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ABOUT THE COVER

Holistic approach is needed for farmers to be competitive. An important component of rice competitiveness is integrated rice crop management. Pre-harvest and post-harvest crop management techniques should be cost-effective and result in increased productivity, product quality, and production efficiency. Despite good agricultural practices, farmers' hardwork is sometimes reduced into nullity as natural calamities hit the farms. As such, farmers should consider crop insurance. The nutritional status of household members is also linked to agricultural productivity; thus, this aspect of rice farming, which is less mentioned in agricultural studies, should also be improved. To further sustain rice farming and farm households, technological and socioeconomic support and policies should be enhanced.

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FUTURE OF SMALLHOLDER RICE FARMING IN ASIA: EMERGING ISSUES, CHALLENGES, AND OPPORTUNITIES

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Abstract

Rice is life in Asia. An estimated 140 million smallholders cultivate rice on 132 million hectares of physical rice area (145 million hectares of harvested area in 2014) to produce 667 million metric tons of unhusked rough rice (90% of the global rice output). Two of the four rice ecologies – irrigated and rainfed lowlands, contribute to 90% of the Asian rice output. The Asian rice sector employs 300 million people in the rice value chain. It is an important staple food for 60% of the Asian population. The mean farm size of one hectare is too small to support a family of 5-6 members. Further, continuous fragmentation of rice farms after each generation poses serious challenges to the viability of rice farming in Asia. Despite the mounting pressures to quit rice farming, smallholders continue to persist, especially in South and East Asia, where the economy is developing fast and urbanization is becoming an increased phenomenon. There is also a growing agrarian crisis in most Asian developing countries due to long neglect of rural areas where most smallholders live and farm. They suffer from poverty, malnutrition, dispossession of land assets, and death. This paper examined the emerging technical and socioeconomic constraints, and policy challenges facing the smallholders and how to manage them for sustainable intensification of rice farming in Asia.

Keywords: *Agrarian Crisis, Climate Change, Ecological Intensification, Land Fragmentation, Out-Migration, Persistence of Smallholders, Resource Degradation, Rice-Poverty-Malnutrition Nexus, Soil Health.*

Introduction

Asia is the major rice-producing region in the world. It has 88% of the global physical rice area (89% of the harvested rice area in 2014) and 90% of the world's rice production (FAO, 2017). Of the 90% of the global rice produced in Asia, 87% is consumed within the region, with only 3% exported to the rest of the world. Currently, in Asia, 140 million rice farmers cultivate 132 million hectares (mha) of physical rice area (Table 1) and directly employ more than 300 million people in rice cultivation and related rice value chain activities. The mean farm size is less than a hectare per family (Bouman, 2014). In 2014, the harvested rice area was 145 mha that produced 667 million metric tons (mmt) of unhusked rough

Table 1. Estimated physical rice areas and (harvested rice areas) in different rice ecosystems for the world and Asia and their contribution to global and Asian rice supply.

	World			Asia		
Rice ecosystems	Rice area (million ha)	% of physical rice area	% of global rice supply	Area (million ha)	% of physical rice area	% of Asian rice supply
Irrigated lowlands	82.0 (93.0)	54.7	75.0	74.0 (84.0)	56.1	76.0
Rainfed lowlands	50.0 (52.0)	33.3	19.0	45.0 (48.0)	34.1	18.0
Flood-prone / deep-water lowlands	4.0 (4.0)	2.7	2.0	4.0 (4.0)	3.0	2.0
Rainfed uplands	14.0 (14.0)	9.3	4.0	9.0 (9.0)	6.8	4.0
Total	150 (163)	100	100	132 (145)	100	100

Note: Rice area figures in parenthesis represent harvested rice area in 2014 [Source: FAO 2017. http://www.fao.org/faostat/en/#data/QC (accessed on 14 Oct. 2017)]

Data sources: Haefele and Bouman, 2009; GRISP, 2013; FAO, 2017.

rice. The major rice-producing countries are China, followed by India, Indonesia, Bangladesh, Vietnam, Thailand, Myanmar, and the Philippines in decreasing order. Other Asian countries produced less than 11 mmt of unhusked rough rice per year. The average unhusked rough rice yield across all of Asia was 4.65 metric tons (mt) per ha per year in 2014 (FAO, 2017).

Rice is the staple food for 60% of the Asian population. Myanmar has the highest annual per capita milled rice consumption of 205 kg, followed by Bangladesh, Cambodia, Indonesia, Lao PDR, and Vietnam (149-169 kg). In these countries, rice provides over 50% of the calories in their population's diet (Bouman et al., 2007). As the population of Asia and Oceania is projected to increase from 3.7 billion in 2000 to 5.5 billion in 2050 (Baker, 2003), further intensification of rice cultivation is critical if food and nutrition security is to be maintained in Asia.

Ecologically, lowland rice farming is highly stable. Flooded rice fields contribute to ecosystem services such as aquatic and terrestrial biodiversity, groundwater recharge, and regulation of water flow. These benefits are often not fully recognized and appreciated by the general public. Rice farming is also reasonably benign to the environment, relative to many other crops, e.g., more methane but less nitrous oxide emissions, little or no nitrate leaching, and very little herbicide use (Bouman et al., 2007).

The rice crop is cultivated in four different rice ecosystems – irrigated lowlands, rainfed lowlands, flood-prone or deep-water lowlands, and the uplands. There are two types of estimated rice areas: (a) physical rice area that changes only when new land is brought under rice cultivation and (b) harvested rice area as determined by the number of rice crops grown on the same piece of land per year, that changes from year to year due to changes in availability of rain or irrigation water that determines the cropping intensity in different years. Irrigated and rainfed lowland rice ecosystems are the key rice producing areas and they occupy about 88% of the global physical rice area and contribute 94% of the world's rice production. The other two rice ecosystems including flood-prone or deep-water lowlands and uplands occupy about 12% of the physical rice area but contribute only 6% of the global rice supply (Table 1) (Haefele and Bouman, 2009; GRISP, 2013; FAO, 2017).

Rice demand and supply in Asia

Global rice markets are small and volatile. Only about 7% of global rice output is traded internationally, that results in a tight supply of and demand for rice throughout Asia. The four major Asian rice exporters – Thailand, India, Vietnam, and Pakistan – along with the United States, control 87% of global rice trade (Wailes and Chavez, 2012). Cambodia, Laos, and Myanmar currently have adequate land and water resources for growing rice, not only to feed their own population, but also to potentially export their surplus rice to other countries. Indonesia and the Philippines are currently significant rice importers, despite their continuing efforts to become rice self-sufficient.

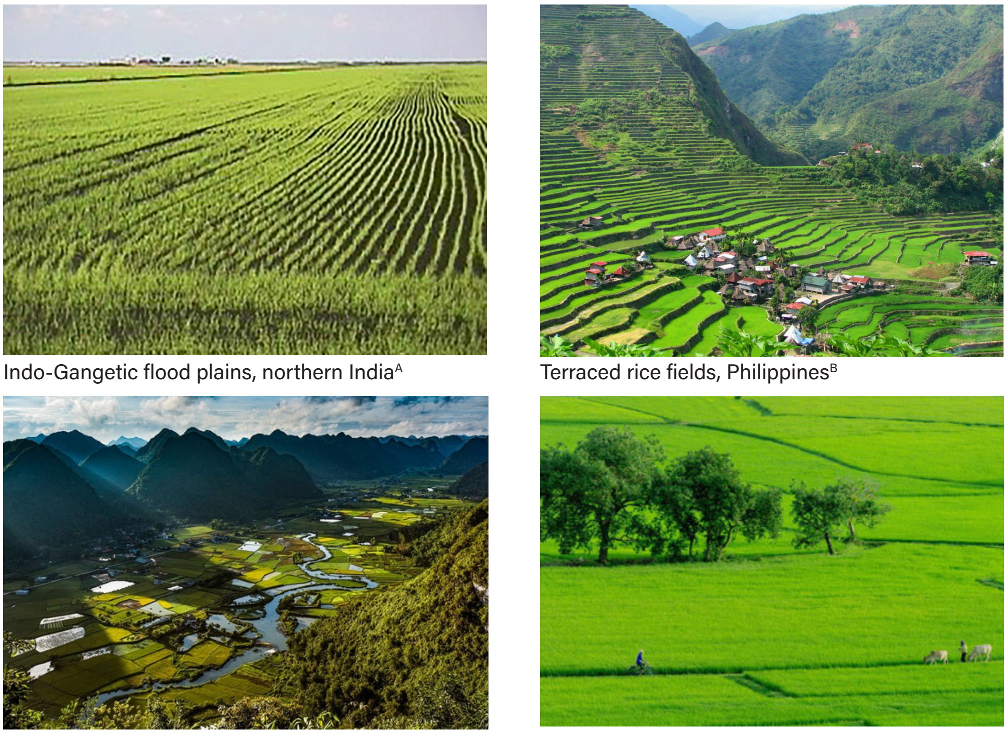
Global demand for milled rice is projected to increase from 439 mmt in 2010 to 555 mmt in 2035. Future demand for rice in Asia will depend on the annual population growth rate, which is projected to decrease from 1.2% (2000-2005) to 0.1% by 2050. A small decline in per capita rice consumption is also expected due to changing dietary patterns of the fast-growing Asian urban population (FAO, 2012). For example, the per capita rice intake is steadily decreasing in China, Japan, South Korea, Malaysia, and Thailand, while it is stable or slightly increasing in other Asian countries.

It is expected, then, that the combination of a slow growth in per capita rice consumption and an increased rice output will keep the global rice prices steady, or even result in a slight decline from 2011 to 2021. For 2012, stochastic estimates of milled rice price per mt ranged between US $405 and $549 with an average of US $471. Similarly, stochastic estimates of the global milled rice trade ranged between 32 and 43 mmt with an average of 38.3 mmt. These estimates are based on assumptions of normal weather and a continuation of current policies set for the rice sector by individual Asian governments. However, should a country (e.g., India) impose rice export bans to tide over an unexpected shortfalls in local rice production in times of extreme weather events or natural disasters, we can expect the international rice trade to tighten quickly, causing serious supply disruptions and price volatility in the global rice market as it happened in 2007-2008 (Wailes and Chavez, 2012).

Rice ecosystems

Irrigated rice ecosystems

Irrigated rice ecosystems in Asia are concentrated mostly in the humid and sub-humid tropics. Irrigated rice-based cropping systems are practiced on alluvial floodplains (e.g., Indo-Gangetic Plains in India), terraced fields on mountain slopes (e.g., the terraced rice fields of Bali, Indonesia or the montane paddy, northern Laos), inland valleys (as commonly found in southeast Asia, e.g., Bac Son Valley bottom rice fields), and river deltas (e.g., Red River Delta and Mekong Delta in Vietnam) (Figure1). An estimated 90% of the global physical or harvested irrigated rice area is found in Asia (Table 1). The countries with large irrigated rice areas are China (31 mha), India (19 mha), Indonesia (7 mha), Vietnam (3 mha), and the Philippines (2.7



Indo-Gangetic flood plains, northern India[A]

Terraced rice fields, Philippines[B]

Bac Son Valley rice fields, Vietnam[C]

Mekong Delta rice fields, South Vietnam[D]

Figure 1. Examples of four types of irrigated rice ecosystems in Asia.

Source: [A]International Efficient Agriculture Solutions and Standards Association: The Rice-Wheat Consortium's Examplehttp://ieassa.org/en/the-rice-wheat-consortiums-example/ March 27, 2013; [B]https://www.usit.ie/tours/24258-northern-philippines-adventure; [C]http://english.vietnamnet.vn/fms/travel/182820/bac-son-valley-attractive-to-tourists-in-rice-harvest-season.html; [D] http://xperiencemekongdelta.blogspot.com/.

mha). Overall, irrigation-based rice cropping systems provide about 75% of the global rice supply.

Irrigated rice is grown as a monocrop (e.g., rice-rice, rice-rice-rice, rice-rice-fallow), or in rotation with other crops, (e.g., rice-wheat, rice-grain legumes, rice-maize-grain legumes, rice-potato, rice-mustard, rice-vegetables). Availability of water for irrigation determines the length of fallow periods between crops and ranges from a few days to three months.

Based on grain yield, the irrigated rice (IR) ecosystem is divided into three zones: there is a high yield zone with mean yields > 5 mt ha^{-1} (Australia, China, Indonesia, Japan, and Vietnam); a medium yield zone with 4-5 mt ha^{-1} (India, Malaysia, Philippines, and Thailand); and a low yield zone with < 4 mt ha^{-1} (Cambodia, Laos, Myanmar, Nepal, Pakistan, and Timor Leste).

Irrigated rice is cultivated in bunded fields with good water control. Soil is mostly puddled and leveled, seedlings can be transplanted or sprouted rice seeds can be direct wet-seeded. A shallow level of water is maintained during the crop growth period. Currently, most irrigated rice systems are highly mechanized and high rates of fertilizers are applied to increase crop productivity. Insecticides are also applied to control insect pests, fungicides to arrest fungal diseases, and herbicides to control weeds.

Mostly, high-yielding, semi-dwarf indica or japonica rice varieties are planted on irrigated rice lands in Asia. High-yielding hybrid rice varieties occupy > 30% of the irrigated rice lands in China (2014) and smaller areas in other Asian countries. Although medium to low in yield potential, high value aromatic rice varieties like Basmati are grown in India and Pakistan while Jasmine rice varieties are popular in Thailand and neighboring countries. These aromatic rice varieties are mainly exported to the Middle East, Europe, and the USA.

Rainfed lowland rice ecosystems

A rainfed lowland rice (RLR) ecosystem is one that is characterized by level to slightly sloping and bunded fields with non-continuous flooding. The rice crop is established by direct seeding or transplanting of rice seedlings. Generally, one rice crop is grown per year, and if the rainy season is long enough to allow

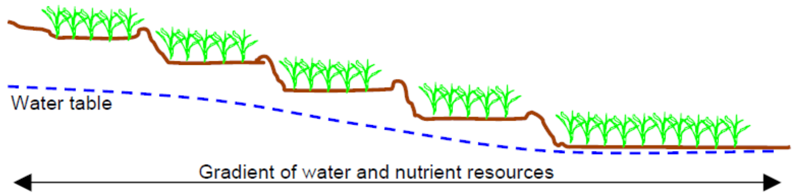


Figure 2. Rainfed lowland rice ecosystems located on an undulating landscape or toposequence in Asia.

farmers to plant another crop it will be a non-rice crop after the rice crop.

In Asia, the RLR ecosystem covers an area of about 45 mha (30% of the global physical rice area of 150 mha and 34% of the Asian physical rice area of 132 mha) (Haefele and Hijmans, 2007). Appreciable areas of the RLR ecosystems are located in India (16.1 mha), Thailand (8.2 mha), Bangladesh (5.1 mha), Indonesia (4.0 mha), Vietnam (2.9 mha), Myanmar (2.4 mha), China (1.8 mha), Cambodia (1.6 mha), and the Philippines (1.3 mha).

Based on their location on the toposequence, Haefele and Bouman (2009) recognized three types of RLR ecosystems: (a) shallow rainfed lowlands on upper terraces, (b) intermediate rainfed lowlands occurring on medium elevation terraces and usually on flood plains near large rivers, and (c) deep rainfed lowlands on lower terraces and in the valley bottom (Figure 2). On upper terraces, a low soil profile depth and coarse soil texture contribute to low water- and poor nutrient-holding capacities. These soils are generally poor in fertility and are highly prone to erosion. On medium elevation terraces, water and nutrient losses in lower terraces tends to be balanced by input from upper slopes. On lower terraces and in the valley bottoms, the water table is nearer to the crop rooting zone, and soils are fine textured and enriched with organic matter and nutrients originating from the higher elevation slopes. As a result of these "resource gradients", higher drought risks and nutrient limitations affect rice crops on upper terraces, while submergence risks are high for the lower terraces and valley bottoms due to runoff from upper slopes. Weeds are serious problems on upper terraces due to shorter duration of flooding, while they are better suppressed by floodwater in lower fields.

Emerging constraints and challenges to rice production in Asia

A number of technical, socioeconomic, and policy constraints affect rice production in Asia.

Technical constraints

Three types of technical constraints impact rice production in Asia: abiotic, biotic, and management.

***Abiotic constraints*:** Globally, abiotic stresses are the most yield-limiting constraints for an intensification of rice farming in Asia and elsewhere. They are related to land and soil, water, biodiversity, and climate.

A. Land and soil related constraints: Most of the land and soil related constraints are similar for irrigated and rainfed rice farming. There is a growing competition for land among agriculture, industrial, and service sectors. Rice farmers experience an accelerating degradation of good agricultural land, and consequently, decline in its productivity. This is due to depletion of certain nutrients (P, K, Si, and Zn) in soil, decrease in soil organic matter content, development of soil salinity and or alkalinity due to faulty irrigation systems, and accumulation of toxic substances (Fe, Mn, Al, S) in irrigated soils due to continuous flooding of fields. Excessive and or improper use of chemical fertilizers and pesticides in rice farming leads to increasing pollution of land, water, and air. There is also increasing arsenic toxicity in areas where groundwater is pumped for irrigation from deep soil horizons containing arsenic-containing minerals as in eastern India and Bangladesh.

Globally, a quarter of the agricultural lands are classed as severely degraded and another 8% is moderately degraded (FAO, 2011). An estimated 11% (34 mha) of irrigated agricultural lands are also affected by salinity due to faulty irrigation practices and poor or no drainage provisions. There are also increases in prawn culture and seawater intrusion in coastal areas, which is causing increased coastal soil salinity and alkalinity. Soil compaction and soil acidification and alkalization are other important forms of increasing soil degradation (Oldeman et al., 1991).

Haefele and Hijmans (2007) estimated that about 7% of the rainfed lowland rice is grown on problem soils such as acid sulfate or saline soils. A third of the rainfed lowland rice is cultivated on relatively fertile soils, slightly less than one-third of rice is planted on soils with low inherent fertility, and slightly more than one-third of rice is grown on soils, which possess multiple soil constraints that are common in Southeast Asia.

B. Water-related constraints: Water is a scarce commodity in Asia as 36% of the available fresh water reserves have to support 60% of the world's human population and the annual per capita availability of water is declining in all Asian countries. Inadequate irrigation will adversely impact rice productivity because rice crops consume more water per unit of grain production than other crops: e.g., 1,500 - 3,000 L are required to produce 1 kg of rice compared with 800 to 1,000 L needed to produce 1 kg of wheat. Increasing water scarcity is now threatening the sustainability of irrigated rice cropping systems across Asia. It is estimated that by 2025, about 2 mha of irrigated dry-season rice and 13 mha of irrigated wet-season rice in Asia will experience a 'physical water scarcity'. This occurs when the demand of the population exceeds the available water resources of the region (IWMI, 2000; Rijsberman, 2006). Also, most of the 22 mha of irrigated dry-season rice in South and Southeast Asia will suffer an 'economic water scarcity' (Tuong and Bouman, 2003). This occurs when water is inadequate due to lack of significant investment infrastructure (IWMI, 2000; Rijsberman, 2006). It is estimated that by 2030, about 55% of the world's countries will depend on food imports due to extreme water scarcity and severe drought (PSR, 2012).

C. Biodiversity loss: With a growing intensification of agriculture, the on-farm biodiversity has declined steadily. Since 1900, approximately 75% of crop plant genetic diversity has been lost as farmers, worldwide, have abandoned traditional crop varieties and embraced high-yielding varieties, the latter having a much narrower genetic base (FAO, 1999). At present, just three crop plants — rice, maize, and wheat — contribute nearly 60% of calories and protein consumed by humans worldwide.

D. Climate change and its impacts: Agriculture affects and is impacted by climate change. Increased emissions of greenhouse gases (GHG) – especially CO_2 from excessive fossil fuel use and the burning of straw from rice and other crops, together with methane (CH_4) and nitrous oxide (N_2O) releases from agricultural soils — have all contributed to climate change (Bijay-Singh et al., 2008; Ladha et al., 2009, Balasubramanian, 2010; Pathak et al., 2011). An estimated 23-30% of the global GHG emissions is attributed to agriculture and the related land use changes.

The changing climate in turn can have a large influence on production of rice and other crops. Most rice scientists agree that (a) higher temperatures, (b) changing rainfall patterns, (c) more frequent occurrence of extreme weather events like the droughts, floods, and storms (Wall, 2011; Avagyan et al., 2015), as well as rising sea levels and increasing soil salinity in coastal areas will have appreciable and adverse effects on rice production, particularly in the tropical and subtropical regions of Asia. Rainfed lowland rice crops will likely suffer the most, due to changes in, and unpredictability of, rainfall patterns. Unexpected rainfall events at the time of harvest can cause tremendous difficulties and crop damage to rice farmers. Drought affects rice productivity on 19-23 mha of rainfed lowlands (Garrity et al., 1986). Shallow flooding is a serious problem on about 11 mha and intermediate flooding depth on 11.6 mha of rainfed lowlands in Asia (Huke and Huke, 1997). Both unexpected droughts and floods will limit crop growth, increase pest and disease infestation, and reduce grain yields and grain quality; thereby, increasing food insecurity (PSR, 2012).

A meter rise in sea level could wipe out rice production in the low-lying deltas and coastal plains such as the Mekong River delta in Vietnam and the Ganges basin in Bangladesh and India (Anonymous, 2006).

An elevated concentration of atmospheric CO_2 (546-586 parts per million, ppm) is known to lower the uptake of iron and zinc and reduce protein content by 5-10%, increase starch and sugar contents in major food crops such as rice, wheat, peas, and soybean, but not in maize and sorghum (Myers et al., 2014). Lower levels of dietary iron and zinc can impair human health by increased occurrence of anemia, weakened immune system, lower IQ, and reduced energy levels.

Biotic constraints

Several insect pests, diseases, and a number of weeds limit rice production in both irrigated and rainfed lowlands.

Management constraints

Use of inappropriate rice varieties and production technologies limit lowland rice production in Asia. Management constraints in irrigated rice production include: excessive tilling or puddling and poor land leveling; insufficient irrigation water management; excessive use or misuse of inputs (fertilizers, pesticides) leading to pollution and degradation of land and water resources and evolution of greenhouse gas (Sutton et al., 2008); poor control of yield-reducing weeds, insect pests and diseases; and poor post-harvest management.

Yield-reducing management constraints in rainfed lowland rice fields include the lack of rainwater harvesting structures for supplementary irrigation; poor land leveling and in-field water management; and use of traditional, low-yielding rice varieties, and inadequate supply of rice cultivars, which are tolerant of stresses such as drought, submergence, soil salinity, acidity and aluminum toxicity, and Fe- and Mn-toxicity.

Socioeconomic and policy constraints

Socially, rice farmers face increasing production costs (due to higher wages and rising cost of inputs) and declining profits in intensive rice farming. Farm holdings have become too small to be productive and profitable due to continuous fragmentation of land with the passage of each generation. The long and continuous neglect of villages in national development programs has led to a serious rural agrarian crisis affecting all farmers in general and rice farmers in particular.

Persistence of smallholder farmers in Asia

In developing Asian countries, smallholder farms constitute 88% of the total holdings and occupy 30% of the total farmland (FAO, 2010). Most of the smallholders cultivate rice in Asia. In population dense and land scarce Asia, especially in South and East Asia, small farmers continue to persist despite fast economic development and increasing urbanization. The persistence of small holdings is probably due to (a) lack of non-farm employment opportunities and inadequate means to train the millions of smallholder farmers for suitable non-farm jobs either in rural areas or in cities; (b) the absence of social safety net to fall back on, in case of emergencies; and (c) an emotional attachment to land and home group peers in villages (Rigg et al., 2016).

Pressures are mounting on smallholder farms. The ever diminishing farm size, ageing rice farmers, and their growing inability to earn enough to meet family needs will force some farmers to leave their farms and search for other jobs. The youngsters who moved to the cities may not return to their villages to take up farming. In contrast, the smallholders in developed East Asian countries like Japan and South Korea still live and farm in rural areas. For others, the economic and social costs of juggling their livelihoods between the cities and their villages may become intolerable, forcing them to make a final choice of the city or the village for their living (Rigg et al., 2016). In spite of all these pressures, the much desired and expected consolidation of farms into large viable units may not materialize in the near future.

Rural agrarian crisis and rural to urban migration in Asia

There is a saying that rice and poverty go together. Owing to stagnant crop yields and rice prices, and steadily increasing cost of inputs, profit in rice farming is decreasing fast. The returns from rice farming is estimated at US$200-US$600 per hectare per season or US$400- US$1200 per hectare with two rice crops per year (Bouman, 2014). With the mean rice farming area being less than one hectare per household, rice farmers remain poor and cannot meet their expenses with rice farming alone. This is the reason why able-bodied young men migrate to cities in search of better opportunities; leaving behind the old men and women to tend the rice farms. In China, for example, one billion more people will move to cities by 2030. Such trends in urbanization and out-migration to cities will increase rice consumption in urban centers and significantly reduce the labor force available for rice farming in rural areas. Despite this increasing rural to urban migration, the number of rice farms is increasing in developing Asian countries due to division of land among children in each generation. In India, about 1.5-2.0 million new small and marginal farms are added every year (SECC, 2011).

Most subsistence farmers are impacted by growing resource scarcity and resource degradation. Smallholders have little or no bargaining power in securing loans from scheduled banks (fewer than 4% of small holders have agricultural credit cards) and very few smallholder farmers carry crop insurance against natural calamities, among other agricultural challenges. In addition, smallholders are especially vulnerable to climate change-aggravated weather events such as untimely rains (especially at harvest time), severe droughts and floods, hailstorms and pest infestations, any of which can wipe out the crops. There are also market uncertainties and most agricultural policies (and institutional support) that tend to favor large farmers and agricultural or food corporations (e.g., industrial agriculture receives 80% of the farm subsidies and 90% of any research funds).

All of the above constitute an unprecedented rural agrarian crisis in Asia. Over the last two decades, it has resulted in most rural households suffering from extreme poverty and serious deprivations – more than 250,000 farmers have committed suicide in India. The situation is same in other developing Asian countries where many rural smallholders suffer from poverty, malnutrition, dispossession of land assets, and death.

Tackling emerging rice production constraints and challenges in Asia

A multipronged approach is needed to tackle the various constraints and challenges including the climate-related ones to rice production in Asia.

Addressing technical constraints

Precision farming and resource-conserving technologies are now available and new ones are being developed to tackle the technical constraints discussed earlier. The Sustainable Rice Platform (SRP) team has prepared the standard for sustainable rice cultivation (SRP, 2015) that enumerates the best management practices for sustainable rice production globally. The currently available technologies are assembled below as Best Management Practices for lowland rice farming in Asia.

Best management practices (BMPs) for lowland rice production in Asia

- **Rice varieties**: Use a locally recommended and most adapted rice variety or varieties that are in high demand and that can command high price in local markets.
- **Good quality seed**: Use high quality seed (certified seed) of the chosen rice variety for planting.
- **Nursery management for growing rice seedlings for use in transplanting:** Use a small area (2-3% of the main field area) for a rice nursery, prepare the soil well, incorporate required amounts of manure + fertilizers into the soil, then make raised beds and sow pre-germinated seeds at a relatively low rate (10-15 kg of dry seed, when soaked and pre-germinated will give sufficient seedling numbers for planting a hectare). This approach to nursery management will produce robust and young seedlings.
- **Preparation of the main field:** Apply the available organic manures and P and K fertilizers by initially spreading them evenly on the soil surface and incorporating them into the soil during the first plowing. Handtractors or large tractors can be used to plough and level the main field prior to flooding and puddling. Good leveling enables a uniform spreading of water during rain events or irrigation. This, in turn, will lead to more efficient water use, less weed infestation, a more uniform plant stand, and of greatest importance, high rice grain yields.
- **Reduced tillage and bed-planting**: Reduced or zero tillage options and raised-bed planting are currently being tested to determine whether crop yields and crop water-use efficiency can be improved in direct-seeded, rainfed rice cropping systems. Based on total irrigation water use of 1372 mm for conventional tillage (CT) with puddling for transplanted rice, irrigation water use has been reduced by 12% in CT with puddling for direct wet seeding, 21-25% in CT without puddling for direct dry seeding or zero tillage for direct dry seeding, and 33% in dry seeding on raised beds (Kumar and Ladha, 2011).
- **Transplanting of rice seedlings:** Use only vigorous and young seedlings (18-25 days old) for transplanting 1-2 seedlings hill^{-1} at a 20 cm x 20 cm spacing between hills to achieve a plant density of 25 hills m^{-2}. Flood the nursery bed, then carefully uproot the seedlings, bundle them (if necessary), transport them to main field, and transplant them on the very same day the seedlings are pulled from the nursery. Any delay in transplanting will reduce the recovery of the transplanted seedlings and could result in poor growth and reduce the final number of tillers.
- **Direct wet seeding of pre-germinated rice seeds:** An alternative to using transplants from a nursery bed is to direct seed the rice at a rate of 40-60 kg of dry seeds per hectare. First, soak the seeds for 12 hours, drain the water and incubate the wet seed in a jute bag, which is kept in a dark room for 24-36 hours to sprout the seeds. Either broadcast the sprouted seeds uniformly or use a drum seeder to sow the seed into rows on the well-puddled and leveled soil. Seeding in rows will facilitate later mechanical weeding and allow for soil stirring between rows of the rice plants – a procedure that will boost seedling growth and increase number of tillers and grain yield.
- **Rainfall management**: Water is the most critical but least available input for farming. For rainfed lowlands, rainfall is the major source of water for cropping. Adequate and better distribution of rainfall will enable vigorous crop growth and high grain yields. Unexpected droughts and floods are the two important constraints in rainfed lowland rice farming.
- **Drought mitigation:** Two key strategies to manage drought in water-limited or rainfed rice fields include: (a) drought avoidance and (b) drought moderation (Haefele and Bouman, 2009). In drought-prone areas, rainwater harvesting into farm ponds can provide water for 1 or 2 supplementary irrigations during any dry spells; thereby, minimizing yield losses due to drought (Bhuiyan 1994; Singh et al., 2003). Farmers can select and plant drought tolerant varieties that fit the changing rainfall patterns or shortened crop growing seasons. Moderation of drought is possible by (a) direct seeding and (b) improved early crop and nutrient management that will help reduce moisture evaporation from soils and increase rice grain yields (Tuong, 1999).
- **Flood management**: Good land leveling and provision of adequate drainage is essential to drain excess water, which will be necessary to save the crop during heavy rains and floods. Raised bed planting also drains the excess rainwater from rice fields (Bhadsavle, 2015). Use of flood tolerant rice genotypes and appropriate crop management can minimize yield loss due to flooding stress (Bhowmick et al., 2014).
- **Irrigation and water management:** Regular and timely irrigation is critical for obtaining high yields in irrigated lowland rice fields. The alternate wetting and drying irrigation is practiced during the vegetative phase when rice fields are irrigated to a depth of 5-6 cm each time the water

disappears from the soil surface. Later, at the reproductive development and grain filling stages (40-70 days after transplanting or 50-80 days after direct seeding), a continuous maintenance of 5-6 cm water depth in rice fields is critical to obtain high grain yields.

- **Integrated nutrient management (INM) – Site specific nutrient management (SSNM):** Integrated nutrient management approach promotes the combined use of crop residues, composts, organic manures, and chemical fertilizers to supply the nutrients required for reaching the targeted yields. SSNM also helps farmers apply the required nutrients to rice crops based on the actual crop needs and the variability of the current soil nutrient supply (Buresh et al., 2003; Doberman et al., 2004; Witt et al., 2004).Apply and spread all available crop residues and organic manures and incorporate them into the soil during first plowing. Apply the full required amount of P and half the required amount of K fertilizers for targeted yields just after first plowing and then incorporate them into the soil during 2nd plowing or harrowing. Apply the 2nd half of the K fertilizer at the panicle initiation stage. For the N fertilizer, divide it into three equal doses and apply the first dose 15 days after transplanting or 21 days after direct seeding. The second dose of N fertilizer should be applied at the active tiller formation stage. The third dose of N fertilizer should be applied at the panicle initiation stage. Alternatively, the simple leaf color chart can be used to apply variable rate of N fertilizers as per crop demand and changing soil N supply (Singh Yadvinder et al., 2007; Varinderpal Singh et al., 2014).

- **Integrated weed management:** Two early weedings are recommended: one at 15 days and the other at 30 days after transplanting (or 18-21 and 35-40 days after direct seeding). Mechanical weeding by use of a rotating hoe will not only remove weeds, but also stir and aerate the soil around the roots of rice plants.

- **Integrated insect pest and disease management (IPM):** This involves growing pest-resistant rice varieties, developing healthy crops with optimum water, and practicing good nutrient and crop management. IPM includes the use of predators to keep pest populations in check and adopting appropriate crop cultural methods that reduce pests. It is especially important to apply effective bio-pesticides or "soft" pesticides only when crop damage by pests is becoming increasingly high. Unfortunately, policy and institutional support for IPM remains lukewarm (Pretty and Bharucha, 2015).

- **Timely harvesting and post-harvest processing:** Timely harvesting of mature rice crops is critical to minimize grain loss due to excessive drying and shattering prior to harvest. Once harvested, crops must be threshed immediately to preserve grain quality and to prevent grain breakage at milling. Threshed grains must be cleaned and dried to 14% moisture content before storage or milling. When sun-drying the rice grains on a hard floor or on a tarpaulin mat, a periodic turning of the grains will be necessary to obtain a uniform drying.

- **Appropriate mechanization**: As labor is becoming scarcer and wages are increasing in rural Asia, use of appropriate farm machines is critical to enhance labor efficiency, make the farm operations timely, and reduce the drudgery in farming. Asian rice farmers are increasingly using tractors, laser levelers, machine transplanting or direct row seeding, rotating weeders, solar irrigation pumps, power sprayers, reapers and portable threshers or combine harvesters, and plastic domes or simple on-farm driers for drying.

Climate mitigation and adaptation measures

Smallholder farmers worldwide have been selecting crop varieties and adapting production practices for a slowly changing climate for thousands of years. However, increasing changes in local weather and climatic conditions due to human activities are beginning to disrupt crop production in an unprecedented manner. We need to develop better climate mitigation options. A useful approach could include combining farmers' local knowledge and traditional coping practices with valid scientific discoveries and technologies. Some climate mitigation options are discussed below.

A. Rehabilitation of watersheds

In deforested upper watershed areas, we must improve vegetation cover, reduce soil erosion, and revive local headwater streams to stabilize the water flow to downstream areas. These objectives can be accomplished through afforestation, sustainable forest management, and reduced or eradicated deforestation, especially in upper watersheds. It is also advisable to develop a payment system for farmers in upper watershed areas for them to develop and maintain vegetation including planted forests and other types of ground cover to reduce soil erosion.

B. What can individual farmers do to mitigate climate change? – "Climate-smart agriculture"

Farmers must make every family farm a climate-smart farm, one which is equipped with the knowledge and technologies essential to manage and mitigate the expected adverse impacts of climate change on agriculture. Achieving the triple objectives – adaptation, mitigation, and food security – is increasingly being called "climate-smart agriculture." In climate smart-farms, farmers should use stress (flood, drought, pests, and diseases) tolerant or resistant rice varieties with appropriate production technologies that reduce such stresses. In addition, farmers need to improve cropland management practices and restore organic matter into the soil. Increasing soil organic matter content in farms not only increases carbon sequestration – a climate mitigation function, but also enhances soil quality, water-holding capacity, nutrient use efficiency, and finally, higher crop yields. Enhancing early crop growth and canopy development and adopting surface mulching are other strategies that reduce moisture evaporation from soil surface. Alternative wetting and drying (AWD) irrigation is currently the most successful method for reducing water use and methane emission in irrigated rice production systems. Through this, nitrous oxide (NO_2) emissions may increase for aerobic rice field soils. Thus, AWD irrigation method has the potential to reduce the global warming impact of irrigated rice farming by one-third, relative to the continuously flooded rice system (Wassmann et al., 2000; Jat et al., 2011). Individual farmers can also increase crop diversity or change the planting dates to better fit changing rainfall patterns or shortened crop-growing seasons.

Wherever possible, farmers can also revive local streams, rivers, and lakes and protect wetlands, including mangrove ecosystems in subtropical coastal regions. Farmers and other agriculture value chain players must reduce greenhouse gas emissions throughout the value chain by adopting energy efficient technologies and farm machines, especially those that use renewable energy (e.g., solar water pumps, solar fencing, solar powered insect traps, and solar driers).

C. What can local and national governments do to moderate climate change?

Important actions that must be undertaken by national or local governments include building irrigation-drainage facilities for farmers to cope with changing rainfall patterns. There must be an adequate supply of good quality seeds and other farm inputs at the right price. Governments should assist in the building rural processing facilities and improve farmers' access to key markets. Government support for affordable rural education and healthcare and renewable energy infrastructure is imperative.

Favorable policy and institutional support are critical for:

- Identifying climate-related risks and stresses along the entire value chain,
- Breeding rice varieties that are more tolerant of climate-related abiotic stress (drought, flood, cold, and high temperature) and also have increased resistance to biotic stressors (insect pests and diseases),
- Deployment of scientific findings and technologies to make farming practices much more efficient at using natural resources of soil, water, and energy, while optimizing necessary external inputs, including fertilizers and pesticides,
- Equipping and empowering smallholder farmers to adopt ecologically sound conservation agriculture practices. These include improving soil health and fertility, a better management of water and energy resources, enhancing biodiversity both on-farm and off-farm, implementing appropriate farm mechanization, and using agroforestry systems whenever feasible,
- Enhancing the adoption of smallholder crop-animal production systems as a means to improve cash flow, family nutrition and health, and resilience against abrupt changes in weather and or markets, and
- Moving or intensifying rice production in new untapped areas with abundant water resources (e.g., Eastern India, Cambodia, Laos, Myanmar, and Timor Leste).

D. Moderating food demand and changing food consumption patterns

Biological systems often have limitations as we cannot keep producing more and more food from limited resources to feed the ever expanding population. Therefore, reducing family size is critical to stabilize population growth and future food demand; education of girls and women and improvement of rural health, particularly for women and children, will go a long way to moderate population growth. It is reported that annual human population growth rate in Asia is projected to decrease from 1.2% (the rate during 2000-2005) to 0.1% by 2050 (Wailes and Chavez, 2012).

The two most important human nutrition challenges are under-nourishment and overeating and obesity-related chronic diseases. Worldwide, 795 million people who go to bed hungry suffer from inadequate intake of calories and protein (FAO, 2015). On the other extreme where excess food is produced, people are not fed better either; an estimated 1.5-2.0 billion people suffer from hidden hunger or micronutrient deficiencies and chronic diseases like obesity, cardio-vascular problems, and diabetes due to poor quality diets (Ng et al., 2014). We need to produce more food in places where people starve to

Figure 3. Food wastage and losses across the agricultural value chain.

reduce hunger and malnutrition, while provision of nutrition education is critical for the other group to reduce excessive eating and to help them consume more nutritious foods. Additionally, changing the pattern of human diets from water use-intensive foods (e.g., animal products) to diets consisting of water use-efficient, plant-based foods would have an appreciable global impact for both irrigated and rainfed agriculture. Simplistically, reducing animal products in human diets offers a huge potential to save water resources.

E. Reducing food wastage and food losses

Globally, a third (1.3 billion metric tons) of the food produced is lost or wasted. This wastage varies from 20% for meat and dairy to 40-50% for root crops, fruits, and vegetables, occurring at different stages of the agricultural chain (Figure 3). The wasted foods could have fed 3.5 billion hungry people. The production and decay of food wastes are also responsible for about 7% of the global GHG emissions.

Wasting foods also means wasting the natural resources embedded in producing those foods: i.e., fresh water-24%, cropland-23%, fertilizers-23%, and energy-18% (Kummu et al., 2012). Cutting current levels of food wastes and food losses by half would go a long way in meeting food demands in the near future without clearing more land and without using more water, nutrients, and energy.

F. A national food self-sufficiency strategy

Having a national food self-sufficiency strategy, one which has the stated objectives of avoiding heavy dependence on food imports and reducing national vulnerability to international food trade and food price volatility, is critical for climate-impacted developing countries. Maximizing consumption of local foods reduces food transport distance, increases savings in transportation fuel (including embedded water "costs"), and reduces the overall water footprint of the food system. However, having a national self-sufficiency policy for all or most rice-producing countries could increase the uncertainty in international rice markets, which is a very important concern for rice-importing countries.

G. Other socio-cultural measures to tackle climate change

Moving away from climate change-inducing consumer-oriented culture and adopting lifestyles with low carbon footprints will be helpful in tackling climate change impacts on agriculture.

Mainstreaming of religious practices as tools for the conservation of natural resources, habitats, and biodiversity could be an important option. Certain taboos and traditional religious practices are currently used to conserve natural habitats and maintain a broad varietal diversity of food crops and animal species, forests, and aquatic ecosystems, including mangrove forests in subtropical coastal regions.

However, taboos and other religious practices have not been useful in limiting legal or illegal commercial harvesting/logging of trees for timber. Rather, profit considerations appear to outweigh "conservation practices". To date, the political will to arrest such destructive activities is lacking in most developing countries.

Educating or training several local leaders in every village as "climate risk managers" could be a useful strategy. These leaders could then help the rest of the community in implementing early disaster warning systems and implementing adaptive measures for droughts, floods, and cyclones, as well as for good, stable weather predictions.

Impacts of rice cropping intensification from traditional (prior to 1960) to green revolution agriculture (1961-2000) to post-green revolution ecological farming (21st century)

Farmers have been intensifying the crop production systems to feed the burgeoning population by adopting more of the BMPs discussed earlier. The impacts of such intensification on input use efficiency, crop yield and profitability, environmental health, and sustainability of production systems are discussed in this section.

A. Pre-industrial traditional agriculture

This era was a period of true conservation agriculture (CA), a time during which farmers developed thousands of crop varieties and many animal breeds over centuries. They accomplished this CA through natural crossing (hybridization) and the selection of crops and varieties that were adapted to local soil, biotic, climatic (drought, flood, storms), and social conditions. Soil fertility was regenerated through long periods of rest (fallow periods of 12-18 years after 1-2 years of cropping), the periodic addition of natural materials such as household wastes, composts and animal manures, and adoption of practices such as crop rotation (especially with N-fixing legumes) and mixed planting (Balasubramanian, 2010). Farmers replanted their own seeds and exchanged their seeds and animal breeds with others; thereby, spreading new planting materials and animal breeds far and wide, while coincidentally preserving biodiversity in farmlands. This form of pre-industrial CA supported the small populations existing during those times. This had to change as agriculture expanded and human populations grew rapidly.

B. Green revolution agriculture

This era marked the development and widespread use of varieties that are semi-dwarf and short-maturing (100-120 days) and adoption of high-yielding rice varieties supported by a liberal application of water, fertilizers, and pesticides. There was also a focused policy and institutional support for intensifying rice farming in favorable irrigated areas. This green revolution (GR) led to a continuous, intensive mono-cropping of rice that increased the annual rice productivity per unit of land; thereby, helping to avert famine and reducing hunger in Asia (Herdt and Capule, 1983; Dalrymple, 1986; Hossain and Fischer, 1995; Hossain, 2005).

However, over time, the GR amplified the incidence of insect pests and diseases, that were controlled by applying larger quantities of toxic chemical pesticides (Rola and Pingali, 1993). Despite the impressive records of food production and avoidance of hunger and famines, there were reports of numerous adverse effects of chemical-intensive monocrop production systems of rice and other cereals, i.e., resource depletion and degradation, increased greenhouse gas emissions, environmental pollution, and the loss of habitats and biodiversity (Tilman, 1998; UNEP, 2012).

C. Post-green revolution agriculture – Ecological intensification

At the beginning of the 21st century, agricultural scientists faced their greatest challenge – one of meeting the increasing demand for food by intensifying agricultural production without harming the environment – while at the same time protecting or enhancing the resource base. This is when the concept of CA -based intensification of ecologically-sound farming practices began to be seriously considered as an alternative to GR agriculture. An intensification of CA-based ecological approaches is now considered to be the most appropriate option for the tropics and subtropics. Climate change in these two regions is likely to result in an increase in the frequency of severe droughts, erratic rainfall events, and an increased degradation of both agricultural and forest lands (Wall, 2011).

A comprehensive understanding of scientific, technical, environmental, economical, and societal issues – including re-education of farmers and stabilization of the human population – is a prerequisite to effectively implementing eco-efficient farming practices (Balasubramanian et al., 2012; Stoop et al., 2017). There is, however, no assurance that all the necessary prerequisites will be met. Food security of billions of human beings depends on success in implementing truly sustainable agricultural ecosystems for growing rice across Asia. Some of the consequences, issues, and challenges to a progressive rice crop intensification in Asia are shown in Table 3.

Addressing socio-economic and policy constraints

Tackling rural agrarian crisis

Rural reconstruction is the key to improving rural livelihoods and reducing rural to urban migration. What we need is to develop smart villages rather than smart cities by improving rural living conditions through better and affordable healthcare and education facilities, better rural infrastructure for farm production, processing and storage, as well as good roads and efficient transport to well-functioning markets. Farmers who wish to stay in villages should be trained and and equipped with modern farming techniques (Table 2) to enhance their productivity and profitability. We also need to create more micro, small, and medium enterprises in rural areas to employ rural residents. We further need progressive polices and better legal framework to address the land tenure issues and gender inequalities (FAO, 2013).

Table 2. Consequences, issues, and challenges facing the sequential intensification of rice farming in Asia.

Particulars	Pre-industrial traditional, low input agricultural systems (Prior to 1960)	High-input monoculture Green Revolution Agriculture (1961-2000)	Optimum-input ecologically-oriented, intensive farming systems (21^{st} Century)
Input use and efficiency			
Indigenous inputs (farm-generated)	High	Low	As much as possible
External inputs (fertilizers, plant protection chemicals)	Nil	High	Optimum, as per crop demand
Agronomic N-use efficiency (kg grain kg $^{-1}$ N)	Low (5-10)	Low-medium (10- 15)	High (20-25)
N recovery efficiency (%)	Low (15-25)	Medium (30-40)	High (50-60)
Water productivity (kg rice m^{-3} water)	Low (0.10-0.15)	Medium (0.4-0.5)	High (0.8-1.1)
Labor productivity	Low	Medium	High
Drudgery	High	Medium	Low
Yield and profit			
Yield	Low	High	High
Profitability	Low	Medium	Medium-high
Environmental impact			
Ground water depletion	Nil	High	Minimal
Pollution of water sources	Nil	High	Low
Methane emission	Low	Medium-high	Low?
Nitrous oxide emission	Nil	Low	Variable?
Rice straw burning	Nil	Medium-high	Low-nil
Sustainability			
Production sustainability	High	Low	High
Economic sustainability	Low	Low-medium	Medium-high
Environmental sustainability	High	Low	Medium-high
Total sustainability	High at low yield level	Low-medium at high yield level	High at high yield level

Minimum support prices, if dynamically adjusted to cover the full cost of production plus a decent profit, will enhance farm production and diversification. It is also important to control the prices of farm inputs to contain the production cost and minimum support prices.

Tackling rural to urban migration

Smallholders have three options to move out of unviable farming livelihoods: (a) sell their land and move to cities in search of better livelihoods, i.e., from rural to urban migration; (b) remain as smallholders in villages (persistence of smallholders in Asia) and improve their living conditions through government-mediated rural reconstruction as stated above and increasing effective farm size; and (c) access and benefit from agriculture value chain by organizing smallholders into voluntary or formal producer groups for better coordination of production, village level pre-processing, and marketing.

A. Can the Asian governments offer alternate livelihood options for the to-be-displaced smallholders?

The planners, scientists, and other decision makers think that moving smallholders out of farming is the key to consolidation of small holdings into large viable units with a view to modernize production methods. However, in reality, it does not work as planned because it is difficult to convince most Asian farmers to give up their land and go for other occupations due to their emotional attachment to their land and their lack of education and skills for alternative employment. The governments in population-rich and land-scarce developing Asian countries can neither train the millions of to-be-displaced farmers for suitable non-farm jobs nor generate adequate non-farm jobs to gainfully employ them. Often those who migrate to cities end up living in miserable conditions, creating more problems and conflicts with the earlier settled city residents. Therefore, this option has limited value in reducing rural to urban migration.

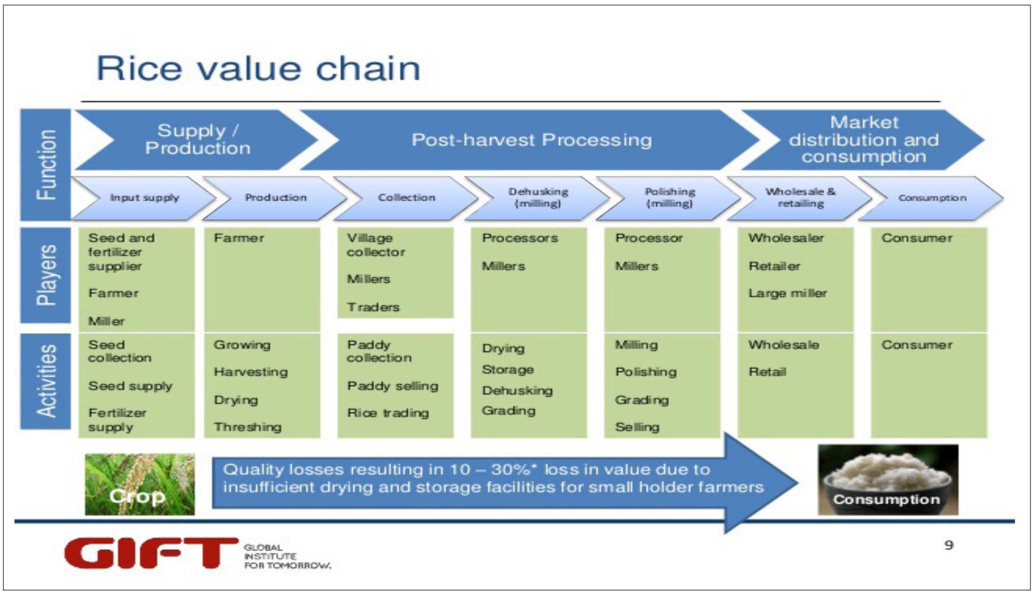


Figure 4. Activities, players, and functions of the rice value chain in Cambodia (GIFT, 2013).

B. Stemming rural to urban migration and land fragmentation

Given the persistence of smallholders in Asia (Rigg et al., 2016), the governments should enable farmers to make a decent living out of their farms. We need to explore some smart ways to increase the effective farm size through consolidation of small holdings without farmers losing their title to their lands. Some examples of increasing effective farm size include a kind of "village farming" in China, "small farmers, large farm" in Vietnam (Bouman, 2014), and professionally managed groups of small holders in Indonesia. Farmers in such large virtual farms should have decent access to good quality water resources, favorable land tenure system, appropriate technologies, training and technical support, credit, insurance, and adequate rural infrastructure (health, education, roads, transport, processing, and storage facilities). Such well-supported large virtual farms will adopt precision farming methods to produce adequate quantities of good quality produce for efficient marketing at attractive price (FAO, 2013).

C. Facilitating smallholders to access agricultural (e.g., rice) value chain

Agriculture value chain starts from the organization and supply of inputs and technical support to farmers for the production of crops and moves on to actual crop production in the field, harvest and post-harvest processing, collection and transport, wholesale including export and retail distribution, and finally consumption (Figure 4). The value chain players such as rural collectors, regional bulk produce handlers and wholesalers, and large rice millers play the most diverse role in the value chain and generally hold the most power in the movement of harvested paddy rice through the value chain and the determination of rice prices at different stages. They generally have high mark-ups (13-80%) in price at different stages of the value chain (GIFT, 2013).

Individual smallholders find it difficult to meet the quantity, quality, and food safety as well as the strict supply schedule requirements of sophisticated modern super markets (FAO, 2015). To overcome this challenge, the actors in the agricultural value chain – farmers, extension personnel, researchers, and agricultural input suppliers, traders, large dealers, millers or processors, and exporters – can come together to establish a commodity platform (e.g., National rice platform as in Madagascar) and interact among themselves through improved information and communication technologies and e-commerce. This will help smallholders in real-time decision making in all transactions and calculate the best possible price for their produce (FAO, 2013). It is even better if smallholder farmers can organize themselves into viable groups to attain the full benefits of agricultural value chains. The three options available to smallholders to get organized into groups are discussed below:

C1. Informal farmer producer organizations: Smallholders should organize themselves as a producer group, preferably on voluntary basis, to gain better negotiation power in joint purchase of farm inputs and joint sale of their produce to traders at competitive prices. Producer groups are often single commodity-based such as jasmine rice, organic rice, banana, sugarcane, cardamom, tea, coffee, and cocoa. The informal groups facilitate discussion, link to live market information including dynamic commodity prices, coordinate production to meet varying market demands (e.g., not all farmers producing and flooding the markets at the same time), enable efficient market transactions, encourage produce quality through training and technical support, and form a common contact point for farmers and traders to come together to make the transactions. These informal groups are neither registered nor have any significant overhead for the transactions they make. They simply enable efficient smallholder production and marketing.

C2. Formal farmer producer companies: In some countries like Cambodia, China, India, Indonesia, Philippines, Thailand, and Vietnam, smallholders have already begun to come together and form Farmers Producer Organizations (FPOs), most of which are registered Farmer Producer Companies (FPCs). The ASEAN Working Group on Agricultural Cooperatives had developed a roadmap on organizing smallholders into effective producer groups to take advantage of the agriculture value chain. The Indian National Policy and Process Guidelines (2013) encourage State Governments to provide incentives, including credits for and support of the formation and ongoing operation of FPOs in various states. By September 2013, over 500 FPOs had been formed and are now successfully operating throughout the country. Those FPOs which are set up as FPCs enable their members to access financial and other inputs and services, including appropriate technologies for farming. The FPCs also organize collection, processing, storage, and marketing of their members' produce in high-value markets at an optimal price. These actions of FPCs reduced the transaction costs and allowed the FPCs to enter into a partnership with private and public sector companies for supplying farm produce on more equal terms.

C3. Contract farming: Contract farming is a system of cultivation of a specified crop or a variety under a mutually agreed contract between the farmers (and preferably farmer producer groups) and the purchaser of the produce (a processing company or a contractor of a company). The contractor specifies the crop variety and quality and quantity of the produce to be supplied by farmers or farmer groups and announces the purchase price well in advance of the farming season. The contractor provides farmers with critical inputs, training and technical support, and even arranges farm credit through banks. Thus, farmers can produce the crop with advanced technologies and are relieved from the risks of market fluctuations and or price volatility. The most important success factor in contract farming is "the trust" between the contracting parties. Without developing this trust, nothing can succeed.

Conclusions

Globally, Asia is the most important rice producing region. The Asian rice sector supports 140 million smallholder farmers, employs 300 million people in the rice value chain, contributes to 90% of the global rice output, and feeds 60% of the population. Despite the increasing urbanization and out-migration of youngsters from villages to cities, smallholders continue to persist, especially in South and East Asia. There is a growing rural agrarian crisis due to a continuous neglect of villages and smallholder farming in developing Asia. Chemical intensive rice farming alone is no longer sustainable due to an increasing ecological and resource degradation. It is therefore important for us to halt further degradation of the natural resource base as we attempt to increase productivity of rice and rice-based farming systems to feed the increasing population. This aim should be feasible if farmers will use new climate smart rice varieties and production technologies and carry out appropriate changes in rural infrastructure. We also need appropriate policy and institutional support systems in place to make intensification of rice farming sustainable, profitable, regenerative, and will support land and water resource bases and the environment. A comprehensive understanding of scientific, technical, environmental, economical, and societal issues – including re-education of farmers and stabilization of the human population – is a prerequisite to effectively implement eco-efficient farming practices. There is, however, no assurance that all the necessary prerequisites will be met; yet, the food security of billions of human beings depends on success in implementing truly sustainable agricultural ecosystems for growing rice across Asia.

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PHILIPPINE RICE COMPETITIVENESS: STATUS, PROSPECTS, AND DIRECTIONS

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Abstract

As a guide to improving Philippine rice competitiveness, this paper examined rice production benchmarks in selected irrigated and intensively cultivated areas in the Philippines, China, Indonesia, India, Thailand, and Vietnam. It profiled yield and production cost across study sites. It compared the domestic price of rice in the Philippines to parity prices of imported rice from Vietnam, Thailand, and India. Results of the study showed that exporting countries had lower production costs than importing countries. Vietnam had the least cost of PhP 6.53 kg^{-1} paddy and the highest grain yield of 20.59 t ha^{-1} yr^{-1} for 3 crops. In the Philippines, cost was PhP 12.41 kg^{-1} and yield was 9.52 t ha^{-1} yr^{-1} for 2 crops. Rice produced in Nueva Ecija cannot compete in Manila wholesale markets with imported rice from Vietnam, Thailand, or India and 35% tariff. With 35% tariff, domestic farm prices in Nueva Ecija would fall to PhP 11.77 kg^{-1} without quantitative restrictions. Farmers have to reduce their production cost from PhP 12.41 kg^{-1} to PhP 6.97 kg^{-1} paddy to maintain current profit margins. Higher yields from use of hybrid varieties and high quality seeds, improved agronomic techniques, and reduced labor cost through direct seeding or use of combine harvesters are key ways to improve competitiveness and farmer profits. Improved milling efficiency and capacity utilization are also important.

Keywords: Competitiveness, Cost, Grain Yield, Production, Rice.

Introduction

Achieving self-sufficiency in food staples, particularly in rice, is enshrined in the food security policy of the Philippine government from 2011 to 2016. To do this, the government has implemented the Food Staples Sufficiency Program, which aims to improve farm productivity and make Filipino farmers globally competitive (DA, 2012). Indeed, paddy production increased by 20% from about 16 million metric tons (mmt) in 2010 to its record high of nearly 19 mmt in 2014. Rice imports went down from more than 2 to 1 mmt at the same time. Consequently, self-sufficiency level has improved from a low of 81% in 2010 to its peak of almost 97% in 2013 before slightly going down to 92% in 2014 (PSA, 2015). At this sufficiency level, the average national per capita consumption was 114.27 kg rice year^{-1} (PSA, 2015). Interestingly, the wholesale price of regular milled rice rose by 29% from PhP 28 kg^{-1} to about PhP 37 kg^{-1} during the same period. In spite of the improvement in self-sufficiency status, why does rice become more expensive and less affordable to Filipinos?

This is where Philippine rice trade policies become intricately related to its quest for self-sufficiency. Since the Philippines joined the World Trade Organization (WTO) in 1995, it has employed the tariff rate-quota system to protect the domestic rice industry from the influx of cheaper imported rice (Hoang and Meyers, 2015). Under this system, the government can restrict the volume of rice to be imported (i.e., quantitative restriction or QR), while maintaining a minimum access volume (MAV). Imported rice within the MAV is levied with an in-quota tariff but is subject to an out-quota tariff if importation exceeds the MAV.

According to Intal and Garcia (2005), the MAV was set originally to 59,000 mt in 1995; then increased to 119,460 mt in 1999 and to 239,940 mt in 2004. The MAV further increased to 350,000 mt in 2005 after the Philippines successfully negotiated for an extension until 2015. The QR trade regime was supposed to end in June 2015, but the country obtained from the WTO a waiver on this commitment until 2017. In return, the Philippines agreed to a higher MAV (805,200 mt) and concessions on the dairy industry (FAO, 2015). Beyond 2017, it may be difficult for the country to negotiate for an extended implementation of QR. However, the effect of QR expiration can only be experienced after amending Republic Act 8178, which stipulates the replacement of quantitative restrictions on agricultural products, except rice, with tariffs (The Official Gazette, 2016).

The in- and out-quota tariffs also gradually decreased. The in-quota tariff started at 50% from 1995 to 2004, then went down to 40% from 2005 to 2015. Similarly, the out-quota tariff declined from 100% in 1995-2004 to 50% in 2005-2015 (Hoang and Meyers, 2015). Upon approval of the waiver, the tariff rate was further reduced to 35% for the most favored nations or the MFN.

Aside from its WTO commitments, the Philippines is a country member of the Association of Southeast Asian Nations (ASEAN) and signatory to the ASEAN Free Trade Agreement (AFTA). Under this agreement, efforts were made to liberalize flow of rice trade within Southeast Asia. However, the country considered rice as highly sensitive to its food security and thus, subject to high tariff rates of 40% until 2014. To deepen economic integration, ASEAN country members agreed to join the ASEAN Economic Community by 2015. As such, Philippine tariffs on imported rice from ASEAN members were further reduced to 35% (ASEAN, 2008).

Can Philippine rice compete if QR is removed? Now that the Philippines is on the verge of opening up its domestic rice market to international competition, examining the production cost and comparing it with international competitors is highly relevant.

First, this paper examined the competitiveness of rice farming in intensively cultivated and irrigated areas in major rice producing countries in Asia: the Philippines, China, Indonesia, India, Thailand, and Vietnam. Specifically, the paper compared and contrasted paddy yield and cost of commercial paddy rice production. Second, the paper estimated the price of imported rice when sold at the domestic wholesale market under different trade scenarios. Third, the paper approximated the farmgate price that rice processors can offer to farmers given the equivalent wholesale price of imported rice and the current domestic marketing costs and margins. Fourth, the paper determined the cost of production that farmers should achieve to maintain the same level of profit prior to trade liberalization. Fifth, recommendations on improving rice competitiveness at the farm and marketing levels were provided.

Materials and Methods

Sampling Procedure and Data Collection

Six major rice-producing countries were covered in this study to have a wider view of rice competitiveness spectrum in Asia. The Philippines, China, and Indonesia represent the importing countries while India, Thailand, and Vietnam comprise the exporting nations. To ensure comparability of results, the study collected primary data from provinces or states that were generally irrigated and had at least two crop seasons annually. These were Nueva Ecija (Philippines), Zhejiang (China), West Java (Indonesia), Tamil Nadu (India), Suphan Buri (Thailand), and Can Tho (Vietnam). Villages that were former sites of the International Rice Research Institute's project on Reversing the Trend in Declining Productivity (RTDP) were selected as study sites. These villages were located within 15-20 radius of a rice research agency and farmers in these areas had easier access to technology (Dobermann et al., 2004).

Data were gathered in all rice planting seasons during crop year 2013-2014. Planting seasons depended on each location and were summarized in Figure 1. For the Philippines, dry season was from December to April and wet season was generally from June to October (Launio et al., 2015). In Thailand, dry season was from November to March and wet season was from May to September (Manalili et al., 2015). Because Indonesia was located in the southern hemisphere, its planting seasons were in reverse order: wet from November to March and dry from May to September (Litonjua et al., 2015). India had *thaladi* (monsoon) season during October-February and *kuruvai* (dry) season during June-September (Bordey et al., 2015). China had *early* season from April to July and *late* season from July to November (Mataia et al., 2015). Vietnam had three growing seasons: 1) winter-spring during November- February; 2) summer-autumn during March-June; and 3) autumn-winter during July- September (Beltran et al., 2015).

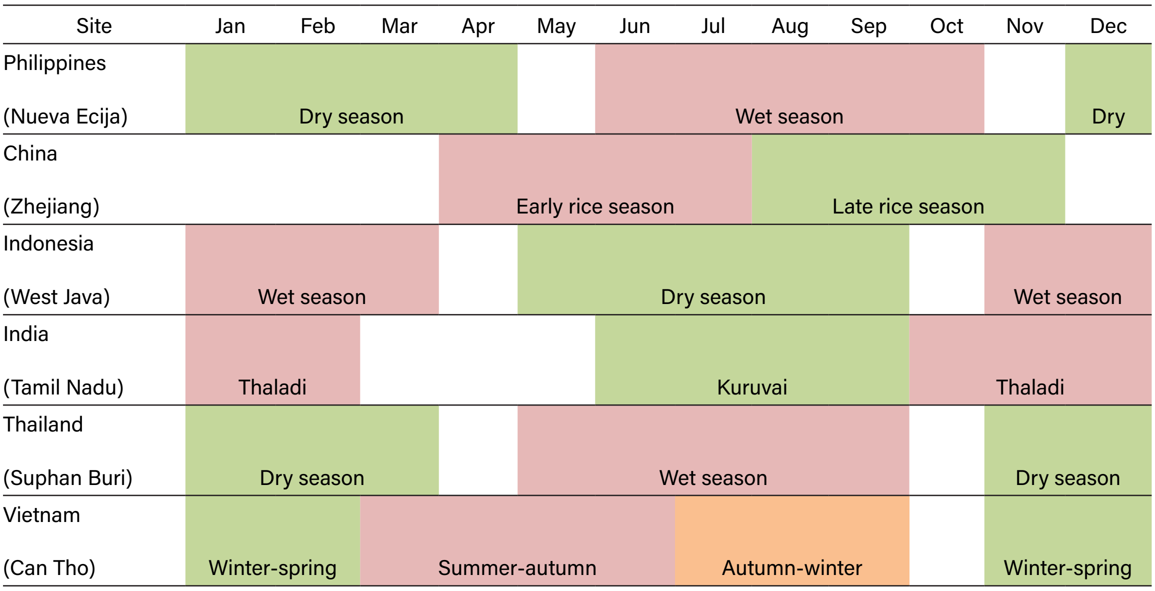

Figure 1. Common rice-growing calendar in project sites for crop years 2013-2014.

Note: Green indicates the high-yielding season; purple for the low-yielding season; orange for the third season; and white for the fallow period.

To facilitate comparison, dry (*kuruvai*) winter-spring and late rice seasons were categorized as high-yielding seasons (HYS) because of the higher yield potential of rice brought by the greater solar radiation (irradiance). In contrast, wet (*thaladi*) summer-autumn and early rice seasons were grouped as low-yielding seasons (LYS) due to the generally lower yields obtained during this period. The autumn-winter season in Vietnam was regarded as third season (TS) as it was the only site with a third crop season.

A quota sample of 100 respondents per province per season was set. The sample farmers were selected purposively. Farmers who participated in the RTDP project were traced and included as respondents. As it was difficult to locate some of the original RTDP participants and because of the need to increase sample size, new respondents were selected by local collaborators based on the following criteria: 1) those living in the same villages, 2) those having at least 10 years of farming experience, 3) those with farms irrigated and planted in crop year 2013-2014, and 4) those willing to be interviewed (Beltran et al., 2015; Bordey et al., 2015; Launio et al., 2015; Litonjua et al., 2015; Manalili et al., 2015; Mataia et al., 2015). Replacements were made in succeeding seasons following the same set of criteria because some respondents were not available during the interview period.

Yield and Farm Budget Analysis

To facilitate yield comparison across seasons and locations, fresh paddy yield reported by farmers were converted into dry equivalent. To do this, we used information on general moisture content during harvest period in each location as indicated in the key informant interviews. The dry yield was computed as:

$$\text{Dry Yield} = \text{Fresh Yield} \times \frac{\left(1 - MC_{fresh}\right)}{\left(1 - MC_{dry}\right)} \qquad (1)$$

where MC_{fresh} was the moisture content of paddy during harvest period and MC_{dry} was at 14% moisture level. The dry yield was used in calculating unit cost.

A farm budget structure was constructed for the production of paddy rice in the irrigated ecosystem using actual and imputed prices. The major cost components included material inputs such as seeds, fertilizer, pesticides, labor, power, land, capital, irrigation, and other minor items. The cost of each item was estimated by multiplying quantity by its acquisition price:

$$C_i = Q_i \text{ x } P_i \qquad (2)$$

where C was cost, Q was quantity, and P the price of input i.

Aside from the actual costs spent by the farmer, we also included the opportunity costs of inputs owned by the farmer and the opportunity costs of the farmer and family labor used in performing the various farm activities. We imputed values to their own inputs and labor using the prevailing prices or wage rates in the site.

To compare across countries, all costs were expressed in United States dollar and then converted to Philippine peso using the exchange rates during the time of study (IMF, 2013). The costs were presented in terms of expenses required to produce a kilogram of paddy. This was done by dividing cost per hectare by yield level. The rice production system became more cost competitive with lower production cost per unit of output.

Analysis of Competitiveness

Competitiveness depended on the capacity of a producer to produce goods that had superior quality at lower costs than its local or international competitors (Yap, 2004). It was affected by technological capacity, market conditions, and existing domestic and trade policies of participating countries in the world market. Given the wide variation in geography, production ecosystem, and technological capability, some farmers could be more competitive than others. In this study, the average competitiveness of farmers in irrigated ecosystems of Nueva Ecija, Philippines, were compared with their counterparts in exporting countries such as India, Thailand, and Vietnam.

A comparison of import parity price with the domestic wholesale price was used in gauging the competitiveness of locally produced rice. Import parity price was defined as the "value of a unit of product bought from a foreign country, valued at a geographic location of interest in the importing country" (USAID, 2008). It was used in assessing incentives to trade and incentives to produce where local producers competed with suppliers from outside the country.

The import parity price was calculated by adjusting the price of the good at the border of exporting country or port of entry in importing country for transport, marketing, and transaction costs that were incurred when the commodity was brought into the considered geographic location. The January-September 2015 average of free on board (FOB) price of white rice with 25% broken from Vietnam, Thailand, and India was used. These were adjusted to import parity price and compared with domestic wholesale price of regular milled rice of ordinary variety in Metro Manila, Philippines. Effects of policies such as taxes, subsidies, and tariffs were also included in the adjustments. A scenario with 35% tariff and no QR was considered. Currency conversion was made using an appropriate exchange rate to express the price in Philippine peso. This resulted in a parity price that reflected the cash or financial value of the good in the location being considered (USAID, 2008).

Sensitivity analysis was done to determine the level of world price that will make domestic rice competitive at 35% tariff and no QR. As the reduction of trade protection was a concern with the elimination of QR, another sensitivity analysis was employed to assess the tariff rate that will make the local rice competitive to the least cost producer when there was no QR.

Assuming that local processors will not adjust their operations after QR elimination and maintenance of 35% tariff, the best farmgate price that they could offer to their paddy suppliers was estimated using the gross marketing margins calculated by Beltran et al. (2016). Similarly, the farmer's profit margin in Nueva Ecija, Philippines calculated by Moya et al. (2016), was used in estimating the necessary cost of production that will maintain farmers' profit.

Partial budget analysis was done to determine some options on reducing the local cost of production at the farm level. The cases of yield increment through use of hybrid rice variety, reduction of labor through mechanization of harvesting, and direct seeding were considered. This used the farm production data in Nueva Ecija, Philippines, generated by Launio et al. (2015).

Data Limitations

While the data in this study can provide insights about the status of rice production in irrigated and intensively cultivated areas in selected Asian rice bowls, there were limitations that should be considered in the interpretation of results. First, the accuracy of the gathered information relied on the farmers' ability to recall their production practices and expenditure in 2013. Second, the reliability of the information also highly depended on the capability of the translators to accurately translate the responses of farmers from the local dialect to English. Third, the information gathered only represented a specific rice production ecosystem and results should not be construed to cover the entire country.

Finally, the study did not analyze comparative advantage of producing rice by comparing social profitability and domestic resource costs using the techniques developed by Monke and Pearson (1989). The social prices of outputs and inputs, which were the prices that would exist in the absence of government interventions, were needed to produce the analysis. However, this was not necessary for the following reasons. First, subsidies were essentially not used in the exporting countries (with the exception of the fertilizer subsidy in India); thus, private prices equal social prices in the exporters. Second, the importing countries all used import restrictions that were binding—without those restrictions, the private sector would import larger quantities than were being imported. This implied that the exporting countries were able to export with only minor subsidies at most, and that these exports were competitive upon arrival in the importing countries—the importing countries must use trade barriers to keep them out (Dawe, 2016).

Results

Yield and Cost

Figure 2 shows the average yield in irrigated areas, by site and season. At 14% grain moisture content (MC), Vietnam garnered the highest annual yield of 20.59 t ha^{-1}. Not only did Vietnam have the highest yield in both high- (HYS) and low-yielding seasons (LYS), it also had the most intensive cropping system—three rice crops a year. This was made possible by continuous availability of water, use of early-maturing varieties, direct seeding, and synchronous planting (Beltran et al., 2015). Yield was highest during the winter-spring (HYS) at 8.56 t ha^{-1} when the field was just flooded and solar radiation (irradiance) was highest. The yield during summer-autumn (LYS) was 6.33 t ha^{-1}. Its lowest average yield was recorded during the autumn-winter (third season [TS]) at 5.69 t ha^{-1} when the rice field was used for the third time within the crop year.

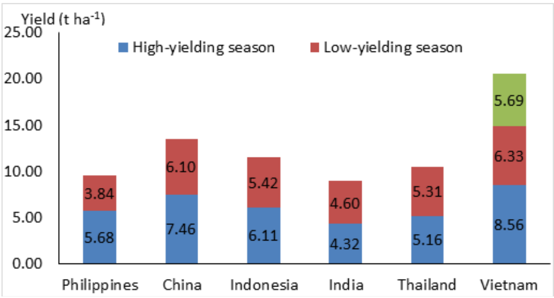

Figure 2. Distribution of paddy yield at 14% MC, by country and season for crop year 2013.

China followed with an annual yield of 13.56 t ha^{-1}. Average yield was 7.46 t ha^{-1} and yield was higher during HYS (late rice season) when hybrid rice was planted. The average yield during LYS (early rice season) was 6.10 t ha^{-1}. Only inbred rice varieties were planted during the LYS (Mataia et al., 2015). The choice of variety was largely affected by the length of growing season. If Chinese farmers had a choice, they would plant hybrid rice varieties in the two seasons. However, hybrid varieties matured longer than inbred varieties. Because the area had a limited growing season (subtropical climate), they planted a shorter maturing variety during LYS only with government support.

Indonesia also had high yield with an average of 6.11 t ha^{-1} during HYS and 5.42 t ha^{-1} during LYS. The *legowo* planting system was believed to have contributed to high yields in Indonesia (Hidayah 2013; Litonjua et al., 2015). Thailand also had relatively high yield, averaging at 5.16 in HYS and 5.31 t ha^{-1} in LYS.

India had the lowest annual yield among the six sites with 8.92 t ha^{-1}. The yield during the HYS (*kuruvai*) was only 4.32 t ha^{-1}, lower than LYS yield of 4.60 t ha^{-1}. The lower yield during HYS could be attributed to water stress (Bordey et al., 2015). The primary source of water was groundwater and there was low water supply because of shortage of electricity to operate the water pumps.

The Philippines had the second to the least annual yield of 9.52 t ha^{-1}. Although its yield during HYS at 5.68 t ha^{-1} was comparable with the average in the six countries, it had the lowest LYS yield of 3.84 t ha^{-1}. This low yield was attributed to cloudiness and lower solar radiation during the LYS, and aggravated by normal typhoon occurrence in the survey area (Launio et al., 2015). On average, about 20 typhoons annually traversed the Philippine area of responsibility and eight to nine of these made landfall and caused some damage to the crop (Bordey and Arida, 2015).

Figure 3 shows the annual average production cost per kilogram paddy/grain across countries. The cost of paddy production was cheaper in exporting countries than in importing countries. Vietnam had the least production cost of PhP 6.53 per kg paddy. Thailand and India followed with PhP 8.85 kg^{-1} paddy and PhP 8.87 kg^{-1} paddy, respectively. However, it was learned that most rice produced in Thailand was of better quality than those of Vietnam and India.

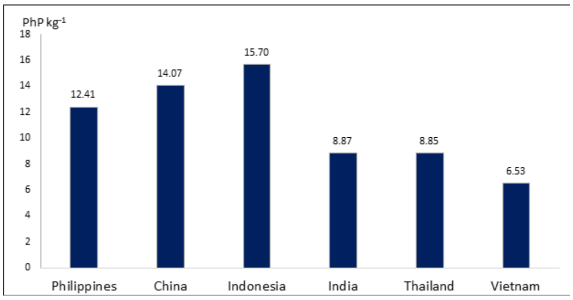

Figure 3. Comparative cost of producing 1 kilogram of paddy/grain in project sites for crop years 2013-2014.

Producing a kilogram of paddy was more expensive in intensively cultivated and irrigated areas in importing countries such as the Philippines, Indonesia, and China than in exporting countries such as Thailand, Vietnam, and India. In such case, exporting countries had an advantage in terms of cost competitiveness at the farm level than importing countries.

Substantial differences in major items of costs such as labor occurred not because of major price differences but because of varying levels of mechanization (Moya et al., 2016; Mataia et al., 2016). Low-cost countries such as Thailand and Vietnam were highly mechanized, resulting in low labor costs compared with those in labor-intensive countries such as the Philippines and Indonesia. Deviations in other cost items also occurred but at a smaller magnitude.

Rice Price and Tariff

Table 1 shows the estimated import parity prices of white rice with 25% broken from Vietnam, Thailand, and India. Of the three sources, Vietnam had the lowest FOB price of US$331.94 t^{-1}, followed by India (IRRI, 2015). The price of Thai rice was generally more expensive due to perceived higher quality. The proximity of Vietnam to the Philippines was considered in approximating freight cost. Freight cost from Bangkok (Thailand) to Manila was assumed to be 50% higher than in Vietnam. Similarly, freight cost from Chennai (India) was also assumed to be twice more expensive than in Vietnam.

Without QR and with only 35% tariff as protection, Vietnam produced the cheapest rice among the three countries (Table 1). A kilogram of 25% broken rice from Vietnam could be sold in Manila wholesale market for PhP 27.32, PhP 29.61 for Indian rice, and PhP 30.89 for Thai rice. All of these were cheaper than the average wholesale price of regular Philippine milled rice at PhP 34.47 kg^{-1}. With 35% tariff, the price of the cheapest imported rice from Vietnam was 21% lower than that of domestic rice. This implied that removal of QR would lead to a reduction in the domestic price of rice.

Results supported the conclusion from studies analyzing the effects of trade liberalization on the price of rice. Litonjua and Bordey (2014) approximated a reduction in the wholesale price of rice to PhP 25.06 kg^{-1} from the 2013 base price of PhP 34.49 kg^{-1} should the QR be removed and only the 35% tariff maintained. Briones and dela Peña (2015) predicted that retail price of rice would decline to PhP 19.80 kg^{-1} from PhP 33.08 kg^{-1} in 2013 if imported rice was allowed to freely enter the country. Hoang and Meyers (2015) found that retail price would decline to PhP 31.4 kg^{-1} using a scenario of gradual phasing out of AFTA tariffs starting 2016 and complete elimination of trade barriers in 2020. Though there were differences in magnitude, all these studies pointed to price reduction should there be liberalization in rice trade.

Sensitivity analysis showed that at a 35% tariff rate and assumed costs of freight, delivery insurance, and other charges, locally produced regular milled rice would be competitive if the price of 25% broken rice from Vietnam was about US$450 t^{-1} or higher (Figure 4). At this FOB price, the estimated import parity price was PhP 34.52 kg^{-1}.

Given the FOB price of Vietnam rice at US$331.94 t^{-1}, domestic rice could be competitive at the Manila

Table 1. Estimated import parity price of 25% broken rice.

Item	Vietnam	Thailand	India
FOB price of 25% broken (US$ t^{-1})[1]	331.94	377.70	344.49
+ Freight Cost (US$-$t^{-1}$)[2]	25.00	37.50	50.00
+ Delivery Cost (US$-$t^{-1}$)[3]	30.70	30.70	30.70
+ Insurance Cost (US-t^{-1})[4]	1.99	2.27	2.07
+ Other Charges and Costs (US$ t^{-1})[5]	38.13	38.13	38.13
Cost of commodity, freight, and insurance (CIF) (US$ t^{-1})	427.76	486.29	465.38
Peso-Dollar Official Exchange Rate (PhP US$$^{-1}$)[6]	45.17	45.17	45.17
Cost of commodity, freight, and insurance (PhP t^{-1})	19,321.87	21,965.76	21,021.14
+Tariff payment (PhP t^{-1})[7]	6,762.65	7,688.02	7,357.40
CIF+tariff payment (PhP t^{-1})	26,084.52	29,653.77	28,378.54
+ estimated local transport cost (PhP t^{-1})	1,232.00	1,232.00	1,232.00
Import parity price (PhP kg^{-1})	27.32	30.89	29.61
Philippine wholesale price, regular milled rice (PhP kg^{-1})[8]	34.47	34.47	34.47
Price difference (%)	-20.76	-10.40	-14.10

[1]The average price of 25% broken rice, January-September 2015. Source: http://ricestat.irri.org:8080/wrs2/entrypoint.htm

[2]Vinafoods II contract with vessel is $25 t^{-1}; Thailand cost is assumed to be 50% higher than that in Vietnam, while India cost is assumed to be double that of Vietnam. Source: http://manilastandardtoday.com/mobile/2014/02/25/-nfa-execs-wined-dined-in-vietnam-/

[3]Vinafoods II contract with DYA Sea Air International Corp is $30.70 t^{-1} for inclusive handling, delivery, and forwarding costs between the Philippine ports of arrival to NFA-designated warehouses. Assumed to be the same with Thailand and India. Source: http://manilastandardtoday.com/mobile/2014/02/25/-nfa-execs-wined-dined-in-vietnam-/

[4]Insurance cost is US$0.60 $100^{-1}. Source: http://www.priorityworldwide.com/resources/cargo_insurance_guidelines.aspx.

[5]The Philippines levied a fee of US$ 915 on a 20-foot container in 2014. It was assumed that a 20-foot container can contain 24 t. These include costs for documents and administrative fees for custom clearance. Source: http://www.tradingeconomics.com/philippines/cost-to-import-us-dollar-per-container-wb-data.html

[6]Average exchange rate, January-September 2015. Source: Reference Exchange Rate Bulletin, Treasury Department, Bangko Sentral ng Pilipinas.

[7]Tariff rate is assumed at 35%

[8]Average wholesale price of regular milled rice in the Philippines, January-December 2015. Source: http://countrystat.psa.gov.ph/?cont=10&pageid=1&ma=L00PRWPC

wholesale market if the tariff level imposed on imported rice was at least 75% (Figure 5). This indicated that the current tariff equivalent of the protection accorded by the combined QR and tariff was about 75%. At this tariff level, the import parity price was estimated at PhP 35.05 kg^{-1}.

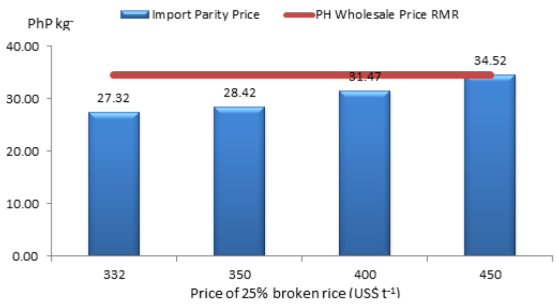

Figure 4. Sensitivity of import parity price relative to variation in price of 25% broken rice and given 35% tariff.

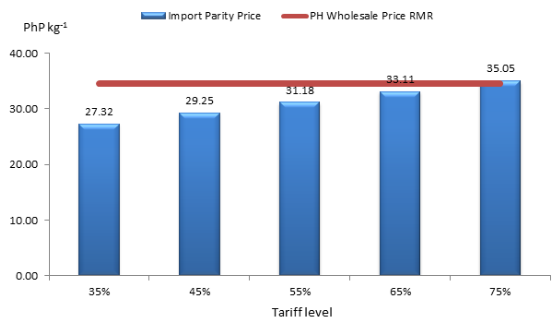

Figure 5. Import parity price of 25% broken rice from Vietnam at different tariff levels.

Effects on Paddy Price

Assuming that the country imported from Vietnam at 35% tariff and that wholesale prices were transmitted to farmgate prices, the gross marketing margin of Philippine market players was estimated at PhP 9.06 kg^{-1} (Beltran et al., 2016). Subtracting this from the import parity price of Vietnam rice at PhP 27.32 kg^{-1} would leave about PhP18.25 that could be used by processors to buy dry paddy to produce 1 kg of milled rice. At the milling recovery ratio of 64.5%, the best price that processors could offer to buy a kilogram of dry paddy was PhP 11.77. To maintain the profit margin of farmers, which was estimated at PhP 4.80 kg^{-1}, their production cost must be reduced to PhP 6.97 kg^{-1}. Thus, improving farmers' productivity was needed.

Discussion

The Philippines will not be competitive by enhancing the rice production system alone. Parallel efforts should be made to improve its marketing system to be able to compete globally. Farmers and processors must be able to produce rice with the same or superior quality at costs than those of international competitors to be competitive. To do this, possible strategies are discussed below.

Hybrid Rice

Increasing rice production per hectare at less cost can help farmers earn the same profit despite lower prices. Data from irrigated rice production in Nueva Ecija in 2013 dry season (DS) showed that hybrid rice achieved a yield of 7.20 t ha^{-1} (at 14% MC). This is 36% higher than the yield of farmers who used certified inbred seeds and 74% higher than the yield of farmers who planted their own seeds (Figure 6). Based on this higher yield, it requires only PhP 9.85 for hybrid rice farmers to produce a kilogram of dry paddy. Users of certified and own seeds have to spend PhP 11.66 kg^{-1} and PhP 13.72 kg^{-1}, respectively.

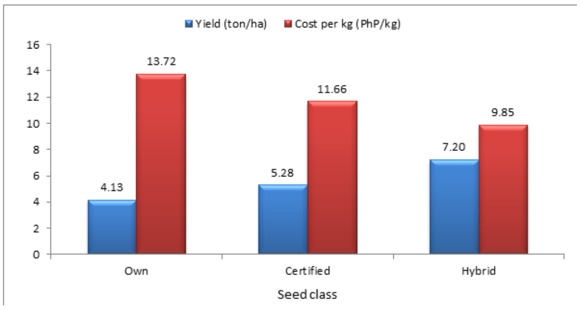

Figure 6. Comparative palay yield (t ha^{-1}, 14% MC) and seed cost, by seed class, 2013 dry season, Nueva Ecija, Philippines.

Hybrid rice can be promoted to increase DS yield. However, because the yields of hybrid rice can vary considerably by location and ecosystem, it is important to ensure that farmers use hybrid seeds appropriate for their specific conditions. Use of hybrid seeds should be complemented with appropriate crop management practices to maximize yield.

The private sector has intensified its production and marketing of hybrid seeds since the removal of the hybrid seed subsidy in 2010. The government can help promote hybrid rice by ensuring the availability of public hybrid seeds, intensifying extension activities for hybrid rice production, and expanding irrigated areas to make farmers' fields suitable to hybrid rice.

Save on Labor to Reduce Cost

Rice farm labor is costly in the Philippines. In irrigated areas of Nueva Ecija alone, hired labor consumes 30% of total production cost or PhP 3.76 to produce a kilogram of paddy (Table 2). Reducing cost in most costly farm activities such as crop establishment, harvesting, and threshing can enhance competitiveness.

As 99% of farmers transplant during the WS, transplanting was compared with direct seeding only in the DS. Hybrid seed users mostly transplant; hence, they were not included in the analysis. While transplanting requires 25 md, direct-seeding utilizes only 2 md in a hectare.

Table 2. Cost of dry paddy production, Nueva Ecija, 2013.

Item	Value (PhP kg $^{-1}$)
Seed	0.58
Fertilizer	1.94
Pesticide	0.36
Hired labor	3.76
Family labor	0.66
Power*	1.73
Land rent	2.11
Irrigation	0.45
Interest on capital	0.43
Others	0.40
Cost per unit	12.41

*Power cost consists of animal and machine rental, including fuel and oil.

Although direct seeding requires additional crop care, reduction in labor costs amounting to PhP 1.14 kg^{-1} savings was recorded (Table 3). Experiments showed yield differences between direct seeded and transplanted rice systems were not significant provided that crop management was proper, particularly for weeds in direct-seeded rice (Akkas Ali et al., 2006).

Table 3. Partial budget analysis of labor cost, by crop establishment method (PhP kg^{-1}).

Item	Transplanted	Direct-seeded	Difference
Hired labor	3.82	2.51	1.31
Family labor	0.60	0.77	-0.17
Net labor savings			1.14

Note: This only analyzed the change in labor cost resulting from use of different crop establishment methods. The resulting change in cost of other inputs such as seed and herbicide were not considered in the calculation.

Harvesting in the Philippines is mostly done manually while threshing is mechanized using an axial-flow thresher, requiring a combined labor use of 21 md ha^{-1} (Mataia et al., 2016). However, a combine harvester can harvest and thresh paddy in a single pass through the field, requiring less than 2 md ha^{-1}. Harvesting and threshing cost PhP 2.95 kg^{-1} (Table 4). Of this total, manual harvesting costs PhP 1.74 kg^{-1} or 10% of harvests/output, while the use of axial-flow thresher costs at PhP 1.21 kg^{-1} or 7% of harvests. However, the cost of using combine harvester is just PhP 1.39 kg^{-1} or 8% of harvests, which is PhP 1.56 kg^{-1} lower. The benefit from using combine harvester does not include the potential cost-saving implications on packaging/handling costs in rice marketing.

Table 4. Partial budget analysis of harvesting and threshing costs.

Item	Value (PhP kg^{-1})
Harvesting and threshing	2.95
Manual harvester	1.74
Mechanical thresher (axial flow)	1.21
Combine harvester	1.39
Net cost savings	1.56

The aforementioned data imply that direct seeding and use of combine harvester can be promoted to reduce cost at the farm level. They can also help prevent seasonal labor shortages that occur during planting and harvesting when farm activities peak. However, use of labor-saving practices is opposed due to labor displacement. Displaced workers need alternative jobs to regain their lost income from planting and harvesting should these activities become mechanized. Job generation outside the agriculture sector such as in factories and construction could absorb these workers.

Squeezing Costs Beyond the Farm

Enhancing competitiveness depends on of the farmers and marketing players. Improving milling efficiency, for example, reduces the processing cost of rice. Recovering 66 kg instead of 64.5 kg of rice from 100 kg of paddy means cost advantage. Assuming that the buying price for dry paddy rice is PhP 11.77 kg^{-1}, about PhP18.25 worth of dry paddy is needed to produce a kilogram of milled rice, if recovery is 64.5%. At 66% recovery, less paddy worth PhP 17.83 is needed to produce the same quantity of milled rice. Hence, improving milling recovery from 64.5 to 66% entails a cost saving of PhP 0.42 kg^{-1}.

To achieve a higher milling recovery, the quality of paddy being processed must be improved. Breeding institutions, that are mostly public, must release varieties that have similar grain length and shape, and with high head rice recovery to help improve the milling process. As an alternative, the National Seed Industry Council may limit the number of newly released varieties. In addition, mechanized drying of paddy can minimize the high percentage of broken rice.

To further improve milling efficiency, capacity utilization of rice mills can be increased through provision of custom services to other market players. For example, paddy traders can venture into rice wholesale/retail business without investing in large equipment and avail of the services of underutilized rice mills. Increasing the capacity utilization of existing rice mills can reduce milling cost.

Focused R&D

Increasing grain yield is the most certain way to reduce production cost per unit output and increase competitiveness. However, average yields in Nueva Ecija's intensively cropped areas in 2013 were not significantly different from average yields in the past 10 years (Launio et al., 2015). The most commonly planted varieties are those with potential yields of more than 10 t ha^{-1} at release time, suggesting that potential yield is a major variety characteristic considered by farmers. The Philippines will benefit if rice R&D will focus on increasing potential yield.

Conclusions

This study shows that the Philippines' ordinary white rice (regular milled) is still more expensive than imported rice with similar quality (with 25% broken rice) even at 35% tariff rate when QR is eliminated. In this respect, Philippine rice is less competitive. Only at FOB prices of about US$450 t^{-1} can Philippine rice start to become competitive given the 35% tariff. Hence, the removal of QR can lead to a decline in domestic price of milled rice and eventually to a lower price of paddy since the farmers are price takers. To maintain their farm income at pre-liberalization level, their cost of production must be reduced to about PhP 6.97 kg^{-1} paddy. This could be done by promoting the use of hybrid rice in suitable areas, focusing R&D in producing breakthrough technologies, and considering improvements in management practices, that could increase yield and reduce production cost per kilogram grain. To further reduce cost, labor-saving technologies such as direct seeding and use of combine harvester will help. Reducing production cost will also result in reduced overall marketing cost. Improving milling recovery through use of varieties with similar grain length and shape and better head rice recovery can contribute to reducing the processing cost.

The said strategies are some of the ways that can improve Philippine rice competitiveness in the medium term. They can result in immediate and significant reduction in production cost to prepare for the eventual lifting of QR. Beyond that, the Philippines needs to continue improving its rice competitiveness by intensifying long-term investment in R&D to look for future sources of yield growth and cost reduction.

This analysis was based on the competitiveness of Nueva Ecija, the largest rice-producing province of the Philippines. There are many provinces, especially those in Mindanao, that produce rice at a lower production cost per kilogram. There are also provinces that produce rice at a much higher production cost relative to Nueva Ecija. While the country continues to work on reducing production cost and increasing yield, it is important to start helping farmers in areas where ordinary white rice will have difficulty becoming competitive due to environmental constraints. They can be encouraged to take advantage of the ASEAN Economic Community and switch to other rices with niche markets such as specialty rice (e.g., pigmented, glutinous, and aromatic). They can be encouraged to plant other suitable crops and engage in agribusiness ventures.

For the past 20 years, protectionism or policy of restricting imports from other countries did not improve the competitiveness of the Philippine industry; it was rather lulled into complacency. The country cannot expect new results if the same policy directions continue. It is high time to face the challenge of liberalization head-on and take the necessary steps to improve competitiveness because it is now a matter of survival.

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FIELD TESTING OF A RICE CROP POSTHARVEST MANAGEMENT PROTOCOL FOR REDUCED POSTPRODUCTION LOSSES AND IMPROVED PRODUCT QUALITY

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Abstract

An integrated rice crop postharvest management protocol can guide farmers and processors to reduce postproduction losses and achieve better product quality. Through inter-agency workshops, a protocol on critical operational checks and corresponding best management practices was drafted. Field experiments were conducted from 2014–2015 at PhilRice field experiment station to test the protocol. Three rice cultivars were grown in a two-hectare paddy field. Crops were harvested at three different maturity stages using four harvest methods. Harvest losses were determined. Sun-drying on concrete pavement and mechanical flatbed drying were used. Storage methods included piling of dried paddy in 50-kg plastic sacks at ambient conditions on concrete floor (with and without plastic pallet underlay) and using hermetic cocoon or PhilRice SACLOB. Germination rates and storage losses were evaluated while laboratory test milling was done after six months. Results showed that harvest losses were less than 2% of field yield when crops were harvested at physiological maturity using a combine harvester or by manual cutting and mechanical threshing on the same day. Highest germination rates, least storage losses, and higher milling recovery were attained with samples that were combine-harvested, flatbed-dried, and stored hermetically. The protocol is now ready for pilot-testing in farmers' fields and commercial rice mills.

Key words: Paddy, Postharvest Management Protocol, Postproduction, Rice, Yield Losses

Introduction

While substantive strides have been made in the Philippine rice production sector, developments in the postproduction industry apparently have not kept pace with increased production. To address the inefficiencies, a sound integrated crop management (ICM) system should incorporate production and postproduction aspects covering harvesting, threshing, cleaning, drying, storing, and milling operations.

The rice integrated crop management system for irrigated lowland developed by PhilRice, called PalayCheck® System, presented best key technology and management practices as key checks. With eight key checks, it covered the principal areas of crop management, such as seed quality, land preparation, crop establishment, nutrient management, water management, pest management, and harvest management (PhilRice, 2007). Manalo and Cruz (2010) stated that based on the results of on-farm testing of PalayCheck® System from 2004-2007 in selected Philippine provinces, "the higher the number of key checks achieved, the higher the grain yield and gross margin." In their evaluation of the PalayCheck® System minus one key check recommendation, they found, among others, that a 3% yield reduction was incurred if Key Check 8 on harvest management (i.e., cut and threshed grains at the right time) was not achieved. In this study, we postulated that if Key Check 8 would be further developed to include operational checks from harvesting to milling, and if best management practices would be done to attain these checks, it would substantially reduce postharvest losses and improve seed quality or milling recovery.

By enhancing ICM for irrigated lowland rice, known as the PalayCheck® system (PhilRice, 2007), with best postharvest management practices, farmers will not only learn to preserve the quality of the paddy that they will sell, but also produce a better quality product that will command a higher price. An integrated rice postharvest management protocol must therefore be developed and packaged for the rice postproduction industry. In this study, the protocol refers to a detailed plan of postharvest procedures and techniques to be followed and carried out to attain operational key checks that will help reduce postproduction losses and improve milling recovery. This can also serve as a training module to equip farmers and processors on how to achieve better product quality that would meet competitive market standards.

The farm-level postproduction component consists mainly of operations from harvesting to threshing. Generally, the term harvesting refers to all operations carried out in the field to collect the palay or paddy when it is ripe or ready for harvest. It includes cutting the rice stalks (reaping) using a sickle, laying the stalks on the stubbles to dry, gathering, bundling and stacking or piling the stalks, and threshing (PRPC-KOKKEN, 2003). Threshing is the removal and separation of palay from the rice panicle and straw using a machine commonly called thresher. After the palay is harvested, it undergoes a series of activities and processes before it finally reaches the bowl of consumers as steamed rice. The harvested grain is first assembled by palay traders from the many small farms, dried and sold to processors where it is milled, and then delivered to wholesalers or directly to retailers. This is one whole system called the rice postproduction system. The key players are traders, processors or millers, and rice wholesalers and retailers. These entrepreneurs are profit-driven and respond to market forces. They form a business network, which is an integral part of the marketing system. Postproduction technologies are the tools of their trade (De Padua, 1999).

Rice postproduction losses are both quantitative and qualitative. They are the result of spillage, inefficient retrieval and processing, inadequate machinery, poor operator skills, biological deterioration, and infestation by storage pests (De Padua, 1999). Loss assessment studies in the Philippines have been conducted in the past, primarily by the Department of Agriculture-Bureau of Postharvest Research and Extension (BPRE). Results of their national study in1994-1995 showed that an average of 14.84% (range: 1.1-31.9%) of the total palay production was lost mainly in the drying (0.74-8.7%) and milling (0.6-6.63%) operations. Factors related to these losses were the carelessness of dryer operators leading to over drying, high percentage of impurities, spillages during loading and unloading, genetic characteristics of the grain (chalky and immature kernels), milling of mixed varieties, limited experience, and technical skills in the operation and maintenance of mechanical dryers, and torn or worn-out underlays used in drying (BPRE, 1999).

In another study conducted by PhilRice in collaboration with BPRE from 2007 to 2009, Francisco (2009) stated that average palay losses incurred from harvesting, piling, threshing, drying, and milling operations averaged 14.42% during January-December, with less losses incurred in the first semester (14%) than in the second (14.84%). This study showed that, in contrast to loss assessment results in 1994-1995, milling operation had the highest contribution to losses at 5.47%. This was followed by drying (3.76%), harvesting (2.81%), threshing (2.21%), and piling (0.18%). Results of the studies of Francisco (2009) indicated the following: (1) high milling loss pointed to the need to improve milling facilities through advocacy among processors to upgrade their facilities; (2) high drying loss meant that drying facilities were still inadequate or farmers or processors were not using more efficient ones; and (3) high harvesting loss implied that the present varieties used by farmers were shattering. Breeding for desirable grain characteristics coupled with proper crop management will contribute to reduction in harvesting losses.

Salvador et al. (2012) assessed the state and magnitude of postproduction losses in the provinces of Camarines Sur, Iloilo, Leyte, and Davao Sur, and found that postproduction operations from harvesting to milling incurred an average loss of 16.47%. They added that milled rice samples obtained from rice mill cooperators had high proportion of broken rice ranging from 24-35%, that fell between grades 3 and 4 of the Philippine national grain standards.

Under these contexts, this study was conducted to: (1) test a rice postharvest management protocol covering harvesting, threshing, drying, storing, and milling operations through field and laboratory experiments; and (2) produce a verified version ready for farmers' field and commercial rice milling plant validation.

Materials and Methods

Identification and Selection of Key Postharvest Operations and Best Management Practices

Strategies to carry out the study and develop the protocol were discussed during meetings involving representatives of Philippine Grains Postproduction Consortium (PGPC) member-agencies, namely: National Food Authority (NFA), Philippine Center for Postharvest Development and Mechanization (PHilMech), Philippine Council for Agriculture and Fisheries (PCAF), Philippine Rice Research Institute (PhilRice), and University of the Philippines-Los Baños (UPLB). Representatives from farmers' association, rice trading and processing sector, scientific community/academe, and the PGPC were gathered in workshops to identify and select the key operations and corresponding best management practices and prepare a draft postharvest management protocol from harvesting to milling.

Testing of Postharvest Management Protocol

Testing the protocol were conducted in the irrigated rice paddy field at PhilRice Central Experiment Station (CES) and at the Rice Engineering and Mechanization Division for four cropping seasons from 2014 dry season (DS) to 2015 wet season (WS). Three rice cultivars, namely: hybrid variety PSB Rc72H (Mestizo 1) and inbred varieties NSIC Rc160 and Maligaya Special or MS 16, were planted in a 2.2-ha paddy field using a strip-plot in a randomized complete block design (RCBD) design lay-out with four replications.

The crops were harvested at three different harvest dates: optimum harvest date, five days before optimum harvest, and five days after optimum harvest. Optimum harvest date was based on the time the crops were physiologically mature. This was determined using the visual and tactile method prescribed in the PalayCheck® System (PhilRice, 2007), which stated that the crop should be harvested when most of the grains in the panicles are golden yellow and only one-fifth or 20% of the grains found at the base or neck of the panicles is in hard dough stage. Harvest methods were: (1) manual reaping on the first day (Figure 1A), collecting and piling on the second day (Figure 1B), and mechanical threshing using a commercial axial-flow thresher of IRRI TH-8 design on the third day (Figure 1C); (2) manual reaping, collecting and piling on the first day, and mechanical threshing on the second day; (3) manual reaping, collecting and piling, and mechanical threshing on the first day; and (4) combine harvesting on the first day (Figure 2). Combine harvesting involved cutting rice stalks, collecting cut stalks and conveying them to the threshing unit, threshing, cleaning (i.e., separating grains from straw and materials other than grains), collecting clean grains in a tank, and bagging.

During harvest, each of the 12 plots in the 2.2-ha field was divided into four strips corresponding to the four harvest methods. Grain shattering losses incurred during each harvest or reaping operation were determined by collecting grains within a one square meter sampling quadrat. Two quadrat loss samples were collected from each harvest treatment strip, resulting in 96 (12 plots x 4 strips x 2 grain loss collection quadrats) harvest shattering loss data sets. For the strips wherein manual harvest methods (1) to (3) were carried out, losses were also obtained from two piles of cut rice plants per strip. Nylon nets were placed underneath the piles to gather shattered grains. Threshing losses were evaluated by determining blower loss, unthreshed panicle loss, and spillage loss. Blower

Figure 1. Manual rice harvesting/reaping (A), collecting and piling (B), mechanical threshing and bagging (C).

Figure 2. Combine harvesting involving cutting of rice stalks, collecting cut stalks and conveying them to the threshing unit, threshing, cleaning or separating grains from straw and other materials, collecting clean grains in a tank, and bagging.

loss referred to threshed paddy grains that went with the straw and chaff separated and blown off during the threshing process. From each pile of straw and chaff, the threshed grains were gleaned and weighed. Unthreshed panicle loss consisted of grains that were still intact on the panicles of the straw blown off the thresher. The grains from the unthreshed panicles were manually removed, collected, and weighed. Spillage loss referred to grains detached from the panicles and scattered on the ground at the threshing space. Through a plastic canvas placed underneath the thresher, scattered grains were collected and weighed. Loss data sets totaled 72 from two piles of paddy threshed for each of the three strips (harvest methods 1 to 3) in each of the 12 plots. All grain loss values were expressed as weight percentages of the field yields and were adjusted to 14% grain moisture content.

Drying methods used were sun-drying on concrete pavement and mechanical drying in a PhilRice Maligaya flatbed dryer with rice husk furnace, using 43-45°C heated air temperature. Storage methods were: pile of 50-kg capacity woven polypropylene sacks of dried paddy (14% moisture content, wet basis) at ambient air condition directly on concrete floor without plastic pallet (Figure 3A); pile of 50-kg capacity woven polypropylene sacks of dried paddy at ambient air condition on plastic pallet (Figure 3B); and 50-kg capacity polypropylene plastic sacks of dried paddy inside a PhilRice SACLOB or cocoon, i.e., a plastic hermetic enclosure (Figure 3C). The combine-harvested crop samples at optimum harvest date were stored in PhilRice SACLOB while the manually reaped and mechanically threshed crop samples on the first day at optimum harvest date were stored using the first two methods. Combine-harvesting at optimum harvest date was recommended as best management practice to be complemented by immediate drying using the mechanical flatbed dryer. To further preserve the quality of paddy, the mechanically dried samples were kept in hermetic storage using the PhilRice SACLOB.

The germination rates of MS-16 and NSIC Rc160 seeds were determined using rag doll method. For the hybrid variety PSB Rc72H (Mestizo 1), germination rate was not determined because harvest from F_1 cultivation was not commonly used as seeds, but only for milling. Storage losses for the three varieties were evaluated after six months based on the method used by Komuro (1995). Standard laboratory milling test of samples from the dried paddy harvest lots was done at the PhilRice Analytical Laboratory six months after storage to determine total milling recovery and head rice recovery.

Figure 3. Storage methods for sack pile of paddy at ambient air condition without pallet (A); sack pile of paddy at ambient air condition with pallet (B); and sack pile of paddy inside a plastic hermetic enclosure/cocoon or PhilRice SACLOB (C).

Results

Rice postharvest management protocol

Through the PGPC inter-agency workshops conducted in Los Baños, Laguna and Muñoz, Nueva Ecija, the rice postharvest management protocol was formulated and consisted of the following rice post-harvest operational checks: (1) harvesting and threshing: cut, piled, and threshed palay at the right time; (2) pre-drying storage: palay sorted according to variety type, moisture content, discoloration, and damage; (3) drying: dried palay with good quality; (4) cleaning: palay with premium purity; (5) storage: market quality preserved and losses to pests prevented during storage; (6) milling: maximized milling and head rice recovery; and (7) packaging: milled rice protected from spillage, pest, contamination, and humidity.

The corresponding best practices identified and recommended to attain each operational check were as follows: (1) Reap and thresh within the day or the following day. Use a thresher or combine harvester with the correct machine settings. Pile the harvest for not more than a day to avoid heat buildup. With heat buildup, grain can be discolored and quality of milled rice reduced. Use underlay (canvass, laminated sack, or net) to catch shattered grains and to protect the pile from ground moisture. Adjust blower air inlet to provide good initial cleaning of the harvest. Too high air flow rate results in higher grain loss while a low air flow rate increases the amount of impurities in the grain. (2) Classify and sort according to variety type, moisture content, discoloration, and damage. Stack bags with sufficient space for natural aeration. Wet grains should be the priority in drying. (3) Dry the palay immediately after threshing. Aerate fresh palay by spreading thinly under shade on concrete pavement, tarpaulin, plastic net, or canvas. Make sure that the drying area is free from impurities such as pebbles, sand, and other debris. Spread the grain 2-4 cm thick and stir every 30 min. If using a mechanical dryer, dry the palay following the recommended drying temperature (43°C for flatbed dryer and 60°C for recirculating dryer). Avoid drying palay on roads to reduce loss, grain breakage, and contamination. (4) Clean palay using a blower, fan, or seed cleaner. Use appropriate air flow adjustment and grain feeding rate. (5) Storage area should be clean, orderly, free from leaks and holes, and safe from floods. Use pallets and sacks that are free from residual infestation. To prevent pests, spray insecticides on the walls, floors, and beams of storage area before storing palay. Provide adequate space from walls and in-between piles for ventilation, cleaning, and pest control. Windows and exhaust fans should be screened to prevent entry of birds and rodents. Conduct regular monitoring for pest infestation. Tag and label piles correctly, i.e., date of piling, weight, variety, grain classification, and pest control measures applied. (6) Milling machines should be operated by a trained and skilled operator. Use machines that can produce at least 65% milling recovery and 80% head rice on milled rice basis. (7) Use a durable packaging material. Follow the recommended color-coded packaging to indicate quality: blue for special or fancy rice, yellow for premium rice, and white (grades 1-5 with 1 for 90% head rice and 5 for 55% head rice).

Harvest losses

In this study, only operational checks 1 through 6 were validated from 2014 DS to 2015 WS. The 2014 and 2015 DS and WS grain loss data for the different harvest methods across the three varieties are shown in Tables 1 and 2, respectively. Results showed that when the crop was combine-harvested (Method 4) five days earlier and at optimum harvest time or

Table 1. Mean grain loss of rice varieties MS-16, Mestizo 1, and NSIC Rc160 in response to four harvest methods and three harvest dates in 2014 dry season (DS) and wet season (WS), PhilRice Central Experiment Station (CES), Muñoz, Nueva Ecija, Philippines. The optimum harvest date is at crop physiological maturity.

Harvest Method	Mean Grain Loss Across Rice Varieties (% Field Yield)					
	5 days early harvest		Optimum harvest		5 days late harvest	
	2014 DS	2014 WS	2014 DS	2014 WS	2014 DS	2014 WS
(1) Cut on 1st day, pile on 2nd day, thresh 3rd day	6.79^{a}	7.92^{a}	5.82^{a}	6.94^{a}	17.99^{a}	18.56^{a}
(2) Cut and pile on 1st day, thresh 2nd day	4.25^{b}	5.41^{b}	4.21^{b}	5.02^{b}	10.99^{b}	12.42^{b}
(3) Cut, pile, and thresh on 1st day	2.19^{c}	3.21^{c}	1.04^{c}	1.85^{c}	6.96^{c}	7.97^{c}
(4) Combine Harvesting	1.40^{c}	2.03^{c}	1.16^{c}	1.56^{c}	2.76^{d}	3.50^{d}

In a column, means with the same superscript letter are not significantly different at $p < 0.05$ using LSD.

Table 2. Mean grain loss of rice varieties MS-16, Mestizo 1, and NSIC Rc160 in response to four harvest methods and three harvest dates in 2015 DS and WS, PhilRice CES, Muñoz, Nueva Ecija, Philippines.

Harvest Method	Mean Grain Loss Across Rice Varieties (% Field Yield)					
	5 days early harvest		Optimum harvest		5 days late harvest	
	2015 DS	2015 WS	2015 DS	2015 WS	2015 DS	2015 WS
(1) Cut on 1st day, pile on 2nd day, thresh 3rd day	6.87[a]	8.23[a]	6.14[a]	7.12[a]	18.52[a]	18.96[a]
(2) Cut and pile on 1st day, thresh 2nd day	5.22[b]	5.69[b]	4.43[b]	5.19[b]	11.50[b]	12.70[b]
(3) Cut, pile, and thresh on 1st day	2.42[c]	3.28[c]	1.16[c]	2.00[c]	7.32[c]	8.21[c]
(4) Combine Harvesting	1.54[c]	2.09[c]	1.19[c]	1.61[c]	2.90[d]	3.54[d]

In a column, means with the same superscript letter are not significantly different at $p < 0.05$ using LSD.

at crop physiological maturity, harvest losses across seasons ranged from 1-2%. For manual cutting, piling, and mechanical threshing on the same day (Method 3), the aggregate losses for reaping or cutting, piling, and threshing across seasons ranged from 1-3% of the field yield and were not significantly different from those of combine harvesting. However, when mechanical threshing was done on the second day after reaping (Method 2), the losses significantly increased to 4- 6%. When threshing was delayed by two days after reaping (Method 1), losses were higher at 6-8%. Across seasons, Methods 1, 2, and 3 incurred significantly higher losses of 18-19%, 11-13%, and 7-8%, respectively, when harvesting was done five days later than the optimum time (Tables 3 and 4).

Combine harvesting (Method 4) five days later than optimum time resulted to higher yield losses, i.e. 2.76% in 2014 DS and 2.9% in 2015 DS, 3.5% in 2014 WS, and 3.54% in 2015 DS (Tables 3 and 4). However, these figures still met the standard performance criterion for maximum total machine loss of 3.5% (BPS, 2015). Tables 3 and 4 showed that regardless of harvesting method, harvest losses could be reduced significantly by either harvesting at optimum time or five days earlier.

Table 3. Mean grain loss of rice varieties MS-16, Mestizo 1, and NSIC Rc160 in response to three harvest dates and four harvest methods in 2014 DS and WS, PhilRice CES, Muñoz, Nueva Ecija, Philippines. Harvest methods were (1): manual reaping on 1st day, collecting and piling on 2nd day, and mechanical threshing on 3rd day; (2): manual reaping, collecting and piling on 1st day, and mechanical threshing on 2nd day; (3) manual reaping, collecting and piling, and mechanical threshing on 1st day; and (4) combine harvesting on 1st day.

Harvest Date	Mean Grain Loss Across Rice Varieties (% Field Yield)							
	Harvest Method 1		Harvest Method 2		Harvest Method 3		Harvest Method 4	
	2014 DS	2014 WS	2014 DS	2014 WS	2014 DS	2014 WS	2014 DS	2014 WS
5 days early	6.79[a]	7.92[a]	4.25[a]	5.41[a]	2.19[a]	3.21[a]	1.40[a]	2.03[a]
Optimum	5.82[a]	6.94[a]	4.21[a]	5.02[a]	1.04[a]	1.85[a]	1.16[a]	1.56[a]
5 days late	17.99[b]	18.56[b]	10.99[b]	12.42[b]	6.96[b]	7.97[b]	2.76[a]	3.50[a]

In a column, means with the same superscript letter are not significantly different at $p < 0.05$ using LSD.

Table 4. Mean grain loss across rice varieties MS-16, Mestizo 1, and NSIC Rc160 in response to three harvest dates and four harvest methods in 2015 DS and WS, PhilRice CES, Muñoz, Nueva Ecija, Philippines.

Harvest Date	Mean Grain Loss Across Rice Varieties (% Field Yield)							
	Harvest Method 1		Harvest Method 2		Harvest Method 3		Harvest Method 4	
	2015 DS	2015 WS	2015 DS	2015 WS	2015 DS	2015 WS	2015 DS	2015 WS
5 days early	6.87[a]	8.23[a]	5.22[a]	5.69[a]	2.42[a]	3.28[a]	1.54[a]	2.09[a]
Optimum	6.14[a]	7.12[a]	4.43[a]	5.19[a]	1.16[a]	2.00[a]	1.19[a]	1.61[a]
5 days late	18.52[b]	18.96[b]	11.50[b]	12.70[b]	7.32[b]	8.21[b]	2.90[a]	3.54[a]

In a column, means with the same superscript letter are not significantly different at $p < 0.05$ using LSD.

Seed germination and storage loss

Evaluation results of drying and storage methods for MS-16 and NSIC Rc160 in terms of germination rate are shown in Table 5. Storage losses for these two varieties and Mestizo 1 are shown in Table 6. Viability of MS-16 and NSIC Rc160 paddy seeds was preserved well through flatbed drying and hermetic storage in a hermetic cocoon or PhilRice SACLOB with germination rates decreasing only from 100 to 97-98% for MS-16 and from 99-100 to 98% for NSIC Rc160 after six months. The germination rate of PSB Rc72H or Mestizo 1 was not evaluated because the harvest from F_1 cultivation of hybrids was not commonly used as seeds, but only for milling. Germination rates significantly dropped by 10 percentage points or more after six months with sun-drying and ambient pile storage, with or without plastic pallet, although the viability of the paddy seeds was still above the 85% norm set by the Philippine Bureau of Plant Industry – National Seed Quality Control Service.

Physical grain losses from ambient piled sack storage, with or without pallet, were significantly higher than the spoilage from hermetic cocoon storage using the PhilRice SACLOB by as much as 9-11 percentage points in 2014 and 6-9 percentage points in 2015. Losses with ambient piled sack storage without pallet were significantly higher than ambient piled sack storage with pallet.

Table 5. Evaluation of drying and storage methods for rice varieties MS-16, Mestizo 1, and NSIC Rc160 in terms of germination rate and storage loss in 2014 DS and WS, PhilRice CES, Muñoz, Nueva Ecija, Philippines. The hermetic cocoon is also called PhilRice SACLOB.

Drying & Storage Method	Germination Rate (%) before storage				Germination Rate (%) after storage				Storage Loss (%), after 6 months, average for 3 varieties	
	MS-16		NSIC Rc160		MS-16		NSIC Rc160			
	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS
Sun-drying and ambient pile without pallet	100	98	100	99	87.5[a]	85[a]	85.5[a]	86[a]	9.9[a]	10.9[a]
Sun-drying and ambient pile with pallet	100	98	100	99	87.5[a]	82[b]	89[b]	85[a]	8.9[b]	9.6[b]
Flatbed heated air drying and hermetic cocoon	100	98	100	99	98[b]	98[c]	98[c]	99[b]	0.0[c]	0.0[c]

In a column, means with the same superscript letter are not significantly different at $p < 0.05$ using LSD.

Table 6. Evaluation of drying and storage methods for rice varieties MS-16, Mestizo 1, and NSIC Rc160 in terms of germination rate and storage loss in 2015 DS and WS, PhilRice CES, Muñoz, Nueva Ecija, Philippines.

Drying & Storage Method	Germination Rate (%) before storage				Germination Rate (%) after storage				Storage Loss (%), after 6 months, average for 3 varieties	
	MS-16		NSIC Rc160		MS-16		NSIC Rc160			
	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS
Sun-drying and ambient pile without pallet	100	99	100	99	87[a]	83[a]	89[a]	85[a]	9.6[a]	10.2[a]
Sun-drying and ambient pile with pallet	100	99	99	99	88[a]	85[b]	89[a]	87[b]	8.5[b]	8.9[b]
Flatbed heated air drying and hermetic cocoon	100	99	99	99	98[b]	98[c]	98[b]	99[c]	2.5[c]	1.2[c]

In a column, means with the same superscript letter are not significantly different at $p < 0.05$ using LSD.

Milling and Head Rice Recoveries

The 2014 DS and WS and 2015 DS and WS results of milling tests for rice cultivars MS-16, Mestizo 1, and NSIC Rc160 are shown in Tables 7 and 8, respectively. MS-16, Mestizo 1, and NSIC Rc160 that were combine-harvested, flatbed-dried, and stored in the PhilRice SACLOB showed significantly higher total milling recovery percentages after six months of storage. The head rice recovery of paddy rice that was combine-harvested, flatbed-dried, and stored in PhilRice SACLOB in 2014 was also significantly higher. However, in 2015, paddy samples from the three drying and storage method lots were not significantly different from each other in terms of head rice recovery, with the exception of NSIC Rc160. The head rice percentages were still higher in rice cultivars that were combine-harvested, flatbed-dried, and stored in the PhilRice SACLOB.

Table 7. Total milling and head rice recoveries of MS-16, Mestizo 1, and NSIC Rc160 in response to three drying and storage methods in 2014 DS and WS, PhilRice CES, Muñoz, Nueva Ecija, Philippines.

Drying and Storage Method	Total Milling Recovery (%) after 6 months						Head Rice Recovery (%) after 6 months					
	MS-16		Mestizo 1		NSIC Rc160		MS-16		Mestizo 1		NSIC Rc160	
	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS
Sun-drying and ambient pile without pallet	59.87^a	61.87^a	57.87^a	53.53^a	56.87^a	49.54^a	58.99^a	58.03^a	55.64^a	47.53^a	54.98^a	41.54^a
Sun-drying and ambient pile with pallet	61.55^a	62.77^a	58.73^{ab}	57.73^b	60.5^b	50.67^a	58.0^a	59.0^a	52.73^a	51.73^b	58.9^b	47.37^b
Flatbed heated air drying and hermetic cocoon	66.34^b	64.42^a	62.31^b	60.13^b	67.55^c	56.27^b	62.0^b	60.26^a	59.9^b	57.26^c	63.9^c	51.27^c

In a column, means with the same superscript letter are not significantly different at $p < 0.05$ using LSD.

Table 8. Total milling and head rice recoveries of MS-16, Mestizo 1, and NSIC Rc160 in response to three drying and storage methods in 2015 DS and WS, PhilRice CES, Muñoz, Nueva Ecija, Philippines.

Drying and Storage Method	Total Milling Recovery (%) after 6 months						Head Rice Recovery (%) after 6 months					
	MS-16		Mestizo 1		NSIC Rc160		MS-16		Mestizo 1		NSIC Rc160	
	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS
Sun-drying and ambient pile without pallet	59.97^a	60.87^a	57.97^a	52.53^a	56.97^a	51.34^a	58.23^a	58.52^a	55.12^a	48.45^a	43.98^a	47.5^a
Sun-drying and ambient pile with pallet	62.55^b	62.57^{ab}	59.73^a	58.13^b	61.5^b	53.4^a	58.5^a	59.5^a	53.6^a	52.73^a	58.8^b	50.3^{ab}
Flatbed heated air drying and hermetic cocoon	67.44^c	64.02^b	63.41^b	59.85^b	67.58^c	56.57^b	59.12^a	61.26^a	56.55^a	58.96^b	60.12^b	54.27^b

In a column, means with the same superscript letter are not significantly different at $p < 0.05$ using LSD.

Discussion

Yield Losses at Harvest

Harvesting the three rice cultivars at optimum harvest time or crop physiological maturity resulted in the least yield losses. Yield losses were evaluated following the PalayCheck® System guideline. However, harvesting the crop five days earlier than the optimum harvest time resulted in higher yield losses. These findings are in agreement with the results of studies of Fageria (1992) that showed that crops harvested earlier than physiological maturity resulted in lower grain yield due to lower grain weight.

Highest grain losses were obtained when the crop was harvested five later than the optimum harvest time (Tables 3 and 4). Ruiz and Castelo (1965), cited in Selvi et al. (2002), obtained a mean grain loss of 5.63% when the rice crop was harvested one week after crop maturity. This study showed that even if the PalayCheck® System recommendation of reaping, piling, and threshing on the same day was followed, losses were high at 7% or more when crops were harvested five days after crop maturity. Fageria (1992) pointed out that if harvesting was delayed after physiological maturity, yield would be reduced due to shattering of grains or a large percentage of grains falling during harvesting. Francisco (2009) indicated that Philippine rice cultivars were shattering. As such, it would be better to use a combine to harvest rice past the physiological maturity stage to significantly reduce shattering losses. Compared with manual reaping, gathering and piling, and mechanical threshing, in which grain losses were incurred in each step, combine harvesting simultaneously performs all these steps as the machine moves through the field; thus, minimizing losses from manual handling and mechanical threshing operations.

Seed Germination and Storage Loss

Drying could affect seed quality in terms of seed deterioration or loss of viability. The paddy seeds dried using the flatbed dryer with drying air temperature varying from 43-45°C significantly had the least reduction in seed viability in 2015 DS and WS, and even no reduction in germination rate in 2014 DS and WS. Paddy seeds could be exposed to ambient temperatures from 36 to 52°C when dried in the sun from 900 to 1300 h at PhilRice Central Experiment Station in Nueva Ecija, Philippines (Regalado and Brena 2006). Rates of sun-drying could be faster in this area owing to higher drying temperatures and irradiance as mode of heat transfer. Fast drying rates could result in "sun-checks" or fissures in the grain. Fissuring is caused by stresses in the kernel, that results from either moisture re-adsorption by the dried seed or rapid moisture desorption (drying). Seed kernel fissuring or cracking may also reduce viability and vigor (Shephard et al., 1995).

The storage methods significantly ($p<0.05$) affected the viability of MS-16 and NSIC Rc160 seeds (Tables 3 and 4). Germination rates of seeds stored in piled sacks with or without pallet underlay under ambient conditions (27-32°C, 60-90% relative humidity) dropped from 98-100% to 82-89% after six months. However, seed viability in polypropylene sacks remained high at 98-99% after six months when piled and kept inside the plastic hermetic enclosure or PhilRice SACLOB. Similar results were obtained by Orge and Abon (2014) who found that hermetic seed storage containers could preserve the viability of stored paddy seeds significantly better than ambient storage.

Milling and Head Rice Yield Losses

The 2014 paddy samples that were combine-harvested, flatbed-dried, and kept in PhilRice SACLOB had significantly higher milling recovery and head rice percentages than the samples that were manually-harvested, mechanically-threshed, sun-dried, and pile-stored in ambient condition. Even the 2015 crop samples that were handled using the improved combination of postproduction methods generally had higher milling and head rice yields, although the differences were statistically insignificant. This can be attributed to the better quality of paddy that was produced using the improved methods. Improved milled rice output and quality start with better rough rice input. Likewise, a rice mill in proper working condition can produce milled rice whose quality (e.g., milling and head rice recoveries) is dependent on the quality of the paddy (Efferson, 1985).

Improper drying techniques and aeration procedures during storage have been cited as primary contributing factors of fissure formation (Craufurd, 1963; Siebenmorgen, 1992; Chen et al., 1997). In general, rice kernels break in milling due to the presence of fissures in the endosperm (Kunze, 1985; Siebenmorgen, 1992). As breakage in milling results in increased bran and brewer's rice production, the presence of heavily fissured or fully cracked grains suppresses milled rice recovery and lowers the quality of milled rice through a reduction of head rice yield (Van Ruiten, 1985). Therefore, paddy drying and storage have to be properly and efficiently carried out not only to prevent grain quality deterioration due to spoilage but also to prevent or minimize kernel fissuring during and after drying.

Conclusions

Postproduction losses could be reduced significantly and high product quality (i.e., high seed viability, milling and head rice recoveries) could be achieved through a postharvest management protocol consisting of the best practices in harvesting, threshing, drying, storing, and milling. The postharvest management protocol established for rice in the present study has to be validated in farmers' fields and commercial rice mills for refinement prior to nationwide dissemination.

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FACTORS AFFECTING FARMER PARTICIPATION IN THE PHILIPPINE CROP INSURANCE CORPORATION'S RICE CROP INSURANCE PROGRAM: THE CASE OF LAKESHORE COMMUNITIES IN LAGUNA, PHILIPPINES

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Abstract

Crop insurance is a coping mechanism by which the farmer is indemnified if there is crop failure due to natural calamities such as droughts, floods, typhoons, and plant pests. However, there is low participation of rice farmers in the crop insurance program of the Philippines. This study determined the following: (a) socio-economic characteristics of farmer-respondents in the lakeshore communities of Laguna, (b) factors that influenced farmers' decision to participate or not participate in the Philippine Crop Insurance Corporation-Rice Crop Insurance Program (PCIC-RCIP) and (c) reasons for participation and non-participation in the RCIP. Descriptive and inferential statistics were used in the analysis of data. Ways to promote wider participation in the RCIP were suggested. Results showed that the major reasons for farmers' participation in the Program were (a) securing rice crop insurance was one of the requirements of Land Bank prior to extending loans to farmers and (b) participation in the insurance program was essential to avoid risk in rice farming. The major reasons cited for non-participation were farmers' lack of awareness of the existence of the insurance program and their "being busy" to attend to the documentation requirements of the Program. The logit analysis showed that the knowledge of farmers about crop insurance, tenure status, and the distance from the lakeshore influenced the participation of the farmers in the RCIP.

Keywords: Crop Insurance, Farmer Participation, Laguna Lakeshore Community, Rice.

Introduction

Agricultural production is adversely affected by weather and climate related disasters (Sivakumar, 2006). This indicates that the impact of natural disasters would be serious for those who venture in the agriculture sector. In rural communities in many developing countries, farming is a primary source of income. More than 2 billion people rely on small-scale farming as their occupation and improving conditions for the farmers would reduce global poverty levels (The Guardian, 2014). To deal with the often erratic weather, farmers could use coping strategies such as crop insurance.

Crop insurance is designed to protect the farmers against financial losses by transferring agricultural risks to a third party. It is a "risk-pooling instrument" involving collection of premium and "assessment and payment of indemnity claims for all or part of financial losses" (Bangsal and Mamhot, 2012). Based on the latest data on weather and climate disturbances in the Philippines, Luzon has been the most affected in terms of floods and drought as well as on the extent of damage on rice production due to natural calamities (Israel and Briones, 2013). Among the classifications of farmers protected by the crop insurance, rice farmers were identified to be the most susceptible to natural disasters leading to significant losses (Rola, 2013).

In the Philippines, the study of Reyes et al. (2009) showed that crop insurance was among the most preferred risk alleviation tools by farmers along with localized climate information, accessible credit, and special assistance programs such as irrigation and seeds provision.

Crop insurance has been proven effective in other countries. It has the potential to cope with the effects of weather and climate related constraints as well as reduce farmers' uncertainties. The Guardian (2014) reported that insurances had impact on farmers' behavior. In India, for example, farmers protected by rainfall insurance shifted funds towards cash crops that were more sensitive to rainfall deficit but yielded high returns. Based on the review of Summer and Zulauf (2012) in the U.S., crop insurance affect production in three ways: (1) subsidies raise the net revenue per acre and thereby raise incentives to plant eligible crops and plant more of crops with higher subsidy rates; (2) the availability of crop insurance, made possible by the government program, encourages planting insured crops on fields that would not otherwise be considered for that crop because of the potential for significant losses; and (3) by reducing chances of losses from low yields and prices, crop insurance creates incentives for growers to undertake fewer risk mitigating practices and therefore focus more on increases in average productivity. In Hungary, Sporri et al. (2012) found that the level of crop protection mirrored more rigorous production systems overall and therefore connected extremely with insurance use. Pathak (1986) indicated that crop insurance through indemnity payments served as a cushion when uncertainties occurred. However, studies on crop insurance in the Philippines showed that income loss was abated to a limited degree due to the small indemnity payment received (Alarkon, 1997; Bacani, 2005; Famorcan, 2006).

In the Philippines, rice farms are vulnerable to agricultural risks. To address this problem, the Philippine government implemented a range of risk management programs for farmers. One of these is the Philippine Crop Insurance Corporation (PCIC) Rice Crop Insurance Program (RCIP). The PCIC is a government organization that implements rice, corn, high-value commercial crop, livestock, non-crop agricultural asset, fishery, and term insurance programs. As the implementing agency of the agricultural insurance program of the government under Presidential Decree No. 1467, as amended by Republic Act 8175, PCIC is mandated to "provide insurance protection to the country's agricultural producers particularly the subsistence farmers, against loss of their crops and/or non-crop agricultural assets on account of natural calamities such as typhoons, floods, droughts, earthquakes and volcanic eruptions, plant pests and diseases, and/or other perils". PCIC can also provide guarantee cover for production loans extended by lending institutions to agricultural producers for crops not yet covered by insurance (PCIC, 2016). Rice farms in the coastal and lowland municipalities in the province of Laguna are vulnerable to floods and typhoons and the PCIC Region 4 office is the service provider of the RCIP.

Despite the existence of this government-backed insurance program, results of the study of Reyes (2015) showed that farmers' utilization rate of the rice insurance of PCIC remained below 10% from 1981 to 2013. Farmer participation was still low despite the inclusion of the budget in the General Appropriation Act (GAA), RA 10651 that was used exclusively for the full (100%) cost of insurance premiums of subsistence farmers and fisher folk listed in the Registry System for Basic Sectors in Agriculture (RSBSA).

In a study on the awareness and adoption of the Rice Insurance Program in Concepcion, Tarlac, Alarkon (1997) found that availability of loans and incidence of natural risks influenced the farmers' participation in the Rice Insurance Program. Employing logit analysis, Rodriguez (2010) found that the farmers in Sta. Cruz and Victoria, Laguna did not avail of crop insurance program because they did not understand well the program and its application process. This also showed that farm size, tenure, and flood susceptibility positively influenced the rice farmers' decision to avail of a rice crop insurance. Contrary to expectations, farm income had a negative relationship with participation in the crop insurance program. The common problems of the farmers in availing crop insurance included high cost of premium and the small amount of indemnity. Lack of information about the insurance program influenced participation in the rice crop insurance program. Bacani (2005) evaluated the PASIPAGAN Program of PCIC and showed that farmers had very limited knowledge and understanding of the mechanics and procedures of the program. This was attributed to the unavailability of brochures and failure to conduct seminars for the farmers to know more about the program.

Famorcan (2006) indicated that the farmers' knowledge of the objectives of the rice insurance program were found to be concentrated only in facilitating ad hoc relief measure (80%) and improving credit worthiness (20%). Farmers were familiar with only three of the four steps in the application process. Previous studies on the agriculture insurance program mostly focused on program evaluation and employed descriptive analysis. Thus, an understanding of how the rice insurance program works is very important. Studies on farmers' participation in the crop insurance program are still limited. Quantification of the reduced income losses has yet to be conducted especially in the event of floods that can possibly be associated with climate change, especially in places like the lakeshore rice farming communities. Also, rice is highly vulnerable to extreme events like drought and typhoon.

This study explored the reasons of farmers' participation in RCIP. This study compared the demographic characteristics of participating and non-participating farmers, nature of membership in associations, sources of capitalization, and how these characteristics affected the farmers' decision making. The study used quantitative techniques to explain factors affecting the decision making.

Materials and Methods

The study was limited to analyzing the factors affecting farmer participation in the RCIP. The study only covered selected municipalities of Laguna; thus, the results, findings, and data limitations of the study may not be used to generalize the situation for other areas.

Conceptual Framework

Based on factors identified in several studies (Alarkon, 1997; Bacani, 2005; Famorcan, 2006; Nahvi et al., 2014; Rodriguez, 2010), the decision of the rice farming households to participate in the RCIP was expected to be influenced by household and farm characteristics (i.e., household income, tenure status, farm size, farm location relative to the lakeshore), level of education, credit access to financial institutions, and their knowledge about the PCIC-Rice Crop Insurance Program (RCIP) (Figure 1). Rice farmers that had higher household income were less likely to participate in the RCIP than the farmers with lower household income because even if they incurred a loss, they would still have other sources of income to be used for the next cropping season. Owner-operators were more likely to participate in the RCIP than leaseholders. Meanwhile, farmers whose rice farms were near the lakeshore were more likely to participate in the Program than the farmers whose farms were located farther from the lakeshore because they expected to incur more crop losses due to flooding. Rice farmers that availed of loan from banks would have a higher probability of participating in the Program than non-bank borrowers because it was a bank requirement for accessing loans from a bank (e.g., Land Bank). Rice farmers that lacked or have limited knowledge about the RCIP were less likely to participate in the Program than those who have more knowledge about the features of RCIP.

Location

The rice-growing and lakeshore municipalities in Laguna (Bay, Calauan, Pila, Sta. Cruz, and Victoria) that were prone to flooding caused by typhoons were purposively selected as the study sites. These municipalities had the highest number of rice farmers that received indemnity payments.

Selection of the Farmer-Respondents

The National Irrigation Administration Region IV Employees Multipurpose Cooperative (NEMCO) and New Batong Malake Multi-purpose Cooperative (NBMMPC) provided a list of rice

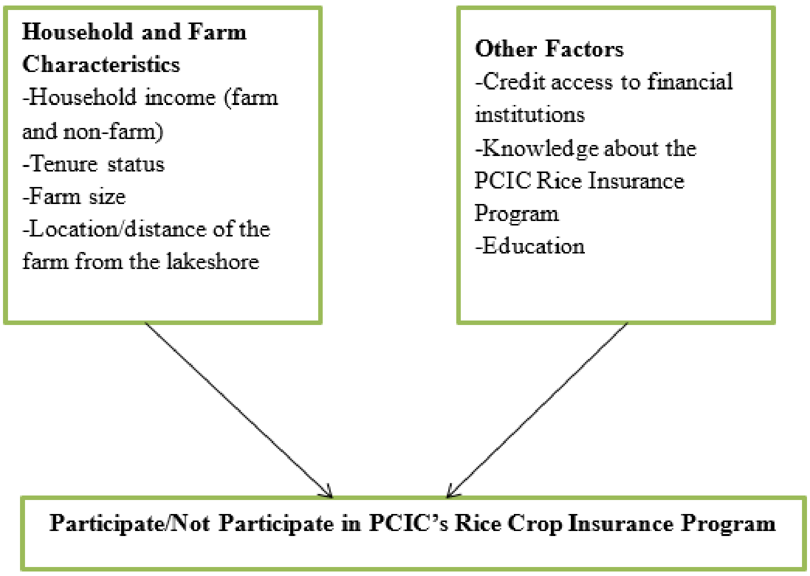

Figure 1. Conceptual framework showing the factors affecting the rice farmers' decision to participate/not participate in the Philippine Crop Insurance Corporation-Rice Crop Insurance Program (PCIP-RCIP).

farmer-participants that applied for indemnity claims in 2012. From the list, 40 farmer-respondents were randomly chosen. All of them filed indemnity claims at the PCIC Office in Region 4. The same number of farmers whose rice farms were situated near the participants' calamity-affected rice farms were purposively chosen to serve as the respondents under the non-participant category.

Descriptive Analysis

Descriptive statistics such as means, frequencies, and percentages were computed and used to describe the socio-economic characteristics of the participating and the non-participating rice farmers in the RCIP as well as the implementation mechanism of the PCIC. Descriptive analysis of the reasons for non-participation in the PCIC-RCIP was determined using frequency counts and percentages. The problems encountered by the participating farmers and the PCIC personnel and their suggested solutions to address the problems were described using frequency tables.

Logit Analysis

Econometric methods that can be used in studying farmers' participation in a crop insurance program are binary models such as logit and probit analyses. Logit and probit models are certain types of regression models in which the dependent or response variable is dichotomous in nature, taking a 1 or 0 value (Vashist, 2011).The logit technique allows the examination of the effects of a number of variables on the underlying probability of a dichotomous dependent variable. The logit model uses a cumulative logistic probability function while the probit model emerges from the normal distribution function. The chief difference between logit and probit models is that the logistic curve has slightly flat tails while the normal or probit function approaches the axes more quickly than the logistic curve. The sigmoid or S-shaped curve of the cumulative logistic function resembles the cumulative distribution function of a random variable (Gujarati, 1988). Qualitatively, logit and probit models produce similar results, but the estimates of the two parameters are not directly comparable. The logit model is generally more preferred than the probit model for the following reasons (Vasisht, 2010; Fernando, 2011): (1) logit analysis produces statistically sound results and that by allowing the transformation of a dichotomous dependent variable to a continuous variable ranging from –α to infinity, the problem of out of range estimates is avoided; (2) logit analysis provides results that can be easily interpreted and the method is simple to analyze; and (3) it gives parameters that are asymptotically consistent, efficient and normal so that the analogue of the regression t-test can be applied. Hence, the logit analysis was employed to determine the factors that significantly influenced the decision of the rice farmers to participate in PCIC-RCIP. The logit regression model was estimated using STATA 10 software program.

The general form of logit regression model is specified as:

$$P = f(\alpha + \beta X) = \frac{e^{(\alpha+\beta X)}}{1+e^{(\alpha+\beta X)}} = \frac{1}{1+e^{-(\alpha+\beta X)}}$$

Where: P is the vector of probabilities of a choice,

E is the base of natural logarithms,

X is the vector of independent variables,

α is the constant, and

β is the vector of other estimated coefficients corresponding to X in the model.

To apply a linear form, the above function can be written as follows:

$$\mathrm{Ln}[P_i/(1-P_i)] = \alpha + \beta_i X_i + \varepsilon_i$$

where: *i* presents the individual farmer *i*,

ε is error term.

In this study, the empirical model of the simple logit functional form to determine the farmer's choice of participating in the RCIP is specified as:

$$Z_i = Ln\left(\frac{p_i}{1-p_i}\right) = \alpha_0 + \alpha_1.educ + \alpha_2.hincome + \alpha_3.fsize + \alpha_4.distancdummye + \alpha_5.loandummy + \alpha_6.awareness + u_i$$

Where:

p_i	= the probability of choice of farmer *i* with regard to participation in the Rice Crop Insurance Program. The value of the dependent variable was 1 if a farmer chose to participate in the program and it took a value of 0 if a farmer decided not to participate in the program.
α_0	= intercept
educ	= level of education of the rice farmer in years
hincome	= household income in pesos per year
fsize	= actual farm area planted to rice in hectares
Distance dummy	= dummy variable for distance of the rice farm from the lakeshore of Laguna de Bay. This variable was used to capture the effect of location of the farm from the lakeshore. A value of 0 was assigned for farms with distance of less than or equal to 5 km from the lake and 1 for farms with distance of more than 5 km from the lake.
Loan dummy	= dummy for loan obtained from a bank, where a farmer who availed of a loan was assigned a value of 1 and zero otherwise

knowledge = extent of knowledge of the Rice Crop Insurance Program measured in terms of knowledge score. The knowledge score was determined using screening questions to test each farmer's knowledge or extent of awareness of the objectives, insurance application requirements, insured risks and indemnity, and claims process under the PCIC-RCIP. The farmers' knowledge score was computed as the number of correct answers to 20 questions about the RCIP and its processes.

α_i (i = 1 to 6) = coefficients of independent variables in the logit model

e = the base of natural logarithms and approximately equal to 2.718

u_i = error term

The parameters were estimated by using maximum likelihood estimation (MLE) technique. The marginal effects of the probability of choice of the farmers were also estimated. To determine the partial effect of factor X_i on P_i, the marginal effect of X_i on P_i was calculated by taking the partial derivative of P_i with respect to X_i. In the logit model, the marginal effect represented the change in probability caused by a unit change in X_i, ceteris paribus.

To test the significance of the coefficients of the explanatory variables in the model, the t-test was used as follows: $t_C = \hat{\beta}/Se(\hat{\beta})$. H_0: β = 0 (the independent variable had no effect on the decision to participate in the RCIP. H_1: β ≠ 0 (the independent variable had an effect on the decision to participate in the RCIP, where β was the estimated coefficient of the independent variable in the model, and and $Se(\hat{\beta})$ was the estimated standard error of coefficient of the independent variable. H_0 was rejected if if $t_C >$ t critical value at an appropriate level of significance

Results

Age, Household Size, Household Income, and Education

Table 1 summarizes the average age, household size, household income, educational attainment of the household head, number of children below 18 years old, and the number of employed children of the farmer-participants and non-participants in the RCIP in Laguna. The rice farmer-participant respondents had an average age of 52.65 ranging from 31 to 99 years old. Meanwhile, the non-participant respondents had an average age of 53.55 years ranging from 31-79 years. Participant and non-participant respondents had an average household size of four. The non-participants had an average annual household income of PhP 198,100.00 while the farmer-participants had an average household income is PhP 190,741. The farmer-participants had significantly higher average formal education than the non-participants. On average, both farmer-respondent categories had more or less one of their children below 18 years old and least one of them was employed.

The t-test did not show significant differences in the mean age, household size, household income, number of children below 18 years old, and number of employed children between the farmer-participants and the non- participants at 10% probability level, except for the mean educational attainment of the household head, that was significantly different between the two farmer groups at 1% probability level (Table 1).

Table 1. Socio-economic characteristics of respondents in selected lakeshore municipalities in Laguna.

SOCIO-ECONOMIC CHARACTERISTICS	FARMER-PARTICIPANTS	NON-PARTICIPANTS
Average age (years)	52.65	53.55
Household size (number)	4	4
Household income (PhP)	190741	198100
Formal education (years)	10.18	7.38***
Number of children below 18 years old	1	1
Number of employed children	2	2

Gender Distribution, Main Occupation, and Engagement in Off and Non-Farm Activities

The number and percent reporting by gender distribution, main occupation, and in off-farm and non-farm activities of the farmer respondents are shown in Table 2. Majority of the farmer-participants and non-participants were mostly male representing 77.5 and 72.5% of the total, respectively. The main occupation of most of the farmer-participants and the non-participants was farming. Table 2 also shows that a higher percentage of the farmer-participants (25%) were engaged in off-farm jobs than the non-participant respondents (15%). Both farmer groups reported that they worked as hired labor in other farms during peak labor demands (e.g., planting and harvesting) to augment their household incomes. In addition, both farmer categories claimed that they made themselves available even in non- farm work particularly during the lean labor demand for their respective farms. A higher percentage (52.5%) of the farmer-participants and non-participant respondents (42.5%) mentioned that they likewise were engaged in non-farm jobs. Majority of the farmer-participants were leaseholders (75%). Only 22.5% were owner-operators while a lone respondent (2.5%) was both an owner and tenant. Most of the non-participants (85%) were leaseholders while 12.5% were owner-operators.

Table 2. Sex distribution, main occupation, engagement in off- and non-farm activities, and tenure status of the respondents in selected lakeshore municipalities in Laguna.

ITEM	PARTICIPANTS		NON-PARTICIPANTS	
	Number	Percent	Number	Percent
Sex Distribution				
Male	31	77.5	29	72.5
Female	9	22.5	11	27.5
Total	**40**	**100**	**40**	**100**
Main Occupation				
Farmer	34	85.0	39	97.5
Government Employee	4	10.0		
Private Employment	1	2.5		
Agricultural Trader	1	2.5		
Carpenter			1	2.5
Total	**40**	**100**	**40**	**100**
Engaged in Off-Farm Work				
Yes	10	25.0	6	15
No	30	75.0	34	85
Total	**40**	**100**	**40**	**100**
Engaged in Non- Farm Work				
Yes	21	52.5	17	42.5
No	19	47.5	23	57.5
Total	**40**	**100**	**40**	**100**
Tenure Status				
Owner-operator	9	22.5	5	12.5
Lessee	30	75.0	34	85
Owner-tenant	1	2.5	1	2.5
Total	**40**	**100**	**40**	**100**

Farm Characteristics

Table 3 describes the farm characteristics of the sample farmer-participants and non-participants in the RCIP. Most of the farmer-participants (82.5%) reported that their rice farms were situated less than 5 km away from the lakeshore. Majority of the non-participants (52.5%) mentioned that their rice farms were located more than 5 km away from the lakeshore. Most of the farms of both respondents were situated in low lying and flat areas.

The major source of irrigation water of the farmer-participants was communal irrigation system (45%), followed by the National Irrigation System (35%). Twenty-five percent of the farmer-participants relied on pumps and spring water for irrigation. In contrast, majority of the non-participants (70%) used pumps or spring water to irrigate their farms. The non-participants sourced their irrigation water from the communal irrigation system (17%) and the National Irrigation System (15%).

The t-test showed that the mean farm size and the mean number of parcels were not significantly different between the sample farmer-participants and the non-participants at 10% probability level. The average farm sizes of farmer-participants and non-participants were 2.68 and 2.43 ha, respectively. On the average, the farmer-participants 14 parcels while the non-participants had 12 parcels.

Credit Access and Knowledge Score

Tables 4 and 5 present the access to credit and scores for the knowledge of the RCIP. All of the farmer-participants had accessed credit from the Land Bank of the Philippines through their respective cooperatives while 32% of the non-participants had credit access to financial institutions. Based on the 20 questions about the RCIP, 72.5% of the participants scored 11 correct answers to a perfect scores with an average score of 13.7, while 90% of the non-participants scored 10 and below correct answers. Most non-participants scored zero resulting in an average score of 2.1 points.

Logit Analysis

Results of the logit analysis showed that knowledge score or awareness of the farmer about the RCIP, tenure status, and the distance of the farm from the lake influenced the farmer's decision on whether or not to participate in the RCIP (Table 6). The coefficient of knowledge score was highly significant at 1% probability level and was positive, indicating that the higher the awareness of the farmer or knowledge about the RCIP, the higher was the probability that he/she would participate in the program.

Table 3. Farm characteristics of the respondents in selected lakeshore municipalities in Laguna.

FARM CHARACTERISTICS	FARMER-PARTICIPANT		NON- PARTICIPANT	
Average farm size (ha)[a]	**2.68**		**2.43**	
Average number of parcels[b]	**14.43**		**12.00**	
	Number	**Percent**	**Number**	**Percent**
Geographical Location				
Less than 1 km from the lakeshore	16	40.0	11	27.5
1-5 km from the lakeshore	17	42.5	8	20
More than 5 km from the lakeshore	7	17.5	21	52.5
Total	**40**	**100**	**40**	**100**
Farm Topography				
Flat/Low lying	34	85.0	37	92.5
Elevated	6	15.0	3	7.5
Total	**40**	**100**	**40**	**100**
Water Source[c]				
National Irrigation System	14	35	6	15
Communal Irrigation System	18	45	7	17.5
Pump/Spring	10	25	28	70

[a] Results of the t-test of means showed that there is no significant difference in the mean farm size between the two farmer groups (t-value is 0.429) at 10% probability level

[b] Results of the t-test of means showed that there is no significant difference in the mean number of parcels between the two farmer groups (t-value is 0.705) at 10% probability level

[c] The total percentage exceeds 100% because two participants and one non-participant reported two sources of irrigation water

Table 4. Credit access of the respondents in selected lakeshore municipalities in Laguna.

ITEM	FARMER-PARTICIPANT		NON-PARTICIPANT	
Credit Access	**Number**	**Percent**	**Number**	**Percent**
	40	100	13	32.5

Table 5. Knowledge score of the respondents in selected lakeshore municipalities in Laguna, wet season, 2012.

Knowledge Score	PARTICIPANT		NON-PARTICIPANT	
	Number	**Percent**	**Number**	**Percent**
0-10	11	27.5	36	90
11-20	29	72.5	4	4
Average Score	13.7	68.5	2.1	10.5

Table 6. Results of logit analysis showing the factors that influenced the farmer's decision to participate or not in the PCIC-Rice Crop Insurance Program.

VARIABLE	COEFFICIENT	t-VALUE	MARGINAL EFFECTS	t-VALUE OF MARGINAL EFFECT
Constant	6.30***	3.06		
Independent Variables:				
Knowledge Score	10.75***	3.98	2.66**	4.03
Education	0.24ns	1.41	0.06ns	1.50
Household Income	-6.74E-07ns	-0.38	-1.67E-07	0.00
Tenure Dummy	1.72*	1.59	0.40*	1.82
Farm Size	0.16ns	0.59	0.04ns	0.57
Distance from the lake	-2.34*	-1.76	-0.52**	-2.17
Credit Access	0.39ns	1.22	-0.09ns	-0.31
X^2	80.43***			
Pseudo R^2	0.72			

***, **, and * - mean significant at 1%, 5%, and 10% probability level, respectively
ns – not significant at 10% probability level

The coefficient of the tenure dummy variable was positive and significant at 10% probability level. This meant that an owner-operator was more likely to participate in the program than a lessee. The more secure the tenure status, the higher was the probability that the farmer will participate in the insurance program.

The coefficient of dummy for the distance of the farm from the lake was negative and significant at 10% probability level. The negative coefficient indicated that the farther the distance of the farm from the lakeshore, the lower the probability that a farmer would participate in the RCIP.

Household income, educational attainment of the farmer, farm size, and credit access from a bank were found to have no significant influence on the farmer's decision to participate in the RCIP at 10% probability level. The possible reason why credit access from a bank had insignificant effect on farmers' participation in the Rice Insurance Program was that both the participant- and the non-participant-respondents might have obtained loans from banking institutions.

The regression line was quite robust with X^2 highly significant and Pseudo R^2 equal to 0.72. The Pseudo R^2 implied that the variation in the independent variables collectively explained 72% of the variation in the probability of farmers' participation in the RCIP.

Marginal effects referred to the changes in probability given a unit change in the independent variable and were more useful basis for interpreting the results of the logit model. The estimated marginal effects as shown in Table 6 suggested that the impact of the independent variables such as knowledge about the program, tenure, and distance of the farm from the lakeshore on the farmer's decision to participate in the RCIP was statistically significant. In particular, knowledge about the program as measured by the knowledge score appeared to have a higher impact on the probability of participating in the RCIP. For example, a 1% increase in the knowledge score would increase the probability of participation in the RCIP by approximately 3% with other factors held constant. An owner-operator had 40% more probability to be a participant in the RCIP than the tenant/lessee. An increase in farm distance by more 5 km from the lakeshore lowered the probability of participation by 52%. The independent variables education, household income, farm size, and credit access had no significant influence.

Reasons for Participating in the Rice Crop Insurance Program

Table 7 shows the reasons for the farmers' participation in the RCIP. The farmer-respondents reported that they participated in the RCIP for an average of 3.24 years. Eighty-five percent of the respondents mentioned that they participated in the program because having a rice insurance was a requirement of the Land Bank of the Philippines prior to loaning from the bank. Sixty-five percent of the respondents claimed that participation in the insurance program was essential to avoid risk that went with rice farming. Five percent of the sample farmer-participants mentioned that they joined the insurance program through the prodding of the cooperative technicians while 2.5% of the participants were convinced by friends.

Table 7. Reasons for participating in the Rice Crop Insurance Program.

REASONS FOR PARTICIPATING	NUMBER	PERCENT[a]
Part of the requirement for applying for an agricultural loan	34	85.0
To reduce risk in farming	26	65.0
Recruited by the technician of the cooperative	2	5.0
Convinced by friends	1	2.5

[a]Total exceeded 100% due to multiple responses of some respondents

Majority of the respondents (95%) indicated that they did not had any difficulty in preparing their respective farm plans and budgets because technicians assisted them, easy to follow instructions were provided, and that their children assisted them. Only two out of the 40 sample farmer-participants encountered difficulties in preparing their farm plans and budget due to too much information requirements (Table 8).

On average, the amount of premium paid by the farmer-participants for their 2012 wet season rice crop insurance was about PhP 2,386.00 while the amount of indemnity received was valued at PhP 13,660.00. Thirty-five of the 40 farmer-participants (87.5%) who filed for indemnity claims had received indemnities from the insurance program. Five farmer-participants were not able to receive indemnity because their losses were below 10% of the total expected yields as assessed by the PCIC personnel.

Table 8. Reasons for easy preparation of farm plans and budget.

REASONS	NUMBER	PERCENT[a]
Simple instructions to follow	20	52.6
Assisted by technician of the cooperative	20	52.6
Assisted by children	3	7.9

[a]Total exceeded 100% due to multiple responses of some respondents

Reasons for Non-Participation in the Rice Crop Insurance Program

Tables 9 shows the number of non-participants who had previously participated in the RCIP. Table 10 shows the reasons for non-participation in the RCIP. The majority of the non-participant respondents (95%) had not previously participated in the RCIP. More than half of the respondents (57.9%) said they did not join because they were unaware of the rice crop insurance program of the PCIC. This implied that the PCIC had the potential to further increase the number of rice farmer clientele, particularly the self-financed farmers, through a more aggressive effort of its Marketing and Sales Division. Lending institutions can conduct aggressive campaigns in terms of increasing their loan portfolios, which have built-in crop insurance packages.

The other major reason of the farmer-respondents for non-participation in the RCIP was their "being busy" to attend to the program's documentation requirements. This was particularly true among self-financed farmers who did not possess the technical capability to prepare the documents required to apply in the program. In particular, the preparation of the farm plan and budget had been repeatedly mentioned as their major limitation. In the case of farmers who are members of a cooperative, the preparation of a farm plan and budget was not a problem because of the assistance provided by the agricultural technicians of NEMCO and NBMMC. For some non-participant farmers, the non-participation was attributed to the unproven benefit of the program, loans were not needed as they had good financial status, and too many requirements.

Table 9. Number of non-participants who had previously participated in the Rice Crop Insurance Program for the past wet season crop.

Had Previously Participated in PCIC RCIP	NUMBER	PERCENT
Yes	2	5
No	38	95
Total	40	100

Table 10. Reasons for non-participation in the Rice Crop Insurance Program.

REASONS	NUMBER	PERCENT[a]
Unaware of PCIC-RCIP	**22**	**57.9**
Too busy to participate	**15**	**39.5**
Benefit of insurance not proven	**6**	**15.8**
Can financially sustain farming business	**5**	**13.2**
Too many requirements	**2**	**5.3**

[a] Total percentage exceeds 100% due to multiple responses of some respondents

Discussion

The farmer-participants generally spent more years in school than the non-participants, indicating that they have a better understanding of rice crop insurance, coping mechanism, and impacts of natural disasters on rice crop farming. Thus, the more educated the farmer was, the more likely he/she will participate in the RCIP.

The location and elevation of the farms of the farmer-participants also influence their participation. Farmers are more likely to participate in the RCIP if their fields are located less than a kilometer or within 5 km and are on low-lying areas. These areas are prone to flooding and crop damage during extreme weather events.

All of the farmer-participants have access to credit through their respective cooperatives and are required to participate in the RCIP to obtain credit approval. Hence, to be able to obtain loans to finance their farming operations, the farmers should pay the rice crop insurance premium. However, the farmer-participants are aware of problems with the implementation of the RCIP such as slow processing of indemnity claims and inaccurate crop damage assessment by PCIC personnel.

Most of the farmer non-participants are not members of any cooperative, have no idea about the RCIP, and are too busy to increase their understanding about the RCIP.

The significant variables identified in the logit analysis include the rice farmer's tenure status, knowledge about the insurance program, and the farm's distance from the lake. The farmer who is also an owner-operator, is more likely to avail of the crop insurance because he/she is more committed to the farm than the lessee/tenant. The farmer who knows more about the RCIP and is familiar with its benefits during times of disaster would likely participate in the program. Farmers whose fields are far from the lakeshore are less likely to participate in the program because their areas are less prone to flood and other calamities.

Conclusions

The study assessed with confidence the factors affecting the participation of farmers from calamity-prone selected lakeshore municipalities of Laguna in the PCIC-RCIP. Farmers joined the crop insurance program for the following reasons: (1) securing a rice crop insurance was one of the requirements of the Land Bank of the Philippines prior to extending loans to farmers to finance their farm operations and (2) understanding that the rice crop insurance would provide a coping mechanism in the event of crop failure due to natural calamities.

However, a better service can be provided by the insurance corporation to the participating farmers by improving the accuracy of the crop damage assessment and hastening the release of the indemnity funds.

To increase farmer-participation in the RCIP, the PCIC should (1) actively provide information on the importance of rice crop insurance and relevant policies and (2) simplify and ensure ease of processing applications and other documents.

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FOOD CONSUMPTION, DIET QUALITY, AND DIVERSITY OF RICE-BASED FARM HOUSEHOLDS IN CENTRAL LUZON, PHILIPPINES

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Abstract

Diet quality is a major determinant of household food and nutrition security. This study evaluated the food intake, diet diversity, and quality associated with the nutritional status of rice-based farm households using the three-day 24-hour food recall data collected in a survey of 953 randomly selected rice-based farm household members in Central Luzon, Philippines. Results showed that male members had more calorie, vitamin A, and iron intakes than female members. Total per capita carbohydrate, protein, and fat intakes were mainly from cereals, fish and seafood, meat, poultry, and offal. Cereals and vegetables were the main sources of iron while vitamin A was mainly from fish and seafood. A household with more than four family members whose iron intakes were below the Estimated Average Requirement (EAR) of 10-26 mg day^{-1} for iron were 2.10 times [Adjusted Odd Ratio (AOR) = 2.10; 95% CI: 1.19, 3.71] likely to become underweight. Adult members whose iron intakes were below EAR for iron were 2.18 times [AOR = 2.18; 95% CI: 1.07, 4.45] likely to become overweight and/or obese. Low diet quality was evident with female children and adults having lower calorie intake than male members. Nutrition- and gender-sensitive food-based intervention must be made to improve diet quality and diversity.

Keywords: Diet Diversity, Diet Quality, Rice-Based Farm Households, Nutritional Status.

Introduction

Diet quality is mainly associated with nutrition and health status. It is measured both by the variety of foods consumed (diet diversity) and nutrient adequacy based on national dietary recommendations (Mclnerney et al., 2016). A poor diet quality, lack of diversity in food, and inadequate nutrient intake often leads to malnutrition and chronic diseases (Sibhatu et al., 2015). In the Philippines, the predominant monotonous rice-based diet has been viewed to cause malnutrition. As the staple food, it is typical that rice and rice products are the major source of energy and other nutrients particularly protein and iron (FNRI-DOST, 2015a). Rice and rice products contributed to 55.5% of the 1810 kcal capita^{-1} day^{-1} intake (FNRI-DOST, 2015a), that is below the 2200 kcal day^{-1} minimum requirement to avoid malnutrition (Soon and Tee, 2014). In the recent years, a change in dietary pattern has been observed. Consumption of traditional complex-carbohydrate food such as cereals including rice, starchy roots and tubers, and fruits and vegetables has declined while consumption of meats, fats, and oils has increased (FNRI-DOST 2015a; Soon and Tee 2014). This pattern resulted in negative changes in nutrient intake and adequacy (Soon and Tee, 2014) and evident in the results of the 8th National Nutrition Survey for 2013. The survey showed that only a small percentage of households (33.3%) met the energy and other nutrient requirements (9-35%) (FNRI-DOST, 2015a). The change in dietary pattern also contributed to the increasing trend in overweightness and obesity (0.73% annum^{-1}) in adults that predisposed them to chronic diseases (FNRI-DOST, 2015a).

Agriculture and nutrition have been closely linked as most undernourished people live in rural farming areas, a common observation in Asian countries (Soon and Tee, 2014; Hawkesworth, 2010). Several studies proved that agricultural interventions through diversifying crop production have the potential to improve nutrient intake and nutritional status in these countries (Pandey et al., 2016). In the Philippines, a lot of successful interventions initiated and implemented by the government, non-government organizations (NGO), or the private sector focused on the "nutrition-sensitive agriculture framework" to improve the food production and nutritional status of the beneficiaries (Zamora et al., 2013).

While large-scale agricultural interventions showed promising results in enhancing the nutritional status of farming communities and agricultural productivity, a closer examination of the food consumption, diet quality, and diversity in rice farming communities suggests the need to incorporate specific nutrition concerns in programs, policies, and strategies for a more effective and sustainable intervention.

This study evaluated the food consumption and nutrient intake of rice-based farm household members in Central Luzon, Philippines (i.e., families involved in rice farming and considered as main rice producers in the region) and examined their diet quality and diversity. Factors associated with their nutritional status were also examined.

Materials and Methods

Study Area and Survey Participants

A cross-sectional survey was conducted in 385 randomly selected rice-based farm households in Central Luzon, Philippines covering the provinces of Aurora, Bataan, Bulacan, Nueva Ecija, Pampanga, Tarlac, and Zambales. Central Luzon is the top rice- producing region in the country contributing 33% of its total rice production. The region has a combination of mountainous areas and plain fields, mainly composed of farm lands and sea harbors (PSA, 2015). The main sources of livelihood in the region are agriculture, tourism, and food processing.

A multi-stage sampling technique was adopted to select 55 households from each of the 11 sample farming barangays (villages) in each province with 385 households. There were 1,619 household members from infants to adults that provided a three-day 24-hour food recall (two weekdays and one weekend). However, infants that only consumed milk and misreporters (under-and over-reporters) of food intakes were excluded. To identify the misreporters, estimates of Basal Metabolic Rate (BMR) were first calculated using standard Schofield's equations for different age groups (Koletzko et al., 2005; European Food Safety Authority, 2014) and Goldberg cut-offs were defined based on the assumed low activity level or a Physical Activity Level (PAL) value of 1.55, that was proposed by Food and Agriculture Organization/ World Health Organization/United Nations University (FAO/WHO/UNU) to be assigned whenever actual PAL was not available (FAO, 2001). Under-reporters and over-reporters were defined as the reported energy intake/BMR<0.906 and >2.163 (1-3 yr); <1.035 and >2.473 (4-9 yr); <1.165 and >2.702 (10-17 yr); <1.305 and >2.473 (18-69 yr); and <1.305 and >2.473 (≥70 yr). Excluding the milk-consuming infants and misreporters, the study covered 953 participants from 314 households comprising 649 adults and 304 children. On average, the sample households were 4.72 ± 3.61 km away from the nearest market, while 32.17% of the households were more than 5 km away from the town center.

Three-Day 24-Hour Food Recall and Household Survey

Interpersonal interviews at the respondents' homes were conducted by trained enumerators to obtain household and individual characteristics using a pre-tested structured questionnaire. A three-day 24-hour food recall (two non-consecutive weekdays and a weekend) was also administered to all members of each sample household. Participants were asked about the recipes and quantities of food and the beverages prepared and consumed at home or outside. Food consumption, calorie intake, and its adequacy among members and the household were measured. Food quality, diversity, and calorie intake of individual members of rice-based farm households were evaluated after processing the respondents' food recall data. Anthropometric measurements (weight, height) in adult members of the households were taken and body mass index (BMI) was calculated.

Diet Diversity and Quality Assessment

A Household Dietary Diversity Score (HDDS) was generated based on the 12 food groups proposed by the Food and Nutrition Technical Assistance (FANTA) and US Agency for International Development (USAID) (Swindale and Bilinsky, 2006) to assess the diet diversity in rice-based farm households. These food groups were cereals, roots and tubers; vegetables; fruits, meat, poultry, and offal; eggs; fish, and seafood; pulses/legumes/nuts; milk and milk products; oil/fats; sugar/honey/sweets; and miscellaneous, that included alcoholic beverages, condiments, and other foods not included in the preceding food groups (Swindale and Bilinsky, 2006). HDDS was calculated as the sum of the number of food groups consumed in the household. A score of 1 indicated that a particular food group was consumed and a score of 0 indicated otherwise. Thus, all values should either be 0 or 1 only summing to a maximum score of 12 per household signifying the 12 food groups. The mean HDDS was calculated as the sum of all HDDS divided by the total number of households (FAO, 2011). Percentages of consumption per food group were also taken.

Diet quality was assessed using the Philippine Dietary Reference Intakes (PDRI) (FNRI-DOST, 2015b). Macronutrient intakes (protein, fat, and carbohydrate) were evaluated using the Acceptable Macronutrient Distribution Range (AMDR), i.e., the range of intakes associated with reduced risk of chronic diseases while providing adequate intakes of essential nutrients. Protein, fat, and carbohydrate intakes were expressed as percentages of total energy intake. Macronutrient consumption above and below these AMDR indicated nutrient inadequacy and increased risk for chronic diseases such as coronary heart disease, obesity, diabetes, and cancer (WHO, 2004). The prevalence of inadequacy in micronutrient intakes (iron and vitamin A) were assessed using the Estimated Average Requirement (EAR) cut-off point method based on PDRI. EAR is defined as the daily nutrient intake level that meets the median or average requirement of healthy individuals in an age and sex group, corrected for incomplete utilization or dietary nutrient bioavailability. Macronutrient intake was considered inadequate when intake was below the EAR (FNRI-DOST, 2015b).

Statistical Analysis

The three-day 24-food recall data such as food group consumption, calorie, macronutrient, and micronutrient intakes were presented as mean and standard deviation (SD). Independent sample t-test was employed to compare the differences in nutrient intakes and Pearson chi-squared test was used to assess the differences in the prevalence of nutrient inadequacy across age groups and between genders using Microsoft Excel 2013 and IBM SPSS version 20 software. Bivariate and multivariate analyses through multinomial logistic regression were performed in IBM SPSS version 20 software to determine the factors associated with the nutritional status of household members based on BMI. The independent variables/predictor variables used in the analyses included household income (annual household income), socioeconomic status (SES) score, household size (number of household members), size of farm area, distance to market, education of the household head, sex and age of the household members, place of residence, food consumption (g capita^{-1}), HDDS, calorie (kcal capita^{-1}), iron, and vitamin A intakes (whether below or above the estimated average requirement of the nutrients). The SES score was the total points gathered from the following: house materials, type of toilet, and the source of domestic water used by the family (deep well or faucet from a community water system).

In bivariate analysis, variables with likelihood ratio *p*-value of <0.20 were included in multinomial logistic regression. The dependent variable, treated as nominal variable, was the BMI of household members classified using BMI classification for Asian Population (underweight = <18.5, normal = 18.5-22.9, overweight = 23-24.9, and obese = $\geq$ 25) coded as 1 = underweight, 2 = normal, 3 = overweight/obese (WHO, 2004).

Results

Characteristics of the Study Population and Rice-Based Farms

Response rate was 100% for the 385 households. Characteristics of respondents are presented in Table 1. Crops grown and their utilization are presented

Table 1. Characteristics of the study population (n = 953) in terms of size, age, health status, farm area, and source of income.

Category	Mean ± SD		
Age of household head (yr)	54.65 ± 12.35		
Household size	5.12 ± 2.05		
Children, yr (n=304)	**No.**	% Male	% Female
1-2	23	43	57
3-5	48	58	42
6-9	67	51	49
10-12	64	45	55
13-15	57	67	33
16-18	45	58	42
Adult, yr (n = 649)			
19-29	142	55	45
30-49	231	46	54
50-59	115	57	43
60-69	105	56	44
>70	56	45	55
Health Status			
Healthy	1495	87.48	
Has abnormality	20	1.17	
Has major illness	188	11.00	
Others/No response	6	0.35	
Mean farm area household^{-1}	1.7 ha (95% for rice farming)		
Mean annual household income	PhP 278,148.57 (47.8% from rice farming)		
Income by source	**Amount (PhP)**		
Agricultural sources	177,684.71		
Rice farming	132,998.91		
Corn farming	3,717.52		
Vegetable farming	11,174.85		
Fruit farming	1,488.78		
Livestock /Poultry	22,172.86		
Off-farm labor	2,934.41		
Other agricultural income	3,207.03		
Non-agricultural sources	100,463.85		
Salary from employment	39,679.23		
Self-employment	14,792.44		
Own business	17,812.96		
OCW remittances	17,081.82		
Local remittances	5,568.83		
Gift/support from relatives	1,784.16		
Other non-agricultural income	3,744.42		

in Table 2. The 304 children and adolescents (55% males and 45% females) aged 1 - 18 years old and adults aged 19 years old and above (52% males and 48% females) were included in this study. Mean age of household head was 54.65 ± 12.35 yr and the mean household size was 5.12 ± 2.05. Ninety-five percent of the mean farm area per household was used for rice farming and the rest for vegetable and livestock production. On average, nearly half (47.8%) of income per household came from rice farming. Other sources of household income were from livestock and poultry production, vegetable farming, and non-agricultural sources such as employment and remittances. The respondents identified hypertension, diabetes, asthma, ulcer, and kidney as health problems. The top ten crops other than rice planted in the remaining 5% of the farm were string beans, eggplant, mungbean, okra, corn, sweet potato, bitter gourd, sponge gourd, bottle gourd, and tomato. The permanent crops grown were coconut, sugarcane, banana, corn, lemon, and mango. Most of the farmers in the region practiced mono-cropping or rice-rice production, especially in Nueva Ecija. More diverse crops were grown in Bataan and Aurora.

Dietary Quality of Rice-Based Farm Households

Table 3 shows the calorie, protein, fat, and carbohydrate intakes of male and female household members in comparison with the recommended intakes. Teenage boys that were 13-18 yr ($p<0.001$-0.05) and male adults that were 19-69 yr ($p<0.001$-0.05) had more calorie intake than girls and female adults in the same age groups. Carbohydrate intake for ages 13-18 yr ($p<0.001$-0.05) was higher for boys than for girls. Protein energy (kcal) in male adult diet of age groups 19-59 yr ($p<0.001$-0.05) was higher than in female diet of the same age. Few children and adults were below the AMDR for protein, fat, and carbohydrate intake (Table 3). There was no significant difference between male and female children that were below the AMDR. However, a higher percentage of female adults from 19-49 yr ($p<.05$) did not meet the recommended carbohydrate intake compared with male adults in the same age group. Common food preparation was either fried or sautéed. Alcohol consumption was high among adult male respondents particularly in Aurora province.

Table 2. Crops grown by the study population (n = 953) and their utilization.

Crops	No. of Times Planted	Sum of Area (ha)	Ave. Area Planted (ha)	% for Home consumption	% Sold to Market	% Given Away
String beans	82	21.82	0.30	36.22	43.21	20.56
Eggplant	61	2.22	0.04	46.98	31.78	21.23
Okra	32	2.43	0.07	43.85	37.16	18.99
Corn	30	20.82	0.38	17.43	62.00	20.57
Sweet Potato	29	2.90	0.11	44.33	32.36	23.31
Bitter Gourd	23	1.32	0.06	37.84	45.73	16.43
Sponge Gourd	18	1.27	0.07	34.77	41.31	23.91
Mungbean	14	8.58	0.61	18.50	73.28	8.21
Tomato	13	2.95	0.15	8.98	76.43	14.58
Bottle Gourd	8	0.042	0.00	34.37	28.75	36.87
			Permanent Crops			
Coconut	3	3.00	1.00	10.00	81.25	8.75
Sugarcane	2	5.70	2.85	0.00	100.00	0.00
Banana	1	0.03	0.03	100.00	0.00	0.00
Calamansi	1	0.60	0.60	0.00	100.00	0.00
Mango	1	1.20	1.20	0.00	100.00	0.00

Table 3. Mean intakes of energy, protein, fat, and carbohydrate per age group and gender and prevalence of inadequacy (n = 953).

	Energy (kcal)		Protein (kcal)		Fat (kcal)		Carbohydrate (kcal)	
	M	F	M	F	M	F	M	F
Children, yr (n = 304)								
1-2 (n=23)	1203.80±430.86	1031.79±254.94	194.72±77.59	166.80±80.87	470.76±336.03	325.36±147.72	588.78±219.60	569.53±132.24
<AMDR of %En			0.00%	7.7%	20.00%	23.08%	60.00%	53.85%
3-5 (n=48)	1410.76±353.52	1222.75±267.52	218.68±77.05	145.25±37.61*	444.76±218.63	367.41±233.99	764.52±221.96	794.63±247.81
<AMDR of %En			0.00%	0.00%	10.71%	10.00%	53.57%	25.00%
6-9 (n=67)	1392.40±356.02	1409.29±319.87	220.91±95.46	203.77±66.35	427.21±251.44	431.97±147.44	804.44±173.54	798.54±186.14
<AMDR of %En			0.00%	0.00%	5.88%	0.00%	47.06%	48.48%
10-12 (n=64%)	1728.26±346.27	1665.82±461.71	248.79±83.27	228.67±106.63	515.24±296.27	480.47±238.28	1046.91±224.17	1000.55±297.50
<AMDR of %En			0.00%	0.00%	3.45%	14.29%	24.14%	37.14%
13-15 (n=57)	1969.27±396.34	1658.54±356.15*	281.89±71.67	224.62±80.08*	469.10±207.42	515.02±225.99	1262.91±310.34	995.54±331.82*
<AMDR of %En			0.00%	0.00%	15.79%	10.53%	23.68%	47.37%
16-18 (n=45)	2053.60±428.35**	1715.71±449.23	298.47±88.43	253.60±104.68	532.22±385.66	384.87±166.64	1314.88±327.38	1079.04±324.73**
<AMDR of %En			0.00%	0.00%	11.54%	15.79%	19.23%	21.05%
Adults, yr (n = 649)								
19-29 (n=78/64)	2188.01±466.88	1782.40±422.65*	298.64±94.46	261.49±84.09**	493.90±273.92	471.23±186.28	1429.69±360.47	1081.21±329.76**
<AMDR of %En			15.38%	9.38%	20.51%	9.38%	15.38%	37.50%**
30-49 (n=107/124)	2163.75±482.68	1771.54±350.21*	302.26±101.94	251.78±84.74*	454.04±248.90	438.97±218.73	1408.23±355.92	1105.51±280.36*
<AMDR of %En			8.41%	12.10%	20.56%	18.01%	9.35%	26.61%**
50-59 (n=65/50)	2122.76±375.21	1773.11±409.06*	314.69±92.59	256.04±80.51**	459.00±211.18	438.83±220.04	1312.38±316.93	1081.58±314.15*
<AMDR of %En			1.54%	8.00%	20.00%	20.00%	23.08%	24.00%
60-69 (n=59/46)	1701.72±374.91	1541.69±418.77**	270.63±100.34	244.82±71.40	387.57±176.18	386.57±151.43	1040.74±271.54	916.34±336.71**
<AMDR of %En			3.39%	10.87%	15.25%	10.87%	27.12%	41.30%
>70 (n=25/31)	1630.48±367.63	1508.69±225.80	259.85±82.91	243.43±58.64	404.44±156.86	343.64±119.09	966.88±317.70	927.76±192.46
<AMDR of %En			4.00%	0.00%	16.00%	9.68%	36.00%	16.13%
All	1917.94 ±508.09	1646.42±414.65	279.69 ±97.18	239.14 ±85.26	457.20±247.39	429.33±200.22	1201.22 ±388.14	1002.97±312.43

*p<0.001, **p<0.05; AMDR-Acceptable Macronutrient Distribution Range

Micronutrient Intakes across Age Groups and between Genders

Per capita iron and vitamin A intakes of participants and percentage of participants not meeting the recommended intakes per age group and gender in comparison with the recommended intakes are presented in Table 4. Boys aged 13-15 yr (p<0.05) and male adults aged 19-29 yr and 60-69 yr (p<0.05) had higher iron intake than girls and female adults of the same age groups. Boys aged 3-5 yr had higher vitamin A intake (p<0.05) than girls. Prevalence of inadequacy in iron and vitamin A intakes were high as indicated by high proportion of participants not meeting the EAR and very low proportion above the upper limit. Higher percentage of girls than boys 3-5 yr (p<0.05), 13-15 yr (p<0.05), and 16 -18 yr (p<0.05) did not meet the required iron intake. Inadequacy in iron intake was highly prevalent in female adults aged ≥19 yr (p<0.001) than in male adults. Female adults (p<0.001) aged 50-59 yr had higher prevalence of inadequate vitamin A intake than male adults of the same age group. There were no significant differences in the prevalence of vitamin A inadequacy between male and female adults in all age groups.

Dietary Diversity in Rice-Based Farm Households

The computed mean HDDS (8.04) indicated a high dietary diversity in rice-based farm households based on guidelines of FAO (2011). Figure 1 shows

Table 4. Mean intakes if iron and vitamin A in relation to age and gender and prevalence of inadequacy (n = 953).

	Iron		Vit A	
	M	F	M	F
Children, yr (n=335)				
1-2 (n=23)	19.15±22.27	14.11±11.67	826.60±566.85	581.88±382.68
%<EAR	20.00%	38.46%	0.00%	7.69%
%>UL	10.00%	7.69%	50.0%	38.46%
3-5 (n=48)	20.52±24.04	20.35±32.59	540.19±564.66	237.60±128.60**
%<EAR	39.29%	70.00%**	32.14%	55.00%
%>UL	14.29%	20.00%	14.29%	0.00%
6-9 (n=67)	8.02±2.93	12.30±12.15	275.16±209.48	448.54±724.98
%<EAR	73.53%**	45.45%	61.76%	60.61%
%>UL	0.00%	3.03%	2.94%	9.09%
10-12 (n=64)	9.77±3.10	10.55±6.61	407.00±618.71	369.30±565.40
%<EAR	75.86%	97.14%**	72.41%	80.00%
%>UL	0.00%	2.86%	6.90%	2.86%
13-15 (n=57)	12.47±5.08	9.40±2.93**	413.37±415.06	253.28±168.18
%<EAR	94.74%	94.74%	81.58%	78.95%
%>UL	0.00%	0.00%	0.00%	0.00%
16-18 (n=26/19)	12.02±2.84	12.11±8.48	494.07±1568.75	291.49±301.92
%<EAR	61.54%	89.47%**	96.15%	84.21%
%>UL	0.00%	0.00%	3.85%	0.00%
Adults, yr (n=649)				
19-29	15.17±12.04	10.42±3.54**	472.36±844.84	432.35±708.72
%<EAR	16.67%	100.0%*	84.62%	82.81%
%>UL	2.56%	0.00%	3.85%	4.69%
30-49(n=107/124)	12.55±3.29	11.37±8.92	321.89±380.03	382.74±579.24
%<EAR	28.97%	97.58%*	87.85%	80.65%
%>UL	0.00%	.81%	.93%	1.61%
50-59(n=65/50)	16.22±16.49	12.24±5.40	377.05±443.96	319.89±354.10
%<EAR	18.46%	98.00%*	86.15%	82.0%
%>UL	3.08%	0.00%	1.54%	0.00%
60-69 (n=59/46)	10.46±3.90	8.86±2.77**	327.42±219.17	396.11±902.54
%<EAR	66.10%	100.00%*	83.05%	86.957%
%>UL	0.00%	0.00%	0.00%	2.17%
>70(n=25/31)	10.03±3.30	8.62±1.86	313.69±217.17	404.96±507.07
%<EAR(n=25/31)	64.00%	100.00%*	88.00%	87.10%
%>UL	0.00%	0.00%	0.00%	0.00%
All	13.30±11.47	11.09 ±8.89	392.02±605.26	380.70±590.98

*p<0.001, **p<0.05; EAR-Estimated Average Requirement per day, Fisher's Exact Test, Pearson Chi-Square the composition of the daily food intake based on food groups. The daily per capita intake for all food groups was 1125.97 ± 414.82 g. The daily food intake was mainly composed of cereals (60.43%); fish and seafood (10.26%); sugar and sweets (8.66%); and meat, poultry, and offal (7.19%). The other food groups were vegetable (3.67%); fruits (2.09%); eggs (1.70%); miscellaneous (1.60%); oil/fats (1.24%); pulses, legumes, and nuts (1.18%); milk and milk products (1.16%); and roots and tubers (0.83%).

Figures 2 and 3 show the contribution of different food groups to the daily per capita food intake of male and female respondents, respectively. Generally, male respondents had a higher daily per capita food intake of 1156.49 ± 433.26 g than the female respondents' daily per capita food intake of 1092 ± 433.26 g. Women and girls had lower intakes of different food groups than men and boys.

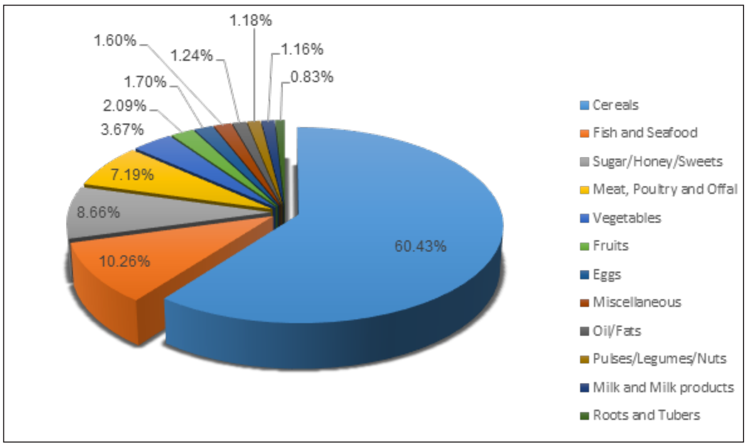

Figure 1. Percentage contribution of different food groups for a total per capita food intake of 1125.97 ± 414.82 g day^{-1}.

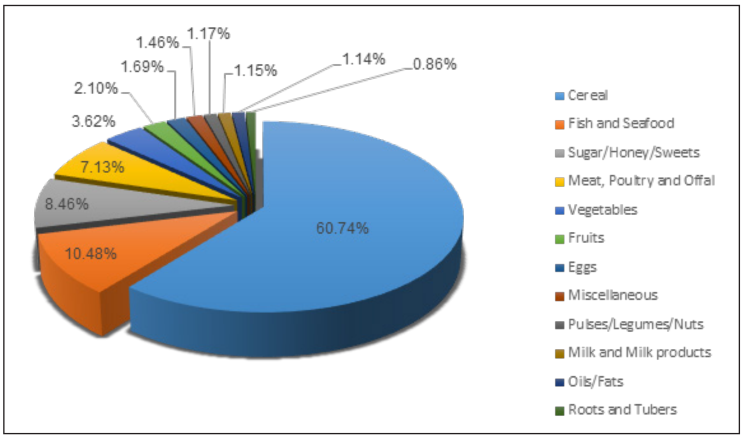

Figure 2. Percentage contribution of different food groups for a total per capita food intake of 1156.49 ± 433.26 g day^{-1} for male respondents.

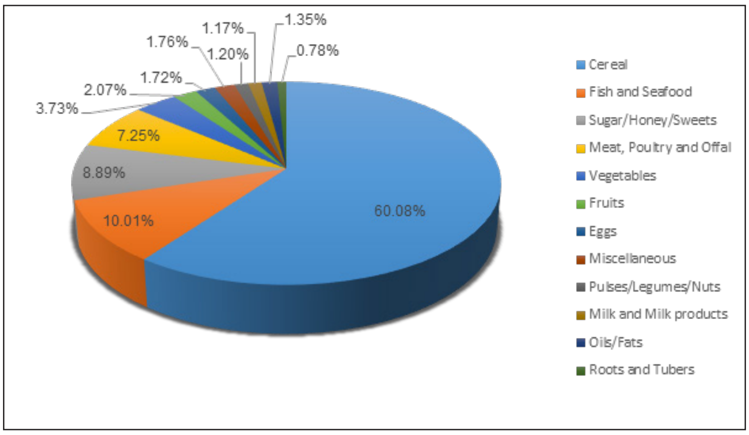

Figure 3. Percentage contribution of different food groups for a total per capita food intake of 1092 ± 390.97 g day^{-1} for female respondents.

The contribution of different food groups to the total per capita calorie and macronutrient intakes is shown in Figure 4. More than half of the total per capita calorie intake (1711.15 ± 567.34 kcal) was contributed by cereals (57.16%). This was followed by meat, poultry, and offal (11.38%); fish and seafood (8.14%); sugar and sweets (7.58%); oil/fats (6.69%); milk and milk products (2.34%); eggs (1.92%); fruits (1.73%); pulses, legumes, and nuts (0.91%); vegetables (0.84%); miscellaneous (0.82%); and roots and tubers (0.50%).

The total per capita carbohydrate intake (1056.46 ± 406.03 kcal) was mainly contributed by cereals (80.79%) and sugar and sweets (11.51%). Fish and seafood (36.48%), cereal (27.50%); and meat, poultry, and offal (21.68%) were the major contributors to the total per capita protein intake of 250.82 ±1 00.37 kcal. The total per capita fat intake (426.38 ± 247.54 kcal) was mainly from meat, poultry, and offal (31.64%); oil/fats (26.63%); cereals (19.89%); and fish and seafood (9.76%).

Figure 5 shows the contribution of different food groups to the total per capita iron and vitamin A intakes. Nearly half of the total per capita iron intake (12.04 ± 10.56 g) was contributed by cereals (39.89%). This was followed by vegetable (17.51%); meat, poultry, and offal (12.44%); and fish and seafood (11.05%). The total per capita vitamin A intake (372.91 ± 552.05 μg retinol equivalent or RE) was mainly contributed by fish and seafood (31.09%); meat, poultry, and offal (28.83%); and milk and milk products (13.44%).

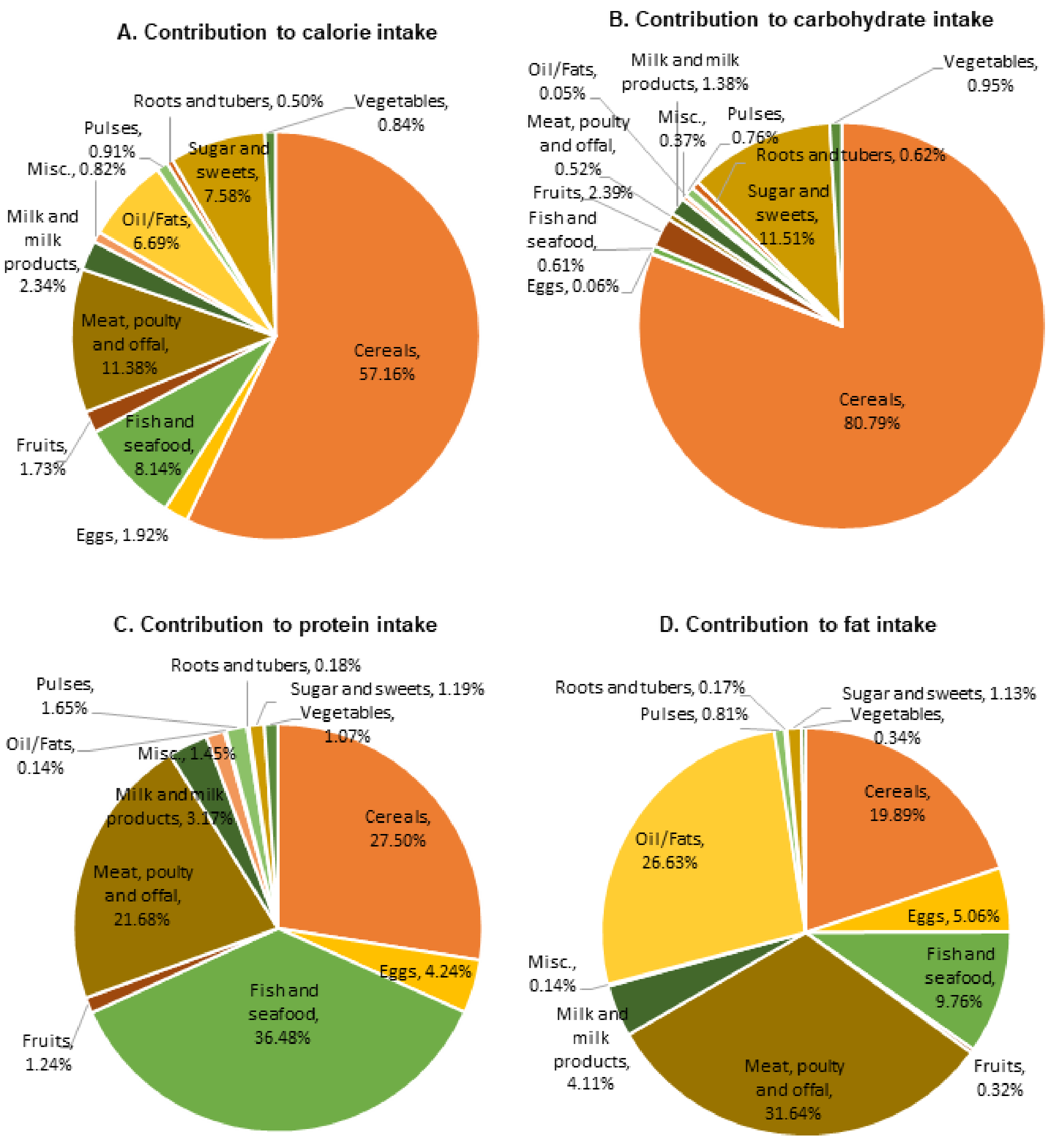

Figure 4. Contribution of different food groups to total per capita calorie, carbohydrate, protein, and fat intakes.

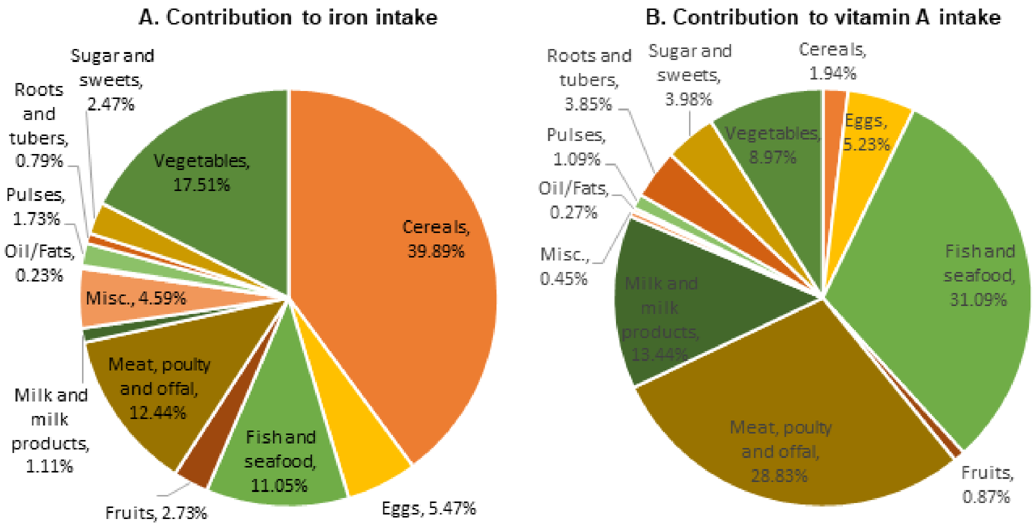

Figure 5. Contribution of different food groups to the total per capita iron and vitamin A intakes.

Factors Associated with Nutritional Status of Household Members (≥ 19 yr) based on BMI

Table 5 shows the results of the bivariate analysis of factors associated with nutritional status of adults in rice-based farm households in Central Luzon. Using likelihood ratio test, household and nutritional characteristics such as household income [x2=7.61; p<0.05], SES score [x2 = 3.69; p<0.10], household size [x2 = 9.23; p<0.05], education of household head (x2 = 4.19; p<0.20), age of the household member [x2 = 52.3; p<0.001], food consumption [x2 = 7.83; p<0.05), calorie intake [x2 = 10.86; p<0.001], iron intake [x2 = 11.31; p<0.001], and vitamin A intake [x2 = 6.60; p<0.05) were found to be closely associated with the nutritional status with an overall significance of p<0.20. These were then used as independent variables in the multivariate analysis to generate the final model.

Results of the multivariate analysis of factors associated with nutritional status of adults in rice-based farm households are shown in Table 6. Data showed that household members belonging in households with more than four members were 2.10 times more likely become underweight than overweight and/or obese [AOR = 2.10; 95% CI: 1.19, 3.71]. Adults aged 30-49 yr would be 12% less likely become underweight than overweight and/or obese [AOR = 0.12; 95% CI: 0.04, 0.36]; and 41% would less likely become normal than overweight and/or obese [AOR=0.41; 95% CI: 0.18, 0.92]. Adults aged 50-59 yr would 20% less likely become underweight than overweight and /or obese [AOR=0.20; 95% CI: 0.07, 0.62]; and 34% would less likely become normal than overweight and/or obese [AOR=0.34; 95% CI: 0.14, 0.79]. Moreover, those older adults aged 60-69 yr would be 32% and 35% less likely to become underweight [AOR = 0.32; 95% CI: 0.11, 0.90] and normal [AOR = 0.35; 95% CI: 0.15, 0.84] than overweight/obese, respectively. Adults whose iron intakes were below the EAR for iron would 2.18 times more likely become underweight than overweight and/or obese [AOR = 2.18; 95% CI: 1.07, 4.45]. Adults whose vitamin A intakes were below the EAR for vitamin A would 1.69 times more likely become normal than become overweight/obese [AOR = 1.69; 95% CI: 1.03, 2.77)].

Table 5. Bivariate analysis of factors affecting the nutritional status of household members ≥ 19 yr based on BMI.

					Underweight					Normal				
	No.	%	x^2	p-value	Coef.	p-value	OR	95% Confidence Interval		Coef.	p-value	OR	95% Confidence Interval	
								Lower Bound	Upper Bound				Lower Bound	Upper Bound
Household Income			7.61	0.02*	0.00	0.03	1.00	1.00	1.00	0.00	0.18	1.00	1.00	1.00
SES Score			3.69	0.16*	-0.06	0.83	0.94	0.55	1.61	-0.31	0.08	0.74	0.52	1.04
Household Size (no. of members)			9.23	0.01*										
>4	337	51.93			0.69	0.01	1.99	1.19	3.32	0.44	0.01	1.56	1.10	2.21
≤4 ®	312	48.07												
Farm Area (ha)			2.97	0.23										
≤1.29	28	4.31			0.89	0.10	2.44	0.83	7.19	0.10	0.83	1.11	0.44	2.79
>1.29 ®	621	95.69												
Distance to Market (km)			0.40	0.82										
>4	549	40.52			0.02	0.93	1.02	0.61	1.72	0.11	0.55	1.11	0.78	1.58
≤4®	100	59.48												
Education			4.19	0.12*										
<College Level and Graduate	548	84.44			0.43	0.23	1.54	0.76	3.11	0.47	0.04	1.60	1.01	2.54
College Level and Graduate®	101	15.56												
Sex of HH member			1.93	0.38										
Female	315	48.54			0.21	0.42	1.23	0.74	2.04	-0.12	0.50	0.89	0.63	1.26
Male®	334	51.46												
Age of HH member			52.03	0.00*										
19-29	142	21.88			-0.17	0.75	0.85	0.31	2.31	0.12	0.79	1.13	0.47	2.70
30-49	231	35.59			-2.23	0.00	0.11	0.04	0.29	-0.84	0.04	0.43	0.20	0.95
50-59	115	17.72			-1.89	0.00	0.15	0.05	0.44	-1.11	0.01	0.33	0.14	0.76
60-69	105	16.18			-1.19	0.02	0.30	0.11	0.83	-1.05	0.02	0.35	0.15	0.82
>70®	56	8.63												
Residence			11.88	0.46										
Aurora	100	15.41			-0.43	0.40	0.65	0.24	1.78	0.11	0.72	1.12	0.61	2.04
Bataan	60	9.24			0.40	0.43	1.50	0.55	4.07	0.11	0.77	1.11	0.54	2.27
Bulacan	94	14.48			0.16	0.72	1.18	0.48	2.88	-0.06	0.84	0.94	0.51	1.73
Nueva Ecija	98	15.10			0.05	0.92	1.05	0.39	2.86	0.58	0.07	1.79	0.95	3.39
Pampanga	96	14.79			0.36	0.42	1.44	0.60	3.46	0.04	0.90	1.04	0.56	1.93
Tarlac	97	14.95			0.40	0.38	1.49	0.61	3.59	0.11	0.72	1.12	0.60	2.08
Zambales®	104	16.02												
Food Consumption (g capita^{-1})			7.83	0.02*	0.00	0.01	1.00	1.00	1.00	0.00	0.28	1.00	1.00	1.00
Household DDS			2.97	0.23										
Medium (3 to 5 food groups)	28	4.31			0.89	0.10	2.44	0.83	7.19	0.10	0.83	1.11	0.44	2.79
High (>=6 food groups) ®	621	95.69												
Calorie Intake (kcal capita^{-1})			10.86	0.00*	0.00	0.00	1.00	1.00	1.00	0.00	0.79	1.00	1.00	1.00
Iron Intake (g capita^{-1})			11.31	0.00*										
<EAR	422	65.02			0.95	0.00	2.59	1.42	4.74	0.11	0.54	1.12	0.78	1.60
>EAR®	227	34.98												
Vitamin A Intake (µg capita^{-1})			6.60	0.04*										
<EAR	548	84.44			0.20	0.55	1.22	0.63	2.35	0.60	0.01	1.82	1.15	2.90
>EAR®	101	15.56												

® Reference Category; *Factors with Likelihood Ratio *p*-value of <0.20 that were included in the multivariate logistic regression.

Table 6. Multinomial logistic regression of factors affecting the nutritional status of household members ≥ 19 yr based on BMI.

		Underweight					Normal				
	Likelihood p-value	Coef.	p-value	AOR	95% Confidence Interval		Coef.	p-value	AOR	95% Confidence Interval	
					Lower Bound	Upper Bound				Lower Bound	Upper Bound
Household Income	.04	.00	.03	1.00	1.00	1.00	.00	.73	1.00	1.00	1.00
SES Score	.26	-.07	.81	.93	.52	1.66	-.28	.13	.76	.52	1.09
Household Size (no. of household members)	.03										
>4		.74	.01**	2.10	1.19	3.71	.34	.07	1.41	.97	2.03
≤4®											
HH Head Education	.34										
<College Level and Graduate		-.09	.81	.91	.42	1.97	.61	.21	1.37	.83	2.24
College Level and Graduate®											
Age of HH member	.00										
19-29		.01	.98	1.01	.34	2.99	.05	.92	1.05	.42	2.61
30-49		-2.10	.00*	.12	.04	.36	-.90	.03**	.41	.18	.92
50-59		-1.59	.01**	.20	.07	.62	-1.09	.01**	.34	.14	.79
60-69		-1.14	.03**	.32	.11	.90	-1.04	.02**	.35	.15	.84
≥70®			.	.	.	.					
Food Consumption (g capita^{-1})	.52	.00	.26	1.00	1.00	1.00	.00	.59	1.00	1.00	1.00
Calorie Intake (kcal capita^{-1}) neg	.43	.00	.52	1.00	1.00	1.00	.00	.48	1.00	1.00	1.00
Iron Intake (g capita^{-1})	.09										
<EAR		.78	.03**	2.18	1.07	4.45	.20	.36	1.23	.79	1.89
>EAR®											
Vitamin A Intake (µg capita^{-1})	.04										
<EAR		-.17	.64	.84	.41	1.73	.52	.04**	1.69	1.03	2.77
>EAR®											

Significance level, *p<0.001, **p<0.05; ® Reference Category

Discussion

Malnutrition, particularly nutrient deficiencies, are not only caused by low quantities of foods being consumed, but also due to low dietary diversity and quality. Results showed that the total per capita calorie from all food groups was 1711.15 ± 567.34 kcal in rice-based farm households of Central Luzon. This value was below the mean national total per capita calorie intake of 1810 kcal (FNRI-DOST, 2015a) and below the minimum requirement of 2200 kcal per day to avoid malnutrition. The daily diet in the region was mainly a combination of rice, fish, and meat, and slightly deviated from the typical Filipino diet that includes rice, vegetable, and fish (FNRI-DOST, 2015a). More than half of the diet were cereals, mainly rice, which is the staple food in the country. The daily per capita intake of cooked rice in the region was 556.90 g ± 287.22. Rice contributed to 49.1%, 11.7%, and 31.7% of the total per capita calorie, protein, and iron intakes, respectively. The percent consumption of vegetable (8.97%) and fruit (3.86%) in a regular meal, except for rice (54.89%) and meat and fish (32.27%), were very low compared with the Philippine recommended healthy meal of 33% rice, 33% vegetable, 17% meat, and 17% fruit (FNRI-DOST, 2015a). Although the dietary diversity score was high, HDDS does not account for the portion size per food group consumed. It is a qualitative method simply counting the different food groups and not the amount of each food group consumed (Jayawardena et al., 2013). Less fruit and vegetable consumption could be attributed to lower production of these commodities because the farm area was mainly for rice farming. Access to other crops such as fruits and vegetables may be limited as many of the rural households covered by the study were far from the source, i.e., markets (>4 km distance) and most had poor access to market roads.

The primary source of energy in the diet is carbohydrate, which plays an important role in metabolism and maintenance of homeostasis. Cereals highly contributed to the total per capita carbohydrate intake than sugar and sweets in the region. This is a good indicator as diet high in complex carbohydrates like the whole-grain rice can reduce the risk to non-communicable diseases such as type 2 diabetes, cardiovascular diseases, and some types of cancer (Hawkesworth et al., 2010). A diet with large amounts of simple carbohydrates from sugars and sweets could lead to weight gain (Hawkesworth et al., 2010) and may eventually lead to overweightness and obesity.

Adequate intake of protein is important for normal growth and maintenance of body protein (Otten et al., 2006). Protein intake in the region was mainly contributed by fish and seafood, rice, meat and poultry, and similar to the dietary results of the 8th National Nutrition Survey (FNRI-DOST, 2015a). Proteins from animal-based foods, also known as complete proteins, provide all nine essential amino acids while proteins from plants (e.g., cereals, legumes, and vegetables) are incomplete proteins and deficient in one or more essential amino acids. Both of these proteins should be present to prevent protein-energy malnutrition (PEM). Deficiency in protein intake may adversely affect the brain and brain function, immune system, increasing the risk of infection, and gut mucosal and kidney function. Excess protein intake could reduce risk of adverse effects in the body (Otten et al., 2006).

Fat intake was highly contributed by meat, poultry and offal; oils/fats; cereals; and fish and seafood. Total fat is a major source of energy in the body and it aids in the absorption of fat-soluble vitamins and carotenoids. Impaired growth and increased risk of chronic diseases may occur when there is an inadequate intake of dietary fat. Not meeting the energy needs due to very low fat, carbohydrate, and protein intake can cause a negative energy balance in an individual. However, fatty acid as a main component of fat in the diet could lead to excess consumption of trans-fatty acids and increase the risk of having cardiovascular diseases, cancer, and insulin resistance (Otten et al., 2006).

Vitamin A is a fat-soluble vitamin that is important for normal vision, gene expression, reproduction, embryonic development, and immunity. Vitamin A from animal-based foods are called pre-formed vitamin A (retinol). Effects of vitamin A deficiency include reduced immune function and increased risk to infections such as respiratory infection and diarrhea (IMFB, 2001). In the region, prevalence of vitamin A intake inadequacy (78.28%) was high. This could be attributed to low amounts of daily consumption of the major dietary sources of vitamin A. Rice does not provide sizable amount of vitamin A but comprised the largest portion of the diet. The major contributors of vitamin A such as fish, meat, milk, vegetables, and eggs were consumed in fewer amounts.

More than half of the household members in the region had inadequate iron intake. This high prevalence of iron inadequacy could be linked to low consumption of other sources of iron. The major contributors of iron in the diet were cereals, meat, fish, vegetables, and eggs (Figure 4). Results also showed that cereals comprised the biggest portion of the daily per capita food intake (60%). Animal-based foods such as meat, fish, egg, and milk in which iron is highly bioavailable (Otten et al., 2006) comprised a small portion of the food intake. Heme iron or iron from fish, meat, poultry is generally well-absorbed by the body (Otten et al., 2006). Plant-based foods that can also provide good amounts of iron such as vegetables (green leafy vegetables), legumes/pulses, and other deep-colored vegetables and fruits (Otten et al., 2006) were also consumed in small amounts. Recent studies have shown the decreasing consumption of fruits and vegetables by Filipinos due to increasing price, contamination from pesticides, fast-paced lifestyle, rise of quick-service restaurants and instant meals, and the lack of knowledge on the health benefits from eating vegetables (Gonzales et al., 2016). These plant-based foods are also sources of vitamin C that have synergistic effect with iron to enhance its bioavailability (Nair et al., 2016). Adverse effects that could result from iron deficiency include reduced physical work capacity, delayed psychomotor development in infants, impaired cognitive function, and adverse effects for both the mother and the fetus such as maternal anemia, premature delivery, low birth weight, and increased perinatal infant mortality (Otten et al., 2006).

Results of the study indicated that female children and adults had lower calorie, macro- and micro-nutrient intakes than their male counterparts. Women had lower carbohydrate intake than men. Physiologically, women have lower metabolic rates and require 25% lower dietary energy per day so they usually eat smaller amount of food than men. Results showed that more women and girls did not meet EAR for iron and vitamin A than men and boys. Even though females need lower dietary energy, they have higher requirement for other nutrients. This high requirement is not fulfilled by their small consumption of food. As such, they are encouraged to eat nutrient-dense food (FAO, 2000; Vlassoff, 2007).

Household size, age of the household member, and vitamin A intake were the main factors affecting the nutritional status based on the BMI of rice-based farm household members in the region. Rice-based farming communities in the region had an average of five household members. Households with more than four members have high probability of members becoming underweight. A bigger number means that food will be divided to more members of the family, lowering down quantities for each member. As the trend suggests, when adults grow older, they become more exposed to overweightness and/or obesity that is usually associated with chronic diseases. In the Philippines, three out of ten Filipinos are overweight/obese and the trend is increasing over time (FNRI-DOST, 2015a). This is due to the shift in the dietary pattern of the Filipinos, from traditional foods to foods that are higher in fat and carbohydrate but low in nutrients (Soon and Tee, 2014).

Studies have shown that healthy and well-nourished agricultural population is more productive and has a higher wage-earning potential since optimal nutrition of farmers strengthens agricultural production (FAO, 2012). Micronutrient-deficient or anemic adults had a 17% decrease in productivity in agricultural work that required heavy manual labor and underweight adults had lower agricultural productivity (Horton and Ross, 2003).

Given the connection of agriculture to nutrition, the government and concerned stakeholders should implement interventions to improve the nutritional status of the rice-based farm households. A good example of an intervention that successfully produced impact to its beneficiaries was the Homestead Food Production Program of Helen Keller Foundation implemented in 2002-2007 (HKIAP, 2010). Women of selected households from target areas in the Philippines were provided with nutrition education and training to establish home gardens and small poultry. They produced various vegetables and fruits as well as meat for their own households in a fixed size of land that sustained them throughout the year. As a result, household food security and nutrition status of young children and women in the target areas improved. The Program had impacts in terms of increased consumption of animal food, decreased anemia in children, and increased income (HKIAP, 2010; Talukder et al., 2010).

At present, under the Philippine Plan of Action for Nutrition 2017-2022, government agencies and organizations (i.e., Department of Health, National Nutrition Council, FNRI, Local Government Units or LGU, and Non-government Organizations) focus on implementing programs and projects that are nutrition-specific and nutrition-sensitive. In Central Luzon, the target areas are Aurora, Bataan, Bulacan, and Nueva Ecija where LGUs will be intensely mobilized to ensure that target outcomes are achieved. One of the programs that promote diet diversity and food quality is the National Dietary Supplementation Program that includes projects on supplementary feeding or provision of food aside from regular meals to pregnant women, infants, pre-school, and school children as well as promoting the planting of crops in the communities that will be used in producing supplementary foods (NNC, 2017). The HKF's Homestead Food Production Model could be integrated in this program. LGUs of rice-based farming communities should involve and capacitate members of households using this food production model to establish home-based gardens of local vegetable crops and small poultry. Their produce could be used as ingredients to the free meals provided by the supplementary feeding programs or for their own household consumption.

The *Gulayan sa Paaralan* (School Vegetable Garden) Program is another initiative of the government implemented by the Bureau of Plant and Industry and the Department of Education. It promotes food security in communities by training teachers, school children, and involving the parents in establishing school gardens. In this way, they are encouraged to produce their own food and appreciate agriculture (PFSIS, 2018). The *Gulayan sa Paaralan* in Cavite is a successful program, in which the schools partner with an NGO, the International Institute of Rural Reconstructions (IIRR) in gaining knowledge and training on Bio-Intensive Gardening. The forefront of IIRR's participation is the community-based approaches in solving rural problems like poverty, food insecurity, and malnutrition (IIRR, 2018).

FAO in the Philippines also implements "Telefood," that provides poor farmers with resources for them to produce crops, livestock, and fish. It also provides tools and skills in value-adding and selling of food products (FAO, 2017). In Cotabato, Philippines, unemployed women and out-of-school youth were involved in the project. They were trained on organic farming techniques enabling them to increase their crop yield (FAO, 2002).

Given all these existing efforts, there is a need to take advantage of the partnership that can be established with LGUs, other government agencies, and/or NGOs to strengthen local nutrition interventions. The farmers, their wives, and other family members must be made aware of the importance of quality diet and nutrition and be trained on achieving household food and nutrition security.

Conclusions

The usual diet of rice-based farm household members in Central Luzon, Philippines was a combination of rice, fish, and meat. Rice was the major source of energy, protein, and iron. Fish and meat were major sources of vitamin A (retinol) and iron. Low diet quality was evident as characterized by lower calorie intakes than the recommended calorie intakes for all age groups and there was high prevalence of iron and vitamin A inadequacies. Female children and adults had lower calorie, macronutrient, and micronutrient intakes than male children and adults. Factors such as age, income, size, iron intake, and consumption of fish and seafood were associated with the nutritional status of children and adult members of the household.

Public health interventions should be community-based and food and agriculture-based, nutrition- and gender-sensitive, and focus on promoting the diet diversity and food quality to ensure balanced diet among rice-based farm households in all provinces in Central Luzon, Philippines. A more partnership-based approach, e.g., linking with government and non-government organizations with good nutrition programs, in implementing public health interventions will result in a more inclusive, integrated, effective, and sustainable health programs.

Acknowledgments

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The Literature Cited follows the instructions in number 2.6 of the Author guidelines.

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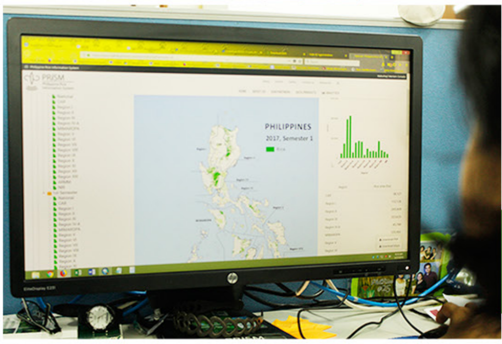

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