Midnapur and West Midnapur) of West Bengal and, from these districts, 85 blocks were selected using systematic random sampling. Two village *panchayats* were selected from each block (one from the southern area and the other from the northern area of the block). From each village *panchayat,* two villages were selected randomly. It was targeted to select 15% of the farm households from these villages and ultimately 7,684 households were selected. Data were collected from April to October 2007.

Results and discussion

Economic status of the selected households and preference for quality of rice. The respondents were asked to identify their household position according to different economic status (Table 1). According to their self-assessment, 52% of the households belonged to the subsistence group and another 43% belonged to the poor group. Only about 5% of the respondents considered themselves as solvent while a very negligible percentage (0.1%) of the respondents considered themselves as rich. Therefore, about 95% of the households belonged to either subsistence or poor groups.

The economic status of the household influences preferred grain quality. As shown in Table 2, 59% of the households, particularly the poorer households, preferred rice with bold short grains. On the other hand, about 40% of the households,

Table 1. Self-stated economic status of the selected households.

Economic status	No. of households	% of total
Rich	5	0.01
Solvent	412	5.4
Subsistence	3,990	52.0
Poor	3,264	42.5
Total	7,671	100.0

Source: Household survey: West Bengal

Table 2. Preferred rice grain quality for consumption by farm size groups (% of households).

Preferred grain quality	Farm size groups (ha)					
	Below 0.5	0.5– <1.0	1.0– <2.0	2.0– <4.0	4.0+	All
Bold short grain	65.0	51.3	44.3	25.0	0.0	59.07
Well-polished white rice	34.0	47.7	55.2	75.0	100.0	40.01
Less polished brown/husked rice	1.0	0.9	0.5	0.0	0.0	0.92
Total	100.0	100.0	100.0	100.0	100.0	100.00

Source: Household survey: West Bengal 2007.

particularly those of better-off families, preferred well-polished white rice. A negligible percentage (less than 1%) of the households preferred less polished brown rice. The overall findings indicated that, as farm size increases, the preference for well-polished rice increases, which implies less intake of micronutrients from milled rice.

In terms of preference for varieties, about 64% of the households preferred Swarna, followed by Mota (8.6%), IR36 (7%), etc. (Table 3). This indicates that a majority of the households preferred to buy either medium or coarse-type rice grain for home consumption. Thus, Swarna can be targeted for incorporating micronutrients through biofortification in West Bengal.

Rice cooking practices. In West Bengal, 70% of the households wash rice twice before cooking (Table 4). However, about 29% of the households wash it once and only about 2% of them wash it thrice.

For cooking rice, the proper amount of water was used in only about 4% of the households, for which there was no need to throw out excess water after cooking. Thus, water-soluble micronutrients in cooked rice were retained by a negligible proportion of the rural households in West Bengal. Almost all the households (97%) drained excess water from cooked rice (Table 5). This practice of washing rice more than once and draining out excess water from cooked rice indicates that the rural

Table 3. Preference of buying rice for consumption by variety.

Variety	No. of households	% of total
Swarna	1,695	63.9
Mota	228	8.6
IR36	185	7.0
Ratna	115	4.3
Satabdi	113	4.3
Pankaj	100	3.8
Paijam	72	2.7
Patnai	64	2.4
Nayanmani	52	2.0
Swarna Masuri	29	1.1
Total	2,653	100.0

Source: Household survey: West Bengal

Table 4. Washing rice before cooking.

No. of times rice is washed for cooking	No. of households	% of households
Once	2,208	28.8
Twice	5,338	69.6
Thrice	126	1.6
All	7,672	100.0

Source: Household survey: West Bengal 2007.

people in West Bengal are not well aware of the nutritional importance of retaining micronutrients while cooking rice.

Section 2: Orissa

Methodology

The study was conducted in all 30 districts of Orissa. The sample size consisted of 20–25% of the blocks of each district, 3–5% of the villages under each district, and 10–15% of the farm households under each village. In all the villages included in this study, 6,529 households were selected through random sampling. These households were interviewed using a pretested questionnaire. Interviews were conducted from June to September 2008.

Table 5. Use of water for cooking rice.

Practice	No. of households	% of households
Cooking with proper amount of water so that there is no need to drain	268	3.5
Drain water from cooked rice	7,397	96.5
All	7,665	100.0

Source: Household survey: West Bengal 2007.

Table 6. Percentage of households with incidence of disease by farm size groups.[a]

Farm size groups (ha)	Night blindness	Anemia	Child diarrhea	Postnatal death
Below 0.5	3.47	46.24	4.92	0.72
0.5–<1.0	3.36	33.04	4.15	0.64
1.0–<2.0	4.19	30.14	3.81	0.63
2.0–<4.0	3.85	20.67	2.88	0.36
4.0+	2.78	11.57	2.78	0.46
All	3.69	32.62	4.00	0.61

[a]Multiple responses.
Source: Household survey: Orissa 2008.

Results and discussion

Health and nutritional status of the households. The findings from the survey indicated that night blindness was no longer posing a serious problem to the larger section of society in Orissa. Only about 4% of the households reported that some members of their families were suffering from night blindness. However, in a majority of the cases, they had recovered with vitamin A supplementation either from the Health Department or from a private pharmacy. About 46% of the households in the marginal farm category (below 0.5 ha) reported that some female members were suffering from anemia and it was prominent among scheduled caste families. Diarrhea among children was reported by only about 4% of the households and incidence of postnatal death was quite low (Table 6).

Rice milling practices. Among the households interviewed, 90% of the farmers milled their paddy in the local rice mills (Table 7). About 3% of the respondents used both a wooden husker and traditional huller units for husking paddy. This was mainly done to dehusk small quantities of rice for special religious purposes.

Among the scheduled tribes, about 6% of the households still depend on both a wooden husker and local hullers. In the tribal-dominated inland districts that are remote and inaccessible, a *Musala* (a type of wooden structure) is used for dehusking rice. More than 9% of the tribal households used a *Musala* for dehusking rice.

Table 7. Rice milling practices.

Milling practices	No. of households	% of households
Wooden husker as well as traditional huller units	17	0.3
Local mills	5,899	90.4
Both (wooden husker and mill)	221	3.4
Musala (wooden hammer)	212	3.2
Local mill as well as wooden hammer	179	2.7
All	6,528	100.0

Source: Household survey: Orissa 2008.

Consumers' preference for rice grain. The analysis showed that 86% of the households parboiled paddy, of which 54% parboiled once while 46% parboiled twice. Single parboiling was common in inland districts, whereas, in coastal districts, double parboiling was common. It was also found that single parboiling was common among the large farmers. Although parboiling is very common in Orissa, among the tribal groups, the proportion among households is less than with other social groups. It can be mentioned here that parboiling results in the inward diffusion of water-soluble vitamins, in addition to partial degradation of thiamine during heat treatment (Padua and Juliano 1974). Despite the degradation of thiamine, parboiled milled rice has higher vitamin content than raw milled rice (Padua and Juliano 1974). Thus, parboiled rice has a positive effect on nutrition. Further, parboiled cooked rice grains are less sticky and are resistant to disintegration; the grains are also harder.

Only about 1% of the households included in the survey of Orissa did not polish rice after milling. The survey also revealed that only 35% of the farmers asked the millers for single polishing. Households (64%) that have a marketable surplus preferred their paddy to be polished twice to get a higher price in the market (Table 8).

Preference for quality of rice also varied across different districts. Compared to the coastal region, most of the households in the inland districts of Orissa were found to prefer white rice, implying more polished rice with less micronutrient content. Over the last decade, in the coastal region also, peoples' choice has changed drastically toward polished rice. Previously, farmers were more laborious; as such, they needed traditional rice with bold and brown color for their consumption in the form of water rice (*Panta*). But, with the changes in economic conditions, many of the young family members are no longer in farming and they have migrated to larger cities (both inside and outside the state). Their preference for rice has changed over time toward more polished rice.

Regarding preference for rice grain quality, it was found that 76% of the farmers gave first preference to bold short grain type of rice while only about 16% gave preference to long slender type of grain (Table 9). Analysis by farm size showed that more than 70% of the marginal and small farmers preferred bold short grain compared

Table 8. Number of times rice was polished during husking.

Number of times polished	No. of households	% of households
Do not polish	52	0.8
Polish once	2,230	35.4
Polish twice	4,018	63.8
All	6,300	100.0

Source: Household survey: Orissa 2008.

Table 9. Preference for rice grain quality for family consumption.

Rice grain quality	No. of households	% of households
First choice		
Long slender grain	1,018	15.6
Bold short grain	4,991	76.4
Superfine/aromatic rice	519	7.9
Well-polished white rice	1	0.0
All	6,529	100.0
Second choice		
Long slender grain	9	0.1
Bold short grain	234	3.6
Superfine/aromatic rice	75	1.1
Well-polished white rice	5,242	80.3
Less polished brown/husked rice	968	14.8
All	6,528	100.0

Source: Household survey: Orissa 2008.

with long slender grain. It was observed that, in the coastal districts, this phenomenon is more common than in inland districts as most of the traditional varieties of the coastal districts have bold short grains.

Marginal farmers are mostly agricultural workers and they have to spend long hours in the field; as such, they require a full belly for most of the day. Bold short grains make them feel full-bellied consuming either water rice or plain rice. On the other hand, rich farmers mostly like long slender grains and about 17% of medium farmers and 44% of large farmers prefer superfine/aromatic rice, which commands a higher price in the market. Among the different social classes, 26% of the general caste households preferred long slender grain type of rice, whereas more than 82% of the scheduled caste and tribes had an affinity toward bold short grains.

Table 10. Practice of washing rice before cooking.

No. of times rice is washed for cooking	No. of households	% of households
Once	460	7.0
Twice	5,921	90.7
Thrice	148	2.3
All	6,529	100.0

Source: Household survey: Orissa 2008.

Table 11. Use of excess water drained out from cooked rice.

Use of excess water drained out from cooked rice	No. of households	% of households
Household members drink it	3,153	48.3
Feed animals	3,323	50.9
Throw away	20	0.3
Add to water rice	33	0.5
Total	6,529	100.0

Source: Household survey: Orissa 2008.

Rice cooking practices. For cooking rice, 91% of the respondents reported that rice is washed twice (Table 10). Only about 7% of the households wash rice once. Single washing is mostly reported in some tribal households. Washing three times was reported by only about 2% of the households. However, during the survey, it was found that some families had rice-washing containers made of bamboo (locally called *Pachiya* or *Ttokei*) or aluminum with perforated bottoms. Water is poured over the rice and washed thoroughly until clear water oozes from the perforated holes. In that case, all the micronutrients attached to the epidermal layer are likely to be leached with the washed-out water.

For cooking rice, about 89% of the households drained excess water from cooked rice while the proper amount of water was used in only about 11% of the households (for which there was no need to drain out excess water after cooking). Thus, water-soluble micronutrients in cooked rice were retained for only about 11% of the rural households and this was mostly practiced among the tribal families (30%).

The excess water drained out after cooking was mostly used for livestock feed (51%) as well as for drinking purposes (48%) of the household members (Table 11). It was also found that excess water is sometimes added to water rice. It was reported that, when a certain portion of the drained-out sticky starch is added to water rice, it helps with better fermentation of water rice and adds taste to it.

Among different caste groups, it was observed that 91% of the tribal farmers used the excess water for drinking purposes. Mostly in tribal families, while cooking rice for lunch, a proper amount of water is used and there is no need to drain out water. But, in the evening, rice is cooked with excess water and the excess water is drained. The excess water drained out is used for drinking purposes, preparing water rice, given to animals as feed, and sometimes used for making liquor. In the case of marginal farmers, 73% used it for adding to water rice. With the increase in farm size, it was found that a majority of the households used the excess water for feeding animals.

Section 3: Jharkhand

Methodology

Out of the 24 districts of the state, 20 were included in this study. To select sample farmers, 20–25% of the blocks under each district, 3–5% of the villages under each block, and 10–15% of the farm households under the selected villages were randomly selected. Thus, 53 blocks and 203 villages were selected, from which 3,219 households were selected for this survey. The survey was conducted during May to December 2007.

Results and discussion

Health and nutritional status of households. Of the total households interviewed, 8%, 15%, and 6% reported that their young children suffered from night blindness, anemia, and diarrhea during the previous month, respectively. Only 3% of the respondents reported death of women during child birth. It is clear from the findings that incidences of diseases/death were very low, as has been reported by the respondents. This might be because the respondents are not aware of problems such as night blindness, anemia of women, etc. They never go to the doctor such a checkup as they think that these problems are natural phenomena and they don't have sufficient money to pay the doctor or pay for transportation.

Paddy milling practices. The findings of the study revealed three types of milling/dehusking practices (of paddy) adopted by the respondent households in Jharkhand (Table 12). About 14% of the respondents reported that they used a *Dheki* (wooden husker) for husking paddy. However, with the advance in technologies, rice mills are available even in small towns. As such, 56.14% of the respondents reported that they husked paddy in rice mills. About 30% of the respondents reported that both a *Dheki* and rice mills were used for husking paddy.

The study identified different options regarding parboiling of paddy before husking (Table 13). It was found that 64% of the households parboiled paddy only once. On the other hand, about 25% of the respondents reported that paddy was parboiled twice. The respondents mentioned that rice from parboiling of paddy twice is used for medicinal purposes, especially for stomach problems rather than nutritional or other considerations. However, about 11% of the respondents reported that they did not parboil paddy before husking. It can be mentioned that everybody eats nonparboiled rice (*Arwa* rice) during festivals.

Table 12. Milling/husking practices in paddy for family consumption.

Milling/husking practices	No. of households	% of households
Traditional method using *Dheki*	437	13.6
Rice mill	1,807	56.1
Both *Dheki* and rice mill	975	30.3
All	3,219	100.0

Source: Household survey: Jharkhand 2007.

Table 13. Parboiling of paddy before husking.

No. of times paddy is parboiled	No. of households	% of households
Once	2,068	64.2
Twice	813	25.3
Don't parboil	338	10.5
All	3,219	100.0

Source: Household survey: Jharkhand 2007.

Preference for polished rice by respondents' households. The survey revealed that a great majority of the households (87.4%) did not like polished rice (Table 14). About 10% of the respondents preferred rice that was polished once and 3% preferred double-polished rice. The farmers reported that, if rice is not polished (almost brown rice), the cooked rice becomes tasty, which is also the source of vitamins. Therefore, the findings confirmed that till now rural people in Jharkhand prefer unpolished rice, although their preference is changing slowly. On the other hand, in urban areas, people do not like brown rice. They usually prefer polished (white) rice.

Type of rice preferred by respondents' households. The study revealed three types of rice preferred by different categories of households. About 38% of the households preferred long slender grain. Among different castes, about 54% of the respondents from the backward class category preferred long slender grain. This type of grain was also preferred by 47% of the households of the scheduled caste. The lowest percentage for this type of grain was recorded for households of the scheduled tribe group (27%).

On the other hand, 47% of all the households preferred bold short grain. In this case, the highest percentage was recorded for the scheduled tribe category of households (55%), followed by other backward class.

About 15% of the respondents preferred superfine/aromatic rice (Table 15). The farmers grow an aromatic rice, Basmati rice. However, the area covered by Basmati rice is small. It was also found that traditional variety Kalajeera is being grown by farmers, especially by tribal farmers. They have also been growing scented (aromatic)

Table 14. Number of times rice is polished for consumption.

Number of times rice is polished	No. of households	% of households
Do not polish	2,814	87.4
Polish once	318	9.9
Polish twice	87	2.7
Total	3,219	100.0

Source: Household survey: Jharkhand 2007.

Table 15. Type of rice preferred by the sample households.

Type of rice preferred	No. of households	% of households
Long slender grain	1,420	38.2
Bold short grain	1,741	46.8
Superfine aromatic rice	556	15.0
Total	3,717	100.0

Source: Household survey: Jharkhand 2007.

rice for ages. These findings reveal that farmers of different castes/classes have different preferences for rice for home consumption.

Cooking practice for rice. About 56% of the respondents reported that they wash rice twice before cooking. On the other hand, 22% of them wash rice only once while 22% wash rice thrice. This may be because those who buy rice from the market usually wash rice thrice before cooking as more dust remains on the rice.

The analysis showed that about 19% of the respondents used an electric rice cooker for cooking rice. Cooking rice using a rice cooker ensures retaining micronutrients in cooked rice. This finding is a little bit exceptional as a considerable percentage of the rural people in Jharkhand use an electric cooker for rice cooking.

It was found that 60% of the respondents drained water from cooked rice. For ages, this practice has continued. In this regard, a very high percentage has been recorded for the scheduled tribe category of respondents, followed by the schedule caste category (63%). The percentages for other backward class, backward class, and general categories that drained water from cooked rice ranged from 45% to 50%. Only 21% of the respondents reported that there was no need to drain water after cooking as they used a proper amount of water for cooking.

The study revealed different uses of water drained from cooked rice. Some 37% of the respondents, especially in the scheduled tribe group, reported that water drained from cooked rice was used for family consumption in the household. About 67% of the respondents from the scheduled tribes reported that they used the water drained from cooked rice as a drink for the children and elderly family members. Second,

Table 16. Use of water for cooking rice.

Practice	No. of households	% of households
Electric rice cooker used; no need to drain out water	711	19.0
Rice cooked with adding proper amount of water	784	20.9
Drain excess water from cooked rice	2,257	60.2
Total	3,752	100.0

Source: Household survey: Jharkhand 2007.

Table 17. Uses of water drained out from cooked rice.

Uses of water drained out from cooked rice	No. of households	% of households
Family members use it for drinking	842	37.3
Used to feed animals	1,267	56.1
Just thrown away	148	6.6
All	2,257	100.0

Source: Household survey: Jharkhand 2007.

they used the water for making soup, which has been practiced by the tribal group of this region for ages. This might be because of a lack of pulses, tribal people prepare such food for consumption (as a substitute for pulses). On the other hand, 56% of the respondents fed the drained-out water to animals in their household. This is also a common practice among the farmers in rural areas. About 7% of the respondents reported that they throw away the drained-out water from cooked rice. However, the households of the scheduled tribe category did not throw away excess water from cooked rice.

Summary and conclusions

Findings in relation to cooking practices in West Bengal showed that 70% of the households wash rice twice and excess water from cooked rice is drained out by almost all the households (97%). This indicates that rural people in West Bengal are not well aware of the nutritional benefits in retaining micronutrients while cooking rice. In Orissa, incidence of diseases such as night blindness and diarrhea among children was very low. However, about 46% of the female members in Orissa were found to be suffering from anemia.

In terms of milling practices in Orissa, it was found that more than 90% of the farmers milled their paddy in the local husking mills and 86% of them parboiled paddy. About 54% of them parboiled once while the rest parboiled twice. Regarding polishing rice, it was found that almost all (99%) of the farmers ask the millers for polishing and 64% of them ask for double polishing. Regarding preference for rice grain quality,

76% of the households, particularly marginal and small farmers' households, gave first preference to bold short grain type of rice while only about 16% preferred long slender type of grain.

For cooking rice, 91% of the households in Orissa washed rice twice and, for cooking rice, a proper amount of water was used in only about 11% of the cases. The excess water drained out after cooking was mostly used as livestock feed (51%), followed by a drink (48%) for the household members.

In Jharkhand, the incidences of diseases such as night blindness, diarrhea, anemia, etc., as well as death of women during child birth were very low.

Most of the farmers husk rice at mills. However, a considerable proportion of the farming households use a *Dheki*/other traditional methods for husking paddy. It was found that 89% of the farmers in Jharkhand parboil paddy for milling and only about 25% of the households parboil it twice. The respondents mentioned that rice from parboiling of paddy twice is used for medicinal purposes, especially for stomach problems. This indicates that the farmers are not well aware of the nutritional benefits from double parboiling.

The survey revealed that 87% of the households did not like polished rice and only about 10% of the households preferred rice that was polished once and 3% preferred double-polished rice. The farmers reported that, if rice is not polished (almost brown rice), the cooked rice becomes tasty. It was also found that 47% of the households preferred bold short grain while about 38% preferred long slender grain. All these findings indicate that rice grain in Jharkhand is likely to contain more micronutrients than in West Bengal and Orissa.

Regarding cooking practices, it was found that about 56% of the households washed rice twice before cooking. A majority of the households (60%) drained water from cooked rice. About 21% of the households used a proper amount of water, for which there was no need to drain out water, and another 19% of the households used an electric rice cooker, which means that micronutrients are retained in cooked rice for 40% of the households. However, using a rice cooker in rural settings seems to be an exceptional case.

The three states (West Bengal, Orissa, and Jharkhand) have different socioeconomic and cultural settings that influence rice milling and cooking practices. It is also evident from the findings of this study that the perceptions of quality of rice and preference for polished or nonpolished rice as well as single- or double-parboiled paddy are largely dictated by socioeconomic and cultural values rather than by nutritional values, which have different implications for the health and nutrition of the people in these three states of India.

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Rice Biofortification

The potential of rice biofortification to overcome micronutrient deficiencies in the Philippines

Z.M. Sumalde and M. Hossain

In the Philippines, micronutrient undernutrition is prevalent among children below 5 years old, pregnant and lactating women, and the elderly. Current interventions to alleviate the problem focus on supplementation but this short-term solution entails huge budgetary requirements. One of the long-term solutions identified to alleviate micronutrient deficiency is through biofortification of staple food.

This report presents the results of a qualitative study on the potential of adoption and consumption of biofortified rice in the Philippines. Focus group discussions and key informant surveys were conducted in three regions of the Philippines to determine farmers' and consumers' responses and perceptions about biofortified rice.

Farmers cultivate different varieties for home consumption and for sale. For home consumption, farmers and consumers prefer rice varieties that are early maturing and have good eating quality. For sale, they prefer varieties that are early maturing, resist pests and diseases, and command a higher price. Despite the good traits of existing varieties, farmers are open to trying biofortified rice varieties if the desired characteristics are present. They are willing to accept a 10–15% reduction in yield if the biofortified rice is pest and disease resistant since they can save from the use of chemical inputs.

During lean times, households never sacrifice rice consumption. They instead reduce expenditures on nonfood and other food items but will consume the same amount of rice. When explained about health and nutritional benefits, consumers would be willing to pay 5–10% more than the existing price for biofortified rice.

Economic analysis showed that biofortified rice is cost-effective in reducing micronutrient deficiencies and is economically viable in the long run.

The responses of both producer and consumer groups imply that potential exists for the adoption and consumption of biofortified rice. To capture maximum benefits from biofortification, the desired traits of the rice variety by producers and consumers must be considered.

Keywords: biofortification, cost-effectiveness, micronutrient deficiencies

Introduction

Background

Micronutrient undernutrition has been an increasingly important development-related problem, particularly in developing countries. Poor nutritional status is by far the largest single risk factor for disease, leading to 1.1 billion days of illness a year worldwide (World Bank 2002). It is estimated that 124 million children worldwide are deficient in vitamin A (Datta et al 2003) and over 3 billion people in developing countries are iron-deficient. As a consequence, globally, about 3 million pre-school-age children have visible eye damage owing to vitamin A deficiency and, in poor countries, more than half of the pregnant women and more than 40% of nonpregnant women and preschool children are anemic (Hossain et al 2006). Vitamin A–deficient children are two to four times more susceptible to respiratory diseases and twice as susceptible to diarrhea (World Bank 2002). On the other hand, iron-deficiency anemia increases death and associated low birth weight, impairs growth and retards cognitive development, and lowers work capacity and productivity (ACCN/SCN 2002).

Nutritional situation and food intake in the Philippines

Based on the 2003 National Nutrition Survey (NNS) conducted by the Food and Nutrition Research Institute of the Department of Science and Technology (FNRI-DOST), based on food intake, the average Filipino is inadequate in almost all nutrients except niacin (Table 1). The worst nutrient inadequacies are suffered by pregnant women.

The prevalence of vitamin A deficiency (VAD) among 6–60-month-old children was reported to increase from 38% in 1998 to 40.1% in 2003. While VAD among pregnant women decreased moderately from 22% in 1998 to 17.5% in 2003, the situation got worse among lactating mothers, who increased in VAD from 16.5% in

Table 1. Nutrient adequacy of Filipinos, based on food intake, 2003 (%).

Nutrient	Average Filipino	Pregnant women	Children 6 months to 5 years old
Energy	98.3	78.0	83.0
Protein	99.2	84.7	102.8
Iron	60.1	28.8	72.7
Calcium	57.1	52.3	73.4
Vitamin A	91.4	72.6	79.0
Thiamine	86.3	65.9	123.2
Riboflavin	68.0	48.1	142.3
Niacin	156.4	112.7	163.8
Ascorbic acid	75.0	73.6	105.5

Source: FNRI (2005).

Table 2. Micronutrient undernutrition in the Philippines by age group and micronutrient (%), 1998 and 2003.

Nutrient/age group	1998	2003
Vitamin A deficiency[a] (deficient and low)		
6 months to 5 years old	38.0	40.1
Pregnant women	22.2	17.5
Lactating mothers	16.5	20.1
Iron deficiency anemia[b]		
6 months to 5 years old	31.8	32.4
6 months to < 1 year	56.6	66.2
1 year old	29.6	53.0
Pregnant women	50.7	52.2
Lactating mothers	45.7	52.2
Iodine deficiency disorder[c]		
6 months to 12 years old	35.8	11.4
Pregnant women	No estimates for 1998	20.0
Lactating mothers		23.7
Zinc deficiency[d]		
Overall in 2003	No estimates in 1998	9.8
Males		10.6
Females		9.1
4 years old		13.7

[a]Based on plasma retinol. [b]Based on blood hemoglobin (Hb). [c]Based on urinary iodine excretion (UIE) and WHO/UNICEF/ACCND cutoff points in determining degrees of public health significance. [d]Based on serum zinc concentration.
Source: FNRI (2005)

1998 to 20.1% in 2003 (Table 2). On the other hand, a prevalence of iron deficiency anemia (IDA) has been reported among 31% of Filipinos. By age group, the worst hit are children under 5 years old and pregnant and lactating women (Table 2). The prevalence of iodine deficiency disorder (IDD) is considered mild, with a median UIE excretion value of 71 µg/L, on average. However, 11.4% of children 6–12 years old are suffering from severe IDD. Based on serum zinc concentration, the prevalence of zinc deficiency was also moderately high, with zinc of 10–20% (Table 2).

In terms of food consumption, rice is still the main contributor to nutrient intake. Rice constitutes 34% of food consumed, followed by vegetables and fish, meat, and poultry, with 12.5% and 9.2% shares, respectively, of total food intake, and fruits with 6.1%.

Rice is the main source of energy and iron, contributing 52.8% and 28.8%, respectively, of the total intake of these nutrients. It also contributes 37% of the total protein intake. On the other hand, fish, meat, and poultry combined provide 38.2% of

the total protein intake, while vegetables give 24.1% of the total vitamin A intake. It is apparent that, except for vitamin A, rice is the major source of nutrient intake among Filipinos. However, as shown above, Filipinos are inadequate in most micronutrient and vitamin intake.

Nutrition intervention in the Philippines

Current intervention programs

Current interventions to alleviate micronutrient deficiencies focus on supplementation and food fortification. However, nutrient supplementation is considered a short-term solution to the problem. It entails huge budgetary outlays and, with the current fiscal situation in the country, the program may suffer from budgetary cuts. On the other hand, food fortification was another intervention. Among the food items fortified are instant noodles, soy sauce, juice drinks, cooking oil, snack foods, canned sardines, salt, and rice. Except for rice, these fortified foods are available in the market and most of the items consumed are noodles and canned sardines. However, no study has been made on the effects of these fortified food items on the nutrient intake of Filipinos, especially low-income ones.

Rice fortification, which has been tested since 1946, was not able to have a full takeoff. Despite the success of pilot studies on iron-fortified rice, the program wavered because of the reluctance of millers and traders to cooperate with it. In addition, the price of fortified rice is higher than that of ordinary rice. In 2004, rice fortification was revived with the passage of Republic Act 8976 (R.A. 8976) or the National Food Fortification Law. Under this law, all millers and traders should fortify the rice that they sell. However, the premix to be added to rice has to be imported and the enriched rice would entail an additional cost of at least PhP 1.00 per kg (personal communication with Ms. Gerth Agustin of the National Food Authority, 2004). Thus, the effectiveness of the law, which took effect on 7 November 2004, remains to be seen.

Issues to be examined

Micronutrient undernutrition is a public health concern in the Philippines. Nutrient supplementation may not be sustained. The budget allocation for health in 2007 amounted to only PhP11.5 billion or 1.02% of the 2007 total budget. Health ranked only eighth among the top ten departments for budget allocation. Worse, low-income people cannot afford to buy nutrient supplements. It has been shown that previous rice fortification programs wavered. Thus, there is a need for an alternative and cost-effective long-term solution to micronutrient deficiency problems.

One approach that is considered a long-run solution to micronutrient deficiency is through biofortification. This is the technique of breeding crop varieties that fortify themselves by loading minerals and vitamins into their seeds and roots. It is perceived to be the most viable, economical, and sustained option of reducing micronutrient malnutrition (Welch and Graham 1999). Staple foods such as rice, maize, wheat, etc., are the usual intervention point of fortification. A few years back, breeders developed crops enriched with iron and vitamins. In the Philippines, "Golden Rice" has been

piloted and it has shown promising results. Preliminary results on the biological efficacy of consuming biofortified rice also demonstrated modest but significant improvement in serum ferritin and body Fe of iron-depleted nonanemic women. High-Fe rice IR68144-3B-2-2-3 with the name Maligaya Special #13 (MS-13) has been formally released in the Philippines. However, it remains to be tested on a wider scale.

Biofortification of staples is the most viable, economical, and sustained option to reduce micronutrient deficiencies. The questions to be addressed, however, include

1. Would farmers adopt biofortified rice?
2. What conditions would make farmers adopt it?
3. Would consumers accept it?
4. What conditions would make consumers consume it?

From the above, the development and deployment of biofortified rice (BR) need careful examination of the acceptance of varieties by both producers and consumers. Adoption by farmers and acceptance by consumers depend on a wide range of agronomic and economic factors that need to be assessed. As a starting point, a qualitative study on the conditions for adoption and consumption was conducted.

A qualitative study in the Philippines

Objectives of the study

In general, the study aimed to carry out group interviews with emphasis on rice production, food consumption pattern, and micronutrient deficiencies in three selected regions in the Philippines. Specifically, the study was guided by the following objectives:

1. To discuss the production environment and demographic and socioeconomic profile of the selected areas;
2. To identify the food consumption and food acquisition patterns of common consumers' groups;
3. To provide information on health and nutrition programs in the areas and the perception of health workers on health challenges in the community; and
4. To identify conditions conducive to the adoption of biofortified rice in terms of agronomic traits and economic characteristics valued by farmers.

Location of the study

The study was carried out in three regions: Region III, Region IV, and Region V in Luzon. The provincial site for Region III is Nueva Ecija, Laguna for Region IV, and Masbate for Region V. These provinces were selected based on the extent of micronutrient deficiencies and their rice production performance. Nueva Ecija, a major rice-producing province, has a high prevalence of vitamin A deficiency while Masbate is the leading province as far as vitamin A, iron, and iodine deficiencies are concerned. In the case of Region IV, Laguna was chosen since rice is one of the major crops in this province and the impact of rice biofortification can be more evident. From each province, one municipality was chosen.

In consultation with the municipal agricultural officer (MAO) and municipal nutrition action officer (MNAO), one barangay was chosen from each municipality.

Table 3. Study sites and number of FGD respondents, 2004.

Region	Province	Municipality	Barangay
III	Nueva Ecija	San Jose City	*Tondod* Rice producers = 7 Low-income women = 12 High-income women = 8
IV	Laguna	Pakil	*Gonzales* Rice producers = 10 Low-income women = 13 High-income women = 7
V	Masbate	Mobo	*Nasunduan* Rice producers = 13 Low-income women = 10 High-income women = 4

Two groups (rice producers and a women's group) were chosen from each barangay for the FGDs. Women's groups were classified into low-income and high-income groups, whose selection was based on the perceptions of the barangay officials and barangay health workers (BHW) or barangay nutrition scholars (BNS). The sampling of producers was done with assistance from barangay officials and municipal agricultural officers. Table 3 shows the sample sites.

Methods of data generation

To achieve the objectives of the study, four modules were developed. These include the following:

Module 1: Community-level information related to production environment and socioeconomic and demographic characteristics
Module 2: Community-level information on micronutrient deficiency
Module 3: Production-related information from farmers
Module 4: Food consumption and preferences, and health and nutrition awareness from women consumers

Focus group discussions (FGDs) and key informant interviews (KIIs) were conducted to obtain information related to production, consumption, and health and nutrition conditions in the study areas.

Key informant survey (KIS). Local officials and workers at the health centers were the key informants. The community-level information surveys were conducted with the MAO, MNAO, and barangay officials. Basic information regarding the cultivation pattern, government interventions in both agriculture and in health, and a general overview on the community dynamics were obtained. On the other hand, an interview with health workers was conducted to acquire information regarding their perceptions on the health challenges in the community.

Focus group discussions (FGDs). Three FGDs among rice producers, a low-income women's group, and high-income women's group were conducted in each barangay. The information gathered included (1) varieties planted, characteristics of

rice varieties for home consumption and for sale, production and marketing practices; (2) institutional environment (government and nongovernment programs in the village, sources of information on agricultural technology, farmers' organizations in the village); (3) preferred consumption characteristics (attributes of the staple food, varieties of rice produced in the community); (4) consumption patterns of the household; (5) food acquisition patterns; and (6) information about causes of illnesses and responses to them.

Cost-effectiveness analysis was based primarily on the analysis of Javelosa (2005) and Meenakshi et al (2006).

Results of the study

General characteristics of the study areas. The information contained here was obtained from KIS from the municipal agricultural officer, agricultural technician, and MNAO of each municipality, and barangay officials, a barangay health worker/ barangay nutrition scholar of each barangay, and a preschool teacher.

Socio-demographic characteristics. All the barangays visited are rice-producing areas and are accessible by motor vehicles. Almost all households have an electricity connection. This may be attributed to the Rural Electrification Program of the government. The five percent of the households without an electricity connection in Laguna are those that are considered migrants from other provinces.

The study village in Nueva Ecija has the largest land area perhaps because of the broad rice lands in the area.

In terms of population and number of households, the barangay studied in Laguna has the highest population while the barangay in Nueva Ecija has the highest number of households. The barangay in Masbate has the lowest number of both population and households but has the highest family size (Table 4).

Only the village in Masbate has no complete elementary school. The barangay has only up to grade 2 and the children have to go to a nearby barangay to complete their elementary education. Because of this, only 80% of the school-age children are attending school. For secondary schooling, only the barangay in Nueva Ecija has a barangay high school funded by the government such that the tuition fees are minimal. This is why a high proportion of school-age children are attending secondary schools.

In Laguna, however, the relatively lower proportion of attendees at secondary school is due to the absence of a public secondary school in the area such that the tuition fees in private schools limit school participation. On the other hand, no record on secondary schooling is readily available in the barangay in Masbate. College education was highest among the households in Laguna. Again, there were no records of households with college education in Masbate but the respondents said that it is minimal.

Agriculture-related information. Being located in the major rice-producing region in the country, the barangay in Nueva Ecija has the widest area devoted to rice production and total dependency on agriculture (Table 5). In Masbate, although 98% of the households in the barangay studied depend on agriculture, it has the smallest area in terms of absolute and proportion of land devoted to rice. This may be because

Table 4. General characteristics of the study areas, 2004.

Characteristics	Laguna	Nueva Ecija	Masbate
Land area (ha)	81.27	921.92	155.7
Total population	2,862 (2003)	2,600 (2002)	975 (2004)
Number of households	600 (2003)	700 (2003)	159 (2004)
Households with electricity connections	95%	100%	100%
Presence of complete elementary school	Present	Present	None, up to grade 2 only; to complete elementary, children have to go to nearby barangays
School-age children attending elementary school	100%	88%	80%
Presence of secondary school	None	Present	None
School-age children attending secondary school	60%	97%	No record
Proportion of households with college education	60%	50%	No record but minimal

rice is not the primary crop grown in the area. In fact, corn (maize) is the major agricultural crop in the province. Nevertheless, the barangay studied will be the pilot site for the Hybrid Rice Commercialization Program of the municipality. All rice area in Laguna and Nueva Ecija is covered with an irrigation system.

High-yielding varieties (HYVs) are very popular in the areas studied (Table 5). Almost 100% of the area is planted to HYVs or hybrid rice varieties. In Masbate, hybrid varieties are still in the pilot stage as part of the Hybrid Rice Commercialization Program. In Nueva Ecija, farmers are already planting the Mestizo hybrid variety that was bred by IRRI but commercialized by PhilRice. Contact with the agricultural technicians who are also the major sources of agriculture-related information is more frequent in Nueva Ecija and Laguna than in Masbate.

Rice varieties grown for home consumption and for sale. In general, there are no differences in rice varieties grown during the wet and dry seasons. In Laguna, rice is grown only during the dry season due to flooding from Laguna Lake during the wet or rainy season. In Nueva Ecija, one farmer tried Bigante, a hybrid variety, last dry season and he was contented with the harvest of 5,600 kg that he got from his 0.70-hectare lot.

*Varieties planted by usage***.** There are differences in production pattern among the farmers in the study areas when it comes to varieties planted for home consumption and for sale. In Nueva Ecija and Masbate, farmers do not differentiate varieties by usage whereas farmers in Laguna grow different varieties for home consumption and for sale (Table 6). The Nueva Ecija farmers grow the same varieties for home consumption and for sale. The only difference is in terms of milling. Undermilled rice is normally used for home consumption while rice for sale is well milled since buyers

Table 5. Agriculture-related information in the study areas, 2004.

Characteristics	Laguna	Nueva Ecija	Masbate
Area planted to rice (ha)	69.2	796	41
Proportion of area planted to rice (%)	85	86	28
Irrigation coverage (%)	100	100	88
Households dependent on agriculture (%)	55	100	98
Area planted to HYVs (% of rice area)	Almost 100	Almost 100	95
Popular inbred/local variety	PSB-Rc 12	IR64	PSB-Rc 18
	PSB-Rc 18	PSB-Rc 82	PSB-Rc 82
	IR1606	Mestizo	
Frequency of extension worker's/ag technician's visit	Once a week	2–3 times a week	Seldom, once a month
Source of information about agriculture/ rice technologies	Agricultural technician	Agricultural technician and PhilRice	Agricultural technician

prefer whiter milled rice. In Masbate, farmers may consume different varieties but this happens only when they run out of stock from their harvest such that they are forced to buy whatever rice variety is sold in the market.

Characteristics of rice varieties for home consumption. For all farmers, the common characteristics of the varieties for home consumption include early maturing, good eating quality, and good texture of leftover rice (Table 6), which means that leftover rice does not harden when left for several hours. This is particularly true for Laguna, where households usually cook more during breakfast so that the leftover rice will be eaten at lunchtime, especially for those with children and household members who packed a lunch for school or the work place. The farmer respondents who have planted HYV Bigante said that they will plant the variety again this coming dry season but keep the harvest for home consumption due to its good eating quality, aromatic smell, and high yield.

Characteristics of rice varieties for sale. IR1606 that was grown for sale by Laguna farmers has heavier and bigger grains and thus higher yield (Table 6). This may seem odd since heavier grains can be thought to have fewer grains per panicle. However, the farmers said that this variety has good tillering capacity and a plant that can also handle more grains. Other characteristics that made the variety attractive to be grown for sale are early maturing, grains that do not change color even if not properly dried during the rainy season, good eating quality, and higher price. On the other hand, most farmers in Nueva Ecija are reluctant to plant hybrids (Mestizo series and Bigante) because these varieties do not command a higher price due to low head recovery. The varieties were classified by buyers into what they call "rumble" or lower-class varieties with a price discount of at least PhP1.00 per kg compared with the price of the inbred varieties that they are planting. However, according to one of the farmers, the low head recovery may be due to improper drying. Based on his

Table 6. Rice varieties planted and characteristics by study area, 2004.

Item	Laguna	Nueva Ecija	Masbate
Varieties planted			
HYV	PSB-Rc 12	IR64	PSB-Rc 18
	PSB-Rc 18	IR82	IR82
	IR1606		
Hybrid	None	Mestizo, Bigante	None
For home consumption	PSB-Rc 12 PSB-Rc 18	IR64 Bigante	PSB-Rc 18
For sale	IR1606	IR64, IR82	IR82
Characteristics of the variety			
For home consumption	Early maturing, good eating quality, leftover cooked rice does not harden when cold	Early maturing, good eating quality, aromatic	Early maturing, good eating quality
For sale	Heavier grains, good tillering capacity, high price	Early maturing, does not change color even when not properly dried during rainy season, good eating quality, high price	Early maturing, resistant to drought, heavier grains, high price

experience, Bigante has to be milled at once after the second drying[1] to have higher head recovery during milling.

This situation calls for proper coordination between breeders and postharvest experts to determine the appropriate postharvest practices to get the most out of a good variety. If the problem of low head recovery can be solved by proper drying, the potential for hybrid adoption will be greater. In line with this, the Rice Hybrid Commercialization Program of the Department of Agriculture (DA), and later the Biofortified Rice Program, should also consider the appropriate postharvest practices for the hybrid and include them in the package of technology to be extended to farmers for them to get the maximum benefits, not only in terms of harvest but also increased income through a reasonable rice price. According to our respondent farmer, if only the hybrid varieties were priced the same as the inbred or long-grain varieties, all farmers would plant hybrid rice varieties.

[1]After harvest, there is predrying (skin dry) before paddy is stored. Second drying will be done before milling. There are cases, however, wherein palay is stored after the second drying. For Bigante, the paddy should not be stored after the second drying; rather, it should be milled immediately to obtain good head recovery.

Table 7. Willingness to adopt and accept a lower yield for a new variety.

Item	Laguna	Nueva Ecija	Masbate
Criteria in choosing from varieties with the same yield	Crop duration, resistance to pests and diseases	Crop duration, resistance to pests and diseases	Eating quality
Willingness to accept a lower yield			
If variety is resistant to pests	500 kg/ha (current yield is 7,500 kg/ha)	750 kg/ha (current yield is 8,500 kg/ha)	250–500 kg/ha (current yield is 3,750–4,000 kg/ha)
If variety has better eating quality	375 kg/ha	None	250–500 kg/ha
If variety contains vitamins that reduce night blindness	375 kg/ha	None	250–500 kg/ha
If variety contains more iron	500 kg/ha	None	250–500 kg/ha
Will plant nutritious rice variety with off-white color	Yes, provided taste will not be affected, good eating quality, and leftover cooked rice does not harden	Yes, provided price is still the same or higher	Yes, as long as the rice has good eating quality

Perception of new rice varieties and attitude on their adoption. Despite the popularity of existing rice varieties, farmers are open to trying new varieties with desirable traits.

Criteria in choosing a rice variety. Yield is one of the criteria considered by farmers. However, if other varieties exist that would give the same yield, farmers will consider other traits. These include crop duration, resistance to pests and diseases, and good eating quality. Farmers wanted a short-duration rice variety for the simple reason that they can get the output immediately and save time attending to the field (Table 7). Savings from the use of chemical pesticides are the main justification for choosing a variety that is resistant to pests and diseases.

Since most of the farmers keep a portion of their harvest for home consumption, they prefer varieties with good eating quality. Farmer respondents from Laguna mentioned that they do not want a variety that smells good for it would attract rats. They had experienced adopting a hybrid (Gloria or Mestizo) variety that was produced and introduced by PhilRice. The variety had good yield, was aromatic, and had good eating quality, but it was attractive to rodents so they stopped planting it.

Willingness to adopt a new rice variety. In general, farmers are open to trying hybrid and biofortified or nutritious rice varieties. When explained the meaning of biofortified rice, most of the FGD respondent farmers were curious about whether seed was already available. Based on their responses, it appeared that they had knowledge about the potential benefits of eating nutritious rice.

For home consumption, they would be willing to sacrifice some yield if the rice variety was resistant to pests and diseases (Table 7). They said that the reduction in yield might be offset by the savings that they would get from using less chemical pesticide application and that the health hazard associated with the use of chemicals would be reduced. However, unlike farmers from Laguna and Masbate, farmers from Nueva Ecija would not accept a reduction in yield for rice varieties that have better eating quality and contain vitamins and iron. While those from Laguna and Masbate claimed that the reduction in yield might be offset by the reduction in cost of taking supplemental vitamins and iron, the farmers from Nueva Ecija said they would just consume other foods that will give them vitamins and minerals. They said they would need surplus production for sale so they could buy other needs. For nutritious rice but off-white color, the farmers said that they would adopt it for home consumption as long as the taste and eating quality of the cooked rice were not affected. Nueva Ecija farmers are more concerned about price. They would sacrifice the color of rice provided they were guaranteed the same price or a higher one. The different responses given by Nueva Ecija farmers compared with those from Laguna and Masbate may be because the former have a marketable rice surplus and they are hence concerned about changes in rice price. On the other hand, most of the Laguna and Masbate farmers are keeping most of their harvest for home consumption.

Food consumption and preparation. The quantity and type of food that an individual or household consumes and the ways foods are prepared are among the factors that affect nutrient intake of the household and community. Thus, in any nutritional improvement intervention, there is a need to determine the food consumption pattern and food preparation practices to serve as a guide in intervention strategies. The discussions that follow are based on the information gathered through FGDs with women's/consumers' groups in the three study areas.

General socio-demographic characteristics. In general, high-income women are older than low-income women (Table 8). For the low-income groups, Laguna households have the highest average number of members while Nueva Ecija has the lowest. On the other hand, among the high-income groups, Masbate has the highest average number of household members. Average monthly household income ranges from PhP812.50 to 1,990 for the low-income groups and PhP2,500 to 7,488 for the high-income groups. The same trend follows when it comes to average per capita monthly income. The lower incomes reported by women in Nueva Ecija may be because they are counting only the money income received from a paid job but not the value of rice harvested.

Sources of rice for home consumption. Rice for home consumption is sourced from own harvest and purchases from the market. A majority of those who purchase rice buy it every week, except for the high-income group from Masbate, which buys palay and has it milled every month (Table 9).

Per capita rice consumption. In general, low-income households consume more rice than high-income households (Table 8). This situation follows the Engel Law, which states that, as income increases, consumption of cereals decreases because of the tendency of households to consume other energy-giving foods. However, in Masbate

Table 8. Women consumers' profile by income group and study area, 2004.

Item	Laguna		Nueva Ecija		Masbate	
	Low income (n = 12)	High income (n = 8)	Low income (n = 13)	High income (n = 7)	Low income (n = 10)	High income (n = 4)
Age (range)	38	42	37	34	46	48
	(25–62)	(26–65)	(18–65)	(24–61)	(30–68)	(35–64)
Household size	7	5	4	4	5	6
	(4–11)	(4–8)	(3–6)	(3–6)	(2–8)	(4–7)
Children below 6 years old	2	1	1	1	1	1
	(0–3)	(0–3)	(0–4)	(0–4)	(0–3)	(0–2)
Average household income (PhP/month)	1,990	2,500	813	3,415	1,726	7,489
Average per capita income (PhP/month)	271	500	203	854	345	1,248
Source of rice for home consumption (% of responses)						
a. From own harvest	8	25	31	71	20	25
b. Purchase	67	25	0	14	60	25
c. Harvest and purchase	25	38	69	14	20	50
Frequency of rice purchase (% of responses)						
a. Every day	33	0	Seldom, when run out of stored rice	0	20	0
b. Every week	58	38		14	50	0
c. Every month	0	13		14	10	100
Quantity of rice consumed (grams/capita)	288	261	417	289	497	425
Expenditure for fortified food (PhP/month)	284	2,000	375	1,015	483	1,750

and Nueva Ecija, households consumed more rice than those from Laguna. This may be because the households surveyed in Laguna, being closer to the town proper, have easy access to substitutes for rice such as bread and noodles.

Expenditures for fortified foods. Households in the study areas are all aware of fortified foods in the market. These foods include instant noodles, sardines, tomato catsup, cooking oil, salt, margarine, powdered fruit juices, and chocolate drinks, among others. The expenditures for these food items vary significantly by income group. In general, the higher income groups spent more for fortified foods than the

Table 9. Meals or food pattern by income group and study area, 2004.

Item	Laguna		Nueva Ecija		Masbate	
	Low income	High income	Low income	High income	Low income	High income
Usual food eaten						
Breakfast	Rice, dried fish, eggs	Rice, bread, hotdog, egg, processed meat	Rice, dried fish, instant noodles	Rice, egg, fish, meat, and meat products	Rice, dried fish, egg, bread, and coffee during weekends	Rice, egg, fried fish, easy-to-cook foods such as processed or canned meat
Lunch	Rice, vegetables, fish	Rice, vegetables, fish or meat bought at food counters	Rice, vegetables, legumes, fish	Rice, vegetables, fish or meat	Rice, fish, vegetables	Rice, fried fish or meat, soup
Dinner	Same as lunch, sometimes left over from lunch	Rice, vegetables with fish but cooked at home	Rice, vegetables, canned sardines or fish	Rice, vegetables, fish or meat	Rice and vegetables	Rice, fish with vegetables or meat
Foods avoided or food taboos	Beef because of its smell and imported foods because of prohibitive price, eggplant and banana blossoms for pregnant women	Some canned goods and instant noodles because of too much monosodium glutamate and preservatives, eggplant and banana blossoms for pregnant women	Instant foods and expensive foods, eggplant for pregnant women	Instant foods and flavorings because of preservatives and chemicals	None, just do not buy because of budget constraint, eggplant, salty foods and sweets for pregnant women	Expensive foods, eggplant and banana blossoms for pregnant women
Changes in consumption pattern	From conventional home cooking to introduction of ready-to-cook or instant foods	From consumption of more vegetables to eating processed foods, especially meat; proliferation of instant foods, dining out is also becoming popular	Prices of foods nowadays are very prohibitive	Almost everything is bought now	Limited quantity and kinds of food because of limited budget but high price of foods	Now people are faced with foods that have too many preservatives

low-income groups (Table 8). While the low-income groups spent more on fortified instant noodles, the high-income groups spent more on cooking oil, fortified juices, and chocolate milk.

For breakfast, the low-income households usually have dried fish, steamed rice, or fried rice if there is leftover rice from the previous night. The high-income group has rice, bread, hotdogs, eggs, and processed meat (Table 9). For both groups, combinations of these foods are eaten alternately within the week.

For lunch, households have fish or meat and vegetables (Table 9). For those with school children, the children take a packed lunch to school so, more or less, the family members have the same type of food during lunch. However, households in Laguna usually buy cooked food (could be vegetables, meat, or fish) from small food counters in the barangay. They claim that it is cheaper since they can save on fuel and water. They can also avoid leftover food that is normally wasted since they will buy just enough for one meal. In addition, this is less time consuming since they can do away with washing utensils. The low-income households from Laguna also mentioned that they do not want to eat beef because of its smell.

The high-income group has meat (chicken, pork, or beef) more often instead of fish during lunch and dinner due to the high price of fish. This may sound odd, but the fact is that prices of fish vary significantly depending on the species. Some species of fish are more expensive than meat (PhP240–280 per kg of high-quality fish such as grouper and blue finned tuna compared with PhP90–105 per kg of chicken, PhP120–150 per kg of pork, and PhP160–220 per kg of beef). The fish that the low-income group mentioned are the low-priced species such as tilapia and round scad, whose prices are PhP60–85 per kg.

On the other hand, households in Nueva Ecija and Masbate cook for lunch. Despite the availability of food counters, people seldom buy cooked foods because they find them quite expensive. This may be because vegetables are grown for home consumption in these areas; hence, they can save if they cook. In Masbate, they find it cheaper to cook because of the low prices of vegetables, fish, seafoods, and meat in the area compared with Laguna and Nueva Ecija.

Dinner meals are normally similar to lunch since households, especially in Nueva Ecija and Masbate, cook fish and vegetables for lunch and save some portion for dinner (Table 9). However, steamed rice is always freshly cooked except when there is some left from lunch.

Households prepare different type of meals or menus during weekends. Weekend is the time when people go to the market to buy household necessities and household members are all present. Because of this, they also buy "special" food such as beef, special cuts of meat, and quality fish.

Although fruits are eaten, these are normally not counted as part of the meal. Common fruits eaten are bananas and papayas. Also, seasonal fruits such as mango, oranges, star apple, watermelons, and melons are commonly consumed by households. Desserts and sweets are occasionally eaten after meals.

Eating out is a recent development during special occasions and celebrations among households although this is more common among women respondents from

Laguna. They usually do this at least once a month or on paydays and for special occasions such as birthdays and anniversaries. This was made possible because of the presence of fast-food chains in nearby municipalities and restaurants within the municipality. Before, people used to cook and invite neighbors for a celebration but nowadays they find it more practical to just bring the family and close relatives to dine outside. This may have social implications but it is beyond the scope of this study.

Those from Nueva Ecija and Masbate eat out occasionally. Despite the presence of fast-food chains and restaurants in the city, household members do not go there to eat intentionally. In Masbate, eating out is done only by household members working in the city who fail to take a packed lunch.

Another major change in consumption pattern is the proliferation of ready-to-cook food or instant food (Table 9). Households believe that these foods contain lots of preservatives and are hazardous to health.

Foods avoided and food taboos. Some food items are avoided by households. The low-income respondents from Laguna do not want to consume beef because of its smell. Respondents from the other areas said they do not want to buy imported food items because of income or budget constraints. They also have some reservations about consuming some kinds of canned and processed food items and flavorings because these are laden with chemicals and preservatives, which they believe to be hazardous to health (Table 9). They have the belief that pregnant women should not eat eggplant and banana blossoms since these vegetables may cause women to give birth to blue babies. Similarly, women are advised not to eat sweet and salty foods during pregnancy as they may affect the health of the baby.

Food acquisition and preparation. Women are the decision makers when it comes to food purchases and budgeting (Table 10). In Masbate, men decide on food purchases because they work in government offices in the town and have a chance to go to the market to buy food.

As stated above, rice comes from own harvest or is bought from rice retailers. Vegetables such as eggplant, string beans, camote tops, and squash are normally grown for home consumption but people also buy other vegetables such as cabbage, carrots, and tomatoes. Among the food items, it is rice that households will not sacrifice. In lean times, when income is low or prices are high, households consumed the same quantity of rice and adjusted expenses on other food and nonfood items.

Food preparation. Fish or meat were normally fried or were cooked with vegetables to have a one-dish meal. Rice is normally steamed but is washed 2–3 times depending on the circumstances (Table 10). It seems that households are not aware of the nutrient being lost during washing. Accordingly, 9% of nutrients are lost during washing before rice is cooked (Payumo et al 1982 as cited by Florentino and Pedro at www.unu.edu/unupress/food/v192e/ch09.htm). Households wash only the rice that is recently harvested. They claim that they have to wash the rice more than once if rice is stored or bought from retailers to remove the dirt that accumulates because of rice being exposed to the elements.

Households from Laguna and Nueva Ecija use water from rice washing in cooking fish and vegetables because they believe that it is nutritious but those from Masbate

Table 10. Food acquisition and preparation, by income group and study area, 2004.

Item	Laguna		Nueva Ecija		Masbate	
	Low income	High income	Low income	High income	Low income	High income
Decision maker in food purchases and budgeting	Mother	Mother	Mother	Mother	Mother	Father
Number of times rice is washed before cooking	Twice	Twice to thrice	Twice	Thrice if rice is old stock, twice if rice is newly harvested	Twice if rice is old stock, once if rice is newly harvested	Thrice if rice is bought from the market, twice if palay is bought and milled
Use of rice water before cooking	For cooking fish and vegetables	For cooking fish and vegetables	For cooking fish and vegetables	For cooking fish and vegetables	For watering plants	For swine feed
Use of leftover rice	Fried rice and pop rice with sugar and eaten during snacks, use for porridge	Fried rice, added to next meal, dog or cat food	Fried rice for breakfast	Keep for lunch or dinner	Fried rice for breakfast	Fried rice for breakfast, dog food
Coping mechanisms during lean period	Buy less expensive food items but not sacrifice rice	Reduce expenses for clothing and luxuries, use savings to buy same kind of foods	Use “bagoong” or fermented fish mixed with chili as viand, eat the same quantity of rice	Buy less of expensive foods and luxuries, eat the same quantity of rice	Substitute sweet potato and cassava for rice and buy cheaper foods to meet the needs of household	Use savings and sacrifice nonfood items

never use it for cooking. Instead, they use water from rice washing for watering plants and for feeding swine (Table 10). This is done only to save water. Excess water from rice cooking is used as a milk supplement for infants in all areas although the high-income group who used a rice cooker with exact water measurement in cooking no longer practices this. The low-income group cooks rice in a kettle over fuel-wood fire. To prevent excess water, they have a way of measuring it using their hands, in which fingers are dipped inside the kettle containing rice and water and determine the exact water level before setting the kettle above the stove.

Leftover rice is normally fried and used as food. Some households prepare porridge out of the leftover rice (Table 10). For the high-income groups from Laguna and Masbate, leftover rice and other foods are used as dog and cat food.

Coping mechanisms during lean periods. There are also times when households experience hardship. These lean periods occur before the harvest when they have less income and food available for consumption and when there is a natural calamity such as a typhoon. Respondents admitted that they make adjustments to cope with these circumstances. They limit purchases on luxury items, clothing, and expensive foods. The low-income households in Nueva Ecija said that they just mix "bagoong" (fermented fish) and chili and uses it as a viand. Except for the low-income households from Masbate, who substitute camote and cassava for rice during breakfast or dinner, the respondents said they will consume the same quantity of rice (Table 10).

Willingness to consume and pay for nutritious rice. When asked if they are willing to consume and pay for nutritious rice, most of the women answered affirmatively. Only a few from the high-income group in Nueva Ecija said they would not buy it since they are content with the rice they are consuming and other nutrients can be obtained from the meat and vegetables that they are consuming. However, they said that if a variety is available for planting, the farmers may be willing to plant it, and hence they will consume it. These are the women for whom rice for home consumption comes from their own harvest.

For those who buy rice, they said they will buy biofortified rice if the price is not too high compared with the current price of rice. Those from Laguna would pay 5–10% more in price if the rice would prevent night blindness and anemia (Table 11). The absolute increase in price would be PhP0.90–1.80 per kg (average of PhP1.35 per kg) compared with the current price of rice paid by the low-income group and PhP1.05–2.10 per kg (average of PhP1.57 per kg) for the high-income group. On the other hand, the respondents from Nueva Ecija said they are willing to pay PhP17–20 per kg for the nutritious rice. This is also the range of the price in the market in this area. Hence, they are not willing to pay an additional amount for biofortified rice. A higher price was quoted by the respondents from Masbate, wherein the low-income households are willing to pay up to PhP25 per kg for nutritious rice (with iron and vitamins) while the high-income group would pay PhP22 per kg (Table 11). They are also willing to buy off-white nutritious rice as long as the taste and smell are not affected.

Characteristics that women want in a rice variety. Characteristics of a new variety are crucial in its acceptance for consumption. All women respondents said

Table 11. Willingness to pay for nutritious rice by income group and study area, 2004.

Item	Laguna		Nueva Ecija		Masbate	
	Low income	High income	Low income	High income	Low income	High income
Will pay for nutritious rice (% higher than the current price they are paying)						
Rice that prevents night blindness and makes women stronger	5–10%	5%	6–10%	5% but some are not willing to pay a higher price	25%	10%
Willingness to buy off-white but nutritious rice	Willing if it has good eating quality	Willing if it has good eating quality	Willing as long as taste and odor are not affected	Willing as long as taste and odor are not affected	Willing if it has good eating quality	Willing if it has good eating quality

that a change in color due to additional nutrients would be acceptable. They would consume off-white (yellowish or darker) nutritious rice as long as the odor of the rice and eating quality would not be affected. They also want a new variety to keep for 5–6 hours without hardening.

Adoption potential and consumption for rice biofortification. Results of the study showed that indeed demographic, socioeconomic, and agricultural characteristics and undernutrition are closely interlinked. The magnitude of the problem of micronutrient malnutrition is immense, and will necessitate the use of multiple complementary interventions. Rice biofortification is a significant addition to these tools. The National Food Fortification Law and the Hybrid Rice Modernization Act are two laws that would facilitate the implementation of rice biofortification. Given the constraints and experiences of previous and existing rice fortification, the potential for rice biofortification is great. If the characteristics mentioned by rice farmers and consumers can be incorporated in the development of biofortified rice, the potential for its adoption and consumption would be great.

Cost-effectiveness of rice biofortification. If the government pushes for rice biofortification, is this approach more cost-effective than other interventions, especially nutrient supplementation? Using the disability-adjusted life years (DALYs) approach in measuring the effect of rice biofortification with iron and zinc and information from breeders about adaptive research, results showed that rice biofortification would be cost-effective in the long run. The key costs of rice biofortification are shown in Table 12.

For iron biofortification, a cost-effectiveness analysis shows that the cost per DALY saved for iron would be US$49.60 and $197.30 under the optimistic and pessimistic scenarios, respectively. The benefit-cost ratio is 20 under the optimistic scenario and 5 under the pessimistic scenario (Table 13).

For zinc, under the optimistic scenario, the cost per DALY saved is $7.00 and it is $46.30 under the pessimistic scenario. The benefit-cost ratios are 144 and 22 under the optimistic and pessimistic scenario (Table 13).

Conclusions and policy implications

Conclusions

From the results of the analysis, the following can be concluded:

1. Given the limited budget for health and the constraints to rice fortification using premix, biofortification could be the better if not the best alternative in solving micronutrient deficiencies.
2. Farmers know what varieties they would want to plant either for home consumption or for sale. As such, in breeding a new rice variety, the characteristics mentioned by farmers should be considered. Farmers would be willing to adopt biofortified rice if the characteristics they want in a rice variety are met. In areas having a more marketable surplus, the price of rice is an important factor to be considered.

Table 12. Key cost of rice biofortification, by category, for iron and zinc.

Cost item	Cost (US$ per year)
R & D costs (1–4 years)	320,000
R & D costs (5–10 years)	110,000
Adaptive breeding costs	50,000
Dissemination and maintenance costs (high assumption)	200,000

Source: Based on estimates of Meenakshi et al (2006).

Table 13. Cost-effectiveness of rice biofortification.

Nutrient/scenario	Cost per DALY saved (US$)	Benefit-cost ratio
Iron		
Optimistic	49.60	20
Pessimistic	197.30	5
Zinc		
Optimistic	7.00	144
Pessimistic	46.30	22

Source: Based on estimates of Meenakshi et al (2006).

3. Households would be willing to buy and consume nutritious rice if it is available in the market. They want to have a sample of the biofortified rice so they could evaluate its effectiveness.
4. Rice biofortification is cost-effective in the long run compared with nutrient supplementation.

Recommendations for rice biofortification

From all indications given by farmers and households, there is potential for the adoption of biofortified rice. However, to get the maximum benefits from a biofortification program, the following should be considered:

1. Rice breeders should consider the characteristics mentioned by farmers and consumers. In addition, proper drying or postharvest handling should also be part of the technology improvement. As such, there is a need for teamwork between breeders and postharvest experts to get the most out of biofortified rice. IRRI and PhilRice could be the lead agencies to spearhead this.
2. Demonstrations or on-farm trials at the farmers' site by geographical characteristics should be in place so that farmers could witness and see for themselves the benefits from the biofortified rice. This could be done in collaboration with local government units.

3. Since eating quality is one of the major traits mentioned by both farmers and consumers, there is a need for sensory evaluation to determine the acceptability of the biofortified rice variety.
4. A quantitative impact assessment about the effectivity of biofortified rice as far as reducing micronutrient deficiencies are concerned should be in place. This should be done by geographical, socioeconomic, and physiological characteristics of the individuals to determine the distributional impact of the technology. In this aspect, a multidisciplinary team should be formed to do the impact assessment. The team, to be headed by an agricultural economist, should include a socioeconomist, nutritionist, microbiologist, and medical doctor among others. IRRI and academic/research institutions should be partners in this aspect. A feedback mechanism about the results of the study should be part of the quantitative study.
5. Results of the experiments should be well disseminated so that the public will be properly informed. Appropriate communication and social marketing strategies with a feedback mechanism should be developed for this purpose.

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Notes

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Assessing the potential of biofortification to address micronutrient malnutrition in rice-based cropping systems in Orissa, India

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This study was conducted in 11 villages representing eight sites and seven districts of Orissa, India, to determine the adoption potential of farmers and acceptance of consumers of biofortified rice. Secondary information revealed nutritional deficiency in rural households in the study areas of Orissa. The prevalence of anemia, malnutrition, and other acute diseases such as diarrheal diseases and skin diseases was very common among the study villages. The villages were classified according to the agro-climatic conditions of the area. Both community-level and household-level data were obtained, mostly from the female members of the households. Regarding the adoption and consumption of nutritious rice, that is, biofortified rice, results of the community-level study revealed that farmers considered agronomic traits and eating quality of the variety. For agronomic traits, farmers would choose a variety that is resistant to drought, pests, and diseases, and has reasonable crop duration. In the flood-prone environment, farmers would want a variety that is not prone to waterlogging. To a certain extent, farmers would be willing to accept a yield reduction of 5–20% of their current yield if a variety were resistant to pests. For eating quality, low-income households prefer a variety that has bold grain and is suitable for preparing water rice and pressed rice and one that will make them feel full. On the other hand, the more affluent members of the community prefer a variety that has fine grain, is slender, and is well polished. For rice with good eating quality, farmers in most areas would be willing to accept a 5% yield reduction. Although some farmers, particularly those from the coastal irrigated and rice-deficit villages, would not sacrifice yield in favor of nutritional value, most farmers would be willing to accept a 5–15% yield reduction in favor of nutritional value. However, farmers prefer to grow off-white colored nutritious rice since the local varieties that they currently cultivate are dark colored. In the same manner, consumers would also consume dark or yellowish colored nutritious rice.

From the results of the study, it is important to note the need and potential for biofortification of rice to overcome malnutrition and micronutrient deficiencies among rural poor households as rice is the bread and butter for their survival in Orissa. However, to get the maximum benefit from a biofortification program, the following issues should be considered. Nutrient-enriched rice varieties should be developed by rice breeders so as to overcome multiple micronutrient malnutri-

tion among rural communities. Improved agronomic characteristics and eating quality are of much concern for adopting biofortified rice in Orissa. Nationally and internationally available promising nutrient-enriched rice varieties should be evaluated in farmers' fields to create awareness among farmers as end users. If found suitable, these varieties should be promoted through different nutritional projects involving farming communities. A food package including biofortified rice should be recommended for better use of micronutrients by the poor. The possibility of using the Public Distribution System (PDS) and mid-day meal programs in distributing biofortified rice should be explored.

Farmers are willing to accept a 10–15% reduction in yield if biofortified rice is pest and disease resistant since they can save on the use of chemical inputs. During lean times, households never sacrifice rice consumption. They instead reduce expenditures on nonfood and other food items but consume the same amount of rice. When explained about the health and nutritional benefits of biofortified rice, consumers would be willing to pay 5–10% higher than the existing price for it.

Keywords: Biofortification, micronutrient deficiencies

Background

Micronutrient deficiencies are a global public health problem affecting the quality of life of the people of any country. The largest number of people suffering from micronutrient malnutrition live in Southeast Asia. It is estimated that about 123 million people in the region are at risk of vitamin A deficiency, 1.7 million of whom are affected by xerophthalmia. Out of the 486 million at risk of iodine deficiency, 176 million are affected by goiter and still 616 million are suffering from iron deficiency or anemia (FAO 1997). This situation has serious implications for development since micronutrient deficiencies influence child survival and the health and development of surviving children. Babies can be born mentally retarded as a result of iodine deficiency. Vitamin A deficiency may even result in blindness among children. Besides these two micronutrients, zinc is another important micronutrient for both physical and mental growth.

In India, a UNICEF report released in May 2006 stated that 45% or 57 million of the children under the age of five are underweight. This is the highest number for any individual country. Malnutrition is also a factor in an estimated 54% of all childhood deaths globally (Arnold et al 1996). Despite significant progress, more than half of all under-four-year-old children in India are moderately or severely malnourished, 30% of newborn babies are significantly underweight, and 60% of Indian women are anemic (FAO 1997). The third-round National Family Health Survey (NFHS-III) conducted during 2005-06 indicates that the health and nutritional status of all India's women and children is in vast systematic deficiency, with around 46% of the children below the standard weight-for-age. By state, about half of the children are underweight in

Orissa, Maharashtra, and West Bengal. In several areas, about 20% of the children were severely malnourished and 30% were moderately malnourished (NFHS-II, 1998-99).

Orissa, which is divided into 30 districts, is one of the agriculturally important states of eastern India, with a total area of 15.57 million hectares, which constitutes almost 5% of the land mass of the country. It is located in the subtropical belt between 17°52′ and 22°45′N latitude and 81°45′ and 87°50′E longitude and it has diverse agro-climatic situations. 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 Bay of Bengal. Its regions represent hot and dry subhumid, warm humid, hot and humid, and hot and moist subhumid weather. The various land forms, soil groups, and vast cultivated area and as a whole rainfed farming are the distinguishing agricultural features of the state. Based on the land form, topography, soil, climate, and crop adaptability, it has been divided into 10 agro-climatic zones and 57 farming situations. However, the state is broadly divided into four physiographic divisions: the northern plateau, the central table land, the eastern Ghats, and the coastal region. Regions in the coastal areas have alluvial soils of high fertility. The rest of the regions are plateau and hill terrains and they mostly have red, red and yellow, and lateritic soils of low fertility. The annual average rainfall of the state is 1,451 mm, which varies widely among the districts, from 1,286 mm in Rayagada and Nawpara to 1,623 mm in Boudh. Agriculture occupies a vital place in the economy and makes up 24% of the gross domestic product (GDP) of the state.

Among the eastern and northeastern states, Orissa has one of the lowest productivities of almost all major crops. The gross cropped area in 2005-06 was 8.93 million hectares, of which 33% (2.97 million hectares) were irrigated. About 76% of the total cropped area of the state is under food grains, with cropping intensity of 157%. The principal crops grown are rice, pulses, oilseeds, vegetables, cotton, and sugar cane, along with a large area under fruits.

Rice is the predominant crop in Orissa. Out of the total kharif cropped area of 6.14 million hectares, rice is grown on 4.15 million hectares that constitute more than 67.5% of the total cropped area during the khaki season. Only about 39% of the khaki rice cropped is irrigated and rice cropping is subject to drought, flood, cyclones, and price fluctuations. Rice yield of 1,554 kg/ha (2005-06) is one of the lowest among the rice-producing states in India.

The state has 41.95 million people, who account for almost 4% of the population of the country. Nearly 85% of its 37 million people live in the rural areas and depend mostly on agriculture for their livelihood. Orissa has the third-lowest population density of 236 people per km^2 among the major states of India, next only to Rajasthan and Madhya Pradesh. The coastal region is more thickly populated than the inland districts. The population density varies widely between 667 people per km^2 in Khurda to only 81 in Kandhmal District. More than 45% of the state's population lives in the coastal belts, which constitute only 25% of the state land mass. This has meant a massive spatial concentration of the population.

The agricultural labor force accounts for 73% of the economically active labor force in the state. A big portion (82%) of the total operational holdings is small and

marginal farmers who own 50.27% of the total operated area. The remaining 18%, who are medium and large farmers, owns 49.73% of the total operated area. The average landholding is 1.3 ha and is highly fragmented, mostly in the coastal region.

Orissa is the poorest state in India. Its poverty incidence was 40% during 2004-05 as against the average of 22% for the whole of India (National Sample Survey, NSS). Although the poverty ratio has declined from 67% in 1973, the rate of decline has been relatively slower than in the other states of India. Scheduled tribes and scheduled castes, mostly living below the poverty line, constitute nearly 41% of the population. Frequent droughts, floods, and other natural calamities not only impoverish the people but also make them morbidly stoic toward the pace of development.

Rice is the staple food in the state. Rural people eat rice or rice-based produce almost three times a day. Because of the high incidence of poverty among the rural mass, malnutrition among the peasant community is rampant, more particularly among the women folk, infants, and children. Orissa has one of the highest maternal mortality rates and infant mortality rates among the states of India. Malnutrition among expecting mothers and children, poor health-care facilities, and lack of awareness are the major causes of these high rates. The important nutritional problems such as protein energy malnutrition (PEM), nutritional anemia, vitamin A deficiency, and iodine deficiency cause great morbidity and mortality among the children and the young. The disease burden in the state is high. Communicable, pregnancy-related, and childhood ailments account for about 65% of the diseases. Although infant mortality decreased from 143 in 1,000 to 97 in 1,000 between 1980 and 2000 and 68 in 1,000 in 2004, the infant mortality rate is the second-highest in the country after Madhya Pradesh (Times of India, Orissa publication, 9/4/07). Publicly provided health service outlets are available, more or less in accordance with the all-India norms, but factors such as population density (203 per km^2), geographic inaccessibility, cultural barriers, ignorance, poor service quality, and the deep-rooted influence of traditional healers make the overall outcome of service systems unsatisfactory. Iron deficiency anemia is currently a major nutritional public health problem in India, including in Orissa. In spite of the anemia control program that has been in operation since the 1970s, dietary intake of iron is inadequate. This is due to poor absorption of iron from predominantly plant-based staple diets that contain inhibitory substances (phytic acid, dietary fiber, and polyphenols) that affect iron absorption. Studies carried out in the state show that the problem of anemia in Orissa is higher than in the nation as a whole. Overall, 63% of the women and 73% of the children are suffering from different grades of anemia. Pregnant women are moderately to severely anemic and are much more vulnerable than nonpregnant women. The prevalence of anemia is particularly high for the rural population and scheduled tribal communities. The contributing factors other than diet are attributed to poverty, low female literacy rate, intestinal worm infestations, and parasitic infections.

In Orissa, a combination of economic, social, ecological, and nutritional factors contributes to food insecurity. A high level of poverty, a large tribal population living in remote areas with poor connectivity, and the periodic occurrence of drought and floods (sometimes simultaneous in different parts of the state) give rise to a situation

of chronic and endemic food insecurity. Taking chronic energy deficiency (CED) as a measure of chronic and severe undernutrition and malnutrition, and hence an indicator of food insecurity, it has been estimated that as high as 57% of the state's population suffers from CED. This is in spite of the fact that per capita cereal consumption of the state is very high and the deficit of production relative to consumption of cereals is only a little above 11%. Thus, in spite of a fairly comfortable food availability situation in the state (Food Insecurity Atlas, p. 82), food insecurity is chronic. A comprehensive measure of food access, taking into account several direct and indirect indicators, places Orissa in the category of "very low" food access (Food Insecurity Atlas, Map No. 3.9, p. 67). This is mainly due to poor entitlement on account of high incidence of poverty, inadequate employment opportunities during lean seasons, and poor economic access to public distribution of subsidized food grains. Taking into account food availability, food access, and food absorption, represented by 19 indicators, Orissa has been put in the category of "severely food insecure" regions. It has been pointed out that severe food insecurity in Orissa is primarily due to the presence of a vulnerable rural population with poor livelihood access or livelihood susceptible to natural disasters. A lack of safe drinking water and proper health infrastructure, poor rural infrastructure, and low female literacy are also features of severely food insecure states like Orissa. Thus, a lack of basic amenities due to poor governance in the social sectors reinforces the severely food insecure status of the state.

The nutritional status of women and children is a robust indicator of social well-being as they are the most vulnerable sections of society from the point of view of nutritional stress. In addition, malnourished children are particularly susceptible to infectious and communicable diseases, which, in turn, can adversely affect food absorption, thereby aggravating the degree of malnutrition. In this connection, it is significant to note that a strong correlation (0.71) has been established between child malnutrition and child mortality (whereas that between child malnutrition and poverty is rather weak at 0.38). Body mass index (BMI)—weight (in kg) per unit height (squared, in m)—is often used for women as an indicator of chronic energy deficiency, with a BMI of less than 18.5 suggesting undernutrition and less than 16.5 suggesting chronic energy deficiency. Based on this, it has been estimated that 48% of the women in Orissa suffer from nutritional deficiency [International Institute for Population Sciences (IIPS) and ORC Macro 2001, p 153; hereafter referred to as NFHS-2]. The numbers are much higher in the case of illiterate women (55%), scheduled tribe women (56%), and women with a low standard of living (55%). The average iron intake in Orissa is close to the recommended daily allowance (Food Insecurity Atlas, p 77) as per the norms set by the Indian Council for Medical Research (ICMR). Despite this, as many as 63% of married women aged 15–49 years in Orissa have some degree of anemia (NFHS-2, p 157). Based on weight-for-age (an indicator of both chronic and acute undernutrition) measures, 20.7% of the children below 3 years of age are severely underweight and another 54% are moderately underweight. Based on the height-for-age measure, 18% of the children suffer from chronic undernutrition of the severe type and another 44% from the moderate type (NFHS-2, p 167). The extent of anemia among children aged 6–35 months is greater than it is among women: as high as 72% of the

children have some degree of anemia. Though only 3% suffer from severe anemia, as many as 43% have moderate anemia (the rest, 26%, have mild anemia). There is a positive relationship between the anemia status of mothers and prevalence of anemia among children. It should be noted that anemia among children is a serious matter, as it can affect cognitive ability, locomotor development, and scholastic achievement as well as lead to increased susceptibility to infectious diseases.

Objectives of the study

The study aims to identify present consumption patterns and assess the adoption potential of farmers and consumers to accept biofortified rice in selected villages under different agro-climatic conditions in Orissa, India.

Specifically, the study aims to

1. Assess the perceptions of the village communities about food consumption, nutrition, health, and sanitation.
2. Identify food consumption and food acquisition patterns of the village communities.
3. Identify the constraints as well as opportunities related to potential adoption of biofortified rice by farmers and its consumption by the people.

Methodology

Selection of the sites and households

Kharif rice is the main crop in all the districts of Orissa. Since there was a lack of information on household food consumption patterns, nutritional data, and health-related information from different sites, seven districts representing different physiographic divisions, that is, the northern plateau (Keonjhar), the central table land (Angul and Balangir), and the coastal region (Cuttack, Jagatsinghpur, Kendrapara, and Khurda), excepting the eastern Ghats, were chosen to be the study sites. Because more than 45% of the state's rural people live in the coastal region, more districts representing the coastal region were selected. Also, due emphasis was given to the selection of districts on the basis of close proximity to the Central Rice Research Institute (Cuttack and Jagatsinghpur), where the adoption of modern rice technology is more; flood- and cyclone-prone areas (Kendrapara, Jagatsinghpur, and Khurda); districts having a high concentration of scheduled caste and scheduled tribe populations (Keonjhar); drought-prone areas (Balangir); and areas with much industry and many mining operations (Angul and Keonjhar).

From each district, one village was selected as the study site except in Jagatsinghpur (with four villages) and Balangir (with two villages). In Jagatsinghpur, two sites in two blocks representing irrigated favorable (one village) and rainfed unfavorable (a cluster comprising three villages) rice farming situations were selected as study sites. All in all, 11 villages were studied. Because of time constraints, community-level information related to socioeconomics, demography, food consumption, nutrition, and health and agriculture was obtained through participatory discussions with women,

distinguished farmers/village leaders, local officials, and teachers of selected districts of Orissa.

Household-level information related to food consumption, health, and nutrition and perceptions about biofortified rice were obtained through a household survey of women with children below 5 years old. In each district, a minimum of 50 households were randomly chosen from the village or cluster of villages except that for Jagatsinghpur, where more than 100 households have been surveyed.

Characteristics and agro-climatic conditions of the studied villages

The villages studied were Thailo, Kurunia, and Alikanta of Jagatsinghpur District under a rainfed unfavorable flood-prone situation; Salijanga under an irrigated favorable situation; Debendranarayanpur in Kendrapara; Athantara in Cuttack; Taraboi in Khurda; Handiguda in Angul; and Belpadar and Haldi in Balangir District.

Thailo, Kurunia, and Alikanta villages are located in Balikuda block about 30 km from the district headquarters of Jagatsinghpur and they are highly flood prone with poor road connectivity. During the 1999 cyclone, these villages were severely affected and almost all the mud and thatched houses were flattened. Since these villages are being affected by floods almost every year, most of the farming households have adopted some form of coping mechanism in dealing with this situation. Many members of the farming community have gone outside the state for nonfarm employment and are sending remittances. Also, agricultural laborers in the villages are getting plenty of farm work in the adjoining irrigated villages. Fishing is also a regular practice as these villages are situated beside a river. The living standard of the members of the farming community in Thailo and Kurunia is better than that in Alikanta Village, where more than 50% of the population belongs to the scheduled caste community. Because of flooding, most of the released high-yielding rice varieties have not been able to thrive. Only a prereleased variety of CRRI locally named Chakaakhi 1590 is adapted to the situation. As such, traditional rice varieties are very common in these villages. During the rabi (winter) season, black gram, green gram, horse gram, chilli, and some vegetables are grown for home consumption.

Salijanga Village is located in Biridi block of Jagatsinghpur District and it is quite close to the Central Rice Research Institute (CRRI) in Cuttack District. The district headquarters is 20 km from the village. Nearly 80% of the cultivated area in the village is canal irrigated and rice is the predominant crop during the kharif season. In the rabi season, black gram, green gram, horse gram, and some vegetables are grown while during summer pulses are planted as cash crops.

Athantara is situated in Niali block of Cuttack District and it is about 56 km from the district headquarters and is well communicated. The village has a higher percentage of educated families and has diverse sources of income. Along with rice farming activities, vegetable production, dairy, backyard poultry, and fishing are very common among the farming community. More than 40% of the households have some members working outside the state and they have a higher percentage of service workers (government as well as private). Livestock raising is very common and every day more than 600 liters of milk are sent to the Orissa Milk Federation Union (OMFED)

for processing. Also, many households are engaged in cheese making and the product is supplied regularly to sweetshop owners of Bhubaneswar and Cuttack cities. About 53% of the cultivated area is canal irrigated during kharif season. Rice is the main crop during kharif season, followed by sugarcane and vegetables. In the rabi season, black gram, green gram, groundnut, horse gram, sunflower, and a lot of vegetables are raised.

Taraboi is situated in Jatani block of Khurda District and is only about 7 km from the district headquarters. Most of the household members are engaged in farming activities during kharif season. Nonfarm labor income is very common among the landless and marginal farmers. Since there are lots of economic activities in the adjacent towns of Khurda and Jatni, nonfarm labor opportunities are available. Many of the farming household members are also engaged in weaving. There is a weaver cooperative society in the village. Also, the members of many households are engaged in the railway at Jatni, which is an important railway headquarters in the East Coast Railway. Rice is the main crop during kharif season and is mostly rainfed. It is followed by green gram in a very limited area. Vegetables are raised in backyards in almost all households.

Belpadar and Haldi are the two villages studied from the district of Balangir. Belpadar is located in Muribahal block of Balangir and it is about 6 km from Titilagarh town, which is the subdivisional headquarters, and about 60 km from the district headquarters. At least one member of each household in the village goes to Titilagarh daily for nonfarm labor. Rice is the main crop and it is grown in about 40% of the cultivated area and is mostly rainfed. Only about 6% of the cultivated area is being irrigated through a water harvesting structure (WHS) but the system is inefficient. Other important crops are black gram, mung (green gram), horse gram, *arhar* (pigeon pea), groundnut, and vegetables (ladyfinger, eggplant, pumpkin, bitter gourd, ridge gourd, snake gourd, tomato, *samba*, bottle gourd, beans, onion, garlic, and greens). There are some vegetable-growing communities in the village called Putel, which raise vegetables throughout the year and sell the produce in the Titilagarh market.

Haldi is situated in Muribahal block of Balangir District and it is about 19 km from Titilagarh and about 75 km southwest of the district headquarters of Balangir. This village has a higher percentage of educated family members and about 25% of the households have members working outside the state. Bidi making and working in the granite stone quarry are the major nonfarm activities in the village. About 28% of the cultivated area in the village is canal irrigated but, because of inefficiency, the village is prone to drought. Rice is the main crop and is grown in about 48% of the cultivated area. Other important crops are black gram, green gram, horse gram, arhar, groundnut, and vegetables.

Handiguda is an upland village located in Chhendipada block of Angul District and it is about 48 km from the district headquarters, with poor road communication. The scheduled caste and scheduled tribe constitute more than 40% of the village population. This village has diversified farming activities and nonfarm labor income from *bidi* making is very common. Members of the farming community are less educated and are engaged mostly in vegetable farming and banana, mango, citrus, and cashew

plantations. There is a farmers' club in the village. Rice is grown in only about 23% of the cultivated area and is mostly rainfed. Irrigation to vegetable and fruit orchards is mainly done by pumping water from dug wells, deep tube wells, and a canal (one small rivulet). Among the important crops in the village are mango, sesame, banana, pigeon pea, black gram, green gram, groundnut, and vegetables such as pointed gourd, eggplant, pea, ridge gourd, bitter gourd, ladyfinger, pumpkin, cucumber, tomato, cauliflower and cabbage, onion, garlic, greens, etc. Middlemen from different industrial hubs in the district visit daily to procure vegetables and fruits from the village. Also, the representatives of the farmers' club help in marketing of farm produce, mainly vegetables and fruits.

Kasada Village is about 20 km from the district headquarters of Keonjhar District and it is in tribal-dominated Banspal block. The village is a hilly mountainous terrain with very poor road infrastructure. The village economy is mainly forest-based and most of the tribal women go to the forest to collect nontimber forest products that are sold in the local huts. Most male members of the community work in the local mines for nonfarm labor. Shifting cultivation is rampant. Short-duration traditional rice cultivars are grown in undulated uplands, whereas some HYVs are grown in valleys. Other major crops are maize, *niger*, *toria, bajra*, and vegetables.

Debendranarayanpur Village is situated in Rajnagar block of Kendrapara District and is about 16 km from the district headquarters. The village is entirely rainfed and saline prone. Saline backwater from the ditches and rivers inundates the rice fields every year. Fishing is an important activity among the community members. More than 50% of the households have at least one member working outside the state. Most of the workers are engaged in plumbing activities in northern Indian states. Rice is the sole crop in the kharif season. Since no saline-resistant variety could be successful, traditional varieties are very common. One variety, called Pateni, which was long ago introduced by the inhabitants of Bangladeshi origin from the nearby Mahakalpara block, is the main rice variety that is adapted to the area. Some vegetables are being raised in backyards for home consumption.

Based on the characteristics and locations, the villages are classified under seven agro-climatic conditions (Table 1). The coastal irrigated area includes the villages of Salijanga in Jagatsingphur District and Athantara in Cuttack District. The coastal rainfed flood-prone consists of the villages of Alikanta, Kurunia, and Thailo, all from Jagatsingphur. Taraboi from the district of Khurda is a coastal rainfed drought-prone village while the villages of Belpadar and Haldi, both from Balangir District, are upland rainfed drought-prone. On the other hand, Handiguda in Angul District is also upland rainfed but it is not drought-prone. Kasada, a tribal community in Keonjhar, is a mountainous forest-based area, and Dependayanaranpur in the district of Kendrapara is a saline-prone rainfed coastal village. A summary of the agro-climatic conditions and number of households surveyed is given in Table 1.

Types of information gathered and the respondents

Based on the objectives of the study, five modules were developed to gather community-level information. They included the following:

Table 1. Distribution of districts and villages by agro-climatic conditions.

Agro-climatic condition	District	Villages	Number of households surveyed
Coastal irrigated	Jagatsingphur, Cuttack	Salijanga Athantara	50 54
Coastal rainfed flood-prone	Jagatsingphur	Alikanta Kurunia Thailo	52
Coastal rainfed drought-prone	Khurda	Taraboi	52
Upland rainfed drought-prone	Balangir	Belpadar Haldi	53
Upland rainfed	Angul	Handiguda	56
Mountainous forest-based	Keonjhar	Kasada	51
Coastal rainfed saline	Dependayanaranpur	Kendrapara	No household survey

Module I. Includes information related to demographic and socioeconomic characteristics and agriculture and food availability. This information was collected through participatory discussions with village leaders, school teachers, Anganwadi workers, and elderly persons in the village and panchayat members.

Module II. Covered under this module is information on sanitary conditions, health facilities and programs, nutrition interventions in the community, morbidity status and disease profiles, and perceptions of health workers on health facilities available in the community. This information was obtained from village leaders, local government officials, school teachers, health workers, and elderly people and Anganwadi workers.

Module III. This module focused on farm characteristics, production and marketing practices, and perceptions about biofortification of rice varieties. Varietal traits valued by the farmers and potential and constraints to adoption of biofortified rice were also included. The informants for this module were village leaders, large and small farmers, and block-level government officials.

Module IV. This included food consumption and dietary pattern of the village community, along with perceptions about good food, consumption characteristics, and willingness to pay for biofortified rice. This information was gathered from women's groups and their children under the age of 10–15 years.

Module V. This focused on health and perceptions of chronic diseases and felt needs for health improvement. The informants for this module were women with young children.

Results and discussion

The following discussion will follow agro-climatic conditions but with mention of a village or district when there are specific differences.

Basic characteristics of the study area

Geographical information. By agro-climatic conditions, distances of the villages from the nearest town center vary considerably although, on average, the upland rainfed areas seem to be the farthest (Table 1). Of all the villages, the coastal saline rainfed and coastal rainfed drought-prone areas from the districts of Kendrapara and Khurda, respectively, have paved roads within the villages. No river port facility is available in any village under study. Also, the drought-prone villages of Taraboi, Belpadar, and Salijanga are nearer to the railway station than others but all of them can be accessed by means of bus, trekker, two-wheelers, three-wheelers, etc. Although every village has electricity connections, more households have electricity in the coastal villages than those living in the uplands. In the case of Kasada, a mountainous forest-based village, household electricity has been disconnected due to the privatization of electricity at the distribution level that resulted in higher electric bills. As a consequence, most households in the village and tribes cannot pay even the minimal charges (Table 1).

The total land area of the studied villages varies from 36 to 926 ha. Among the villages, the coastal rainfed drought-prone village of Taraboi in Khurda District has the largest cultivated land of 754.7 ha, followed by the upland rainfed drought-prone areas in Balangir District and upland rainfed Handiguda Village of Angul District (Table 2). Although the mountainous forest-based Kasada Village has a large area, only 25% of the total village area is available for cultivation, and the rest is covered by forest. As such, shifting cultivation still prevails in the area. Kurunia, one of the coastal rainfed flood-prone villages studied in Jagatsingphur, with a total village area of 36 ha, is considered to be the smallest village.

The largest cultivated areas with irrigation facilities are in districts of Jagatsinphur (Salinjanga Village) and Cuttack (Athantara). Kasada in Keonjhar District, which is under hills and forests, and Debendranarayanpur in Kendrapara District with saline soil are totally rainfed while the other villages have minimal irrigation coverage ranging from 0.7% to 28% of cultivated land. As expected, the coastal villages are the ones affected by flood during monsoon. Although Salijanga in Jagatsingphur has about 10% of the land submerged by flood during peak monsoon, 80% of the other three villages in the same district get submerged during the rainy season. These three Jagatsingphur villages were severely affected by a super cyclone in 1999. Except for the coastal rainfed flood-prone and mountainous forest-based villages, serious drought occurred in 1996 and in Debendranarayanpur another drought was experienced in 2001 (Table 2).

Demographic characteristics. According to the 2001 census, the total population and number of households were reported to be the highest in the coastal rainfed drought-prone village of Taraboi (Khurda District), which also has the broadest village area, while Kurunia, one of the coastal rainfed flood-prone villages in Jagatsingphur

Table 2. Basic geographical Information on the studied villages in Orissa, India, 2006.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Distance from village to nearest town (km)	15–56	30	7	6–19	48	20	16
Distance from village to nearest motorable road (km)	1–3	4	0	0.5	3	5	0
Distance of the village from the nearest rail station (km)	5–56	65	7	5	50	145	90
Major means of communication to central area	Bicycle, two-wheelers, three-wheelers, bus, auto, trekker, tractor	Bicycle, two-wheelers, bus, auto	Bicycle, two-wheelers, bus, automobile	Bicycle, two-wheelers, bus, auto, trekker, tractor	Bicycle, two-wheelers, bus, bullock cart	Bus, trekker, cycle, two-wheelers, walking	Bus, trekker, cycle, two-wheelers
Access of village to electricity	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Households with electricity connection (% of all households)	25–85	14–40	40	12–16	18	Nil (due to privatization of electricity at distribution level, the village community has to pay higher rent, so electricity connection was disconnected about five years ago)	25

Continued on next page

Table 2 continued.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Total village area (ha)	138–214	36–255	937	239– 689	595	672	173
Total cultivated area (ha)	114–140	26–204	764	215–540	447	162	132
Coverage of irrigation (% of cultivated land)	53–80	1–8	0.7	6–28	2	Nil	Nil
Land normally flooded by knee-deep water during peak monsoon (% of total area)	2.5–10	80	5	Nil	Nil	Nil	30
Was the village affected by typhoon in this year's flood?	No	Yes	No	No	No	No	No
Year when the village was seriously flooded	1999	1999	–	Never	Never	Never	1999 and 2005
Year when the village was affected by serious drought	1996	Nil	1996	1996	1996	No information	1996 and 2001

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District.

District, with the least village area, has the lowest number of population and households (Table 3). All villages are dominated by the Hindu religion except in coastal rainfed drought-prone Taraboi Village with 16% Muslims. Female-headed households were minimal in all villages.

The highest percentage of landless households was reported in the upland rainfed drought-prone areas. Sharecroppers were more in Alikanta (Jagatsingphur) (65%) and Athantara (Cuttack) (60%) compared with other villages, and there were none in Kasada (Keonjhar District). This is because Kasada has minimal land area under cultivation and vast areas of forest where shifting cultivation takes place.

In general, coastal areas have more households with college-/university-educated members than upland villages. By specific conditions, the coastal irrigated villages have the highest reported attendance in tertiary education while the mountainous forest-based village of Kasada had the least (Table 3). This may be attributed to the fewer income opportunities and nature of livelihood in this village.

A higher proportion of people working outside the village, outside the block, and outside the district in search of work for their livelihood is also from the coastal areas (Table 3). By specific village, Athantara has the highest (45%) record of those with household members working outside the state. However, the highest total number of people who work outside are from the coastal saline rainfed village. These relative differences may be because of more facilities and employment opportunities at their door step and exposure to urbanization in the villages and the limited agricultural productivity in the saline-prone area.

School and education information. Every studied village has at least one primary school except in one of the coastal flood-prone villages, where children go to the adjacent village for schooling. The coastal rainfed drought-prone village of Taraboi, with some Muslim households, is the only one with a religious school. At the primary level, attendance of boys and girls is quite high in all the areas except in the mountainous forest-based village where a very low percentage (5%) of girls goes to school even at the primary level (Table 4). This may be because, at this stage, girls usually take care of the younger siblings when the mother works outside to earn a living and perhaps due to the nature of livelihood in the village. In all cases, the percentage of girls attending secondary school is lower than that of boys. This may be because of the male chauvinist culture in the area and the absence of a secondary school in most of the villages. Every primary school has a mid-day meal program managed by school and village committees and, in some cases, self-help groups and Anganwadi workers of the villages (Table 4).

Agriculture-related information. Except in the upland rainfed and mountainous forest-based villages, 41% to 100% of the cultivated areas are planted with rice. Being mountainous and forest-based, a great part of Kasada Village is covered with forest, whereas, in the upland rainfed village of Handiguda, more area is planted with fruit trees. During kharif season, a majority of the rice land is planted with high-yielding rice varieties (HYVs) except in one coastal flood-prone village, mountainous area, and coastal saline rainfed villages (Table 5). Among the kharif HYVs, Swarna, Khandagiri, Pooja, and Lalat are the most popular ones among the farmers. Except in a few

Table 3. Demographic characteristics of the studied villages in Orissa, India, 2006.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Total population (2001 census)	682–1,501 (scheduled caste = 339–388)	233–858 (scheduled caste = 33–296)	4,561 (scheduled caste = 352, scheduled tribe = 115)	613–2,554 (scheduled caste = 33–526, scheduled tribe = 147–440)	1,302 (scheduled caste = 229, scheduled tribe = 309)	484 (all scheduled caste)	2013 (scheduled caste = 86, scheduled tribe = 117)
Number of households	149–297	45–173	820	126–440	280	100	393
% households							
Hindu	100	100	84	100	100	100	100
Other religion	–	–	16	–	–	–	–
Female-headed households (%)	5–8	0.2–10	7	7–8	4	10	Nil
Landless households (%)	2–30	1–32	24	20–40	9	18	20
Sharecroppers (%)	40–60	2–65	35	15–25	14	Nil	40
With college-/university-educated members	60–70	20–50	40	33–40	6	2	10
With a member working outside the village (% of households)	22–35	10–30	15	0.02–20	1	10	30
With a member working outside the block (% of households)	8–15	5–10	30	15–45	2	5	20
With a member working outside the district (% of households)	5–7.5	5–20	25	0.02–10	1	1	20
With a member working outside the state (% of households)	2–45	18–40	15	12–25	Nil	Nil	40

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District.

Table 4. Schooling and preschool information in the studied villages in Orissa, India, 2006.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Number of primary[d] schools in the village	1–2	0[e]–1	5	1–3	2	1	1
Number of religious schools in the village	Nil	Nil	1	Nil	Nil	Nil	Nil
Girls of school age attending primary school (%)	90–100	80–100	80	80–90	70	5	90
Boys of school age attending primary school (%)	95–100	100	95	90–95	90	40	100
Number of secondary schools in the village	1	0–1	1	0–1	Nil	Nil	Nil
Percentage of girls attending secondary school	65–70	30–90	50	20–80	50	Nil	40
Percentage of boys attending secondary school	80–90	90–100	75	50–90	80	10	70
Availability of school feeding program in the village	Yes (mid-day meal program)	Yes	Yes	Yes	Yes	Yes	Yes
Who manages the school feeding program?	Self-help group (SHG) and school committee and teachers	Village Education Committee and school teachers	Village committee and SHG	School teachers and SHG	Village committee and school teachers	School committee and teachers	School committee

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District. [d]Primary school has up to fifth grade and secondary school up to tenth grade. [e]In the village without primary school,

Table 5. Agriculture-related information in the studied villages in Orissa, India, 2006.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Land cultivated with rice (% of cultivable land)	90–92	99–100	99.5	41–48	23	19	100
Cultivated area covered by HYVs in kharif season (% of total kharif paddy area)	80–90	5–55	45	60–80	90	10	10
Three popular kharif HYVs[d]	Swarna, Khandagiri, Pooja	CR 1018, Swarna, Pooja	Swarna, Pooja, Lalat	Swarna, Lalat, Pooja	CR 1001, Swarna, Pooja	Lalat, Swarna, Khandagiri	Pooja, Swarna, CR 1018
Cultivated area covered by HYVs in summer season (%)	0–100	100	100	0–100	100	Nil	Nil
Three popular boro/aus HYVs	Lalat, Khandagiri	Parijat, Lalat, Khandagiri	Lalat, Khandagiri	Lalat, Khandagiri	Lalat, Khandagiri, Sarathi	Nil	Nil
Other major crops (in order of importance)[e]	Pulses, groundnut, lentil, sugarcane, vegetables, oilseeds	Pulses, chilli, vegetables	Pulses, colocasia, vegetables	Pulses, pigeon pea, ground nut, vegetables, sesamum	Mango, sesamum, banana	Maize, *niger*, vegetables, and *bajra*	Nil

Continued on next page

Table 5 continued.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Land cultivated with vegetables (%)	1–10	0.2–0.4	0.2	0.4–1	3	0.5	1
Major vegetable crops[f]	Pulses, lentil, potato, eggplant, green leafy vegetables	Ladyfinger, eggplant, green leafy vegetables	Greens, ladyfinger, bitter gourd, tomato, eggplant	Ladyfinger, eggplant, bitter gourd, tomato, leafy vegetables	Gourd, eggplant, cowpea	Cowpea. pumpkin, eggplant, gourd, ladyfinger	Gourds, eggplant, chili, leafy vegetables
Number of commercial poultry farms in the village	Nil	Nil	1	0–2	2	Nil, but every household raises local poultry	Nil
Households depending on fisheries for livelihood (%)	5–10	0–12	Nil	0.02–1.5	Nil	Nil	35

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District. [d]Other kharif HYVs are Nali Jaganath, Gayatri, Sarala, Khandagiri, Padmini, Kalashree, Mahalaxmi, Pratap, Konark, Parijath, Annapurna, Pankaj, Tulasi, CR 1918, CR 1009, Durga, CR 1092, and Chakaakhi. [e]Other crops are black gram, pigeon pea, green gram, groundnut, fruits, vegetables, cauliflower, cabbage, onion, garlic, papaya, and jackfruit. [f]Other important vegetables are okra, colocasia, pumpkin, groundnut, cauliflower, cabbage, *samba,* and yam.

villages, summer paddy is also cultivated. In Salijanga, an irrigated coastal village, people grow pulses during summer due to the higher income earned from these cash crops. On the other hand, no summer rice crops are grown in mountainous forest-based and coastal rainfed saline villages since these areas are unfavorable for summer rice cultivation. Vegetables such as potato, ladyfinger, pumpkin, eggplant, tomato, and cauliflower are grown in limited areas in the studied villages except in the coastal village of Athantara (Cuttack District), where vegetables are grown relatively widely on 10% of the cultivated area. Commercial poultry farms are quite limited only in the upland rainfed villages. As a tradition of the tribal community, each household in the mountainous forest-based area raises indigenous poultry layers. To a limited extent, households in the coastal villages also depend on catching fish and crabs from ponds, rivers, creeks, and the sea for their livelihood (Table 5).

Sources of agriculture-related information. Of all the villages, only in Haldi (Balangir District), an upland drought-prone village, does the community get benefits from an extension center since the village agricultural worker resides in the village. In other villages, visits of agricultural extension workers are minimal (Table 5). In some villages, fertilizer dealers in the village provide information regarding the use of pesticides, fertilizer dose and time of application, and new crop varieties. This situation makes the farmers vulnerable and puts them at the mercy of the fertilizer dealers, especially on the use of inorganic fertilizer and chemicals. A few nongovernment organizations (NGOs) such as AWARENESS, CAS Foundation, and UNNAYAN provide some support services such as literacy and health awareness campaigns, microcredit financing, self-help group formation, and training on handicraft making and marketing in the coastal flood-prone and upland drought-prone villages. At present, radio and television are the most popular sources of information related to agricultural technology in most of the villages. Krishi Vigyan Kendra (KVK) also plays a leading role in disseminating agricultural technology in the upland rainfed and mountainous forest-based villages where it is functioning. In addition, newspapers, government officials, model farmers, village agricultural workers, and relatives and friends are other sources of information on agricultural technology (Table 6).

Food availability and diet-related information. From the information gathered, it appears that the coastal villages are more rice-sufficient than the upland and mountainous forest-based villages, the latter having the highest proportion of households that cannot have three meals a day during lean periods (Table 7). For the other rice-insufficient villages, food security is attained not from own production but from the ability to earn from employment opportunities that enable them to purchase rice in the market. In the mountainous forest-based village of Kasada, the least food-secure village, maize, roots, and tubers from forest, jack fruit, mango, and other forest-based fruits are an alternate source of food during food scarcity. In addition, Annapurna rice under the Public Distribution System (PDS)/other government sources is being supplied in every village at relatively low prices so that poor households can satisfy their hunger.

Availability of green leafy vegetables is reported in almost all villages except in the coastal rainfed saline areas due to a lack of irrigation and insufficient homestead

Table 6. Source of agriculture-related information in the villages studied in Orissa, India, 2006.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Availability of an extension center in the village	No	No	No	Yes	No	No	No
How often do extension workers come to the village?	2–5 times a year	0–3 times a year	Once a month	Once or twice a year, in one village VAW resides in the village	2–3 times in a month	2 times a month	2–3 times a month
Number of fertilizer dealers in the village	Nil	Nil	3	0–1	2	None, but there is one 6 km away from the village	Nil
Do fertilizer dealers provide information to farmers?	No	na	Yes	No	Yes	Yes	Nil
What kind of information is provided by fertilizer dealers?	na	na	Fertilizer application rate and dose	na	Use of pesticides and fertilizer, new vegetables and crop varieties; information on prices of fruits and vegetables	Fertilizer and pesticide availability and their dosage	na

Continued on next page

Table 6 continued.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Are there NGOs in the village?	No	Yes	No	Yes	No	No	Nil
Name major NGOs	na	UNNAYAN, CYSD	na	AWARENESS, CAS Foundation	na	na	Na
Major areas covered by NGOs	na	SHG formation, micro-credit, training on handicrafts and selling at trade fairs outside the state	na	Literacy campaign, SHG formation, micro-financing, health awareness	na	na	na
Household membership in NGO (%)	na	50–90	na	40	na	na	na
Major sources of agricultural technologies by farmers[d]	Television, radio, model farmers, relatives, and friends	Television, radio, relatives, neighbors and friends, model farmers	Television, radio, newspaper, model farmers, relatives, and friends	Television, radio, model farmers, relatives, and friends	Scientists of KVK,[e] model farmers, television, radio, newspaper, relatives, and friends	Radio, KVK, Agriculture Department	Radio, newspaper, model farmers, extension workers

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District. [d]Other sources of information are newspaper, scientists from universities, fertilizer and pesticide dealers, private companies, demonstration farms, [e]Krishi Vigyan Kendra. na = not available.

Table 7. Food availability and diet in the studied villages in Orissa, India, 2006.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Households meeting family rice needs from home production (%)	60–95	40–70	60	20–30	20	5	70
Households that cannot have three meals a day (%)	0.2–3	Nil	Nil	0.03–2	1	20	10
Lean months when rice is not affordable	Nil	August-October	Nil	July-September	July, August, September	April, May, June, July, August	August, September, October
Do households substitute rice with other food when rice is scarce?	No	No	No	No	No	Yes	No
What food is substituted?	na	na	na	na	na	Maize, roots and tubers, green leafy vegetables, colocasia leaves, fruits	na
Availability of leafy vegetables throughout the year	Yes	Yes	Yes	Yes	Yes	Yes	No
Months when leafy vegetables are not available	na	na	Nil	April-June	Nil	Nil	April, May, June

Continued on next page

Table 7 continued.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Change in vegetable consumption over the last 10 years	Increased consumption of new vegetable species such as pea, carrot, bell pepper	Increased vegetable consumption, especially greens	Increased by 30–40% due to backyard gardening	Increased consumption by 20%	Increased consumption	Increased consumption	Increased
Change in fish consumption over the last 10 years	Increased fish consumption due to increased income	Fish consumption increased because of increased disposable income	Increased due to increased disposable income	Increased by 10%	Increased by 15–20%	No change	Decreased (fish caught are now sold in the market)
Change in meat consumption over the last 10 years	Decreased due to high price but chicken meat consumption[d] increased	No change, eaten mostly during festival season	Chicken meat consumption increased but mutton consumption decreased	Increased by 10%	Increased by 15–20%	No change	Increased due to availability of broiler chickens but mutton consumption decreased due to high price
Change in rice consumption over the last 10 years	Decreased due to substitution of wheat products as a result of changing food habits	Decreased due to substitution of wheat products	Declined by 10–15% due to substitution of wheat products	No change	Increased with increased household members although some households substituted wheat products for rice	Increased by 30% due to introduction of HYVs	No change

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District. [d]Nowadays, women are no longer restricted to eating chicken, meat, and eggs, which was practiced earlier for

land for vegetable gardening in the latter. Most of the households develop nutritional gardens in their backyard and regularly obtain some vegetables by purchasing during lean months when vegetables are not available in their garden. Although there has been increased vegetable consumption in all the villages studied, April to June was reported to be the dearth months for getting green leafy vegetables. Fish consumption has likewise increased over the last ten years in most of the villages except in the coastal rainfed saline villages where a decrease in fish consumption is attributed to the selling of fish caught instead of using them for home consumption. This may be due to the increasing urbanization in the area and the availability of commercial items on which money is spent. There is also an increasing trend in meat consumption in some study villages (Table 7). Chicken consumption has been increasing in all the villages since married women who were previously restricted from eating eggs and chicken due to social taboos are now consuming these food items because of changing food habits and nutritional awareness. However, some households still have separate *chula* and utensils to cook chicken outside the kitchen. In rural areas, meat consumption is still confined to functions and festivals. Because of changing food habits and exposure to urbanization over the years, rice consumption is decreasing and being substituted by wheat products. In addition, people are eating less rice than in earlier days as labor hours have declined. Nowadays, the young generations are not putting in enough labor hours as in the past when community members were accustomed to hard labor with long working hours. But, in some upland and mountainous villages, total rice consumption has increased due to increasing family size, the introduction of HYVs, and the availability of subsidized rice at the village level through the government. In other villages, it was reported that, over the years, no change in rice consumption among households was experienced (Table 7).

Sources of drinking water, sanitary conditions, and health profile. Except in the mountainous forest-based, upland rainfed, and coastal drought-prone villages, tube wells are the main source of drinking water in the studied villages. In the mountainous village of Kasada, two units of tube wells have been installed by the government but these did not work properly and dried up eventually due to an inaccessible groundwater source. As a result, the tribal community relies on nearby rivers or streams as the main source of drinking water. The highest number of tube wells was reportedly owned by the households in the coastal irrigated villages in addition to the units installed by the government. This situation signifies better health care practices. However, no arsenic tests have been conducted in any of the tube wells such that the presence of arsenic cannot be ascertained but it was reported that water from the tube wells contained a sufficient amount of iron. The use of boiled or treated water for drinking is not practically observed in the villages studied (Table 8).

Health and sanitation campaign. The use of sanitary latrines is minimal in most of the villages. Some villages also don't have sanitary latrines and open defecation still prevails in the tribal community, which is the main source of infection and worm infestation. Health and sanitation campaigns were being organized in all agro-climatic conditions except in some villages. These health campaigns that are being organized through the Integrated Child Development Scheme (ICDS), NGOs, school teachers,

Table 8. Sanitary conditions in the studied villages in Orissa, India, 2006.

Information	Agro-climatic conditions						
	Coastal Irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Principal source of drinking water	Tube wells	Tube wells	Dug well	Tube wells	Dug well	Stream water[d]	Tube wells
Number of public pumps for drinking water in the village	5–10 from the government and numerous privately owned wells	1–6	25	5–19	5	2	11
Are tube wells tested for arsenic[e]	No	No	No	No	No	No	No
How many have arsenic problem? (%)	na	na	na	na	na	na	na
Households using ponds/rivers as source of drinking water (%)	Nil	Nil	Nil	Nil	Nil	100	Nil
Households drinking boiled water (%)	Nil	Nil	2.5	Nil	Nil	Nil	Nil
Households with sanitary latrines within the homestead (%)	10–15	6–12	12.5	0–5	1	Nil[f]	Nil
Any health/sanitation campaigns in the village?	Yes, in one of the villages	Yes, in one of the villages	Yes	Yes, in one of the villages	Yes	Yes	Yes

Continued on next page

Table 8 continued.

Information	Agro-climatic conditions						
	Coastal Irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Organization that initiated/managed the campaign	Anganwadi workers, health workers, and doctors nearby	UNNAYAN	Some unknown NGOs	BIKALPA (an NGO) in coordination with government agency	School teachers and block officials	Anganwadi center, government of Orissa, Health and Family Welfare Department	Health and Family Welfare Dept. under ICDS, government of Orissa
Kind of campaign	Immunization, family planning and delivery, sanitation, balanced nutrition, leprosy, and AIDs campaign	Use of sanitary latrines, immunization campaign, delivery of child in hospital and with trained personnel	Provided sanitary latrines to some BPL families	Awareness campaign on sanitary latrines	Establishment of sanitary latrines and immunization campaign	Immunization, family planning, sanitation, malaria control, supply of ORS for controlling diarrhea	Immunization, family planning, balanced nutrition, anti-AIDs, leprosy, and polio campaign

Continued on next page

Table 8 continued.

Information	Agro-climatic conditions						
	Coastal Irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Recent change in people's attitude toward sanitary practices	Use of tube-well water for drinking and household chores; increasing use of sanitary latrines; use of tooth-paste, soap, and shampoo rather than the old practice; dish-washing soap and use of slippers.	Establish-ment of sanitary latrines. Use of soap in cleaning and use of toothpaste common. Use of bath soap and shampoo is also practiced nowadays.	Households have constructed their own sanitary latrines. Use of tube-well water is now increasing. Use of toothpaste, detergents, and bath soap is now a common habit.	Use of tooth-paste, detergents, bath soap, and shampoo; cleaning of surroundings for controlling malaria-carrying mosquito, declining use of ash and mud for cleaning utensils.	Households established sanitary latrines. Toothpaste is now used by 20–25% of households. Use of detergent in washing clothes. Rural households are also using bath soap and shampoo now.	No change since all mothers are wage earners and go to the forest to collect fuel woods, roots, and tubers for their livelihood and they have no time to practice sanitation.	Every household replaces dug well with tube well as source of drinking water. Toothpaste is now used; use of soap, detergent, and shampoo is now popular.

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District. [d]Government-constructed tube wells have dried up. [e]Not tested for arsenic but the well has more iron content. [f]Nobody used the government-supplied sanitary latrines; plenty of forest land is available for open defecation.

and health officials include immunization, family planning, the use of sanitary latrines, the use of ORS, balanced nutrition, and other diseases such as AIDS, leprosy, tuberculosis, polio, etc. (Table 8).

The campaign resulted in increased health awareness and good sanitary practices among the rural households except in the mountainous forest-based village. No change has been observed among the tribal community in this area since almost all the women are wage earners and go to the forest to collect nontimber forest products (NTFP) such as fuel wood, roots and tubers, fruits, leafy vegetables, mushrooms, etc., for their livelihood (Table 8).

Health care facilities and disease profile. Health care facilities are available in most of the villages in four agro-climatic conditions only (Table 9). For the villages without health care facilities, they are available within up to 16 km distance from the village. However, an Anganwadi center providing health care facilities and referral services is being set up in every village under the ICDS by the Family Welfare Department, government of Orissa, India. Above all, the coastal rainfed drought-prone village of Taraboi in Khurda District has better health care facilities than other villages. However, 10–30% of the households prefer to consult homeopathic/ayurvedic doctors and practitioners for acute diseases, especially for children. Except for the mountainous forest-based households without an Anganwadi center and with only 20% immunization coverage among children, 80–100% of the children from all villages have been immunized in the Anganwadi centers. The mountainous forest-based village also had a low percentage of women giving birth in health-care hospitals and old practices at home by elders are still prevalent in the tribal community. As a result, this area has the highest percentage of women who gave birth to dead children and children's death within one year after birth (Table 9). However, in general, the infant mortality rate (IMR) and maternal mortality rate (MMR) in all villages have been declining in recent years due to a special package for target groups/areas through the government and NGOs (Table 9).

Diseases and health profile. Cough, cold, fever, diarrheal diseases, and worm infestations were very common in every village whereas malaria was reported to be a menace in upland and mountainous forest-based villages. An outbreak of malaria was reported in the upland rainfed village in 1997 (Table 10).

Children suffering from diarrhea are more in upland rainfed and mountainous forest-based villages and one village in the coastal rainfed flood-prone area. These areas also have the highest prevalence of pneumonia, pregnant women suffering from low hemoglobin, and malnourished children. Night blindness was minimal in all villages (Table 10). Specifically, it was observed that women of the scheduled castes and scheduled tribes have low hemoglobin during their child-bearing stage. As such, in terms of health and diseases, it can be said that the upland rainfed and mountainous forest-based and some flood-prone coastal villages are prone to diseases and disadvantages in terms of health conditions. This may be due to the inability to provide protein- and vitamin-rich foods, poverty, ignorance, and also poor sanitary practices and that most of the farm women are not able to take care of their children since they work off-farm.

Table 9. Access to health-care facilities of the villages studied in Orissa, India, 2006.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Availability of health-care facility in the village	Yes, in one of the villages	Yes, in one of the villages	Yes	Yes, in one of the villages	No	No	No
Type of health-care facility	Community health center at block level	Health sub-center and Auxiliary Nurse-cum-Midwife (ANM) Center	Health Aid Center and Primary Health Center	ANM Center	na	na	na
Distance of health-care facility from the village (km)	2–10	5	na	6	4	7	16
Number of MBBS doctors practicing in the village	Nil	Nil	1	Nil	Nil	Nil	Nil
Distance of nearest place where there is an MBBS doctor (km)	2–4	5–7	na	6–8	8	7	16
Number of homeopath/ kabiraj doctors/quacks in the village	1–4	1–2	2 homeopaths, 2 quack doctors, 1 ayurvedic doctor	Nil	2	Nil	2
Households consulting homeopath/kabiraj when family member gets sick (%)	25–30 for all age groups and 80 for mothers with under-5-year-old children	10–25	30 for homeopaths and 10 for ayurvedic doctor	4–10	30–40	10	20

Continued on next page

Table 9 continued.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Place where children go for vaccination/immunization	Anganwadi center and immunization camp within the village	Anganwadi center and immunization camp within the village, ANM center	Health Aid Center and immunization camp in the village	Anganwadi center, immunization camp within the village, and ANM	Anganwadi center and immunization camp within the village	Anganwadi center in adjacent village	Nearest Community Health Center, Anganwadi center
Children vaccinated/ immunized (%)	100	100	100	95–100	80	20	80
Women giving birth in health-care centers/ hospitals (%)	40–70	50–85	60	2–50	30	2	60
Women died from childbirth (%)	0.10–0.25	0.10–0.20	Nil	0.01–0.02	3	4	0.02
Women gave birth to dead child (%)	0.1–0.2	0.20–0.25	0.1	0.02–0.05	1	5	0.05
Children died within one year after birth (%)	0.25–0.4	0.5	0.2	3	3	10	0.5
Decline in mortality rate in recent years	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Infant mortality declined in recent years	Yes	Yes	Yes	Yes	Yes	Yes	Yes

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of

Table 10. Disease profile in the studied villages in Orissa, India 2006.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Common diseases in the village (in order of importance)	Cough, cold, and fever, malaria, intestinal diseases, anemia, jaundice, skin diseases, intestinal parasites, diabetes, typhoid, high blood pressure, filarial pain, ulcer, tonsillitis, gastric acidity, malnutrition	Cold, cough, and fever, intestinal diseases, endemic filarial, asthma, skin diseases, intestinal parasites, malaria, diabetes, malnutrition	Intestinal diseases; cold, cough, and fever; filarial, fatigue; tuberculosis; pain in hip; rheumatism; skin diseases; intestinal parasites; malaria; jaundice; diabetes; high blood pressure	Cold, cough, and fever leading to pneumonia, dysentery, diarrhea, malaria, typhoid, jaundice, gastric acidity, skin diseases, worm infection, tuberculosis, asthma, malnutrition	Malaria; cold, cough, and fever; typhoid; intestinal diseases; skin diseases; rheumatism; jaundice; other intestinal parasites; malnutrition	Malaria; diarrhea; cough and cold; worm infestation; skin diseases; jaundice; tuberculosis	Fever, cough, cold, gastritis, diarrhea, dysentery, typhoid, jaundice, diabetes, worm infestation, low hemoglobin, protein energy malnutrition, malaria
Last time a major epidemic occurred (year)	None in one village and 35 years back in the other	Cannot remember	Nil	–	1997	Not known	Nil
Kind of disease that occurred	Diarrhea	na	na	–	Malaria	na	Nil
Children up to age 5 who suffered from diarrhea (%)	25	35–70	40	50	65	70	50

Continued on next page

Table 10 continued.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Population frequently suffering from pneumonia (%)	10–15	10–35	30	25–30	30	40	5
Children in the village suffering from night blindness (%)	0–0.25	0.10–0.20	Nil	0.1–0.5	Nil	2	0.2
Pregnant women suffering from low hemoglobin (%)	30–45	35–60	30	40–60	40	80	40
Children short for their age (%)	5–25	25–60	50	35–40	45	65	10
Children who have low weight for their age (%)	20	25–30	30	25–30	30	85	50
Perceived that the illnesses are due to inadequate intake of some food	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Illnesses attributable to nutrient deprivation	Anemia and fatigue among women, malnutrition, and stunted growth in children	Low hemoglobin among pregnant and lactating women, low weight and height of children	Anemia among pregnant and lactating women and low weight and height of children	Fatigue and anemia in women and low weight and height among children	Low hemoglobin of pregnant and lactating women; low weight and height for age of children	Insufficient food and unaware about nutrition	Low hemoglobin, short-for-age, low-weight-for-age

Continued on next page

Table 10 continued.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Why some children are malnourished while others are healthy	Poverty prevents mothers from caring for their children since they have to do some off-farm labor; breast feeding is also hampered. Lack of awareness about balanced diet and poor sanitary practices.	Lack of nutritious food intake among poor households. Lack of knowledge about locally available nutritious foods. Poor sanitary conditions.	Imbalanced food, unsanitary practices to keep children disease free; young marriage; improper care of children given by siblings among poor households.	Poverty and ignorance of mothers to provide balanced nutritious food to children. Most farm women cannot take care of their children since they are going out to work. Also, poor sanitary measures among the poor.	Lack of nutrition education of mothers; no time for the children since mothers are engaged in on- and off-farm activities; poverty.	Lack of nutrition knowledge; those who are malnourished (grades 1–3) are those with insufficient food because of low income.	Lack of nutritional awareness among mothers; low income or poverty.

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Table 10 continued.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Government-sponsored health education/nutritional program in the village	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Explain what program does	Mid-day meals in primary schools and provision of protein- and fat-enriched food to pregnant women; provision of emergency food to disabled aged persons; house-to-house visits by Anganwadi workers; vit. A prophylaxis program	Mid-day meals in primary schools and providing rice and pulses to pregnant women and emergency food to disabled elderly persons	Provision of health checkup guidelines to pregnant mothers; supplementation with iron tablets; provision of rice and pulses to pregnant women; mid-day meals in primary schools, emergency food to disabled elderly people	Mid-day meals in primary schools and provision of protein- and fat-enriched food to pregnant women and 0–5-year-old children. Provision of emergency food to the elderly.	Mid-day meals in school; emergency food for disabled elderly people	Anganwadi workers do house-to-house visitation to advise mothers but infants are not covered by the program.	Immunization, health care for pregnant/lactating women, distribution of iron and folic acid under ICDS
Households covered by the program (%)	60–70	70–80	50	50	70	40	60

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Table 10 continued.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Government institution that initiated/managed the program	Health and Family Welfare Department. ICDS through Anganwadi workers	Health and Family Welfare Department. ICDS through Anganwadi workers	Health and Family Welfare Department. ICDS and Education Department	Health and Family Welfare Department. ICDS through Anganwadi workers	Health and Family Welfare Department. ICDS through Anganwadi workers	Health and Family Welfare at block level known as Integrated Child Development Scheme (ICDS)	Department of Health and Family Welfare, government of Orissa, ICDS
NGO-sponsored health/nutrition program in the village	No	No	No	No	No	No	No
Households covered by the program (%)	na	–	na	–	na	na	na
Program targeted at pregnant women	Yes	Yes	Yes	Yes	Yes	yes	Yes
Women covered by the program (%)	90–100	80–100	100	70–90	80	20	90

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Table 10 continued.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Type of program	Provision of iron supplements, tetanus injections, provision of rice and pulses to pregnant women, and house-to-house visits by Anganwadi workers to provide pre- and postnatal instructions. Nutrition education for mothers	Provision of iron supplements and protein- and fat-enriched foodstuffs, tetanus injections, regular household visits by Anganwadi workers to provide pre- and postnatal instructions	Provision of iron supplements, tetanus injections, provision of rice and pulses to pregnant women and house-to-house visits by Anganwadi workers to provide pre- and postnatal instructions	Provision of iron supplements, tetanus injections, provision of rice and pulses to pregnant women and house-to-house visits by Anganwadi workers to provide pre- and postnatal instructions	Provision of iron supplements, tetanus injections, regular visits by Anganwadi workers to households to provide pre- and postnatal instructions	Provision of iron and vitamin supplements and tetanus injections	Provision of iron supplementation and tetanus injections
Institution that managed the program	Health and Family Welfare Department, government of Orissa, Anganwadi Center, and ICDS	Health and Family Welfare Department, government of Orissa	Health and Family Welfare Department, government of Orissa	Health and Family Welfare Department, government of Orissa, ICDS	Health and Family Welfare Department, government of Orissa	ICDS	ICDS under government of Orissa

Continued on next page

Table 10 continued.

Information	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Which government institutions or NGOs would be most effective in managing a nutrition or health-related program?	Anganwadi Center, Health and Family Welfare Department, ICDS, and Education Department, but needs adequate dedicated staff	Health and Family Welfare Department, ICDS, and Education Department with proper personnel and attitude	Health and Family Welfare Department, ICDS, and Education Department	Health and Family Welfare Department, ICDS, and Education Department	Health and Family Welfare Department, ICDS, and Education Department	ICDS	Health and Family Welfare Department, government of Orissa, ICDS, Education Department

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District.

Government-sponsored programs. ICDS is functioning at the village level and every village has a mid-day meal program at the primary school level. ICDS in India is the world's largest integrated early childhood program, with over 40,000 centers nationwide. The purpose of ICDS is to improve the health, nutrition education for mothers, nonformal education to preschool children, supplementary feeding for all children and pregnant and nursing mothers, growth monitoring and promotion, links to primary health-care services such as immunization, and vitamin-A supplementation (Table 10). No NGO has been reported to provide a health and nutrition program in any of the villages.

Farm characteristics, rice production, and farmer perceptions. The average landholding in the studied villages is quite small, and ranges from 0.332 ha to 1.7 ha. The largest average landholding of 1.7 ha is reported in one of the drought-prone upland villages, Belpadar (Balangir District), while the smallest of 0.332 ha is in the saline coastal rainfed area. The upland rainfed and mountainous villages also have larger landholdings, with an average of 1.6 ha each per household (Table 11). However, it has to be recalled that, despite the larger landholdings in the mountainous forest-based village of Kasada, only a small portion of land is cultivated as a majority of the area is covered with forest. As such, there is no record of tenancy in the village. The highest numbers of farmers operating under tenancy arrangements are reported in all the coastal areas.

Of the total area cultivated, 90–100% is planted with rice in the coastal villages, with total area ranging from 26 ha to 750.8 ha (Table 11). However, the percentage of area planted with vegetables is minimal, with the highest percentage (10% of operated land or 12 ha) being recorded in Athantara in Cuttack District. Had the area cultivated for vegetables been larger, vegetable consumption in the villages could have been higher since most households consume vegetables if production is sufficient.

During the kharif season, farmers grow both HYVs and local rice varieties. The most popular HYVs are Swarna, Lalat, Pooja, Khandagiri, CR 1018, and CR 1001, which are almost the same in all the villages studied but some differences occur across districts when it comes to local rice varieties (Table 11).

Other HYVs are also reported to be grown in separate villages and districts depending on the soil conditions and availability of irrigation facilities. Similarly, other local varieties are specifically grown in the different districts. Not all villages plant rice during summer. Farmers from the mountainous forest-based and coastal saline rainfed villages are not growing rice because of saline soil conditions and a lack of irrigation facilities that make the soil not suited for summer rice varieties. On the other hand, one of the villages in the coastal irrigated area grows pulses instead of rice during summer since pulses are more profitable. No local varieties are grown in the villages where rice is cultivated during summer.

Most of the farmers in the different agro-climatic conditions do not distinguish rice varieties to be grown for home consumption and for sale. In the coastal irrigated areas and coastal rainfed drought-prone villages, only the large farmers distinguish rice varieties for sale and for home consumption. In general, the varieties preferred for home consumption are those that have medium and "bold" grains that are suitable

Table 11. Farm characteristics and rice production in the studied villages in Orissa, India, 2006.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Average landholding in the village (acres)	1.2–1.9	1.5–3	2.3	2.25–4.25	4	4	0.83
Farmers operating under land tenancy (%)	40–60	25–65	35	15–25	14	Nil	40
Operated land cultivated with rice (%)	90	99–100	99.5	43–48	23	19	100
Actual area cultivated with rice (acres)	254–310	65–500	1,877	224–640	254	76	236
Operated land cultivated with vegetables (%)	1–10	0. 20–0.40	0.2	0.40–1.0	3	1	Backyard only
Do farm households consume more vegetables when they produce them than when they buy them from the market?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Most popular rice varieties grown in the kharif season, HYVs/hybrid varieties[d]	Lalat, Swarna, CR 1018, Pooja, Khandagiri	CR 1018, CR 1009, Swarna, Pooja	Swarna, Pooja, Lalat	Swarna, Pooja, Lalat, Khandagiri	CR 1001, Swarna, Lalat, Pooja	Lalat, Swarna, Khandagiri	Pooja, Swarna, CR 1018

Continued on next page

Table 11 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Local varieties[e]	Athagadia, Dhusura (scented), Barhagali, Saruchinamali, Mayukantha (for polished rice "khai"), Nandikiri	Matiya, Khajura, Oriyan, Chandrakanti, Kedargouri, Kakharua, Dandanbalunga, Mayukantha	Padmakeshari, Gopalbhog, Godikhajara, Mayukantha	Saria, Nenka, Chetka, Mugundhi, Ranisiali, Gelei[b]	Laxmi bilash, Dalua dhan, 6 Numbari, Dadaraghati	Goti khalika, Kanchi, Banki, Bada banki, Kansari Kalam kathi, Nal bansi, Sathia	Pateni, Duladha, Harimati sola, Bhundi, Lilabati (scented and fine)
Most popular rice varieties grown in the summer season							
HYVs/hybrid varieties	Lalat, Khandagiri	Parijat, Lalat, Khandagiri	Lalat, Khandagiri	Lalat, Khandagiri	Lalat, Khandagiri, Sarathi	Nil	Nil
Local varieties	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Do farmers distinguish rice varieties for home consumption and varieties for sale?	Yes, except for the poor farmers	No	No, in the case of small farmers, but large farmers grow fine varieties	No	No	No	No, since there is limited chance of using other varieties

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Table 11 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Rice traits preferred for home consumption	Medium bold grain, suitable for water rice	Medium bold	Medium bold	Medium to fine	Slender and fine stalks, tasty	Coarse, suitable for water rice, fermented rice	Local adaptability (saline tolerant and resistant to waterlogging) and good grain quality
Does preference vary between poor and nonpoor households?	Yes	Yes	Yes	Yes	Yes	No	Yes
Traits preferred by poor households	Bold, which makes one feel full, suitable for water rice	Bold, which makes one feel full	Bold and easily makes one feel full, tastes better as water rice	Medium grain for water rice and can make one feel full	Good to eat when eaten as water rice (*pakhala*) that makes one full	na	Bold, which makes one feel full

Continued on next page

Table 11 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Traits preferred by nonpoor households	Slender, fine, polished bold grain that makes good water rice	White, slender, fine polished grain	Fine, slender, and polished	White polished slender rice	Fine slender and polished type	na	Medium to slender
Mostly cultivated varieties for sale	CR 1018, CR 1009, Swarna, Nandikiri, Kedargouri, Mayurkantha, Dhusura	No specific variety	Swarna, CR 1009	Swarna	Swarna, CR 101, Pooja	Nothing is sold; use for home consumption	Pateni
Rice traits selected for sale	Bold and heavy for local market, fine and slender grain for rich people	White colored, good for water rice, *mudhi*, bold and heavy	High yielding, high priced, heavy, medium to fine grain	High yielding and fine quality with good market demand	High yielding and fine quality	na	Long and slender

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District. In coastal rainfed-flood prone areas, the other local kharif varieites are Chandrakanti, Dandabalunga, and Mahalaxmi. In coastal drought-prone villages, they are Azana, Laghu, Godikhajara, Motora, Gulabhundi, Ranachudi, Sukasari, and Saunlimadhei.

for water rice (*pakhala*) and make one feel full. Preferences also vary between poor and nonpoor households. The poor households prefer coarse and medium to "bold" varieties that taste good for water rice while the nonpoor households prefer slender, white, and polished grains. On the other hand, rice varieties for sale must be high yielding, with heavy grains, and those would command a higher price (Table 11).

If farmers are presented with varieties that would give the same yield, they would consider the agronomic and eating quality of the varieties. For agronomic traits, farmers would choose ones that are resistant to drought, pests, and diseases and that have reasonable crop duration (Table 12). Farmers do not want a variety that has short duration since this is prone to insect attack as no other hosts are available. In terms of eating quality, farmers would pick a variety with higher nutritional values and good eating quality. Farmers in the coastal saline rainfed village are biased toward a variety that is saline resistant due to the salinity of their soil while the farmers in the coastal rainfed flood-prone villages that are always submerged in flood during monsoon would prefer a variety that is resistant to waterlogging.

For a variety that is pest resistant, farmers would be ready to sacrifice some yield, from 5% to 20%, whereas, for good eating quality, the reduction in yield must be from 5% to 10% only and, in the coastal irrigated villages, this would be only for large farmers. In the mountainous forest-based village, which is one of the food-deficit areas, farmers would not sacrifice yield for good eating quality. For them, they need a sufficient quantity first before they think of good eating quality. For improvement in nutritional values, farmers in the coastal rainfed drought-prone, mountainous, and upland rainfed villages would not be willing to sacrifice yield, whereas, for the other agro-climatic conditions, a 5–15% reduction in yield could be traded off for an improvement in nutritional values of rice. An insufficient quantity of rice may be the reason why some villages would not trade yield for nutritional values. It should be recalled that, in these villages, some households cannot have three meals a day such that their priority must be to have sufficient quantity rather than quality of rice. However, farmers would be willing to grow rice varieties that contain vitamins or iron even if these are off-white in color provided market demand exists for them. This is so because the traditional varieties they normally grow are dark colored. It is only in the coastal irrigated and coastal rainfed drought-prone villages where households would pay an additional amount for a rice variety that could reduce the risks of diarrhea and pneumonia. Households in most of the villages would not be willing to pay a higher price for nutritious rice that would prevent the risks of these diseases since they believe that these illnesses are not caused by nutrient deprivation but by unsanitary practices and improper care by mothers. On the other hand, in most of the areas studied, households would be willing to pay a higher price for a rice variety that would make pregnant women strong since they perceived that women become fatigued easily during pregnancy due to a lack of good food.

Success stories and time path of adoption. As shown in the previous discussions, several popular rice varieties are found in the villages studied. However, over time, certain varieties are still popular among the farmers. Swarna has been adopted in

Table 12. Farmers' perceptions about the adoption of new rice varieties in the villages studied in Orissa, India (i.e., biofortified rice).

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
If two varieties have the same yield, what other criteria are considered in deciding which variety to grow?	Pest resistant, good eating and nutritional quality, crop duration, threshing quality	Resistant to waterlogging, good eating quality, pest and weed resistant, crop duration	Pest resistant, good eating quality, weed resistant, crop duration	Pest resistant, low production cost, good eating quality, crop duration	Pest resistant, crop duration, drought resistant, good eating and nutritional quality	Crop duration	Saline resistant, crop duration, pest resistant, good eating quality and nutritional value
Willing to sacrifice yield if a new variety is resistant to pests? (%)	10–20	10–20	15–20	15–20	20	5	5–10
Willing to sacrifice yield if a new variety has better eating quality? (%)	10, especially the rich farmers	0–10	5	10	5	Nil	5
Willing to sacrifice yield if a new variety contains vitamins that help reduce night blindness? (%)	0–2	10–15	Nil	5–10	Nil	Nil	5
Would amount differ between poor and nonpoor farmers?	Yes, in one of the villages	Yes	No	Yes, in one of the villages	Not confirmed	Not confirmed	Yes
How much less yield would a poor farmer accept? (%)	Nil	10–15	na	10	na	na	No compromise

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Table 12 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
How much less yield would a nonpoor farmer accept? (%)	5	5–10	na	15	na	na	10
Willing to sacrifice yield if the new rice variety contains more iron that would help make pregnant and lactating mothers stronger and reduce the risk of death from childbirth? (%)	10 in one of the villages	10–20	Nil	10–15	10	Nil	10
Would amount differ between poor and nonpoor farmers?	Yes	Yes, in one of the villages only	No	Yes, in one of the vilages	Not confirmed	Not confirmed	Yes
How much less yield would a poor farmer accept? (%)	10	15	na	10	na	na	5
How much less yield would a nonpoor farmer accept? (%)	5	20	na	15	na	na	10
If no, what is the reason?	na		na	na		na	na
Would farmers grow a rice variety that contains more iron with more yield but the color is less white?	Yes	Yes	Yes, but there should be demand for such a variety	Yes, if there is a market for it	Yes, but it depends on market demand	Yes	No

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Table 12 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Would low-income consumers care whether the color of rice is white or yellow if the price is the same?	No	No	No	No	No	No	No
Would low-income consumers be willing to pay a higher price if a new paddy variety reduces the risk of night blindness?	Yes, by 2% in one of the villages only	Yes, by 5–10%	No	No	No	No	No
Would low-income consumers be willing to pay a higher price if a new paddy variety reduces the risk of diarrhea?	Yes, by 10% in one of the villages only	Yes, by 10–20%	Yes, by 10–15%	No	No	No	No
Would low-income consumers be willing to pay a higher price if a new paddy variety reduces the risk of pneumonia?	Yes, by 10% in one of the villages only	Yes, by 10–15%	Yes, by 10%	No	No	No	No
Would low-income consumers be willing to pay a higher price if a new rice variety helps make women stronger during pregnancy?	Yes	Yes	Yes	No	Yes, but it depends on the market price of the variety	No	Yes
How much more? (%)	10	15–20	10	na	10	na	10

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District.

35–67% of the rice areas in most of the different agro-climatic areas. This variety was first introduced in 1989 in that coastal rainfed drought-prone area and in early 1990 in other districts by the village agricultural workers through government demonstration farms (Table 13). The other HYVs that became popular in other agro-climatic conditions are CR 1001, Lalat, Pateni, and Chakaakhi. In contrast to Swarna, which was introduced only by the Agriculture Department, these other varieties were introduced also by friends from neighboring villages. However, these other varieties covered only up to 50% of the cultivated area in the villages. For Swarna and Pateni, it took up to 10 years before the varieties were adopted in 50% of the area. According to key informants, adoption took longer since a lot of HYVs were introduced and competed with each other.

For summer, the most adopted varieties are Lalat and Parijat. Both varieties were introduced in mid-1980 through a demonstration farm of the Department of Agriculture. Now, at least 80% of the boro areas are planted with these varieties (Table 13). In contrast to the kharif season, it took only 5–6 years for the varieties to cover 50% of the boro areas. The reasons for the differences in time path of adoption between the kharif and boro rice varieties are that cultivation is under controlled conditions in the latter and farmers can choose from several kharif varieties. In terms of characteristics, the varieties are quickly adopted due to their high yield, eating quality, resistance to pests and salinity, and high price, and they are highly responsive to fertilizer.

Several HYVs were also adopted but they were not continuously planted. The reasons for noncontinuous adoption include low yield, poor threshing quality, uneven maturation period, seeds are not readily available, high seed cost, and fertilizer requirements.

Rice marketing, storing, and processing. Except for the mountainous village where the rice produced is used solely for home consumption, surplus farmers in all villages sell paddy (Table 14). In almost all villages, farmers keep the entire harvest and sell paddy when needed. In the coastal saline rainfed area, some farmers sell the entire harvest and buy rice in the market subsequently, whereas, in the coastal rainfed drought-prone area, farmers sell the surplus at harvest after keeping the quantity needed for home consumption. Among the surplus farmers, marketing patterns differ. For the villages in the coastal rainfed flood-prone area, farmers keep paddy for two years as a safeguard during uncertainty in production. However, most of them keep part of the harvest and sell it when the price is high or when there is an urgent need in the family. In the coastal irrigated villages, farmers keep the traditional varieties first and sell them when there is high demand for them, especially during festivals. Even though the villages are relatively near the market, paddy is sold to traders who usually come to the farmers. Most of the farmers sell paddy instead of milled rice.

For varieties that are sold, these are the ones with fine and slender grain, heavy grain, and high milling recovery, and they are scented. On the other hand, for home consumption, coarse and bold varieties that are suited for pressed rice and water rice are kept.

Table 13. Success stories about rice production and lessons from failure in the studied villages in Orissa, India, 2006.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Kharif paddy variety that became most popular over the last 10 years	Swarna	Chakaakhi	Swarna	Swarna	CR 1001	Lalat	Pateni
Year introduced in the village	Early 1990	1992	1989	Early 1990	1994	1994-95	1995
How introduced	Agriculture Department, purchase seed from government sale center	Through friends and relatives of neighboring village	Through government demonstration	VAW	Agriculture Department	Agriculture Department	Through demonstration by Agriculture Department
Kharif area covered by the variety now (%)	50–60	30–50	35	60–67	45	20	50
Years it took to cover 10% of the area	2–3	3	3	3	3	5	2
Years it took to cover 25% of the area	5	5	5	5	5	10 (25 not yet reached)	5
Years it took to cover 50% of the area	8–10	8	na	9–10 years	Not yet covered	Not yet reached	10

Continued on next page

Table 13 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Summer paddy variety that became most popular over the last 10 years	Lalat, but in one of the villages only	Parijat	Lalat	Lalat, but in one of the villages only	Lalat	No paddy cultivation in summer	Nil
Year introduced in the village	Late 1980	1985	Mid-1980	Late 1980	Mid-1980	na	na
How introduced	Agriculture Department through demonstration	Demonstration by Agriculture Department	Agriculture Department through demonstration	Agriculture Department	Agriculture Department through demonstration	na	na
Boro area covered by the variety now (%)	90	80	80	80	80	na	na
Years it took to cover 10% of the area	2	2–3	2	2	2	na	na
Years it took to cover 25% of the area	4	4	4	4	3	na	na
Years it took to cover 50% of the area	5	5–6	5	6	5	na	na

Continued on next page

Table 13 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Reasons for the success for quick adoption	High yielding, market price, pest resistant, good eating quality	Resistant to waterlogging, quick tillering, high yield, weed and pest resistant, good eating quality	High yield, weed resistant, pest resistant, more grain weight	High yielding, fertilizer responsive, good market demand, good eating quality	High yield, pest resistant, good market demand, good eating quality	Drought resistant	Saline resistant, waterlogging resistant, high yield, good eating quality
Example in which a new variety was introduced but was not popular in the village and ultimately disappeared	Parijat and Jajati	Almost all HYVs introduced failed	Jagannath	Hybrid varieties and Daya	Pankaj	None yet	No major variety
Why did the variety fail?	Quick germination if rain occurs during maturity period and prone to pests and difficult to harvest	Susceptible to waterlogging and low yield	Poor threshing quality, uneven maturity period	High seed cost, high fertilizer requirement, stickiness, low yield and grain recovery, low market demand	Yield was not comparable with that of Swarna	na	na

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District.

Table 14. Marketing, storing, and processing information in the studied villages in Orissa, India, 2006.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Marketing pattern:							
Sell the entire crop at harvest and buy rice from the market subsequently						Rice is not sold since all produced is used for home consumption	Yes
Sell the surplus at harvest after keeping amount needed for family consumption	50% for household consumption in one of the villages		Yes				
Keep the entire harvest and sell by installment when suitable	Yes	Yes		Yes	Yes		Yes
Does the marketing pattern differ between deficit and surplus farmers?	Yes	Yes	Yes	Yes	Yes	na	Yes
Describe marketing practices of deficit farmers	Rarely or do not sell paddy at all	Do not sell paddy at all	Sell the immediate surplus at harvest and purchase rice at regular intervals	Paddy kept for home consumption	Not sold and normally insufficient to meet the requirement for the whole year	There is no surplus production	Not at all sold

Continued on next page

Table 14 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Describe marketing practices of surplus farmers	Traditional varieties are sold when demand is good for them. For the HYVs, harvest is sold when urgent need exists in the family.	Keep paddy for almost 2 years due to uncertainty in production	Keep the entire harvest and sell in installments when needed	Keep the entire harvest and sell whenever needed	Keep the paddy for minimum of 6–8 months before selling to traders who usually pick up rice from the farmers' house	No surplus farmers	Sell when they need cash
Distance of local market from the village (km)	5–6	6–7	7	6–8	8	5	16
Do farmers take the product to the trader or do traders come to the farmers?	Traders come to farmers	Traders come to farmers	Both: traders come to farmers as well as farmers go to traders	Both practices are observed	Traders come to farmers	Rice is not sold	Traders come to farmers

Continued on next page

Table 14 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Attributes of the varieties that made them suitable for marketing as opposed to being consumed by the household	Scented and slender grain rice is sold due to high price, Coarse grain is preferred by low-income people since these varieties are suitable for water rice.	There is no distinct preference but fine-quality grains have higher demand.	Milling recovery in case of marketable varieties. In the case of Swarna vis-à-vis Azana, the latter is mostly consumed at home.	There is no preference in varieties for trading and home consumption.	Fine slender varieties	na	Grain quality and weight
Do farmers store paddy or milled rice?	Both paddy and milled rice	Paddy	Paddy	Paddy	Paddy	Paddy	Paddy
How is paddy/rice stored?	Polythene sack, jute sack, *amara* made of bamboo, also cement structure	Jute sack, *marei*, cement and elevated structure	Mostly jute sack and infrastructure (*marei*) meant to keep paddy	Stored in structure made of straw (*Poda*), jute sack	In bamboo structure (*doli*), jute sack	Polythene sack or in structure made of paddy straw called *Puduga* in tribal language	*Amara*, *marei*, and underground storage

Continued on next page

Table 14 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Is the paddy milled at home or in a commercial mill?	Commercial mill	Commercial hulling unit in the village	Commercial hulling in the village	Hulling units	Hulling units in the village itself	Milled in wooden structure (traditional method) and very little commercial milling	Hulling unit in the village
Is the paddy parboiled before milling?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cultivated varieties that are also cooked at home	Tulasi, CR 1018, Swarna, CR 1977, CR 1014	Matiya, Khajura, Oriyan, and other local varieties	Azana, Swarna, Padmini, and almost all varieties	Swarna, Lalat	Swarna, CR 1001, Nali Jagannath, Lalat, Pooja, Khandagiri	All varieties	Pateni, Swarna
Does the household consume a variety that they don't cultivate?	No	Yes	No, except in the case of BPL rice	No	No	Yes	Not at all sold
If yes, why?	na	During lean periods, purchased from Public Distribution System	When purchased from Public Distribution System and from market	na		During scarcity of paddy, households purchase from local markets as well as Public Distribution System	Buy paddy during scarcity period

Continued on next page

Table 14 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Major changes in rice marketing over the last 10 years	More traders are frequenting the village. Lately, the government opened up a procurement center for paddy to keep price from declining.	More traders are frequenting the village but price is not increasing. Less demand for traditional bold varieties.	More traders are frequenting the village and also the government has started procuring paddy from the village but only large farmers are benefited.	Now, paddy as well as milled rice is traded. Some households prepare *mudhi* and pressed rice for sale.	More traders are frequenting the village but price is not increasing though cost of production increased significantly.	No change since no rice marketing is done.	Government is now procuring paddy through authorized dealers; traders come to the village to buy paddy from farmers.
Major changes in rice milling over the last 10 years	Commercial milling has increased due to labor saving and grains are not broken; hulling units are still used.	No change	No change; hulling units have been operating in the village since 1980.	No change; milling is done in hulling units within the village.	No change; hulling units have been operating in the village since 1980.	Commercial milling has increased due to labor saving and grains are not broken.	From traditional method to commercial milling with improved sheller.

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For farmers that keep paddy, storage is done using a bamboo structure and in some cases jute sack or elevated cement structure to keep the rice from being submerged when it rains. In the tribal community in mountainous forest-based areas, paddy is stored in a straw-made structure called "puduga." In almost all villages, rice is milled in commercial hulling units within the village. Only in the mountainous village is milling done in the traditional way. As a matter of tradition, rice is parboiled in all cases before milling.

Although farmers keep paddy for home consumption, in some cases the households consume a variety that they do not cultivate. This is particularly true among deficit farmers, wherein, during a lean period, they have to purchase Annapurna rice from the Public Distribution System (PDS).

Over the years, changes in rice marketing have been observed. Among these are the frequent visits of traders to the village to buy rice and government paddy procurement activities to prevent the price from falling. Nowadays, demand is decreasing for traditional bold varieties but demand is increasing for slender fine varieties for urban consumers. In addition, households are now starting to sell ready-made *mudhi* and pressed rice. In terms of rice milling, there has been no major change since commercial hulling units have been operating in the villages since the 1980s (Table 14).

Institutional environment. The Office of Agricultural Extension (OAE) under the Department of Agriculture is in charge of disseminating agriculture-related information to the farmers in the villages. However, only 20–75% of the farmers are familiar with the OAE. The village agricultural worker (VAW), agricultural extension officer (AEO), and junior agricultural officer (JAO) are the titles of the officers that farmers expect to help them (Table 15). However, only the farmers in one of the villages in the upland rainfed drought-prone area seem to be benefiting from the services of the AEO who resides in the village. In the other villages, visits of the VAW, JAO, and AEO are relatively limited and, in coastal rainfed flood-prone villages, no visit by the AEO is made at all. As such, farmers from these villages sourced agriculture-related information from radio, television, neighbors, and model farmers. In fact, in almost all villages, mass media and friends are the usual sources of information related to agriculture. For new HYV seeds, the common sources of supply are government seed sale centers, large farmers, relatives, and friends.

Except for the three coastal rainfed flood-prone and upland rainfed drought-prone villages, nongovernment organizations (NGOs) are not operating in the villages studied. However, NGOs, where they are present, do not provide information related to new agricultural technologies. Their services are limited to social preparation such as self-help groups, micro-credit financing, and health and sanitation awareness campaigns. The presence of farmers' organizations is also very limited in the villages studied.

Perceptions on food and nutrition. Most of the respondents of the selected villages defined a healthy child as active, having a good physique in relation to height and weight, having a good appetite, and being free from diseases (Table 16). Food rich in balanced nutrition was the basic concept perceived to make a child healthy. In addition, the respondents believe that breastfeeding for at least six months also helps

Table 15. Institutional environment in the studied villages in Orissa, India, 2006.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Percent of farmers who knew of the Department of Agricultural Extension (%)	20–60	10–40	50	30–75	75	20	50
Title of the officer of the Department who should help the farmers	Junior agricultural officer (JAO); agriculture extension officer (AEO); village agricultural worker (VAW)	JAO, AEO, VAW	JAO, VAW	VAW	AEO, VAW	VAW	AEO
Number of times officer visits the village in a month	6–7 times a year because of their official assignment	Nil	Nil	5–6 times a year and VAW resides in one of the villages	3–4 times	Rarely, and it is mostly when he has his own specific government assignment	Rarely

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Table 15 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Sources of information about new agricultural technologies	Radio, television, newspaper, neighbor, model farmer, large farmer, fertilizer and pesticide dealers, sugar factory	Television, radio, newspaper, neighbor, model farmer, large farmer	Television, radio, newspaper, VAW, model farmers, scientists from agricultural university, relatives, and friends	VAW, radio, television, neighbor, model farmer, large farmer	Extension officers of line departments, scientist of KVK, horticulturist of district headquarters, pesticide and fertilizer dealer, model farmers, television, radio, newspaper, relatives, and friends	Scientists of KVK, radio, fertilizer trader, neighbor	JAO, radio, newspaper, model farmer, neighbor, AEO
Source of seeds when farmers adopt a new rice variety	CRRI, government seed sales center, relatives and friends, neighbors	Relatives and friends, government seed sales center	Relatives and friends, neighbors, government seed sales center	Relatives and friends, government seed sales center	Government seed sales center, demonstration of minikit, large farmers, relatives, and friends	KVK, government seed sales center, fellow farmers	Government seed sales center, CRRI

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Table 15 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Major NGO operating in the village	Nil	UNNAYAN	Nil	AWARENESS, CAS in one of the villages only	Nil	None	Nil
Does any NGO assist farmers in obtaining information on a new rice variety?	No	No	No	No	No	No	No
Whom the farmers trust more regarding information on new technologies	Scientists of CRRI, fertilizer trader, television, radio, newspaper, VAW	AEO, friends and relatives, model farmer, large farmer	Friends and relatives, model farmer, VAW, scientist of Agricultural University	VAW, friends and relatives, model farmer, large farmer	Scientists from KVK, extension officers of line departments, horticulturist of district range, fertilizer and pesticide dealer, model farmer	Scientists from KVK	Model farmer, VAW/AEO
Does the village have any farmers' organization?	No	No	No	No	Yes	No	No

Continued on next page

Table 15 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
What kind of organization?	na	na	na	na	Swaminathan Krushak Club (registered under cooperative act)	na	na
Functions of the organization	na	na	na	na	Provide loans to members, marketing of produce, advise farmers about cultivation practices. Facilitate training programs for farmers, rural youth, and women.	na	na

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Table 16. Perceptions about food and nutrition in the studied villages, Orissa, India, 2006.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Characteristics of a healthy child	Good physique, normal height and weight, more active, mentally sound, free from diseases, good appetite	Physically and mentally sound, good appetite, cheerful, good memory, disease free	Disease free, normal height, active and sound mental health	Good weight and height, good mental growth, good appetite, free from illnesses, cheerful	Normal height, disease free, good appetite, mentally stable and cheerful	Looking fatty, disease free, good feeding habit	Active, good appetite, disease free
What makes a child healthy?	Eating protein-rich food, good sanitary practices, breastfeeding for at least 7–8 months	Providing vegetables, fruits, commercial milk formula, and breastfeeding with good sanitary practices; the other two villages have no common idea	Breastfeeding for at least 6 months. Providing them with food that contains protein and less fat.	Mother ate good food while pregnant, child exclusively breastfed until 6 months, good-quality diet	Foods such as milk, vegetables and pulses, fruits, small fish, and egg; breastfeeding for at least 1 year; keeping child clean and free from intestinal parasites	Maybe sufficient food	Providing good food and keeping the child clean

Continued on next page

Table 16 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Understanding about good-quality diet	Educated families have idea of good diet but poor families are not aware of quality diet; diet should contain good amount of protein, vitamins, and minerals	No awareness among majority of the farming community; but, in one of the villages, provision of good food makes for a quality diet	Children are given *khe-chudi*, boiled vegetables, milk and boiled eggs, and pressed rice	No good understanding about good-quality diet. The households believe that a good diet means eating non-vegetarian food	People have no idea about good-quality diet and mothers just want to make sure their children are made full	No idea. Good food means eating non-vegetarian foods such as eggs, meat/chicken	Adequate quantity and quality of food
Familiarity with foods that protect the eyes and make pregnant women stronger	Yes, about 60% of the households are aware that fresh vegetables are good at protecting eyesight	About 20–60% of the village communities are aware	Yes. Children are given vitamin A capsule and fed fish, rice, fruits, and green vegetables	Yes, foods such as papaya, green vegetables, fruits, eggs	Very little knowledge	No idea	Aware about importance of leafy vegetables and seafood

Continued on next page

Table 16 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Number of meals a day containing leafy vegetables during June to October	At least two meals	1–2 times	At least one	Two meals	At least one	One or two	Once a day
Number of times having lemon with meal in a week	2–3 times in one village but not regular in the other vilage	Rarely	Not regular since it has to be bought from the market	2–3 times and very rare in one of the villages	3–4 times a week since lemon is a common plant in the village	Nil	Nil
Number of times eating meal with meat	2–3 times a year, during festivals	2–3 times a year, during festivals only	Once a month	About once a month and during festivals	2–3 times a year and only during festivals	Occasionally, during festivals only	5–6 times a year
Number of times eating meal with fish	2–3 times a week from nearby rivers and ditches	2–4 times a week	2–3 times by purchasing sea fish	2–3 times from the market or by catching from ditches	Nil, since fish are not readily available	Very minimal, only during rainy days when they can catch fish from streams and rivers	5 days a week

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to make a child healthy. The mothers in most of the unfavorable agro-climatic areas (flood-prone and upland drought-prone areas, the mountainous forest-based village) did not say anything about a nutritious diet that makes a child healthy even if a lot of health awareness campaigns were organized in these villages. The mothers of the coastal rainfed areas (a favorable agro-climatic setting) and educated people of other villages know that quality foods mean richness in proteins, minerals, and vitamins whereas uneducated poor families interpreted good food as eating nonvegetarian food and eating high-cost off-season vegetables, milk, and milk products, etc. Constraints to achieving quality food arose from a lack of money and lack of awareness. Awareness about food that protects eyesight and makes pregnant women stronger varied from 20% to 60% of the respondents in almost all villages. All households had at least one meal containing green leafy vegetables in a day during November to May and June to October because of the nutritional garden in the backyard in a majority of the households. However, lemon intake, which helps in iron absorption in the body, is not observed regularly with their meals. Consumption of meat was not a habitual practice for all. Meat is eaten at least twice or thrice in a year and occasionally during festivals and ceremonies whereas fish is commonly eaten at least two to three times in a week. This is especially true in the coastal villages, where fish are caught in creeks, ditches, and nearby rivers.

Meal pattern. Breakfast time varies from 0700 to 1100 in all villages. Water rice with some vegetables cooked in different ways is the most common meal in almost all villages in Orissa. Tea, puffed rice, and pressed rice are consumed in the early morning prior to a heavy breakfast in most of the villages. As the housewife eats last, a lesser quantity of vegetables is normally left for her. For preschool children, pressed rice, puffed rice, *khichidi* (rice, pulse, vegetable, *ghee*, and sometimes sugar cooked together), and water rice and rice cake (*pitha*) are most common during lean months. Nobody in the family misses breakfast even during lean months (Table 17).

In all villages, lunch time is from 1300 to 1500. The usual meal in most households consists of rice with pulses and vegetables or fish curry. Dietary variation during lean months can be observed in the poorer sections of all communities, with water rice with roasted vegetables or fish. The same items are given to their children but, during the lean period, children are given water rice, salt, and pickles.

Dinner time is from 1900 to 2200 in all selected villages. During dinner, rice or chapati and a pulse with vegetables (*dalema*) such as potato, eggplant, and pumpkin are usually the common food of farm households. The same food is also served for children and housewives. Households do not miss their dinner at all as they are getting benefited through the Public Distribution System.

For a family consisting of five members, the maximum quantity of rice cooked during normal times ranges from 1,750 to 2,500 grams per day. The least quantity of rice is cooked in the mountainous forest-based areas compared with other areas. However, during the lean period, households in most villages reduce the amount of rice consumed (Table 18). Dining out is not usually practiced except for those who work outside the villages. During a lean period, needy households go to borrow or purchase rice from their neighbors and from the nearest shops. Since most of the

Table 17. Meal pattern of households in studied villages, Orissa, India, 2006.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Breakfast							
Time breakfast is eaten (a.m.)	0700-0800 and 0900-1100	0700 and 1000	0800-0900	0800	0700-0900	0800	1000
Do household members eat breakfast together?	No	No	No	No	No	No	No
If yes, typical food items							
If no, food items eaten by head of family	Fried pressed rice and tea at 0700 and *pakhala* with chilli, onion, green vegetables, or dried fish and pickles at 1000	*Mudhi/khai* and tea at 0700 and *pakhala* with chilli, onion, greens, or potato or pickle or dried fish at 0900-1000	Fried pressed rice and tea	Mostly *mudhi* and tea	Water rice, chilli, onion/garlic, mango pickle; some fried vegetables	Water rice, pickles, onion, roasted brinjal, greens	Water rice, roasted fish, roasted brinjal/potato
Is breakfast missed by head of family during lean months?	No	No	No	No	No	No	No

Continued on next page

Table 17 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Food items eaten by wife	*Pakhala* with chilli, onion, green vegetables, and roasted vegetables or pickle at 1000	*Pakhala* with chilli, onion, greens or potato or pickle at 1000	Water rice, roasted or fried vegetables	Same as head of the family	Same as household head	Water rice, onion	Water rice, roasted fish
Is breakfast missed during lean months?	No except when little amount is left for wife	No	No	No	No	Yes, in some cases	No
Food items eaten by children	Pressed rice and ripe banana and cow's milk; *chatua*, popped rice, *suji*, biscuits	*Mudhi*, *pitha*, and water rice	Pressed rice and water rice	*Mudhi*, rice cake, and water rice	*Khechudi*/ rice cake (*pitha*), and water rice	Water rice, biscuits, maize	Water rice, biscuits
Is breakfast missed during lean months?	No	No	No	No	No	Yes, in some cases	No

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Table 17 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Lunch							
Time lunch is eaten (p.m.)	1300-1500	1300-1430	1300-1400	1300	1300-1400	1500	1330-1430
Do household members eat lunch together?	No	No	No	No	No	No	No
If no, food items eaten by head of family	Rice, dal, pulses, some fried or curried vegetables, and sometimes fish	Rice, pulses and curried or fried vegetables with fish	Rice, vegetable or fish curry, fried pulse	Rice, pulses, some curried or fried vegetables	Water rice, pulses, vegetables curried or fried vegetables	Rice, vegetables	Rice, vegetable/fish curry
Is lunch missed during lean months?	No	No	No	No	No	No	No
Food items eaten by head of family in lean times	Same as in normal season	Water rice, chilli, onion, pickles, tamarind or mango	Water rice, green vegetables	Rice, pulses	Water rice, chilli, onion, garlic, tamarind/lemon/mango pickle, or dried green mango	Boiled tender jackfruit, rice, mango and other available fruits, roots and tubers from forest	Water rice and roasted fish/potato/brinjal/chilli, salt
Food items eaten by wife	Same as head of family, or rice and vegetables only	Same as head of family	Rice, vegetable or fish curry, fried pulse	Same as head of family	Same as household head and some roasted vegetables	Rice, vegetables	Rice, vegetable/fish curry

Continued on next page

Table 17 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Is lunch missed by wife during lean months?	No	No	No	No	No	No	No
Food items eaten by wife during lean months	Same as normal time	Water rice, chilli, onion, and pickled tamarind *ambula*	Water rice, green vegetables	Rice and pulse	Water rice, chilli, onion, garlic, tamarind/ lemon/ mango, pickle or dried green mango	Same as head of family	Water rice and roasted fish/ potato/brinjal, chilli, salt
Is lunch missed by children during lean months?	No	No	No	No	No	No	No
Food items eaten by children during lean months	Same as in normal season	Water rice, salt, pickle	Water rice, green vegetables	Rice and pulse	Water rice, salt, pickle	Same as adults	Water rice, roasted fish or vegetables
Dinner							
Time dinner is eaten (p.m.)	2000-2200	2030-2200	2000-2100	2000-2100	1900-2100	1930-2000	2030-2130
Do household members eat dinner together?	No	No	No	No	No	Yes	No
If yes, typical food items at normal times						Rice and leafy vegetables	
If yes, typical food items at lean times						Sometimes fermented rice (country liquor)	

Continued on next page

Table 17 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
If no, food items eaten by head of family	Rice, pulses, some fried or curried fish or vegetables. In some households, chapati is also eaten with milk.	Rice, pulse with vegetables, fried or curried fish; sometimes chapati is also eaten with milk and sugar.	Water rice, roasted or fried vegetables	Rice, pulses, and vegetables, and chapati in some cases	Water rice, fried or curried vegetables, and in some cases chapati		Rice, vegetable/fish curry
Is dinner missed by head during lean months?	No	No	No	No	No	No	No
Food items eaten by head during lean months?	Same as in normal time	Water rice, onion, salt, chilli, pickled tamarind	Water rice, onion, chilli, salt	Rice and pulses	Water rice, onion, salt, chilli, garlic, tamarind/mango/lemon, pickle	Water rice, chilli, salt, tubers, insects, jackfruit, country liquor	Water rice, fried potato or fried fish
Food items eaten by wife	Rice, vegetables with pulse	Same as head of family	Same as head of family	Same as those eaten by household head	Same as head of family	Rice and leafy vegetables	Rice, vegetable/fish curry

Continued on next page

Table 17 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Food items eaten by wife during lean months	There is no distinction between lean and harvest months	Water rice, chilli, onion, pickle	Water rice, chilli, onion, pickle	Rice and pulses	Water rice, chilli, onion, pickle	Other fruits and nuts collected from forest, country liquor	Water rice, fish, or fried vegetables
Food items eaten by children	Rice, dal, mashed vegetables, *khechudi*, *chatua*, pressed rice with sugar and banana, chapati with milk	Same as adults except for infants, for whom special formulation is given	Same as those eaten by adults	Same as those eaten by adults	Same as adults but in some cases *khechudi* or *pitha* is also given	Same as what mother eats	Same as what mother eats
Is dinner missed by children during lean months?	No	No	No	No	No	No	No
Food items eaten by children during lean months	Same as above or sometimes same as adults	Water rice, salt, onion	Water rice, salt, onion	Rice and pulses	Water rice, salt, onion	Mango, jackfruit	Water rice, fish, or fried vegetables

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District.

Table 18. Other meals in studied villages, Orissa, India, 2006.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Quantity of rice cooked for a family of five at normal times (grams/day)	2,000–2,500	2,500	2,250	2,000–2,500	2,500–2,700	1,750–2,000	2,400–2,800
Quantity of rice cooked for a family of five at lean times (grams/day)	2,000	2,500	2,000	1,500–2,500	2,000	1,000	2,000
What to do if no rice is available at home?	Borrow or purchase			Borrow or purchase	Purchase or borrow		
Do family members eat outside?	No	No	Yes, especially those going out for non-farm work	No	No	No	No
How many times a month?			20–25 days a month for wage earner				
Number of days a week lunch/dinner contains leafy vegetables	Almost every day	Almost every day	Almost every day	7–9 times	Almost all days	8–9 times	2–3 days
Number of days a week lunch/dinner contains fish?	2–4 times	2–4 times	2–3 times	2–3 times	Nil	Nil	5 days

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Table 18 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Number of days a week lunch/dinner contains meat/eggs	1–3 times for meat in a year and 2–3 times a month for eggs	7–8 times a year	Once a month	Once a month in one of the villages but once or twice a year in the other village	Nil	Once in the case of eggs; nil for meat	5–6 times a year
Does family consume lemon with food?	Yes, but not regularly	Yes, but not habitually	Not regularly	Yes, but not regularly	Yes	Nil	No
When the price of rice is high:							
Do households buy same amount of rice and decrease consumption of other foods?	Yes	Yes, but not habitually	Yes	Yes	Yes	Yes, because rice is the staple food[d]	Yes
Do households buy less rice and maintain intake of other food items?	No	No	No	No	No	No	No

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District. [d]Under BPL quota, the households can get rice with a very low price or sometimes 10 kg of rice free under the

households studied have a nutritional garden in their backyard, the use of vegetables in their diet is common. Eating fish at least two to three times in a week is observed in a majority of villages. Households living below the poverty line get subsidized or sometimes receive free rice (up to 10 kg per month) under the Annapurna scheme. As such, no further starvation was reported in poor communities. Intake of lemon is not a regular practice in any village.

Food acquisition and preparation. Decisions in buying rice are made by either the husband or wife or both but actual purchasing is dominated by the husband or male members of the household (Table 19). Extremely poor households purchased rice either on a daily or monthly basis from the PDS in all selected villages except in the mountainous forest-based village, where purchasing of rice is done on a weekly basis. Varieties of rice consumed by extremely poor households varied from village to village as per their availability. Mostly coarse-grain varieties such as CR 1001, Nalbainsi, Pateni, CR 1018, Matiya, Swarna, and Khandagiri are the most suitable varieties, preferred because of their suitability for water rice. No such difference was found between moderately poor and extremely poor households in variety selection. But, nonpoor households (relatively rich) preferred fine-grain quality such as Tulasi, Padmakeshari, Lalat, Swarna, CR 1014, Nail Jagannath, etc. Most households preferred to purchase milled rice rather than paddy. Milling of rice was done in commercial hulling mills in most cases. Traditional milling is still practiced in the mountainous forest-based village as a commercial mill is too far from the village.

Rice is normally cooked with excess water that is eventually drained out. The drained-out water is used for water rice preparation or for livestock feeding. In the mountainous village, excess water in rice cooking is used for making fermented rice. Usually, boiled and fried potato, onion, green chili, roasted eggplant and fish, dried fish, and pickles are eaten with water rice. No change in food preparation has been practiced among the poor families over time. However, in affluent families, wheat and wheat products, readymade foods, and processed foods are already being consumed (Table 19). Chapati has been introduced at dinner time in some families instead of eating rice. Children prefer to eat processed and ready-to-eat food. Varieties of curry and different types of food preparations (both vegetarian and nonvegetarian) have been introduced for the interest of housewives through audiovisual systems, newspapers, and magazines.

Rice varieties introduced in the communities were mainly used for home consumption. Informants claimed that there are not many restrictions during pregnancy although, in some areas, spices, water rice, and sour items are not allowed to be eaten even if someone feels hungry or desires to eat something. Also, intake of fish or nonvegetarian items is limited to avoid having a big baby that will make delivery difficult (Table 20). In short, pregnant women are deprived of nutritious food that is needed to have a healthy child. In some tribal villages, women are not allowed to take in iron and folic acid tablets (folifer) provided through Anganwadi workers as they think that the tablets will make the baby heavier in the womb. After delivery, many restrictions were observed in almost all villages. The intake of nonvegetarian food such as pumpkin, bitter gourd, radish, colocasia, poi (one type of creeper, green with a succulent stem),

Table 19. Food acquisition and preparation in the studied villages, Orissa, India, 2006.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Who decides about buying rice?	Husband, but husband and wife in one of the villages	Husband in two villages but wife in the other village	Husband	Wife in one of the villages and husband in the other village	Husband	Both husband and wife	Male members
Who actually buys rice?	Husband	Husband	Husband	Husband	Husband	Both husband and wife	Male members
Pattern of buying rice	Normally monthly basis or when money is available	Depending on the availability of money	Daily basis for wage earner, BPL card holders purchase from PDS on monthly basis	Mostly weekly except when purchased from PDS, which is done monthly	Extremely poor family purchases daily but the nonpoor purchase on a weekly or monthly basis	Weekly basis	Extremely poor family purchases on daily wage basis but the nonpoor purchase on a monthly basis
Rice variety usually consumed by extremely poor households	Rice from PDS and CR 1018	Matiya, Khajura, Oriyan, or whatever is harvested	BPL rice from PDS, Swarna	Lalat, Khandagiri, Swarna	CR 1001	Nal bainsi and Goti khalika	Pateni
Rice variety usually consumed by moderately poor households	1242, Swarna, CR 1018, and Nandikiri	Chakaakhi or whatever is harvested	BPL rice from PDS, Swarna, Azana	Swarna	CR 1001, Swarna	Lalat, Konark	Pateni

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Table 19 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Rice variety usually consumed by nonpoor households	Swarna, Lalat, Tulasi, CR 1014	Chakaakhi, Swarna, or whatever is harvested	Azana, CR 1014, Padmekeshari, Swarna	Swarna	Swarna, Nali Jagannath	Lalat, Konark	Pateni and Swarna
Do households buy paddy, store it, and mill it on a regular basis?	No, purchase rice directly	No, purchase rice directly	No, purchase rice directly. Only small proportion of households purchase paddy and mill rice	No, purchase milled rice directly	No, purchase milled rice directly from market/ village shop	No, purchase rice	No, purchase rice
Where is milling done?	Commercial hulling units in the village	Commercial hulling units in the village	Commercial hulling units in the village	Hulling units in the village	Commercial hulling units in the village	Both in commercial mills and at home	Commercial mills
If rice is purchased, do households purchase parboiled or nonparboiled rice?	Parboiled rice	Parboiled rice	Parboiled rice	Parboiled rice	Parboiled rice	Parboiled rice	Parboiled rice
Number of times rice is washed before cooking	Twice	Twice	Twice	Twice	Once	Twice	Twice

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Table 19 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Amount of water used in cooking rice	Always excess water is used for cooking	Excess water is drained	Excess water is drained	Always excess water is used for cooking	Proper amount of water is used so no need to drain excess water	Some amount of water is drained and is used for fermented rice	Excess water is drained after rice is cooked
Use of drained excess water	For livestock feed or use for *pakhala*	For feeding livestock or thrown away	For feeding livestock or thrown away	For preparing water rice and feed for livestock	If ever, used for feeding livestock or thrown away	For making liquor	Used for cattle feed
Are households aware of nutritional value of excess water from cooked rice?	Yes	No	Yes	Yes	No	No	Yes
Do households eat leftover rice (from previous dinner with water *pakhala*)?	Yes, for breakfast	Yes	Yes, for breakfast	Yes	Yes, for breakfast	Yes, for breakfast	Yes, for breakfast

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Table 19 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
What additional food items are eaten with *pakhala*?	Onion, chilli, pickled onion, green vegetables, roasted dried fish, roasted or fried vegetables, and salt	Onion, chilli, greens, fried or boiled potato, pickles, dried fish	Onion, chilli, green vegetables, roasted dried fish, roasted or fried vegetables	Onion, chilli, green vegetables, lemon, pickle, salt, roasted eggplant, fish	Onion, garlic, chilli, green vegetables, fried or boiled potato, some fried or roasted vegetables, pickles	Pickles, leafy vegetables, onion, dried tamarind	Potato and greens from kitchen garden, roasted or fried fish
Changes in cooking or food preparation pattern over time	No change for poor families. For affluent families, use of cooking oil and spices.	Not so many changes although in some households wheat products are gaining importance	Now more cooking oil and spices are used. Some instant noodles are also used.	No change	No change	No change	Yes, for those families whose members had gone outside the state for livelihood

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District.

Table 20. Preferred consumption characteristics in the studied villages, Orissa, India, 2006.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Varieties introduced in the community that are not used for home consumption	None	No	None	None	None	None	None
Food taboos in the village	No restriction during pregnancy but, during lactation up to 6 months, leafy vegetables, jackfruit, ripe mango, curd, and *khai* are restricted; no intake of nonvegetarian food after delivery	After delivery, no intake of nonvegetarian food; lactating women are advised to eat bottle gourd	During pregnancy, no spices and fermented foods are given. After delivery, no intake of nonvegetarian food is allowed	No intake of nonvegetarian food after delivery. For pregnant women, limited intake of nutritious food to avoid big babies	After delivery, no intake of foods that are believed to increase the incidence of cold; during pregnancy, limited intake of foods to avoid too big babies	During lactation, mushrooms, some vegetables, some pulses, leafy vegetables, ripe mango, and jackfruit are restricted	No fish or nonvegetarian food is given. Spices are also restricted until the baby is 6 months old. Ripe mango, jackfruit, green leafy vegetables, and dal are restricted.
Knowledge about good-quality diet and strategy to achieve it	Means consumption of milk and nonvegetarian food items and foods high in protein.	No common idea	Good diet means consumption of milk and protein-rich foods and other nonvegetarian foods	Means consumption of protein-rich food and nonvegetarian food items	No idea	No idea	Good diet and eating nonvegetarian foods. Fish is eaten regularly as it is plentiful and available in creeks and ditches.

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Table 20 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Number of months mothers exclusively breastfeed their children	6–7 months and maximum of 1 year	6–7 months	6–7 months	6–7 months	6–7 months	1 year	6–7 months
Age of children when they receive complementary foods	6–7 months or at 1 year	7–8 months	7–8 months	7–10 months	7–8 months	After 1 year	After 6–7 months
Foods used for complementary feeding	Roasted pressed rice with flour mixed with milk, commercial milk formula	Boiled pressed rice with milk, cooked rice with pulse water, boiled potato and papaya, biscuits, sagu	Cooked pressed rice flour with *amul*/milk, sagu water, vegetable soup	*Chura* with milk; rice flour cooked with milk or boiled water with sweeteners. Cow's milk and water are also given when mothers have no milk.	Fried pressed rice flour, sagu, boiled rice in liquid form, rice *jau*, *khechudi*, *pitha* in liquid form, biscuits, boiled papaya, potato, and tomato	Rice, biscuits, rice cakes, roasted rice paste	Pressed rice flour with milk, double cooked rice with pulse, *khechudi*, boiled vegetables, *mudhi* flour
Age of children when rice is introduced	1–2 years old	After 1 year	After 9 months	9–10 months	10–12 months	After 1 year	After 1 year

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Table 20 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Foods given to children below 6 years old	After they are 2 years old, children eat family diet in addition to *tochatua*, *jau* milk and sugar, biscuits	Cooked pulse and rice together, but children 1.5–2 years old are given adult diet	Normal adult diet	*Mudhi*, roasted pressed rice, boiled egg and vegetables; ORIMIX from the government	Cooked pulse and rice together; *pitha*, ripe banana with mashed rice, roasted/boiled maize, ripe mango and papaya, and milk	Sometimes fermented rice (*handia*) is given; no special diet is given to children	Normally, adult food is given to children above 2 years old
Why are these foods given?	Easily digestible, nutritious, increase immunity	Easily digestible and good for the health	Easily digestible and good for the health	Easily digestible and good for the health	Easily digestible and good for the health	It is believed that *handia* increases immunity against diseases	Easily digestible and nutritious
Age at which children start eating adult diet	2–2.5 years old	2–2.5 years old	1.5 years old	1.5–3 years old	2 years old	2 years old	2 years old
Are children fed at the same time as adults?	No	No	No	No	No	No	No
If not, how often do children eat?	4–6 times	5–6 times	4–5 times	5–6 times	5–6 times, whenever the child feels hungry or otherwise sitting with adult member	4–5 times in a day but no fixed time	5 times a day for small children but those above 2 years old eat together with adult members

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Table 20 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
How much milk do children drink in a day?	300–500 mL	200–500 mL	250 mL	250–300 mL if available	>50% of the children do not have access to milk	Nil	If available, maximum of 2 glasses
Foods given to children above 6 years old	Normal adult diet	Normal adult diet	Normal adult diet	Normal adult diet	Normal adult diet	Roasted rice cake, rice, and adult diets, including fermented rice	Normal adult diet but small fish are regularly given to make bones stronger
Why are these foods given?	Children are accustomed to normal adult diet	No common idea	No common idea	No need for special food for these children	No idea	Increase immunity and for fast growth	No consideration
Age at which children start eating adult diet	2–2.5 years old	2–2.5 years old	1.5 years old	1.5–3 years old	2 years old	2 years old	2 years old
Are children fed at the same time as adults?	Yes and when they feel hungry	Yes	No, about 4 times a day	Yes and when they feel hungry	Yes	No, 4–5 times a day	No, 4 times a day when the child is hungry
Do children get food in school?	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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Table 20 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
What foods do they get?	Mid-day meal	Mid-day meal	Mid-day meal	Mid-day meal	"Mid-day meal" at the primary level	Mid-day meal	Mid-day meal at which *khechudi* is given. Egg is provided once a week.
What happens if there is less food at home?	Eat water rice with onion, tamarind, or dried unripe mango	Eat water rice with onion, tamarind, or dried unripe mango	Households eat water rice with green vegetables. Also borrow or purchase rice.	Eat water rice with onion, tamarind, or dried unripe mango or *mudhi*	Children eat water rice along with onion, tamarind, or unripe mango or pickle	They go to the forest to find other food items	Borrow or buy rice
New ways of preparing food for children introduced in the community	Yes, through Anganwadi workers	No	Yes	None	No	No, but processed foods such as cakes, biscuits, and salty foods are now available in local shops.	No

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Table 20 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Describe the food preparation	*Chatua* with rice or pressed rice flour; cover the food while cooking, large cut of vegetables to avoid loss in nutrients while cooking	Some educated and economically sound families provide commercial milk formula	For children's food, the households are asked to prepare flour containing roasted or pressed rice, roasted wheat, roasted Bengal gram, peanut, and cashew kernel. The flour is mixed with milk or *amul*.	na	na	Readily available in local stores	na

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District.

all types of green leaves, dry fish, one type of catfish (Balia), puffed rice (*khoi*), sour foods, green gram, etc., is avoided. Ripe mango, ripe jackfruit, and some food items that are not easily digestible are also not given to lactating women as these food items are believed to give an upset stomach to babies that are breastfed by the mothers. In general, no intake of fish or nonvegetarian items is observed on Monday, Thursday, *sankranti*, and solar/lunar eclipse days due to traditional beliefs. Permissible foods are papaya, plantain, eggplant, drumstick vegetable (*Moringa oleifera*), bottle gourd, and potato with rice or chapati. Just after delivery, nursing mothers were given rice and dried ginger with *ghee* as a therapeutic diet. A quality diet means the consumption of milk, curd, *ghee*, egg, fish, meat, and other nonvegetarian items and vegetables.

Mothers exclusively breastfeed their children up to 6–8 months of age and after this complementary feeding starts. Although the complementary foods given to children varied from household to household in all selected villages, usually roasted pressed rice with milk, milk, commercial food such as Lactogen, Cerelac, Nestum, *sago* with milk, rice, boiled papaya, tomato, and mashed potato, etc., are given among children below 2 years old. Rice is introduced after 7 months to 1 year in most villages. At the age of 2, children started eating an adult diet when rice, pulse, boiled vegetables, rice cakes (prepared with rice and black gram powder either in frying or cooking in steam), pressed rice powder with milk, and chapati drenched in milk are given. These foods are considered easily digestible and good for health. Usually, children eat 4–5 times in a day in almost all villages. In addition, they eat with adults as and when they desire. Except in the mountainous forest-based areas, children are given at least 200–300 mL of milk in a day. Above 6 years old, children normally eat an adult diet.

In a mid-day meal program in primary school, rice and pulse with some vegetables are provided to each child. This consists of 100 g of rice, 15 g of pulse and vegetables, egg once a month, and some quantity of vegetable oil for cooking. At times when food is scarce, children eat water rice, onion, and pickle, which give very limited nutrients.

Intrahousehold food allocation. Foods are normally served individually but children often sit with older family members at one plate in almost all villages. Children and older male members of the household eat first and the daughter-in-law and mother-in-law eat last. Leftovers are kept for the next morning as water rice. If there is a shortage of rice mostly purchased or borrowed from neighbors, the female members starve or eat less food (Table 21). No special diet is served for pregnant women. But, for lactating women, special foods are given such as warm rice or *arhar* pulse (pigeon pea) with boiled vegetables. Sunthi powder (dried ginger) with ghee is advised to be eaten with warm rice by the mother-in-law. Sometimes, boiled sago with milk and boiled bottle gourd were given to lactating women for improving milk secretion.

Women do not have control over income except in the mountainous forest-based village, where women are the earning members of the family. In some villages, women are given money and have control over food expenditures. Certain foods are purchased because of food habits and seasonal availability. Among the food items purchased are oils, salt, certain spices, sugar, tea, and certain vegetables.

Table 21. Intrahousehold food allocation in the studied villages, Orissa, India, 2006.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Are meals served individually or is food eaten on a common plate?	Individually but children eat with older members on one plate, although a common plate in other villages	Individually except in some cases when children share with adult members	Individually	Individually	Individually but children often sit with older family members	Common plate for male and children	Mostly individually but children below 6 years old eat with adult members using common utensils
Do households eat meals together in one sitting?	No	No	No	No	No	Yes, in some cases	No
If not:							
Who eats first?	Old male members, male children	Old male members, followed by male children	Old male members, followed by male children	Children, followed by old male members	Most children, followed by older male members	Children, male members	Children and male members
Who eats last?	Female members	Female members	Female members	Daughter-in-law and mother-in-law	Daughter-in-law	Female members	Female members
What happens to leftover food?	Eaten by female members the next morning	Eaten by females the next morning	Eaten by female members the next morning	Eaten the next morning	Kept for the next day	Eaten by female members for breakfast the following day	Eaten by female members for breakfast

Continued on next page

Table 21 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
If there is a shortage of rice, what coping mechanisms do households use?	Purchase or borrow; otherwise, female members starve	Purchase or borrow or female members starve	Borrow or purchase	Purchase or borrow	Mostly borrow and take rice as payment for off-farm labor	Borrow from neighbors and go to the forest to collect roots and tubers	Borrowing from neighbors or purchasing rice in the market
Are there special foods for pregnant and lactating women?	Yes	No	Yes	No	No	No, but there are some restrictions	Not necessarily but advised to eat certain foods
If yes, what are these foods?	Ask to eat warm rice with boiled vegetables and a few spices only. At early stage of pregnancy, they are not allowed to eat water rice; bottle gourd for lactating women.	Advised to eat papaya and bottle gourd; warm rice with water and brinjal curry. In rich families, fruits are provided.	Garlic and ginger are prohibited	Ask to eat lots of green vegetables, papaya, and bottle gourd. *Badi besara* is given during lactation; ORIMIX is given after delivery.		Restricted diet for pregnant women so the baby would not grow big for easy delivery	Warm rice with boiled vegetables; boiled sagu and bottle gourd are eaten for improving milk secretion

Continued on next page

Table 21 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Do women have control over income?	No	No	No	No	No	Yes, because females are the earning members	No
Do women have control over food expenditures?	Yes	No	No	No	No	Yes	No
Why are certain foods purchased? And, which are not?	Based on food habits and purchasing capability; choice of family members	Depends on season, availability, and food habits	Depends on season and availability of food as well as food habits	Because certain foods are not produced so one needs to buy them (salt, tea, sugar, oil, certain spices)	Only potato is purchased and other food items in negligible amounts, including cooking oil, spices, and sugar	As per food habits	As per food habits

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District.

Willingness to pay for nutritious rice. By agro-climatic conditions, households from the coastal flood-prone, upland rainfed, and mountainous areas are willing to pay for a new rice variety that will prevent night blindness. In other settings, some villagers are willing to pay but others are not. This depends on their perceived prevalence of night blindness in their area. But, all communities were willing to pay 10–20% more for a new rice variety that will make pregnant women stronger (Table 22). A majority of the people are willing to use yellowish rice that will prevent child blindness. This is so because people preferred to consume yellowish rice on some special occasions by cooking rice with turmeric, sugar, and ghee. Dark-colored nutritious rice will also be consumed since most of the traditional varieties planted are dark or brown colored. The households were ready to accept dark-colored rice that will make pregnant women stronger, but it should be readily available and it also needs a proper information campaign before introduction. Its taste should not be different from that of existing available rice.

It was observed that food consumption patterns have been changing in all villages. The use of oil, spice, and sugar has increased considerably. Previously, only water rice was eaten as breakfast. Now, tea and puffed rice are the main breakfast. The use of ragi, maize, and other minor millets has also declined considerably. Trends of eating biscuits, nonvegetarian items, fast foods, and processed foods have emerged. The use of wheat items such as *suji*, *ata*, and *maida* (refined flour) has also increased over the years. Now, more oil and sugar are used, leading to gastric acidity and diabetes among the household members. Previously, there was a ban on cooking chicken, egg, and mutton in the household kitchen. Nowadays, women are no longer restricted on eating egg, chicken, and mutton.

Illnesses, chronic health problems, and episodes of illness. The rainy season followed by summer is the peak period for the occurrence of different diseases such as cold, cough, fever, diarrheal diseases, skin diseases, worm infestations, malaria, and pneumonia for all age groups (Table 23). The most common diseases for children are diarrheal diseases, cold, cough, pneumonia, skin diseases, worm infestations, malaria, etc. Cold, cough, pneumonia, and fever are common during the rainy season while diarrheal diseases and skin diseases are more common in summer. Body pain, fatigue, gynecological problems, migraine, gastritis, acidity, and gall stone have now become more common problems with women in every rural community as they are the most neglected people in society. Winter is the peak period of illness for women since, at that time, tedious farm operations such as cutting of paddy, bundling, and transporting are mainly done by women.

The children of all villages suffer from diarrhea due to water and food contamination and unsanitary practices such as playing with dirt, open defecation, putting fingers regularly into the mouth while playing, and eating food without washing the hands (Table 24). To prevent diarrheal diseases, the use of safe drinking water, preventing food contamination, keeping surroundings clean, and eating warm food, etc., are the perceived possible solutions. Frequent loose bowels, vomiting, and dehydration are the main symptoms of a child with diarrhea. In most cases, the mother practiced local remedies and consulted Anganwadi workers to give ORS (oral rehydrated solution).

Table 22. Willingness to pay for nutritious rice in studied villages, Orissa, India, 2006.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Would households be willing to pay for a new rice variety that will prevent night blindness?	No in one village and yes in the other village	Yes	No	No in one village but yes in the other	Yes	Yes	No if price is higher than the current price
If yes, what percent of current price?	10 for those who are willing to pay	10–20	–	5–10	10–15	10	–
Would households be willing to pay for a new rice variety that will make pregnant women stronger?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
If yes, what percent of current price?	5–10	20–30	10–15	10–15	20	10	10
Would households buy or consume yellowish rice that will prevent night blindness?	Yes, but needs proper information campaign before introduction	Yes, since most of the traditional varieties are brown or dark colored	Yes	No, since night blindness is not a health problem in the area	Yes, since most of the traditional varieties planted in the village are bold and brown or dark colored	Yes, if the price is low	Yes

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Table 22 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Would households buy or consume dark-colored rice that will make pregnant women stronger?	Yes, but needs proper information campaign before introduction	Yes, since most of the traditional varieties are brown or dark colored	Yes, but it should be readily available	Yes, but needs sufficient information campaign	Yes, since most of the traditional varieties planted in the village are bold and brown or dark colored	Yes	Yes
How do consumption patterns and intrahousehold food intake change over time?	Rice is affordable nowadays; mostly green vegetables are cultivated. Use of cooking oil, spices, and sugar became common now. Females are not eating eggs, chicken, and mutton.	Use of oil, spices, sugar, and wheat products increased considerably. Females have started to eat mutton and chicken.	Vegetable consumption increased due to increased income. More varieties of vegetables are available now. With increased consumption of wheat products, women are no longer restricted to eat egg, chicken, and mutton	Now, *mudhi* and tea are consumed at breakfast and use of ragi and maize declined. Buying of biscuits and wheat products is becoming common. Use of more cooking oil.	Use of cooking oil, spices, and sugar increased considerably. Females started to eat chicken and eggs. Use of wheat products has been increasing over the years.	Before, households depended on forest for food consumption. With the introduction of HYVs, rice availability increased and rice is now available as a staple. There is now increased use of cooking oil, spices, and sugar.	More cooking oil, spices, and nonvegetarian foods and sugar are consumed now. Red tea is a regular drink now. Consumption of wheat products has increased.

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District.

Table 23. Episodes of illness in the studied villages, Orissa, India, 2006.

Items	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Illnesses suffered by people in the community	Cold, cough, and fever leading to pneumonia, intestinal diseases, malaria, worm infection, migraines, hip and limb pain, diabetes, high blood pressure	Cold, cough, and fever leading to pneumonia, fatigue, intestinal diseases, filarial asthma, skin diseases, migraines, hip and limb pain, rheumatism, malaria, diabetes, high blood pressure	Diarrhea, cold, cough, and fever, pneumonia, fatigue, intestinal diseases, malaria, skin diseases, migraines, body pain, rheumatism, high blood pressure	Cold, cough, and fever leading to pneumonia, fatigue, diarrhea diseases, worm infection, skin diseases, rheumatism, and hip and limb pain	Malaria, cold, cough, and fever leading to pneumonia, typhoid, intestinal diseases, skin diseases, hip and limb pain	Malaria, diarrhea, dysentery, cold, cough, pneumonia, weakness, skin diseases	Cold, cough, fever, pneumonia, gastritis, weakness, malaria, typhoid, skin diseases, diabetes, hypertension, worm infection
Do the illnesses vary by season?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
If yes, what is the peak season of illness?	Rainy season	Rainy season	Rainy and winter seasons	Rainy season	Rainy season	During rainy and summer seasons	Rainy season
Illnesses suffered by infants?	Cold, cough, and fever leading to pneumonia, diarrhea, indigestion, worm infection, measles, skin diseases	Cold, cough, and fever leading to pneumonia, dysentery, diarrhea, vomiting, low appetite, indigestion, measles, skin diseases	Diarrhea, cold, cough, and fever leading to pneumonia, measles	Cold, cough, and fever leading to pneumonia, diarrheal diseases, worm infection, skin diseases	Cold, cough, and fever leading to pneumonia, malaria, dysentery, diarrhea, measles, skin diseases	Malaria, diarrhea, cold, cough, pneumonia, skin diseases, and measles	Diarrhea, common cold, fever, pneumonia, measles, skin diseases

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Table 23 continued.

Items	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Do the illnesses vary by season?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
If yes, what is the peak season of illness?	Rainy season	Rainy season and winter	Rainy season	Rainy season	Rainy season	Rainy season	Common cold during rainy season, diarrhea during summer and rainy season, other illnesses are not seasonal
Illnesses suffered by children?	Cold, cough, and fever leading to pneumonia, dysentery, diarrhea, worm infection, measles, skin diseases, PEM, malaria	Cold, cough, and fever leading to pneumonia, dysentery, diarrhea, worm infection, measles, skin diseases	Diarrhea, cold, cough, and fever leading to pneumonia, measles, worm infection, skin diseases	Cold, cough, and fever, leading to pneumonia, diarrheal diseases, worm infection, skin diseases, measles	Cold, cough, and fever leading to pneumonia, malaria, dysentery, diarrhea, typhoid, measles, intestinal parasites, skin diseases	PEM, malaria, diarrhea, dysentery, cough and cold, pneumonia, skin diseases, worm infection	Cough and cold, fever, diarrhea, pneumonia, measles, worm infection, skin diseases, malaria, jaundice
Do the illnesses vary by season?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
If yes, what is the peak season of illness?	Rainy season	Rainy season and winter	Rainy season	Rainy season	Rainy season	Rainy season and sometimes summer	Rainy and summer seasons

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Table 23 continued.

Items	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Illnesses suffered by women	Fatigue, migraines, intestinal problems, body pain, hip and limb pain, rheumatism, gynecological problems, high blood pressure, asthma	Fatigue, migraines, body, hip, and limb pain, rheumatism, gynecological problems, intestinal problems, asthma, high blood pressure	Fatigue, migraine, hip and limb pain, gynecological problems, gastric problems and acidity, high blood pressure	Fatigue, migraines, body, hip, and limb pain, rheumatism, gynecological problems, intestinal problems, asthma	Malaria, typhoid, fatigue (anemia) body pain, hip and limb pain, rheumatism, gynecological problems, asthma	Malaria, body pain, anemia, migraines, rheumatism, skin diseases, gum disease	Intestinal diseases, body and joint pain, cold, cough, fever, gynecological problems, weakness, malaria, migraines, skin diseases, diabetes, hypertension, jaundice, gall stone
Do the illnesses vary by season?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
If yes, what is the peak season of illness?	Rainy season	Rainy season and winter	Rainy season and winter	Winter	Rainy season up to winter	Rainy season	Rainy season

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District.

Table 24. Sources of illnesses and responses in the studied villages Orissa, India, 2006.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Diarrhea							
Why or how do children in the community get diarrhea?	Water and food contamination and playing with soil, presence of houseflies, unsanitary practices	Water contamination, fly nuisance, unsanitary practices	Water contamination and playing with soil, presence of houseflies	Water contamination and playing with soil, food contamination due to houseflies, unsanitary practices	Poor sanitary practices, drinking water from dug well	Water pollution, eating stale foods, excessive eating of jackfruit and ripe mango, and presence of houseflies at home	Poor sanitation, soil and water contamination
What can be done to avoid getting diarrhea?	Prevent water and food contamination, cover foodstuffs, eat warm food and boil water for drinking, follow sanitary practices	Prevent food and water contamination, provide warm food and boiled water	Prevent water and food contamination, cover foodstuffs, boil water for drinking	Prevent food and water contamination	Prevent food and water contamination	Keep surroundings clean and follow sanitary practices	Use safe drinking water, avoid food from being contaminated
What are the symptoms of a child with diarrhea?	Frequent shaking, vomiting, dehydration	Frequent shaking, dehydration	Frequent shaking, vomiting, dehydration	Frequent shaking with mucus, dehydration	Frequent shaking, dehydration	Watery stool and vomiting	Shaking and vomiting
What do mothers do when their children get diarrhea?	Check food intake. Ask Anganwadi workers for ORS and medication.	Medication	Provide children with ORS	Consult Anganwadi workers and ANM and tablets provided by the health center	Going to *kabiraj* and homeopaths and in serous cases to the hospital	Mothers give local remedies and in serious cases go to Anganwadi worker for ORS packets	Go to Anganwadi worker and ask for advice and ORS

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Table 24 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
What foods are given to children when they have diarrhea?	Boiled rice with lemon, lemon water with sugar and salt, or ORS, in one of the villages when no food is given to children	Boiled pressed rice with lemon, *misri* water, or ORS	Liquid food, barley, sagu water	Boiled rice with lemon, lemon water with sugar and salt, or ORS	Boiled mashed rice/rice with lemon, liquid diet such as sagu water, lemon water	No food is given when children have diarrhea	Liquid food
How do mothers know when children are seriously ill?	Fainting, drowsiness, vomiting, no appetite, shrunken eyes	Fainting, drowsiness, excess vomiting, no appetite	Fainting, drowsiness, vomiting, no appetite	Frequent shaking with mucus, drowsiness, excess vomiting, no appetite	Fainting, drowsiness, excess vomiting	Drowsiness, excess thirst, weakness, speechless	Drowsiness, dryness of mouth, weakness
Where do they go for treatment or advice and whom do they see?	Nearest hospital and private doctors	ANM, hospital at block headquarters	Consult Anganwadi workers or go to hospital	Anganwadi center, ANM centers, and hospital	Hospital at block headquarters	Nearest hospital	Nearest hospital
What is the purpose of ORS?	Prevent dehydration, excess loss of water from body	Prevent dehydration and provide supplemental essential nutrients	Prevent dehydration and provide supplemental essential nutrients	Prevent dehydration and provide supplemental essential nutrients	Rehydration and supplemental essential nutrients	Prevents diarrhea	Prevents dehydration

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Table 24 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Pneumonia							
Why or how do children in the community get pneumonia?	Exposure to rain and cold weather, contact with infected person	Exposure to rain and cold weather, bathing in dirty streams and ponds	Exposure to rain and cold weather, contact with infected person	Exposure to rain and cold weather, contact with infected person	No idea	Excess bathing in the rain	Excess bathing, exposure to rain, close contact with ill person
What can be done to avoid getting pneumonia?	Avoid excess bathing, cover body when going outside	Not venturing out on rainy days or in cold weather, keep children away from infected persons	Protect from cold and rain, avoid contact with ill persons	Avoid cold water	No common idea	Avoid excess bathing	Avoid excess bathing
What are the symptoms of a child with pneumonia?	Cold, cough, fever, frequent and heavy breathing, heavy coughing	Cold, cough, fever, breathing problems	Cold, cough, and fever	Cold, cough, and fever	Cold, cough, and fever, excessive sneezing, running nose	Fever, cold, throat infection	Fever, cold, high respiratory rate, difficulty in breathing
What do mothers do when their children get pneumonia?	Massaging with garlic and mustard oil; giving ginger or *tulasi* juice with honey; homeopathic treatment	Massaging with warm fried garlic and mustard oil; giving ginger juice with sweeteners	Massaging with garlic and mustard oil; giving ginger or *tulasi* juice with honey	Massaging with warm mustard oil, providing ayuvedic preparations	Massaging with garlic oil, salt massages, giving children ginger or lemon juice with honey	Massaging kerosene oil, *karanj* oil on throat and feet	Massaging with mustard and garlic paste; giving children ginger and *tulasi* juice with honey

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Table 24 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
What foods are given to children when they have pneumonia?	Mostly hot and warm food and any liquid or milk	Mostly hot and warm food	Mostly hot and warm food	Mostly hot and warm food	Hot and warm food	Tea liquor, fermented rice	Warm liquid food
How do mothers know when children are seriously ill?	Severe cough, choking of respiratory tract, difficulty in inhalation	Severe cough, choking of respiratory tract, difficulty in inhalation	Severe cough, choking of respiratory tract, no appetite, fainting	Severe cough, choking of respiratory tract, difficulty in inhalation	Choking of respiratory tract, difficulty in breathing, severe cough	When child becomes unconscious; when child respirates frequently	Child respirates frequently, cannot eat, choking of respiratory tract
Where do they go for treatment or advice and whom do they see?	Hospitals and doctors at block headquarters and also private doctors	Doctors at block headquarters; ANM center	Consult Anganwadi workers, doctors, and homeopaths	Anganwadi workers in the village, ANM center	Doctors at block headquarters	Hospital	Hospital

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Table 24 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Night blindness							
Are there children or adults in the community who have problems with eyesight at night?	2–3 persons	Very few cases	Very few cases	Very few cases	Rare	2–3 persons	No
Are the people aware of fortified wheat (*ata*)?	No	No	No	No	No	No	No
Is there a government program distributing vitamin A-enriched food to children in school?	Yes, vitamin A prophylaxis under ICDS program and immunization program	Yes, vitamin A drops are administered along with immunization program.	Yes, vitamin A drops are administered together with immunization program.	Yes, vitamin A drops are administered along with immunization program.	Yes	A prophylaxis program under ICDS	Vitamin A prophylaxis under the ICDS program
If yes, how many days do children get them?	Every 6 months	No answer	No mention	Once a month	No idea	Every 6 months	Every 6 months

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District.
[c]Consists of Belpadar and Haldi villages in Balangir District.

Usually, liquid food such as *sago*, pressed rice with lemon, lemon, and *misri* water are given to children with diarrhea. In severe cases, drowsiness, excess thirst, weakness, excess vomiting, and sometimes fainting are observed by the mothers. In this situation, children are taken to the nearest hospital or doctor. The households know that the purpose of giving ORS is to prevent dehydration and supplement essential nutrients for the child.

Children of these communities are believed to get pneumonia through exposure to rain and cold weather, excess bathing in dirty ditches, ponds, and contamination through infected persons. To prevent pneumonia, excess bathing should be avoided and the body should be kept covered with clothes when going outside. In addition, massaging should be done with warm mustard oil with garlic and kerosene oil on the feet and throat. Sometimes, ginger and lemon juice with honey and hot and warm foods are given to children suffering from pneumonia. Choking of the respiratory tract, difficulty in breathing, and severe cough are the symptoms of serious cases of pneumonia observed by mothers. At that time, they are referred to the hospital (Table 24).

Very few cases of night blindness are observed in all villages. The communities in some agro-climatic conditions gave positive responses regarding good foods that are required to have good eyesight. No fortified wheat is available in any of the communities studied but vitamin-A solution is given to the children at the time of immunization and a vitamin-A prophylaxis program through ICDS at 6-month intervals (Table 24).

Chronic health problems. Fatigue due to low hemoglobin, body and limb pain, cough, cold, fever, gynecological problems, acidity, malaria, and migraines are chronic health problems observed among women. Educated people with exposure to a health awareness campaign had an idea about the foods that make pregnant women strong. In some agro-climatic settings, households have the idea that milk, fish, meat, fresh vegetables, pulses, and fruits are ideal foods for pregnant women (Table 25).

Cough, cold, diarrheal diseases, worm infestation, skin diseases, and PEM are the most common diseases among children. Poor sanitation, improper child care, and eating contaminated food are the major factors contributing to children getting sick easily. Nobody was giving boiled water to the children in all the study villages. In fact, sanitation conditions in the communities are perceived to be very poor by the key informants. Men and women also have very poor access to sanitary latrines (Table 25).

Needed changes for key sanitary measures in the villages include having clean surroundings, clean clothing, and brushing teeth every day. Improving sanitation, eating good-quality food, regular health checkups, and early response to disease occurrence are possible steps to make children and women healthier.

An immunization program, iron tablet supplementation, provision of preventive and curative medicines, a vitamin-A prophylaxis program, a health and sanitation awareness program, growth monitoring, and referral services are the existing short-term interventions through the Anganwadi centers under the ICDS program. Some 50–80% of the women have access to the program in all villages except in the mountainous

Table 25. Perceptions of chronic health problems in the studied villages, Orissa, India, 2006.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Chronic health problems							
What are the chronic health problems among women?	Fatigue, anemia, migraines, body pain, cold, cough, and fever, rheumatism, asthma, gynecological problems, gastric acidity, skin diseases	Fatigue, anemia, migraines, body pain, cold, cough, and fever, rheumatism, asthma, gynecological problems, gastric acidity, skin diseases	Fatigue, anemia, filarial fever and pain, gynecological problems	Fatigue, anemia, migraines, body, hip, and limb pain, cold, cough, and fever, rheumatism, gastric acidity, asthma, and skin diseases	Fatigue, anemia, migraines, body and limb pain, cough, cold, and fever, rheumatism, gynecological problems, gastric acidity, asthma, gall stone, and skin diseases	Fatigue, malnutrition, body pain, migraines, malaria	Fatigue, gastric acidity, body pain, migraines, jaundice, typhoid, malaria
Are the people familiar with foods that make pregnant women strong?	Some are aware; vegetables, milk, pulses, fish	30–50% are aware	Yes. Foods include green vegetables, carrots, milk, fish, and pulses	Very few families have knowledge about good foods for pregnancy	No, but vegetables are given	No idea	Yes, such as fish, milk, vegetables

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Table 25 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
What are the chronic health problems among children?	Cough and cold, diarrhea, worm infection, PEM, skin diseases, malaria	Cold, cough, and fever leading to influenza, diarrhea, worm infection, measles, skin diseases	Diarrhea, cold, cough, and fever, worm infection, measles, skin diseases	Cold, cough, and fever leading to pneumonia, diarrheal diseases, worm infection, measles, malaria, typhoid, skin diseases	Cold, cough and fever leading to pneumonia, diarrhea/dysentery, worm infection, measles, skin diseases	PEM, malaria, diarrhea, cold, cough, fever, pneumonia	Diarrhea, cold and cough, upper respiratory ailments, measles, worm infection
Sanitation							
Factors that contribute to why children get sick easily	Playing with soil, eating contaminated food, unsanitary practices, improper child care	Poor sanitation, unsanitary practices	Poor sanitation, improper child care	Poor sanitation and sanitary practices, eating contaminated foods	Very poor sanitary practices, not using clean clothes and beddings, drinking unclean dug-well water	Playing with soil, eating any kind of food, open defecation	Poor sanitary practices, playing with soil
Is water boiled or filtered before drinking?	No	Very rarely and only when ill	No	No	No	No	No
Do women and men have access to sanitary latrines?	Only those who have latrines	No	No	No	No	No latrines in the village	No latrines

Continued on next page

Table 25 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Gauging felt needs							
What areas would be changed to make children and women healthier	Improving sanitary conditions and vigorous health education and awareness campaign, early response to illnesses	Improving sanitary conditions, health awareness campaign	Improving sanitary conditions and vigorous health education and awareness campaign	Improving sanitary conditions and practices, provision of ORIMIX to children	Improving sanitary conditions through health education program and awareness campaign	Food and sanitation	Eating good food and improving sanitation practices
What are the existing health programs?	Family planning, iron supplementation, immunization, safe motherhood, vitamin A prophylaxis, mid-day meal program	Immunization program, vitamin and iron tablet supplementation, provision of ORIMIX, mid-day meal program in primary school	Immunization, iron supplementation, provision of rations to elderly people, and mid-day meal program in primary school	Immunization program, iron tablet supplementation, provision of ORIMIX, mid-day meal program in primary school	Immunization, iron tablet supplementation, provision of preventive and curative medicines, mid-day meal program in primary school	Providing iron and folic acid tablets and tetanus injection among pregnant women	Program of Anganwadi centers for pregnant women
Access of women to the programs	About 70% are using the program	About 50–80% have access	50% of women have access to the program	75–80% of women have access to the program	60%	20% only due to lack of awareness and official apathy	No information

Continued on next page

Table 25 continued.

Item	Agro-climatic conditions						
	Coastal irrigated[a]	Coastal rainfed flood-prone[b]	Coastal rainfed drought-prone	Upland rainfed drought-prone[c]	Upland rainfed	Mountainous forest-based	Coastal rainfed saline
Do people go to the health center?	Yes, when necessary	Yes	Yes	Yes	Yes	No	Yes
What changes are needed in the health centers?	Attitudinal change among health workers, cleanliness of hospital premises, availability of low-cost medicines, and increase in number of staff	Attitudinal change among health workers, cleanliness of hospital premises, availability of low-cost medicines, and increase in number of staff	Attitudinal change among health workers, cleanliness of hospital premises, provision of cheap medicines, regular visits by doctors	Attitudinal change among health workers, cleanliness of hospital premises, provision of cheap medicines, increase in number of paramedical staff	Attitudinal change among health workers, cleanliness of hospital premises, increase in number of health personnel, availability of low-cost medicines	There should be a health center in the village. Medical officials should be available and provision of free medicines.	Health centers should have adequate and available staff

[a]Consists of Salijanga Village in Jagatsingphur District and Athantara Village in Cuttack District. [b]Consists of Alikanta, Kurunia, and Thailo villages in Jagatsingphur District. [c]Consists of Belpadar and Haldi villages in Balangir District.

forest-based village with very minimal (only 2%) access due to a lack of awareness and official apathy. Attitudinal change among health workers, cleanliness of hospitals, more availability of low-cost medicines, an increased number of paramedical staff, and regular visits by doctors are the changes needed in health centers (Table 24).

Household survey results

Socioeconomic characteristics of the respondents. A total of 368 respondents with children under 5 from 10 villages under different agro-climatic situations in Orissa were surveyed. Almost all the respondents were females except in the coastal irrigated and mountainous forest-based areas, with 3% and 6% male respondents, respectively. Out of the total respondents, the majority were married and 19 to 65 years old (Table 25). The average family size is highest (6.58) in the coastal irrigated villages but lowest (5.24) in the mountainous forest-based village, where the married couple is supposed to stay separately from their parents or from other members of the family although very few stay with either the mother or father. Educational status is better in coastal areas (Salijanga and Athantara) but is lowest in mountainous forest-based Kasada Village, with tribal-dominated households.

Of the total family members, more than 40% are dependents of the working members of the households. Major occupations are agricultural production, agricultural laborer, and nonfarm worker. In the upland rainfed areas, *bidi* making is another important source of income, whereas, in the mountainous forest-based village, working at mining sites is also an important occupation (Table 26).

Types of houses and sanitary conditions. A *kutcha* house with many rooms is the common dwelling in all villages. This is followed by *pucca* houses in the coastal rainfed flood-prone, coastal irrigated, and upland rainfed areas (Table 27). More pucca houses were constructed in the coastal belt after the super cyclone in 1999 when these villages were severely affected and almost all the mud and thatched houses were flattened. A semi-pucca house is also common in the upland and only one temporary *jhupri* is found in coastal irrigated areas. A majority of the households do not have sanitary latrines and only a few in the costal areas have access to one. Tube wells are the major source of drinking water in all households except in the mountainous forest-based village, where households depend on rivers and dug wells for their water source (Table 27).

Health conditions, prevalent diseases, and working family members and mortality. Health status was collected from the respondents by recalling the illnesses suffered during the previous month. A majority of the working family members were reported to be healthy, with the highest percentage reported by households in upland rainfed drought-prone villages, whereas occasional sickly members were more prevalent in mountainous forest-based areas, people from coastal rainfed-drought prone areas were frequently sick, and the most disabled people came from upland drought-prone areas (Table 28). Among the prevalent diseases are respiratory-related ailments (i.e., cough, cold, and fever) and gynecological problems among women at all sites. Rheumatism and muscular pain are also high among adults and malnutrition among children in the study communities. This may be due to the heavy workload during busy seasons.

Table 26. Socioeconomic characteristics of respondents in the studied villages, Orissa, India, 2006.

Item	Coastal irrigated	Coastal rainfed drought-prone	Coastal rainfed flood-prone	Mountainous forest-based	Upland rainfed	Upland rainfed drought-prone
Number of respondents	104	52	52	51	56	53
Age (years)	31.50	30.48	28.00	27.02	26.70	26.83
Range	(19–65)	(19–70)	(20–38)	(17–47)	(18–38)	(19–40)
Gender (% of respondents)						
Females	97	100	100	94	100	100
Males	3	0	0	6	0	0
Status (% of respondents)						
Married	98	96	100	96	96	100
Divorced/separated	0	0	0	2	0	0
Widow/widower	2	4	0	2	4	0
Educational attainment (no. of years of schooling)						
Mean	6.97	7.68	7.71	3.94	6.64	7.56
N	90	31	38	50	34	16
Range	(0–15)	(2–15)	(3–15)	(0–10)	(2–12)	(3–15)
Average (all)	6.03	4.58	5.63	3.86	4.03	2.28
Family size						
Mean	6.58	5.12	6.90	5.24	6.00	5.96
Range	(2–16)	(3–13)	(3–12)	(2–9)	(3–14)	(3–14)
Main occupation of working members (%) (over total number of working members)						
Owner-farmer	43	28	64	59	67	52
Agricultural laborer	31	48	20	9	38	38
Sharecropper	30	46	17	0	9	10
Nonfarm labor	3	69	0	11	10	34
Business/ shopkeeping	8	17	18	6	4	9
Houseworker	9	4	10	1	5	10
Skilled worker	12	7	10	2	2	6
Bidi making	0	0	0	0	25	0
Mine labor/iron worker	0	0	0	15	0	0
Others	9	22	13	6	8	6

Table 27. Household type and availability of sanitary latrine and source of drinking water in the studied villages, Orissa, India, 2006.

Item	Coastal irrigated	Coastal rainfed drought-prone	Coastal rainfed flood-prone	Mountainous forest-based	Upland rainfed	Upland rainfed drought-prone
Number of respondents	104	52	52	51	56	53
House type						
Jhupri	1	0	0	0	0	0
Katcha with many rooms	36	60	42	65	39	66
Katcha with single room	9	23	2	27	20	13
Pucca	36	10	46	0	21	9
Semi-pucca	19	8	10	8	20	11
Is there a sanitary latrine in the homestead?						
No	82	83	98	100	100	100
Yes	18	17	2	0	0	0
Source of drinking water						
Dug well	3	58	0	24	98	2
Pond/river	0	0	0	76	0	0
Tube well	97	42	100	0	2	98

Lifestyle-attributable diseases such as diabetes, heart disease, and hypertension have been increasing in coastal irrigated areas and rainfed flood-prone areas due to changing food habits toward oily and spicy foods along with sedentary work. A higher percentage of malaria is reported in upland rainfed areas and mountainous forest-based areas than in other villages since the conditions in these areas are conducive as a habitat to malaria-carrying mosquitoes. Other diseases such as jaundice, dental ailments, kidney disease, etc., were minimal in the study areas. The percentage of family members with night blindness was also minimal.

Due to illnesses, working members of the households missed a maximum average of 4.5 days in a month. However, by specific households, the number of days that work is missed can reach 30 days. This situation, when properly valued, can have serious implications for household income and its effect on nutritional well-being.

Pregnancy-related information. In all villages, the average number of pregnancies during the past five years ranged from 1 to 3. Pregnant women have also suffered from several illnesses. In general, more women from upland and mountainous areas suffered more illnesses than those from coastal areas. A higher percentage of women in all villages suffered from fatigue, body pain, influenza, vomiting, nausea, and gastritis.

Table 28. Health conditions and prevalent diseases of working family members, Orissa, India, 2006.

Item	Coastal irrigated	Coastal rainfed drought-prone	Coastal rainfed flood-prone	Mountainous forest-based	Upland rainfed	Upland rainfed drought-prone
No. of working family members, excluding youngsters, students, housewives	259	83	146	127	140	134
Health status of family members who are working (%)						
Healthy	71	69	65	31	66	78
Occasionally sick	26	29	21	67	21	11
Frequently sick	2	2	13	2	13	10
Disabled	0	0	1	0	1	1
Type of illness (%) (some exhibit more than one disease)						
Healthy	59	53	64	23	46	66
Gynecological problems	11	11	12	17	9	3
Cold, cough, etc.	19	19	8	31	18	13
Rheumatism and body pain	7	7	12	24	9	10
Malnutrition	11	7	8	20	7	16
Lifestyle disease	4	1	4	4	4	1
Diarrheal disease	4	1	1	7	0	0
Malaria	2	5	2	24	24	1
Skin and other infections	1	1	1	4	0	1
Asthma	0	0	3	0	0	1
Other disease	4	4	3	9	5	2
Night blindness in the family (%)						
Yes	3.5	2.4	1.4	6.3	0.0	0.7
Average number of days unable to work due to illness						
Mean (total no. of workers)	0.4	2.1	1.5	1.8	2.4	1.1
Mean (excluding healthy)	0.9	4.5	4.2	2.4	4.4	3.4
N (excluding healthy)	107	39	52	98	76	45
Minimum-maximum	(0–19)	(0–25)	(0–30)	(0–15)	(0–15)	(0–15)

Anemia was highest in mountainous forest-based areas, followed by those from the upland drought-prone households (Table 29). During pregnancy, diarrhea was more common in the coastal rainfed drought-prone areas and mountainous forest-based areas.

A majority of the women received medical care, iron, and vitamin A supplementation during pregnancy except in the mountainous forest-based areas, where only a small number of the households received such medical assistance (Table 29). More babies in the coastal areas are delivered in hospitals and clinics than in upland communities, where deliveries are attended to by older women at home. This usually resulted in infant mortality at birth and maternal mortality during deliveries. Out of the four maternal mortality cases, 50% were reported from the mountainous forest-based areas and others were from the coastal irrigated and upland rainfed drought-prone villages. All maternal deaths were in the age range of 21–25.

Mortality and cause of death in the family. Over the last five years, at least one death occurred among the households in each agro-climatic setting. Total deaths ranged from 8 to 28 persons in 7 to 25 households. Those who died were relatively old, with age at death being 49–65. However, the highest reported causes of death

Table 29. Pregnancy-related information in the studied villages, Orissa, India, 2006.

Item	Coastal irrigated	Coastal rainfed drought-prone	Coastal rainfed flood-prone	Mountainous forest-based	Upland rainfed	Upland rainfed drought-prone
Number of pregnancies over the last five years?						
Average	1.38	1.47	1.31	1.55	1.45	1.4
N	104	51	52	51	56	53
Did woman suffer from health problems during pregnancy? (%)						
No	20	47	48	0	25	21
Yes	80	53	52	100	75	75
Illness during pregnancy (% of those who answered yes)						
Fatigue	58	96	89	67	83	93
Weakness	31	0	30	16	21	18
Rheumatism, body pain	14	19	7	25	24	40
Influenza	13	26	22	6	24	13
Vomiting, nausea, gas pain, gastritis, stomach pain	40	15	4	63	12	8
Anemia	12	0	0	31	2	5
Migraines	13	19	4	2	2	0
Loss of appetite	10	0	0	6	0	0

Continued on next page

Table 29 continued.

Item	Coastal irrigated	Coastal rainfed drought-prone	Coastal rainfed flood-prone	Mountainous forest-based	Upland rainfed	Upland rainfed drought-prone
Edema (swelling)	6	11	0	16	0	8
Bleeding	2	0	4	0	0	3
Malaria	0	4	0	37	29	3
Diarrhea	2	19	0	4	0	0
Other illnesses	10	11	11	6	10	8
Did woman receive medical care during pregnancy? (%)						
No	29	24	15	98	21	4
Yes	71	76	85	2	79	96
Did woman take iron supplementation during pregnancy? (%)						
No	14	18	15	82	25	4
Yes	86	82	85	18	75	96
Did woman take vitamin supplementation during pregnancy? (%)						
No	38	22	13	96	30	6
Yes	62	78	87	4	70	94
Where was baby delivered? (%)						
Clinic/hospital	61	45	77	12	18	57
At home under care of elderly woman	12	43	4	82	66	28
At home by midwife	26	10	17	6	13	6
Delivery occurred in less than 9 months	2	2	2	0	4	6
Age of the woman at death (years)						
Age	24	0	0	24.5	21	0
N	1	0	0	2	1	0
Did the pregnancy result in stillbirth? (%)						
Abortion	2	0	0	0	0	0
No	96	96	98	96	96	89
Yes	0	2	0	4	0	5
No answer	2	2	2	0	4	6

were stillbirth and ailments of children under age 5, especially in the mountainous forest-based village. Natural death or old age and lifestyle-related diseases came to be the highest causes of death among adults, although malaria was the highest reported cause of mortality in the mountainous and upland communities (Table 30).

Nutritional status and feeding of children under 5. Out of 368 households of 10 villages, 543 children were below 5 years old, with at least one child per family. The immunization rate was up to 99% in all villages except the mountainous forest-based village of Kasada, with only 61%. Above all, the coverage of immunization under the ICDS was almost satisfactory. The children are weaned from breastfeeding at least above the age of 2 although breastfeeding up to a later age (43 months) was observed in Kasada. A majority of the children eating food with the family was observed in upland rainfed and mountainous forest-based areas (Table 31). After weaning from breastfeeding, children are given supplementary foods. Exclusively breastfed children were more in upland rainfed drought-prone villages, whereas a higher percentage of children receiving only supplementary feeding were from the coastal irrigated and mountainous forest-based areas. High percentages of children whose weights were below the weight-for-age standard were observed in the mountainous forest-based village (79%) and coastal rainfed drought-prone (70%) areas while the lowest percentages of children below the weight-for-age norm were found in upland rainfed drought-prone and coastal irrigated areas. The highest percentage of children who are short for their age was found in the mountainous forest-based village. This indicates chronic malnutrition among the children from this area.

Food pattern of the household. Rice-dominated food was observed in all villages as rice is the staple food in Orissa. Water rice, puffed rice, pressed rice, and rice cake (*pitha*) are very common in almost all rural households. Consumption of water rice with vegetables was reported most in upland rainfed areas, whereas water rice with nonvegetarian items was more common in the coastal rainfed flood-prone village as it is located near the river where fish are caught. In poorer households, water rice with onion, green chili, and pickle was the usual meal. Before breakfast, tea with puffed rice or pressed rice is consumed in the early morning prior to a heavy breakfast at mid-morning, practiced in a majority of the villages (Table 32).

For lunch, rice with vegetable curry, rice with nonvegetarian items with pulse and vegetables, and rice with dalema (a combination of pulse and vegetables) were the food combinations found in the villages. Again, meal patterns differ a lot across villages and agro-climatic situations. The combination of rice, pulse, and vegetables was observed the most in the villages under study. Water rice with vegetables was highest in upland areas during lunch, whereas, in the mountainous forest-based area, combinations of rice and vegetables are commonly eaten.

At dinner, rice with vegetables and other food items such as fish was common in all villages except that the number of observations differs. Eating of chapati has been increasing in the rural areas (Table 32). Meat consumption is not common among the households surveyed. Meat is not a component of their diet except during festivals and special occasions.

Table 30. Mortality and cause of death in the family in the studied villages, Orissa, India, 2006.

Item	Coastal irrigated	Coastal rainfed drought-prone	Coastal rainfed flood-prone	Mountainous forest-based	Upland rainfed	Upland rainfed drought-prone
Number of respondents	104	52	52	51	56	53
Number of households with family member who died	21	11	7	13	25	13
Mean age of family member who died	63.46	65.55	64.13	48.67	53.84	57.75
Cause of death (% over total no. of deaths)						
Natural death	13.6	16.7	12.5	0.0	17.9	28.6
Lifestyle disease	13.6	25.0	37.5	6.7	3.6	7.1
Malaria	0.0	0.0	0.0	20.0	14.3	0.0
Paralysis	4.5	0.0	12.5	0.0	14.3	7.1
Diarrheal disease	9.1	16.7	0.0	0.0	3.6	0.0
Cancer	13.6	0.0	0.0	0.0	3.6	7.1
Tuberculosis	0.0	0.0	0.0	0.0	3.6	21.4
Pneumonia, cold, and cough	0.0	0.0	0.0	6.7	3.6	7.1
Accident	4.5	0.0	0.0	0.0	3.6	0.0
Gastric and related problems	0.0	0.0	12.5	0.0	0.0	7.1
Rheumatism/body pain	4.5	8.3	0.0	0.0	0.0	0.0
Sun stroke	0.0	0.0	12.5	6.7	0.0	0.0
Mental depression/ disease	0.0	8.3	0.0	0.0	0.0	0.0
Asthma	0.0	0.0	12.5	0.0	0.0	0.0
Polio patient	4.5	0.0	0.0	0.0	0.0	0.0
Tetanus	0.0	8.3	0.0	0.0	0.0	0.0
Stillbirth and under 5 years old	31.8	16.7	0.0	60.0	32.1	14.3

Table 31. Nutritional status and feeding of children under 5 in the studied villages, Orissa, India, 2006 (percentage of responses).

Item	Coastal irrigated	Coastal rainfed drought-prone	Coastal rainfed flood-prone	Mountainous forest-based	Upland rainfed	Upland rainfed drought-prone
Number of respondents	104	52	52	51	56	53
Average number of children below 5 years old	1.27	1.33	1.31	1.41	1.36	1.28
Children immunized (age in months)						
% Immunized	89	99	99	61	99	96
% Not immunized	11	1	1	39	1	4
Mean age at immunization (months)	31.93	31.13	29.01	34	33.96	24
Mean age when breastfeeding was stopped (months)	22.80	24.29	20.80	28.54	24.69	23.73
Feeding status? (%)						
Fully breastfed	5	14	7	11	13	18
Eats food with family	40	52	35	58	64	50
Eats supplementary food	28	16	22	28	21	24
Eats both food with the family and supplementary food	27	17	35	3	2	8
Compared with normal child, is weight low for age? (%)						
High/normal	46	70	53	79	66	43
Low	54	30	47	21	34	57
Compared with normal child, is height short for age? (%)						
No/normal	34	67	43	31	64	–
Yes	66	33	57	69	36	–

Table 32. Food patterns in the studied villages, Orissa, India, 2006.

Item[a]	Coastal irrigated	Coastal rainfed drought-prone	Coastal rainfed flood-prone	Mountainous forest-based	Upland rainfed	Upland rainfed drought-prone
Number of respondents	104	52	52	51	56	53
Breakfast meal pattern (% of respondents)						
WR + others (NV, Pk, F, tea, C, R, RC, PR, PF, MP, Ch, Mz, Cr)	17.3	15.4	7.7	19.6	7.1	0.0
WR, V	33.7	13.5	9.6	25.5	50.0	9.4
WR, V + others (NV, Pk, F, tea, C, R, RC, PR, PF, MP, Ch, Mz)	33.7	5.8	34.6	33.3	37.5	1.9
PR, tea	4.8	26.9	32.7	0.0	0.0	58.5
PR, tea + others (NV, R, P)	1.9	5.8	1.9	0.0	1.8	3.8
R, P + others (tea, NV, PF, RC, C)	2.9	5.8	0.0	2.0	0.0	9.4
Ch + others (V, PF, PR, tea)	3.8	19.2	9.6	0.0	1.8	3.8
RC + others (tea, C, P)	1.0	9.6	5.8	2.0	0.0	1.9
R, V + others (PF, RC)	1.0	1.9	0.0	11.8	0.0	3.8
Mz + V	0.0	0.0	0.0	5.9	0.0	0.0
None	0.0	0.0	0.0	0.0	1.8	0.0
Lunch meal pattern (% of respondents)						
R, NV	14.4	9.6	3.8	0.0	1.8	3.8
R, P + others (Ch, NV, V)	8.7	5.8	9.6	2.0	3.6	9.4
R, P	2.9	3.8	3.8	2.0	1.8	5.7
R, P, V	42.3	61.5	59.6	19.6	14.3	50.9
R, P, V + others (F, NV, MP)	2.9	1.9	9.6	0.0	0.0	1.9
R, V	10.6	15.4	5.8	56.9	10.7	20.8
R, V + others (C, NV, MP, Pk)	2.9	1.9	1.9	13.7	3.6	3.8
WR + others (NV, P, Pk)	3.8	0.0	0.0	2.0	7.1	3.8
WR, V	10.6	3.8	3.8	5.9	42.9	5.7
WR, V + others (NV, F, C, R, P, Pk)	1.9	0.0	5.8	0.0	14.3	0.0
V, P + others (Ch, tea)	1.0	0.0	0.0	0.0	1.8	0.0
Dinner meal pattern (% of respondents)						
Ch + others (V, P, NV, Mz)	13.5	5.8	3.8	2.0	0.0	0.0
R	1.0	0.0	0.0	0.0	0.0	0.0
R + others (P, NV, PF, Pk, tea)	14.4	25.0	19.2	11.8	7.1	50.9
R, V	25.0	5.8	19.2	41.2	7.1	5.7
R, V + others (NV, CP, F, Ch, tea)	42.3	28.8	44.2	45.1	10.7	43.4
WR	0.0	0.0	0.0	0.0	1.8	0.0
WR + others (C, V, NV, P, Pk, RC)	1.0	0.0	0.0	0.0	8.9	0.0
WR, V	1.9	30.8	7.7	0.0	41.1	0.0
WR, V + others (F, Pk, C, NV, P)	1.0	3.8	0.0	0.0	19.6	0.0
PR, C	0.0	0.0	1.9	0.0	0.0	0.0
RC, tea	0.0	0.0	3.8	0.0	3.6	0.0

[a]WR = water rice, NV = nonvegetarian, Pk = pickles,, F = fish, C = curry, R = rice, PR = pressed rice, PF = puff rice, V = vegetables, Mz = maize, Ch = chapati.

Quantity and variety of rice consumed and description of the previous day's meal. On average, the total quantity of rice consumed ranged from 324 to 410 grams per capita per day (Table 33). These amounts were lower than the recommended rice intake for India of 420 grams per capita per day, an indication of food insecurity among the households. For home consumption, Swarna is the most popular rice variety among the households in the upland rainfed drought-prone and coastal rainfed drought-prone villages while Lalat is for the coastal rainfed flood-prone areas. Other varieties, including the traditional ones, are likewise mentioned by all households in the villages. Annapurna rice, which is distributed through the PDS, is common to the coastal rainfed drought-prone and mountainous forest-based villages. Coarse to fine-type grains are the preferences of the households since these are the ones suitable for the preparation of water rice and pressed rice that are commonly included in the diet of the households. The price of rice is relatively cheap and it ranges from Rs 3 to 15 per kilogram.

Description of the previous day's meal and intrahousehold food distribution. Traditionally, it is not a norm for family members to eat together during meal times in rural areas (Table 34). The head (often the male) of the family, together with the children, eats first while the mother/wife is the last person to eat. During lean times, less food is left for the wife and daughter-in-law; hence, their nutritional intake is impaired.

Potential for adoption and consumption of biofortified rice. Based on the results of the study, there is great potential that farmers will adopt biofortified rice (BR) either for home consumption or for sale provided that the characteristics mentioned by the farmers are met. Because of the varied agro-climatic conditions in Orissa, rice breeders should see to it that biofortified rice can be suited to each situation. Because, from the community-level study, households are used to eating yellowish and dark-colored rice, off-white colored biofortified rice due to the addition of vitamin A and/or iron would not pose a constraint to its adoption. To get the most benefit from biofortified rice, it should be targeted to the most disadvantaged group of the community. The presence of the Public Distribution System is a good avenue for the distribution of biofortified rice, especially in targeting rural and low-income people. Also, biofortified rice can easily target school children, who are oftentimes vulnerable to nutrient deficiency in spite of the mid-day meal program in the primary school.

Summary, conclusions, and policy implications

Summary

The study was conducted among 11 villages representing eight sites and seven districts of Orissa to determine the adoption potential by farmers and acceptance by consumers of biofortified rice. The villages were classified according to the agro-climatic conditions of the area. To meet the objectives of the study, both community-level and household data were obtained. Community-level information was gathered from village leaders, school teachers, government officials, health workers, elderly people, women, and young children through a participatory appraisal. Household-level information

Table 33. Quantity of rice/flour cooked, rice variety, and description of previous day's meal in the studied vilages, Orissa, India, 2006.

Item	Coastal irrigated	Coastal rainfed drought-prone	Coastal rainfed flood-prone	Mountainous forest-based	Upland rainfed	Upland rainfed drought-prone
Number of respondents	104	52	52	51	56	53
Family size (mean in years)	6.58	5.12	6.90	5.24	6.00	5.96
Total consumption for the day per capita (g/day)	365	397	382	324	390	410
Rice variety (% of respondents)						
HYVs	**63**	**62**	**6**	**33**	**38**	**70**
Swarna	12	33	0	2	13	66
CR-1018	38	0	2	0	0	0
Annapurna	3	27	4	22	11	0
Lalat	10	2	0	10	14	4
Other HYVs	**13**	**0**	**40**	**0**	**11**	**2**
1590 (Chakaakhi)	0	0	40	0	0	0
Khandagiri	7	0	0	0	4	0
Tulasi	5	0	0	0	0	0
Annapurna	0	0	0	0	2	0
Konark	0	0	0	0	2	0
Parijat	0	0	0	0	0	2
Pooja	1	0	0	0	0	0
Ramchandi	0	0	0	0	2	0
Surendra	0	0	0	0	2	0
Mix	**5**	**0**	**0**	**0**	**30**	**0**
CR-1001	0	0	0	0	30	0
1242 (improved)	3	0	0	0	0	0
CR-1014	2	0	0	0	0	0
Other[a]	**20**	**38**	**54**	**67**	**21**	**28**
Type of rice grain (% of respondents)						
Coarse	58	0	58	45	32	21
Fine	20	37	0	12	23	66
Medium	22	63	42	43	45	13
Average price in the market (Rs/kg)						
Mean (N)	8	8	8	6	8	9

[a]Unknown, Azana, Matiya, Mixed, Banki, Kalamkathi, Nalbainsi, Nandikiri, Agnisara, Kalcharpati, Jagabalia, Salaijhati, Sarathi, Bahrakhai, Kanchi, Kedargouri, Nali Jaganath, Padmakeshari, Gotikhalika, Khajura, Mahalaxmi, Maheswari, Mayurkantha, Moti, Samalei, Sathia.

Table 34. Description of previous day's meal in the studied villages, Orissa, India, 2006.

Item	Coastal irrigated	Coastal rainfed drought-prone	Coastal rainfed flood-prone	Mountainous forest-based	Upland rainfed	Upland rainfed drought-prone
Number of respondents	104	52	52	51	56	53
How would you describe your meal yesterday? (%)[a]						
Better than normal	27	29	40	4	9	42
Normal	73	71	60	82	88	58
Worse	0	0	0	14	4	0
Does all the family eat together in one sitting?						
No	95	87	98	73	84	100
Yes	5	13	2	27	16	0
If the family doesn't eat together in one sitting, who eats first?						
Head	3	8	4	0	13	19
Head/children	31	17	13	41	29	32
Head/male children	43	38	42	27	34	23
Head/female children	18	23	38	2	7	26
Male children	0	0	0	2	0	0
Children	0	0	0	0	2	0
If the family doesn't eat together in one sitting, who eats last?						
Wife	95	87	98	73	82	94
Wife/female	0	0	0	0	2	6
Do male members eat better quality meals than female members in the family?						
No	89	83	94	96	95	100
If the family doesn't eat together in one sitting, who eats first?[a]						
Head	3	4	2	0	7	10
Head/children	32	9	7	21	16	17
Head/male children	45	20	22	14	19	12
Head/female children	19	12	20	1	4	14
Male children	0	0	0	1	0	0
Children	0	0	0	0	1	0

[a]In some cases, there were no responses.

was gathered through a survey of households, mostly from the female members. Five modules were prepared to obtain the community-level data. These included the following: module I for the basic geographic and socio-demographic characteristics of the villages; module II focused on information about health, micronutrient deficiency, and health problems; module III covered production-related information and perceptions about biofortified rice; module IV focused on food consumption and dietary patterns of the rural community; and module V covered the perceptions of infectious diseases.

Secondary information revealed nutritional deficiency in the rural household in study areas of Orissa. The prevalence of anemia, malnutrition, and other acute diseases such as diarrheal diseases and skin diseases was very common among the study villages.

The sanitary conditions in all villages are considered unsatisfactory. A very limited number of households have access to a sanitary latrine and, except for the educated ones, mothers have limited awareness about health and nutrition.

To help poor households obtain access to food, especially during lean periods, the government established the Public Distribution System (PDS) through the Annapurna scheme, in which households can buy rice at a subsidized rate. In primary schools, children are provided with a mid-day meal consisting of rice and pulses every day and one egg every week. This program is managed by the school committee and the ICDS. Somehow, these programs can alleviate nutrition problems among school children and the disadvantaged groups of the community. Iron and vitamin A supplementation are also given to pregnant women through the health centers and Anganwadi centers.

Regarding adoption and consumption of nutritious rice, that is, biofortified rice, results of the community-level study revealed that farmers would consider agronomic traits and eating quality of the variety. For agronomic traits, farmers would choose a variety that is resistant to drought, pests, and diseases and had reasonable crop duration. In the flood-prone environment, farmers would want a variety that is not prone to waterlogging. To a certain extent, farmers would be willing to sacrifice from 5% to 20% of their current yield if the variety were resistant to pests.

For eating quality, low-income households prefer a variety with bold grains that is suitable for preparing water rice and pressed rice. Moreover, bold grains give them satiety. On the other hand, the more affluent members of the community would want a variety that is fine, slender, and well polished. For good eating quality, rice farmers in most areas would be willing to sacrifice 5% of yield. Although some farmers, particularly those from the coastal irrigated and rice-deficit villages, would not sacrifice yield in favor of nutritional value, most farmers would be willing to sacrifice 5–15% of yield in favor of nutritional value. However, farmers are willing to grow off-white nutritious rice since the local varieties that they currently grow have a dark color. In the same manner, consumers would also consume dark or yellowish nutritious rice.

From all aspects, the households in the mountainous forest-based village appear to be the most disadvantaged group. These are the scheduled caste and tribal community.

Based on the results of the study, there is potential for the adoption and consumption of biofortified rice in the villages of Orissa provided that the characteristics desired

by the farmers and consuming households are satisfied. To have greater nutritional impact, biofortified rice can be distributed through the PDS and made a part of the rice provided for the mid-day meal for school children.

Conclusions

Multiple micronutrient problems, especially vitamin-A deficiency, iodine deficiency disorders, and iron deficiency anemia, are a serious public health problem in South Asia that affects millions of people. To combat micronutrient malnutrition, a study was conducted in different agroecological conditions in Orissa. From the results of the community-level study and household survey, more health awareness, better nutrition, and improved sanitation are necessary to overcome malnutrition.

The prevalence of anemia among children and women, respiratory diseases, diarrheal diseases, malaria, gastritis, and worm infestations is of much concern in rural areas, particularly among poor scheduled caste (SC) and scheduled tribe (ST) households. Rice consumption by the households in Orissa is below the national average and consumption expenditures are higher than for other food items. Women suffering from anemia, fatigue, migraines, body pain, and gastritis were more in selected villages. A lack of basic amenities such as safe drinking water, personal hygiene, and excreta disposal makes the population vulnerable to infection. Nutrition deficiency was found more in SC and ST communities. Therefore, health and referral services through the ICDS are to be intensified for them.

The potential for adoption and consumption of biofortified rice is of much concern. Malnutrition in tribal areas can be reduced through biofortification of rice and distributed through the Public Distribution System and the mid-day meal program in primary schools as these help children to have better attendance.

A comprehensive developmental approach, including elimination of poverty, increasing food biofortification, and the provision of health and hygiene welfare services to vulnerable sections will be required to alleviate the micronutrient problem. An extensive campaign is required for the acceptance of biofortified rice and this could be done through the PDS and agricultural extension workers.

Policy implications

From the results of the study, the need and potential for biofortification of rice to arrest malnutrition and micronutrient deficiencies among rural poor households is clear as rice is the bread and butter for their survival in Orissa. However, to get the maximum benefit from a biofortification program, the following issues should be considered.

Nutrient-enriched rice varieties are to be developed by rice breeders so as to overcome multiple micronutrient malnutrition among the rural communities. Although farmers are willing to sacrifice some yield for nutritious rice under different agroecological situations, the incorporation of nutrients in rice varieties can be beneficial to rainfed mountainous forest-based areas, where the rate of malnutrition was observed to be higher than in other areas.

Agronomic characteristics and eating quality are of much concern for adopting biofortified rice in Orissa. Therefore, these should be considered by breeders. A sensory evaluation by researchers is necessary for the acceptance of biofortified rice. A multidisciplinary team consisting of a rice breeder, socioeconomist, nutritionist, and medical doctor should do a qualitative assessment on the effectivity of biofortified rice against micronutrient deficiencies.

Simultaneous to the development of biofortified rice, the amount of nutrition of different traditional varieties should be analyzed. A variety having more nutrition should be recommended and distributed in endemic areas.

Nationally and internationally available promising nutrient-enriched rice varieties should be evaluated in farmers' fields to create awareness among farmers as end users. If found suitable, these varieties should be promoted through different nutritional projects involving farming communities.

A food preparation package, including biofortified rice, should be recommended for better use of micronutrients by the needy poor. The possibility of using the PDS and a mid-day meal program in distributing biofortified rice should be explored.

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Notes

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