Comparative Efficiency of Rice Farming

in Asia and the Philippines

AUTHORS:

FLORDELIZA H. BORDEY
JESUSA C. BELTRAN
IMELDA A. ARIDA
AILEEN C. LITONJUA
MARY GRACE C. LAPURGA
WILFREDO B. COLLADO

Comparative Efficiency of Rice Farming
in Asia and the Philippines

AUTHORS:

FLORDELIZA H. BORDEY
JESUSA C. BELTRAN
IMELDA A. ARIDA
AILEEN C. LITONJUA
MARY GRACE C. LAPURGA
WILFREDO B. COLLADO

The Philippine Rice Research Institute (PhilRice) is a chartered government corporate entity under the Department of Agriculture. It was created through Executive Order 1061 on November 5, 1985 (as amended) to help develop high-yielding, cost-reducing, and environment-friendly technologies so farmers can produce enough rice for all Filipinos.

It accomplishes this mission through research, development, and extension work in its central and seven branch stations, coordinating with a network that includes 59 agencies strategically located nationwide.

PhilRice has the following certifications: ISO 9001 (Quality Management), ISO 14001:2004 (Environmental Management), and OHSAS 18001:2007 (Occupational Health and Safety Assessment Series).

Mailing address: Maligaya, Science City of Muñoz, 3119 Nueva Ecija
Phone: +63 (44) 456-0433, 456-0258, 456-0277
Fax: +63 (44) 456-0651 loc 203
E-mail: prri@philrice.gov.ph
Home page: www.philrice.gov.ph

Published by:
Philippine Rice Research Institute
Maligaya, Science City of Muñoz, Nueva Ecija

Suggested Citation

Bordey FH, Beltran JC, Arida IA, Litonjua AC, Lapurga MGC, Collado WB. 2017. Comparative Efficiency of Rice Farming in Asia and the Philippines. Science City of Muñoz (Philippines): Philippine Rice Research Institute. 121 p.

Editor: Constante T. Briones
Cover design, page makeup, and composition: Carlo Dacumos

ISBN No. 978-621-8022-34-8

TABLE OF CONTENTS

ACKNOWLEDGMENTS

We would like to acknowledge many individuals who have made the writing and publication of this book possible.

First and foremost, to the Philippine Department of Agriculture through the initiative of the National Rice Program led by Undersecretary Ariel T. Cayanan and former Assistant Secretary Edilberto M. De Luna, and to the Bureau of Agricultural Research headed by Dr. Nicomedes M. Eleazar, for facilitating the funding of the project. Due recognition is also given to current and former Agriculture Secretary Emmanuel F. Piñol and Proceso J. Alcala, without whose approval, this project would not have materialized.

Our deepest gratitude to Mr. Edmund J. Sana of the DA-Rice Program, who provided eager support and inspiration. To Dr. Sailila E. Abdula, Dr. Eufemio T. Rasco, Jr., and Dr. Calixto M. Protacio, current and former Executive Directors of PhilRice without whose insistence and institutional backing, this book would not have seen the light of day.

Credit is also due to Ms. Rhemilyn Z. Relado, head of PhilRice Socioeconomics Division, who fully and willingly supported the implementation of this project.

Extra special acknowledgment goes to Ms. Piedad F. Moya for giving technical advice and to the IRRI and PhilRice Benchmarking Project Team for making the international comparative data available.

Thanks are also due to Mr. Constante T. Briones who did the language editing, and Mr. Carlo G. Dacumos who made the cover design and book layout.

Our deepest gratitude we reserve for the rice farmers, paddy traders, rice millers and wholesalers in the various country sites who willingly provided all the information that we needed to write this book.

Last but not least, we thank and beg for the forgiveness of all those who have been with us and have seen us over the course of the years in implementing this project and whose names we have failed to mention.

PREFACE

The Philippine Rice Research Institute (PhilRice) of the Department of Agriculture (DA) planned, designed, and implemented the project *Rice Yield Gap and Economic Efficiency in the Philippines*. The Philippine government, through the DA – Bureau of Agricultural Research, provided the full financial support for this undertaking.

This book on the comparative efficiency of rice farming in Asia and the Philippines is the major output of the project. It is intended for a general audience who would like to learn about the current status of efficiency of rice farming in the Philippines relative to the five major rice producers in the world: China, India, Indonesia, Thailand, and Vietnam. In this book, estimates of technical and allocative efficiencies of rice farming across selected rice bowls in Asia and in selected rice-producing provinces in the Philippines are compared. Factors that can improve efficiency are also determined. Additionally, factors that can increase yield and reduce cost are assessed.

Results from this study can provide insights on narrowing the gap between the high and low yields within each province. Perspective on reducing the production cost within each province is also given. Policymakers and planners can use the information on factors affecting yield and cost in each province in crafting sustainable location-specific rice programs that can contribute to improved national competitiveness and rice security.

Project Leader
Flordeliza H. Bordey

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

Rice self-sufficiency has been the focus of Philippine rice programs. Self-sufficiency results from locally producing an adequate volume of rice for food and other uses. But competitiveness in production also now plays a prominent role as the country's rice policy needs to open up to international trade. Competitiveness requires producing a similar or better quality of rice at lower cost relative to other rice-producing countries. It necessitates efficiency – that is producing the maximum attainable yield using the least-cost combination of inputs.

Self-sufficiency and competitiveness remain elusive since rice yield levels are below the maximum attainable. Yield reached the 4-ton benchmark in 2014, but recent statistics insist that yield levels vary across rice-farming locations. Due to the importance of rice in the Filipino diet, it is not surprising that paddy is being produced in nearly all 81 provinces and two highly urbanized cities in the country, albeit at different magnitude. Rice production environments and yield levels therefore vary greatly. For example, in 2005 to 2015, 24 provinces had at least 4 t ha^{-1}; 40 provinces had 3 to less than 4; 15 provinces had 2 to less than 3; and 2 provinces had less than 2 t ha^{-1}. Over the same period, annual yield grew in 60 provinces and a city; shrank in 19 provinces and a city (PSA).

Yield levels also vary across ecosystems and years. Average yield in irrigated areas is 4.02 t ha^{-1} but is only 2.78 t ha^{-1} in rainfed areas, or a 1.24 t ha^{-1} significant difference (PSA, 2000-2015). The year-to-year outlook is also unpredictable. National average yield grew from 3.07 in 2000 to 3.80 t ha^{-1} in 2007; declined to 3.59 in 2009; climbed to 4 t ha^{-1} in 2014, but dropped to 3.90 in 2015.

Evidences of yield gap also persist. Herdt and Mandac (1981) reported a yield gap of 0.9 and 1.6 t ha^{-1} in wet and dry season rice. Sebastian et al. (2000) reported that farmers' actual yield only ranged 50 to 70% of the on-farm experiment yields, and very few of them had yields comparable to the demonstrated potentials. Their analysis of data from 1991 to 1995 indicated that farmers' average yields were only 3.7 and 3.9 t ha^{-1} in wet and dry seasons, far inferior to 5.7 and 7.5 t ha^{-1} yields in on-farm experiments. Yield differences were 2 t ha^{-1} during wet season (WS) and 3.6 t ha^{-1} during dry season (DS). Sebastian et al. (2006) also lamented that while yields in experimental and on-farm demonstration areas averaged 9 and 6 t ha^{-1}, actual yields in irrigated areas averaged only 4 t ha^{-1}. They opined that narrowing the gap between these yields is a good approach in increasing farm productivity and income.

They further discussed that yield gap has two main components. The first one is due to fixed factors such as climate and environmental conditions (e.g., soil texture and hydrology in the area). The second component deals with differences in cultural management practices, and problems such as macronutrient deficiency and limited availability of water. Micronutrient deficiency in the soil and pest problems can also cause the second component.

Even worse, rice yield in the Philippines is lagging behind yields in intensively cultivated and irrigated areas in neighboring Asian countries particularly during the wet season. A yield comparison among PH, China, India, Indonesia, Thailand, and Vietnam showed that PH was fourth during DS but last during WS in crop year 2013-2014 (Bordey et al. 2016).

Considering these yield level variations and gaps, this study addresses the need to understand their causes across provinces and countries. Are they due to location, and therefore to environment factors? Or to the skills and management capability of farmers? Maybe the varying resources available to them? If the geographic targeting of the national rice programs has to improve, analysis of provincial differences in yield is a must. In addition, information on the efficiency level of our rice farming relative to other countries can help us devise strategies to improve our competitiveness.

According to Ali and Byerlee (1991), the level of efficiency of small farmers has significant implications on development strategy. If farmers are already reasonably efficient, increases in productivity will require new inputs and technology to shift the production function upward. On the other hand, if opportunities to increase productivity through more efficient use of farmers' resources still exist, a stronger recommendation can be made for institutional investments in input delivery, infrastructure, extension system, and farm management services. By having more information on the possible sources of yield growth in each province, a better system of targeting in the national rice program can be put in place with higher probability of success. This study contributes in this aspect.

This study assesses the causes of yield variations across intensively cultivated and irrigated rice areas in selected countries in Asia and across rice-producing provinces in the Philippines. The specific objectives are as follows:

1. Determine the levels of technical and allocative efficiencies of rice farmers in selected countries in Asia, and in selected provinces in PH;
2. Determine how varying levels of technical and allocative efficiencies of farmers contribute to yield differences across countries and provinces;
3. Determine the factors affecting the technical and allocative efficiencies of rice farmers in rice-producing provinces in PH;
4. Generate recommendations to improve rice yields and reduce unit costs in the Philippines and its selected rice-producing provinces.

CHAPTER

2

RICE YIELD AND EFFICIENCY IN THE PHILIPPINES

Despite being the eighth largest rice producer in the world, the Philippines is not on the list of top rice yielders (FAO Statistical Yearbook, 2013). This indicates that the country's rice area is not yet producing its maximum quantity of harvested rice per hectare, compared to other rice-producing countries. It has 4.5 million hectares rice area harvested that produce 16.7 million tons of rice (FAO Statistics, 2005-2014). These correspond to an average of 3.75 t ha^{-1} national yield level, which is lower than the average yields of other Asian countries such as China (6.56), Indonesia (4.92) and Vietnam (5.31).

From 2005 to 2015, the national average yield level in PH ranged 3.59 to 4.00 t ha^{-1} (PSA, 2005-2015). The lowest yields were observed in 2005 and 2009. In 2006 and 2007, yield increased; declined in 2008 to 2009. It recovered in 2010 through 2014 at 3.62 to 4.00 t ha^{-1}. The country achieved the 4-ton benchmark in 2014 but was not sustained in 2015 and 2016 (Figure 2.1).

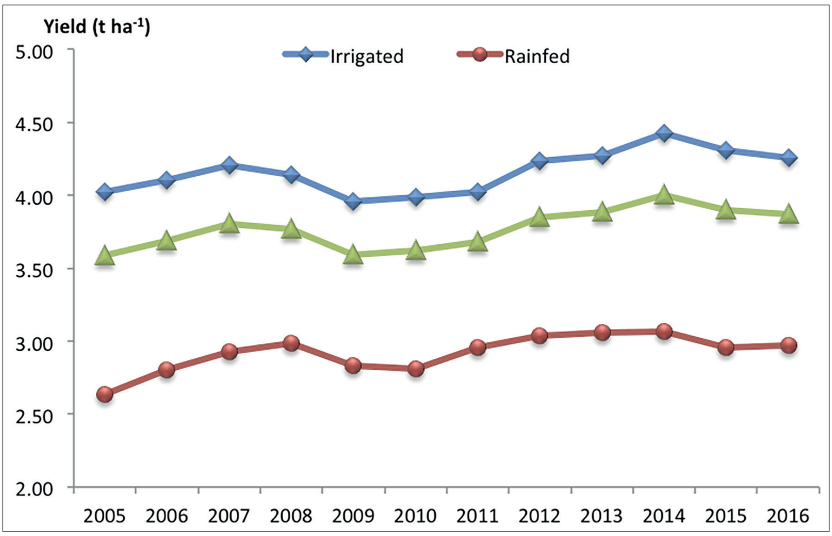


Figure 2.1 Trends in rice yields in the Philippines, by ecosystem, 2005-2016.

Aside from yield variation across provinces, it also varies across production ecosystems. Average rice yield in the irrigated ecosystem is 4.15 t ha^{-1}, which is 1.23 higher than in the rainfed ecosystem (2.92 t ha^{-1}). Irrigated yields ranged 3.95 to 4.43 t ha^{-1} from 2005 to 2015; 2.63 to 3.07 t ha^{-1} in rainfed farms.

Many constraints influence farm yield levels in the Philippines. According to Sebastian et al. (2000), yields are low despite technological breakthroughs because of rice production issues such as emergence of biotypes, low technical efficiency, declining soil fertility, and lack of effective irrigation systems. Even socio-economic constraints such as limited management skills of farmers, deteriorating terms of trade, and lack of appropriate and adequate infrastructure conspire to lower yields.

Technical efficiency (TE) is one of the major concerns of many studies about Philippine rice production. It is the ability of farmers to obtain maximum production using their chosen combination of inputs. Previous studies revealed varying TE estimates in different locations in the country (Table 2.1), proving that rice farmers are inefficient.

Kalirajan and Flinn (1983) analyzed the data of 79 rice farmers in PH predicting TE at 0.38 to 0.91. They also found that transplanting, frequency of fertilizer application, number of years in farming, and number of extension contacts significantly affect variations in estimated TE.

Rola and Quintana-Alejandrino (1993) studied different rice ecosystems and found out that farmers in irrigated areas (72%) were more technically efficient compared to those in rainfed (65%) and upland areas (57%). For irrigated areas, nitrogen, and insecticide and herbicide doses significantly increased production; in rainfed areas, nitrogen, insecticide dose, and hired labor did the same but farm size had a negative correlation. For uplands, nitrogen, and insecticide dose had positive effects, but yield of share tenants was lower than land owners'.

Table 2.1 Selected literatures focusing on technical efficiency (TE) of rice farming in the Philippines.

Author/s	Year	Location	Mean TE(%)	Sample size
Michler and Shively	2015	Palawan	64.0	739
Sullano and Tan-Cruz	2013	Region XI (Davao)	89.8	387
Velarde and Pede	2013	Laguna	62.0	184
Koirala et al.	2013	North Metro Manila, Central Luzon, Laguna	54.6	-
Mariano et al.	2010	Philippines	70 - 84	-
Pate and Tan-Cruz	2007	Philippines	89.8 – 92.4	
Villano and Fleming	2004	Central Luzon	79.0	-
Hidalgo and Flores	1999	Nueva Ecija and Camarines Norte	64 - 73	-
Rola and Quintana-Alejandrino	1993	Central Luzon, W. Visayas, C. Mindanao, Bicol, Cagayan Valley	57 - 72	-
Dawson*	1991	Philippines	54.1	96
Dawson*	1991	Philippines	59.0	22
Dawson*	1991	Philippines	69.7	101
Dawson, Lingard and Woodford**	1991	Central Luzon	84 - 95	22
Kalirajan*	1990	Philippines	79.0	103
Dawson and Lingard**	1989	Central Luzon	60 - 70	32
Kalirajan*	1984	Philippines	63.0	81
Kalirajan*	1983	Philippines	50.0	79
Kalirajan and Flinn**	1983	Bicol	38 - 91	79

* cited by B.E. Bravo-Ureta et al. (2007) ** cited by Villano and Fleming (2004)

In 1995, PhilRice estimated TE of the strategic rice areas Ilocos Norte, Pangasinan, Cagayan, Isabela, Nueva Ecija, Bulacan, Laguna, Camarines Sur, Occidental and Oriental Mindoro, Iloilo, Negros Occidental, Leyte, Bukidnon, Davao, and North Cotabato. In 1992 DS, Laguna had the highest efficiency at 57% while Cagayan had the least at 24%. In 1991 WS, Isabela ranked first at 65% while Nueva Ecija and Bulacan were last with 31% efficiency.

In 1999, Hidalgo and Flores estimated the TE of farmers in Nueva Ecija and Camarines Norte under El Niño in 1998, which ranged 64 to 73% in 1996 to 1998. El Niño did not significantly affect their TE.

Pate and Tan-Cruz (2007) looked at regional-level panel data of 15 regions in the country from 1991-2002 to analyze efficiency of rice production in irrigated and rainfed ecosystems. Similar to Rola and Quintana-Alejandrino (1993), they found higher TE among farmers in irrigated areas (92.4%) than in rainfed (89.8%). Their study suggested that for rainfed ecosystems, land area and cost of seeds and planting materials were the two most important inputs determining the yield. For the irrigated, land area and quantity of fertilizers applied were the most significant.

Mariano et al. (2010) studied the productivity of irrigated and rainfed areas for 1996/1997 to 2006/2007, and saw that rainfed was as productive as irrigated ecosystem. But irrigated farmers had higher TE than rainfed in all seasons except in the 2007 DS, which ranged 70% to 84%.

Aside from farming ecosystems, farmers' socio-demographic profiles had positive pressure on TE (Sullano and Tan-Cruz, 2013). According to Villano and Fleming (2004), younger farmers and those with more training showed higher TE. More education also had positive effects on productivity and efficiency of farmers (Umetsu et al., 2003; Velarde and Pede, 2013). According to Koirala et al. (2013), TE was mostly related to managerial and socio-economic characteristics such as farm size, costs of inputs like seeds, fuel, fertilizer, pesticides, irrigation, total labor, and land rent. Moreover, households that owned a large percentage of their farm were less efficient than those that owned a small percentage (Michler and Shively, 2015). Also, farmers with parcels that are always rented had a higher mean efficiency (67%) than those that are always owned (61%).

While most of the existing analyses focused on TE, certain studies also estimated allocative efficiency (AE) of farmers. The earliest systematic analysis of the relative contribution of both efficiencies was that by Herdt and Mandac (1981). Using 76 sample respondents from Nueva Ecija, they found that the difference between actual and maximum yields with correct level of fertilizer, and weed and insect controls was about 33% in WS and 35% in DS. Considering only the impact of fertilizer and ignoring the effects of insect and weed control, simple profit-seeking behavior accounted for 6-11% of the yield gap. AE accounted for 22-37%; the rest for TE.

Gonzales et al. (2004) estimated both efficiencies of ten top rice-producing provinces -- Ilocos Norte, Pangasinan, Isabela, Nueva Ecija, Laguna, Camarines Sur, Iloilo, Davao del Norte, Davao del Sur, and South Cotabato. They found that in WS under irrigated ecosystem, mean technical efficiency (MTE) rose from 0.70 in 1996-1997 to 0.74 in 1999-2000; in DS, from 0.66 to 0.70; in non-irrigated, from 0.61 to 0.64. Mean allocative efficiency (MAE) of the irrigated ecosystem was from 0.81 to 0.89 in WS 1996-1997 to 1999-2000; from 0.79 to 0.83 in DS; for non-irrigated, from 0.82 to 0.90 in WS.

All these studies contributed to the body of literature on efficiency of rice farming but none has detailed recommendations on how to improve provincial yield levels. It is in this aspect that this study can contribute better not only to the literature but also in planning development programs for the rice industry.

CHAPTER 3

METHODOLOGY

This section discusses the theoretical framework and analytical procedures used in the study. The sources of data are also described in detail.

3.1. Theoretical Framework

The concept of efficiency begins with production frontier, which is defined as the locus of maximum output that can be produced for a given level of inputs and available technology in a population of farmers. Hence, the production frontier depicts the alternative efficient methods of production (Ali and Byerlee, 1991).

Since the pioneering work of Farell in 1957, economic efficiency is referred to as the ratio of the actual output to some optimal value specified by a production frontier. Economic efficiency is often disaggregated into: 1) technical efficiency; and 2) allocative efficiency. TE pertains to the ability of a farmer to produce the maximum attainable production given a combination of inputs. AE refers to the ability of the farmer to choose the least-cost but technically efficient combination of inputs, given the input prices. This requires the capacity to reach a marginal value of product of an input that is equal to the normalized price of that input.

To further conceptualize TE and AE, consider a two-input production system (Figure 3.1). This shows a unit isoquant, SS', which depicts the various combinations of two inputs that a perfectly efficient firm can use to produce a unit of output. Let point P represent the actual combination of input that is used by farmer A. On other hand, point Q represents the combination of inputs used by a technically efficient firm. Thus, we can say that OQ/OP indicates the efficiency of farmer A.

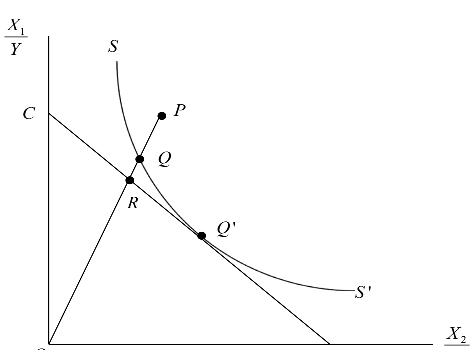


Figure 3.1 The concept of technical and allocative efficiency in two-input space.

Similarly, let CC' represent the isocost line, which depicts the different combination of inputs that will lead to the same cost given the prices of inputs. It has a slope equal to the price ratio of the two inputs. The point of tangency between the isoquant SS' and isocost line CC', which is point Q', represents the optimal method of production. That is, it uses the technically efficient combination of inputs that could lead to least cost. Hence, at Q', the cost of production is just the fraction OR/OQ of those at Q. This ratio measures the allocative efficiency of the farmer (Farrel, 1957).

3.2. Analytical Procedure

3.2.1. Estimating Technical Efficiency and its Determinants

This study estimates a stochastic Cobb-Douglas production function similar to Battese et al. (1996). The use of Cobb-Douglas functional form is parsimonious in representing a production technology making it popular in many studies (Velarde and Pede, 2013; DeSilva, 2011; Pate and Tan-Cruz, 2007; Rola and Quintana-Alejandrino, 1993). The stochastic frontier production function to be estimated is assumed to be:

$$(1) \quad \ln y_i = \beta_0 + \sum_j \beta_j \ln x_{ji} + \sum_k \gamma_k Z_{ki} + v_i - u_i; i = 1..n$$

where

subscript i refers to the i-th farmer
subscript j refers to the j-th input variable
subscript k refers to the k-th dummy variable
ln – denotes logarithms of base e
y – is the paddy output per farm (in kg)
x – represents the input variables[1], namely,
x1 = quantity of seeds used (in kg)
x2 = quantity of nitrogen applied (in kg)
x3 = quantity of phosphorus applied (in kg); P_2O_5 are converted to P by multiplying it by 0.4364.
x4 = quantity of potassium applied (in kg); K_2O are converted to K by multiplying it by 0.8302.
x5 = quantity of active ingredient of herbicides applied (in kg)
x6 = quantity of active ingredient of insecticides applied (in kg)
x7 = pre-harvest labor man-day (excluding field monitoring; 1 md = 8 hours of work)
x8 = number of day machine was used[2]
x9 = area planted (in hectare)
z – represents dummy variables, namely,
z1 = NIS/CIS-user (1 yes, 0 otherwise)
z2 = user of SSIS and natural irrigation (1 if yes, 0 otherwise)
z3 = hybrid-user (1 if yes, 0 therwise)
z4 = registered/certified seed-user
z5 = season (1 if dry season, 0 otherwise)

1 Input variables with zero values were replaced by 1, so taking its natural logarithm gives value of 0.
2 The number of machine days was not part of the questionnaire in the Philippines survey data. To generate an approximate variable for machine day, it was estimated from the sum of labor man-days during land preparation and 25% of labor man-days during threshing. A 1:1 machine-to-man ratio was assumed for land preparation and 1:4 for threshing operation.

z6 = applied nitrogen (1 yes, 0 otherwise)
z7 = applied phosphorus (1 yes, 0 otherwise)
z8 = applied potassium (1 yes, 0 otherwise)
z9 = machine-user (1 yes, 0 otherwise)
z10 = herbicide-user (1 yes, 0 otherwise)
z11 = insecticide-user (1 yes, 0 otherwise)

β, γ – are the parameters to be estimated

v – is assumed to be independent and identically distributed normal random variables with mean, zero, and variance, σ^2, independently distributed of u_i.

u – is non-negative technical inefficiency effects, which are assumed to be independently distributed and arise from the truncation (at zero) of the normal distribution with mean μ_i and variance σ^2.

The technical efficiency (TE) of production for the i-th farmer, defined by the ratio of observed production to the corresponding frontier production associated with no technical inefficiency, is expressed by:

(2) $TE_i = \exp(-u_i)$

The factors explaining TE were determined as follows:

(3) $$\mathrm{TE}_i = \delta_0 + \sum_m \delta_m w_{mi}; i = 1..\mathrm{n}$$

where

subscript m refers to the m-th farmer's characteristics

w – represents variables for farmer's characteristics, namely,

w1 = age of farmer (in years)
w2 = education (1 if the farmer attained at least high school; 0 otherwise)
w3 = training (1 if the farmer attended training from 2009 to 2012; 0 otherwise)
w4 = tenure (1 if owner, 0 otherwise)
w5 = organization membership (1 if member of rice-based farm organization; 0 otherwise)

δ – are the parameters to be estimated

3.2.2. Estimating Allocative Efficiency and its Determinants

Similar to TE estimation, a Cobb-Douglas stochastic frontier cost function was estimated as:

(4) $$\ln c_i = \alpha_0 + \alpha_1 \ln y_i + \sum_q \alpha_q \ln p_{ni} + \sum_k \gamma_k Z_{ki} + v_i - u_i; i = 1..\mathrm{n}$$

where

subscript i refers to the i-th farmer
subscript q refers to the q-th input price variable
subscript k refers to the k-th dummy variable

ln – denotes logarithms of base e

c – is the total cost of production per farm (in Php)

y – is the paddy output per farm (in kg)

p – represents the input price variables[3], namely,
- p1 = price of seeds (Php kg^{-1})
- p2 = price of nitrogen (Php kg^{-1}); estimated using the weighted mean of prices
- p3 = price of phosphorus (Php kg^{-1}); estimated using the weighted mean of prices
- p4 = price of potassium (Php kg^{-1}); estimated using the weighted mean of prices
- p5 = price of active ingredient of herbicides (Php kg AI^{-1})
- p6 = price of active ingredient of insecticides (Php kg AI^{-1})
- p7 = price of pre-harvest labor man-days (Php man-day)
- p8 = price of machine-days[4]
- p9 = land rent (Php ha^{-1})

z – represents dummy variables, namely
- z1 = NIS/CIS-user (1 yes, 0 otherwise)
- z2 = user of SSIS and natural irrigation (1 if yes, 0 otherwise)
- z3 = hybrid-user (1 if yes, 0 therwise)
- z4 = registered/certified seed-user
- z5 = season (1 if dry season, 0 otherwise)

α, γ – are the parameters to be estimated

v – is assumed to be independent and identically distributed normal random variables with mean, zero, and variance, σ^2, independently distributed of u_i.

u – is non-negative allocative inefficiency effects, which are assumed to be independently distributed and arise from the truncation (at zero) of the normal distribution with mean μ_i and variance σ^2.

The allocative efficiency (AE) for the i-th farmer, defined by the ratio of stochastic frontier cost associated with no technical inefficiency to the corresponding observed production cost (Tijjani and Bakari, 2014; Aboki et. al., 2013), is expressed by:

$$AE_i = \frac{C_i^*}{C_i} = \exp(u_i) \tag{5}$$

Since the program of Stata12 software® assesses cost efficiency (CE) that conversely corresponds to AE (Souleymane, 2015; Tijjani and Bakari, 2014), AE is estimated as the inverse of CE, i.e. AE = 1/CE.

Similar to TE estimates, the resulting AE estimates are regressed against factors that could affect the management ability of farmers such as age, education, training, tenurial status, and organization membership, following equation 3.

3.2.3. Estimating Yield- and Cost-Response Functions

This study aims to determine the contribution of TE to yield variation and of AE to cost variation across locations. To do this, a yield response function was estimated as:

---

3 For farmers who did not use fertilizer or pesticide, provincial average price is used to approximate the "missing data" on prices.

4 To estimate machine prices using the Philippines survey data, the following equation was used: p8 = 75% of labor cost during land preparation + 75% of labor cost during threshing. Cost of labor man-days excludes estimated cost for machine use.

(6) $$\ln Y = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln x_i + \sum_{j=1}^{m} \gamma D_j + \lambda TE + \varepsilon$$

where

subscript i refers to the i-th input variable
subscript j refers to the j-th dummy variable
ln – denotes logarithms of base e
Y – is the paddy output per hectare (in kg)
x – represents the vector of inputs used per hectare (i.e., seed, nitrogen, phosphorus, potassium, herbicide, insecticide, pre-harvest labor-days, and machine-days)
z – represents dummy variables (i.e., NIS/CIS User, SSIS user, hybrid seed user, registered/certified inbred seed user, season, and location)
TE – represents the technical efficiency score
ε – error term
α, γ, λ – are the vector of parameters to be estimated.

For each selected province, the estimated coefficients of inputs were used to determine whether the marginal value of additional production due to one-unit increase input is higher than the price of that additional input. If so, it is recommended to increase the utilization of that input for a particular province. The profit-maximizing level of input use was also calculated for each province. The marginal return to increase in TE was also computed.

Likewise, to estimate the contribution of AE to the variation of cost per kilogram across locations, the following equation was estimated:

(7) $$\ln C = \beta_0 + \sum_{i=1}^{n} \beta_i \ln W_i + \sum_{j=1}^{m} \varphi Z_j + \delta AE + \varepsilon$$

where

subscript i refers to the i-th input variable
subscript j refers to the j-th dummy variable
ln – denotes logarithms of base e
C – is the production cost per kilogram of paddy (in kg)
W – represents the vector of input prices (i.e., prices of seed, nitrogen, phosphorus, potassium, herbicide, insecticide, pre-harvest labor-days, and machine-days)
z – represents dummy variables (i.e., NIS/CIS User, SSIS user, hybrid seed user, registered/certified inbred seed user, season, and location)
AE – represents the allocative efficiency score
ε - error term
β, φ, δ – are the vectors of parameters to be estimated.

The estimated coefficient of yield was used in computing the marginal reduction in cost due to increase in yield for each province. Similarly, the marginal reduction in cost due to increase in AE was calculated as well.

Additionally, maps are generated to visually show the geographical distribution of efficiency of rice farmers in the Philippines.

3.3. Data Sources

This study covered six countries, namely: China, Indonesia, and the Philippines, which represent the rice-importing countries; and India, Thailand, Vietnam as the rice-exporting. These are the countries covered in the DA-IRRI-PhilRice project *Benchmarking the Philippine Rice Economy Relative to Major Rice-producing Countries in Asia* (Bordey et al., 2016). These countries were represented by provinces or states that have good irrigation systems and are intensively cultivated (i.e., at least two rice crops annually). The Philippines is exemplified by Nueva Ecija; China by Zhejiang; India by Tamil Nadu; Indonesia by West Java; Thailand by SuphanBuri; Vietnam by Can Tho. Data on rice production, including input uses, prices, and crop management practices were gathered in all rice planting seasons during crop year 2013-2014. A quota sample of 100 respondents per country per season was selected purposively. Over the course of three survey rounds, a total of 1,304 respondents were personally interviewed, guided by structured electronic questionnaires in MS Access format. Bordey et al., (2016) provides a more detailed description of the data collection process.

The local component includes the 2011-2012 survey data gathered in 33 major rice-producing provinces included in the Rice-Based Farm Household Survey (RBFHS). The survey, which is a quinquennial monitoring of RBFH in major rice-producing provinces, is a project of the Socioeconomics Division of PhilRice (Bordey and Malasa, 2016). This has 2,500 randomly selected sample respondents for each of two survey rounds. The first survey round, conducted in March 2012, covers information on July to December 2011 (wet season) rice harvest. The second survey round, conducted in August 2012, covers information on January to June 2012 (dry season) rice harvest. Because other farmers temporarily stopped farming or experienced crop failure for the reference cropping period, the number of sample respondents was reduced to 4,450; 3,487 farmers with irrigated rice parcels and 963 farmers with rainfed rice parcels.

CHAPTER 4

RICE-FARMING EFFICIENCY IN SELECTED ASIAN COUNTRIES

4.1. Social characteristics of farmers

Table 4.1 summarizes the farmers' profiles in six Asian countries. With mean age of 58, Filipino farmers were generally the oldest. However, Thai farmers had the longest experience in rice farming with 35 years, then China (34), and PH (33), although not statistically different. Farming experience in PH is significantly higher than in VN and INDO (both 26 years), and India (25 years).

Table 4.1 Farmers' profiles.

Item	Nueva Ecija, PH	Zhejiang, CN	West Java, INDO	Tamil Nadu, IN	Suphan Buri, TH	Can Tho, VN
	(n=103)	(n=103)	(n=104)	(n=109)	(n=113)	(n=114)
Age (no. of years)	58	54	51	50	55	49
Farming experience (no. of years)	33	34	26	25	35	26
Sex (% male)	87	99	100	97	55	99
Household size	5	4	4	5	5	5
Education (no. of years)	8	7	7	10	5	8
Rice production training (% with training)	62	70	48	47	51	64
Organization (% member)	64	96	68	28	82	39

Table adopted from Bordey et al., 2016.

More than 86% were male farmers except for Thailand (55%). Household size across six countries ranged from 4 to 5 family members. Farmers in PH achieved 8 years of formal education and 62% had rice production trainings. This implies that Filipino farmers had reached at least the secondary level of education.

Rice-related trainings could be attributed to the extensive training implemented by both government and private agencies to help boost rice production in PH. Membership in rice-based farm organizations was highest in China with 96%, then Thailand (82%), and Indonesia (68%). About 64% of PH farmers were also members of farm organizations; India had the lowest (28%).

Figure 4.1 shows the percent share of rice to total income across six countries, with PH at about 70%; Thailand had the highest at 81%; China had the least at only 27%.

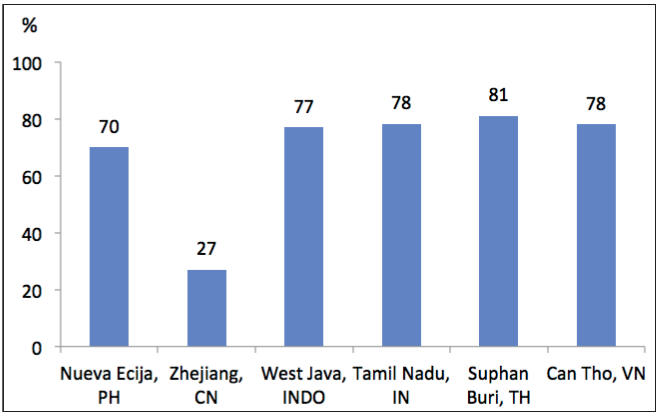


Figure 4.1 Share of rice to total income (%).

The percentage of farmers who owned their cultivated area by cropping season is presented in Figure 4.2. More farm owners can be observed during high-yielding season (HYS) in PH and India, at 64% and 95%. More VN farmers cultivated their owned rice farms during the third season (TS) with 93% of the total farmers.

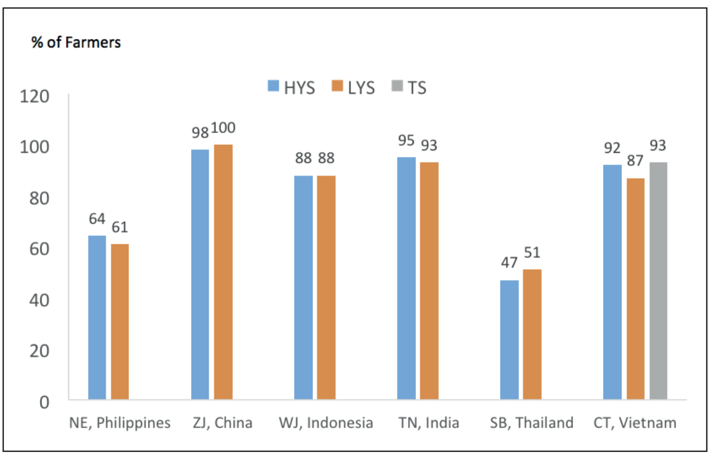


Figure 4.2 Percent share of land ownership.

4.2. Yield, cost of production, and input-use

4.2.1. Rice yield and cost per unit

To compare yields across the six countries, yield was converted into 14% moisture content. Annual yield in PH was significantly different from the other countries (Table 4.2), being significantly higher than India, particularly during HYS. PH had the second lowest yield at 9.51 t ha^{-1}; India had the least at 8.93. HYS and LYS (low-yielding season) yields in PH were significantly different at 5.68 and 3.83 t ha^{-1}. According to Bordey et al. (2016), the variation in yield across seasons may be attributed to typhoons especially during LYS.

Vietnam and Thailand are exporters, and their costs of rice production are very low (PhP 6.53 and PhP 8.85 kg ha^{-1}). The cost difference between PH and these countries is chiefly due to labor and machine costs (Moya et al., 2016). Labor-intensive land preparation, harvesting, and threshing are already fully mechanized in Thailand. Vietnam mechanizes harvesting and threshing as well.

Table 4.2 Yield and cost per unit in the six countries.

Country	Yield (t ha^{-1})				Cost (PhP kg^{-1})
	HYS	LYS	TS	Annual	
China	7.46***	6.10***		13.56***	14.07*
India	4.32***	4.60***		8.93***	8.87***
Indonesia	6.11**	5.42***		11.53***	15.71***
Philippines	5.68	3.83		9.51	12.41
Thailand	5.16***	5.31***		10.47***	8.85***
Vietnam	8.56***	6.33***	5.69	20.59***	6.53***

***,**,* mean significantly different at 1%, 5%, and 10%, respectively
HYS, LYS, and TS mean high-yielding season, low-yielding season, and third season, respectively

Table 4.3 summarizes the comparative yield and cost assessment of five countries relative to the PH, which shows that Vietnam and Thailand have significantly higher yield and lower cost per kg of grain produced. Indonesia and China have both significantly higher yield and cost per kg, while India has both significantly lower yield and cost than PH.

Table 4.3 Comparative yield and cost assessment of five countries relative to the Philippines.

Measure	*Lower cost kg^{-1} than PH	*Higher cost kg^{-1} than PH
*Higher yield than PH	Vietnam, Thailand	Indonesia, China
*Lower yield PH	India	

* Significant at 1%, 5% or 10% level

4.2.2. Area planted

Table 4.4 shows that PH farmers cultivate an average of 1.55 hectares, which is significantly smaller than India (2.4 ha) and Thailand (2.69 ha). But PH has significantly larger farm area than Indonesia and Vietnam with only 1.01 and 0.92 ha. While China has smaller farm area (0.17 ha) than PH, China has significantly higher yield due to quality of seeds used by farmers. About 50% of China farmers used hybrid seeds, and 31.5% used high-quality registered and/or certified seeds (Table 4.5). Hybrid seed usage in PH was only 16.58% of the total respondents; 73.37% of them used registered and/or certified seeds. In addition, China had full access to good water sources like state and communal irrigation canals while only 88.44% of PH farmers had water source.

Table 4.4 Area planted, labor and machine days across the six countries.

Country	Area planted (ha)	Labor man-days ha^{-1}	Machine days ha^{-1}
China	0.17 ***	26.27 ***	6.17 ***
India	2.40 ***	77.43 ***	6.44 ***
Indonesia	1.01 ***	89.82 ***	15.20 ***
Philippines	1.55	67.50	9.70
Thailand	2.69 ***	10.40 ***	4.18 ***
Vietnam	0.92 ***	20.32 ***	6.09 ***

***,**,* mean significantly different from the Philippines at 1%, 5%, and 10%, respectively

Table 4.5 Percentage of farmers in terms of water source and seed class usage across the six countries.

Country	Water source[a] (% of farmers)	Seed class (% of farmers) Hybrid	RS/CS[b]
China	100.00***	50.00 ***	31.50***
India	26.11***	0.00 ***	94.09***
Indonesia	96.00**	0.00 ***	57.00***
Philippines	88.44	16.58	73.37
Thailand	98.50***	0.00 ***	85.00***
Vietnam	58.00***	0.00 ***	33.33***

***,**,* mean significantly different from the Philippines at 1%, 5%, and 10%, respectively

[a] Water source -farmers who have access to state/communal irrigation canals

[b] RS/CS - Registered seeds/ Certified seeds

Note: For water source and seed class, percent use within the country

4.2.3. Input-use

Inputs such as seeds, fertilizers, herbicides, and insecticides were among the variables used to determine the efficiency levels of the six countries (Table 4.6). Majority of the input usage in the five countries were significantly different from that in PH. Vietnam and Thailand had higher seeds at 213 and 196 kg ha^{-1} than 75 kg ha^{-1} seed usage in PH. In contrast, China (62) and Indonesia (22) were significantly lower than PH. India at 79 kg ha^{-1} is at par with PH.

Table 4.6 Seeds, fertilizers, and pesticide usage across selected countries.

Country	Seeds (kg ha^{-1})		Fertilizer (kg ha^{-1}) N		P		K		Herbicide (AI kg ha^{-1})		Insecticide (AI kg ha^{-1})	
China	61.74	***	180.19	***	24.60	***	100.18	***	0.46		1.12	***
India	79.41		106.88		21.20	***	35.06	***	0.27		0.59	**
Indonesia	21.68	***	144.56	***	35.00	***	34.69	***	0.65	***	2.58	***
Philippines	75.30		109.87		16.22		24.08		0.30		0.27	
Thailand	196.39	***	83.25	***	21.10	***	10.35	***	0.81	***	0.36	
Vietnam	213.32	***	96.57	***	28.36	***	32.82	***	0.44		0.39	

***,**,* mean significantly different from the Philippines at 1%, 5%, and 10%, respectively

NOTE: AI – Active ingredients

4.3. Technical efficiency estimates and its determinants

The estimated coefficients of the variables considered in the model are presented in Appendix 1, but the random error components of the frontier model are summarized in Table 4.7. The variation in the composite error term that can be attributed to the inefficiency component is measured by the gamma parameter ($\gamma = \sigma^2_u \div \sigma^2$). The estimated gamma shows that 61.2% of the variation is due to TE. The frontier model was statistically significant implying that rice farmers are inefficient.

Table 4.7 Random error component of the stochastic frontier production model.

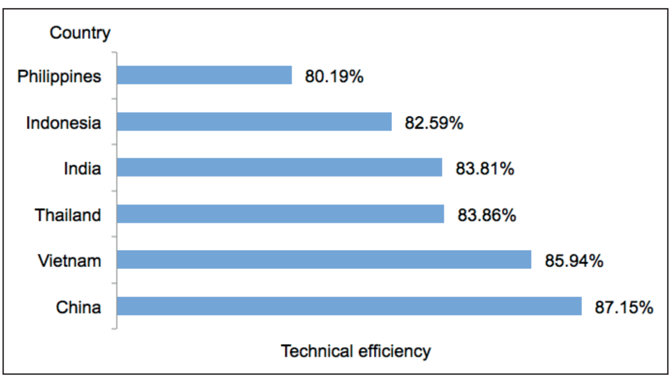
ln(production)	Coefficient	Robust Std. Err.	z	P>z	[95% Conf. Interval]	
ln σ^2_v	-3.780	0.095	-39.980	0.000	-3.966	-3.595
ln σ^2_u	-3.319	0.114	-29.080	0.000	-3.543	-3.095
σ_v	0.151	0.007			0.138	0.166
σ_u	0.190	0.011			0.170	0.213
σ^2	0.059	0.003			0.053	0.065
γ	0.612					

Log likelihood = 68.490 Wald chi²(24) = 28,580.53

Number of observations = 1,302 Prob > chi² = 0.000

Source of data: Benchmarking Philippine Rice Economy Relative to Major Rice-Producing Countries in Asia.

Figure 4.3 shows the predicted mean TE of rice farmers in each of the six countries where PH had the lowest at 80.19%, significantly inferior to China (87.15%), Vietnam (85.94%), Thailand (83.86%), India (83.81%), and Indonesia (82.59%). This implies that PH can produce almost 20% more output, given the same level of input usage.



Note: The other five countries were significantly different from the Philippines

Figure 4.3 Technical efficiency estimates across the six Asian countries.

The variables used to explain TE of sample farmers in terms of their management skills were farming experience, education, training, organization, tenurial status, and an interaction between training and organization. The estimated coefficients of these variables are presented in the TE regression model (Table 4.8), which is statistically significant (F-stat=7.25), with 7.1% adjusted R-squared. This implies that the explanatory variables considered in the study accounted for only 7.1% of the total variations in TE.

Education, training, organization, and tenurial status significantly contributed to the improvement of TE of rice farmers. Farmers with secondary-level or higher education, or who are members of any rice-based organization were more technically efficient.

Participation in rice-related training also positively influenced TE of farmers, as a result of the knowledge gained and through exchange of information with other participants. Farmers are more likely to adopt new technologies that help improve their farm management skills.

Table 4.8 Results of technical efficiency estimation.

Variables	Coefficient	Std. error
[*Dependent variable* = TE]		
Farming experience (years)	0.000	0.000
Education (1 if attained at least high school, 0 otherwise)	0.024***	0.008
Training/seminar (1 if with training/seminar, 0 otherwise)	0.033***	0.012
Organization (1 if member, 0 otherwise)	0.043***	0.011
Tenurial status (1 if owner, 0 otherwise)	0.019*	0.009
Training x Organization	-0.034**	0.015
Constant	0.795***	0.015
Observations		644
F-statistics		7.25
Prob > F		0.000
R-squared		0.071

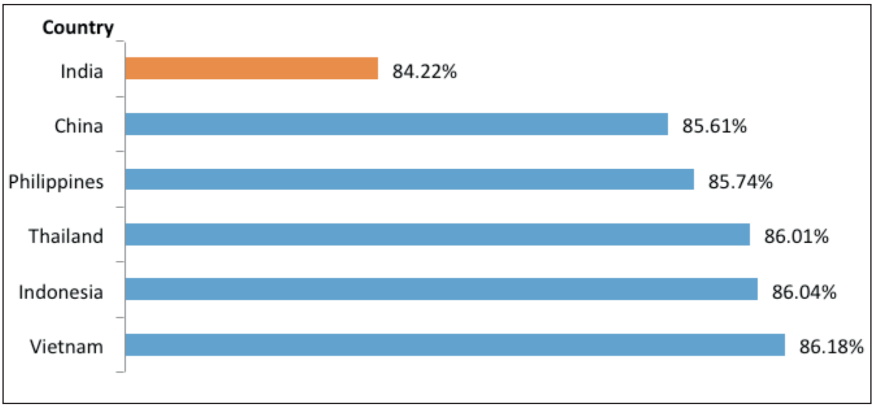
*** p<0.01, ** p<0.05, * p<0.1

4.4. Allocative efficiency estimates and its determinants

AE was estimated using the cost function analysis as summarized in Appendix 2. The gamma estimate shows that 80.6% of the composite error is due to inefficiency (Table 4.9). Mean AE ranged 84.22 to 86.18% across the countries (Figure 4.4). Only India was statistically different from PH. Vietnam had the highest efficiency, then Indonesia and Thailand. PH had MAE of 85.74%, which means Filipinos can still attain the same level of production using only 85.74% of the actual cost kg^{-1}. Table 4.2 says PH produces paddy at PhP12.41 kg^{-1}, which can be reduced to PhP10.63 kg^{-1}.

Table 4.9 Random error component of the stochastic frontier cost exponential model.

ln(cost)	Coefficient	Robust Std. Err.	z	P>z	[95% Conf. Interval]	
ln σ^2_v	-4.673	0.125	-37.440	0.000	-4.918	-4.428
ln σ^2_u	-3.247	0.112	-29.080	0.000	-3.466	-3.029
σ_v	0.097	0.006			0.086	0.109
σ_u	0.197	0.011			0.177	0.220
σ^2	0.048	0.004			0.041	0.055
γ	0.806					
Log pseudolikelihood = 619.703				Wald chi²(20) = 47,485.81		
Number of observations = 1,302				Prob > chi² = 0.000		



Note: India was significantly different from the Philippines.

Figure 4.4 Allocative efficiency estimates across six Asian countries.

Similar to TE, management skills (farming experience, education, training, organization, and tenurial status) were also used in explaining AE measures. However, Table 4.10 shows that none of these variables can significantly improve the AE of rice farmers in the six countries.

Table 4.10 Allocative efficiency regression.

Variables	Coefficient	Std. error
[*Dependent variable* = AE]		
Farming experience (years)	-0.0001	0.0002
Education (1 if attained at least high school, 0 otherwise)	0.0003	0.0053
Training (1 if with training, 0 otherwise)	-0.0085	0.0090
Organization (1 if member, 0 otherwise)	0.0015	0.0081
Tenurial status (1 if owner, 0 otherwise)	0.0107	0.0072
Training x Organization	0.0112	0.0115
Constant	0.848***	0.0105
Observations		644
F-statistics		0.69
Prob > F		0.654
R-squared		0.008

*** p<0.01, ** p<0.05, * p<0.1

4.5. Factors affecting yield

Estimated parameters for the yield-response function are presented in Table 4.11, where about 96% of the total yield variation was explained by the model. Applications of potassium fertilizer and active ingredients of insecticides significantly increase yield. In terms of dummy variable, quality hybrid and registered/certified seeds, and season significantly and positively influenced yield.

It appeared that yield significantly increases by 2.21% (148 kg ha^{-1}) for every 1% increase in the farmers' TE, holding other factors constant. This suggests that improvement in TE either through better educational attainment (at least secondary-school level), participation in training, or membership in organizations will more likely increase yield.

Table 4.11 Estimated yield-response function.

Variable	Coefficient	Robust Std. Error	% increase in yield	Marginal returns (kg increase in yield)
Ln Seed	0.002	0.006	0.002	0.10
Ln N	-0.003	0.005	-0.003	-0.14
Ln P	-0.001	0.003	-0.001	-0.23
Ln K	0.017***	0.003	0.017	2.45
Ln Herbicide AI	-0.003**	0.001	-0.003	-28.93
Ln Insecticide AI	0.003*	0.001	0.003	18.54
Ln Labor	0.006	0.005	0.006	0.73
Ln Machine	0.004	0.003	0.004	2.89
Dummy variables				
Hybrid	0.136***	0.015	14.568	
RSCS	0.008*	0.005	0.803	
Season	0.168***	0.004	18.294	
NISCIS	0.001	0.005	0.100	
China	0.204***	0.011	22.630	
India	-0.091***	0.009	-8.698	
Indonesia	0.194***	0.014	21.410	
Thailand	0.112***	0.013	11.851	
Vietnam	0.351***	0.010	42.049	
TE	2.210***	0.025	2.210	148.35
Constant	6.649***	0.043		
Observations		1,302		
R-squared		0.961		

*Yield as dependent variable

4.6. Factors affecting unit cost

A percent increase in yield would significantly reduce the cost kg^{-1} by 0.88% (Table 4.12). This translates to about PhP 1.80 reduction in cost kg^{-1} for every one-ton increase in yield. Improved AE also significantly reduced cost kg^{-1} by 1.965%.

Table 4.12 Estimated cost-response function.

Variable	Coefficient	Robust Std. Error	% increase in cost kg^{-1}	Marginal returns (PhP change in unit cost)*
Ln Seed	0.0422***	-0.003	0.042	0.2795
Ln N	0.0373***	-0.003	0.037	0.2819
Ln P	0.0170***	-0.003	0.017	0.0332
Ln K	0.0212***	-0.005	0.021	0.1662
Ln Herbicide AI	-0.00367***	-0.001	-0.004	-0.0001
Ln Insecticide AI	0.00231***	-0.001	0.002	0.0001
Ln Land rent	0.166***	-0.003	0.166	0.0046
Ln Labor	0.0267***	-0.004	0.027	0.0281
Ln Yield	-0.880***	-0.004	-0.880	-0.0018
Dummy variables				
Hybrid	0.0906***	-0.009	0.0948	
RSCS	0.0222***	-0.003	0.0224	
Season	0.00326	-0.002	0.0033	
NISCIS	0.0217***	-0.003	0.0219	
Machine (HT)	0.00215	-0.005	0.0022	
China	0.0486***	-0.013	0.0498	
India	-0.271***	-0.010	-0.3113	
Indonesia	0.244***	-0.006	0.2763	
Thailand	-0.160***	-0.008	-0.0078	
Vietnam	-0.285***	-0.005	-0.0052	
AE	-1.965***	-0.016		
Constant	6.885***	-0.036		
Observations		1,302		
R-squared		0.994		
F statistics		12,876.63***		

*Cost/kg as dependent variable; Exchange rate used was PhP42.45/US $, 2013

4.7. Narrowing the yield gap in the Philippines

Table 4.13 shows that yield gap here is higher during HYS (5,738 kg ha^{-1}) than LYS (2,292). Based on Table 4.14, increasing potassium by one or more kg can lead to 2-4 kg increase in yield; and use of large-scale irrigation system can result in 2-4 kg more yield. Given the existing local prices of paddy, complete fertilizer (14-14-14), and muriate of potash (0-0-60), an increase of 1.99 kg ha^{-1} in potassium use during HYS and 1.64 kg ha^{-1} during LYS (Table 4.15) is recommended. Similarly, an additional machine-day for harvesting and threshing can increase yield by 1-2 kg ha^{-1}. The use of hybrid varieties can also raise local yield by as much as 557-827 kg ha^{-1}; certified inbred seeds by only 30-46 kg ha^{-1}.

The gap in production cost is also wider during HYS (51%) than in LYS when the cost of the 10th percentile is 40% lower than the 90th percentile. Table 4.16 shows that a one-ton increase in yield can reduce cost by PhP 1.91 kg^{-1} (HYS) and PhP 3.41 kg^{-1} (LYS). Likewise, a one-gram increase in herbicide application can significantly cut the cost by PhP 0.40 kg^{-1} (HYS) and PhP 0.61 kg^{-1} (LYS). Herbicide application is an effective tool to control weeds and increase rice yield, thus can also improve cost efficiency in the Philippines. Appendix Tables 7-26 present the results of narrowing the yield gap in other five covered countries.

Table 4.13 Yield and cost gaps in the Philippines, by season.

Item/	Percentiles		Gaps	
Crop period	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June (HYS)	2,852	8,590	5,738	201
July-December (LYS)	2,796	5,088	2,292	82
Cost (PhP kg^{-1})				
January-June	8.49	17.40	-8.91	-51.22
July-December	11.46	19.10	-7.64	-40.00

Table 4.14 Marginal productivity of inputs in rice farming.

Item	Marginal productivity of inputs	
	HYS	LYS
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	0.16	0.10
Potassium (kg ha^{-1})	3.82	2.84
Insecticide (g ha^{-1})	0.07	0.04
Labor (man-day ha^{-1})	0.48	0.32
Machine (machine-day ha^{-1})	2.12	1.42
Large-scale irrigation system	3.75	2.53
Hybrid seed	827.48	557.25
Certified inbred seed	45.62	30.72

Table 4.15 Profit-maximizing increase in inputs.

Item	Profit-maximizing increase in input-use	
	HYS	LYS
Seed (kg ha^{-1})	0.03	0.04
Potassium (kg ha^{-1})	1.99	1.64
Insecticide (g ha^{-1})	0.12	0.08
Labor (man-day ha^{-1})	0.03	0.02
Machine (machine-day ha^{-1})	0.03	0.03

Table 4.16 Marginal reduction in costs.

Item	Marginal reduction in cost kg^{-1}	
	HYS	LYS
Yield (t ha^{-1})*	-1.91	-3.41
Herbicide (g ha^{-1})	-0.40	-0.61

CHAPTER 5

RICE-FARMING EFFICIENCY IN SELECTED PROVINCES IN THE PHILIPPINES

5.1. Socioeconomic profile of farmers

The 2011-2012 Rice-Based Farm Households Survey (RBFHS) says farmers have been involved in rice farming for 28 years. On average, their highest educational attainment is second year high school. Majority of them (53%) attended at least secondary-education level (Table 5.1).

Table 5.1 Farmers' profile, Philippines, 2011-12.

Characteristics (n=2,538)	Mean	Std. dev.		Min	Max
Farming experience (in years)	28	14.2		1	76
Years of schooling	8	3.2		0	16
Education (% of farmers who attained at least high school)			53		
Attended rice-related training/seminar (% of farmers)			41		
Membership in rice-related farm organizations (% of farmers)			51		
Tenurial status (% owner)			49		

Most farmers wanted to update themselves about current farm technologies and hone their farming skills. Some 41% have participated in rice-related trainings or seminars from 2009 to 2011, and more than 50% were members of rice-based farm organizations. Almost half of the farmers (49%) owned the largest parcel they were cultivating in 2011-2012.

5.2. Yield, input-use, and cost of production

5.2.1. Rice Yield

Table 5.2 shows that in 2011-2012, farmers averaged 3.88 t ha^{-1} of paddy in all ecosystems and seasons. In all ecosystems, yield in January-June/semester 1 (4.13 t ha^{-1}) was significantly higher than in July-December/semester 2 (3.67). Irrigated farmers had significantly higher semester 1 yields than rainfed. Rainfed farmers produced more in semester 2.

Table 5.2 Yields (t ha^{-1}) of farmer-respondents by ecosystem and season, Philippines, 2011-12.

Ecosystems	July-December 2011 (n=2,399)	January-June 2012 (n=2,051)	All Seasons (n=4,450)	Yield difference
	(a)	(b)	(c)	(a-b)
(d) Irrigated (n=3,487)	3.88	4.45	4.15	-0.57***
(e) Rainfed (n=963)	2.97	2.84	2.91	0.13*
(f) All ecosystems (n=4,450)	3.67	4.13	3.88	-0.46***
Yield difference by ecosystem (d-e)	0.92***	1.62***	1.24***	

In all ecosystems and seasons, Nueva Ecija farmers averaged 4.71 t ha^{-1} (Appendix 4) - lower than Davao Oriental (5.43), Davao del Sur (5.18), Compostela Valley (5.06), Ilocos Norte (5.05), and Davao del Norte (5.05). Davao Region, where hybrids are popularly grown, is the highest yielder. The other 27 provinces produced less than Nueva Ecija. Lowest yielders were Leyte (2.97 t ha^{-1}), Bohol (2.45), and Northern Samar (2.36).

Figure 5.1 compares the semesters 1 and 2 provincial yield levels for all ecosystems. The maps reveal that more provinces in Luzon and Mindanao yielded higher in the 2012 first semester than in the second semester. Low-yielding provinces were in the Visayas. Nueva Ecija yielded highest (6.29 t ha^{-1}), while Northern Samar got the lowest (2.27). Bukidnon, Maguindanao, and Iloilo had better harvests in the second semester. Isabela, Bulacan, Cagayan, Zamboanga del Sur, and Agusan del Norte yielded high in both periods.

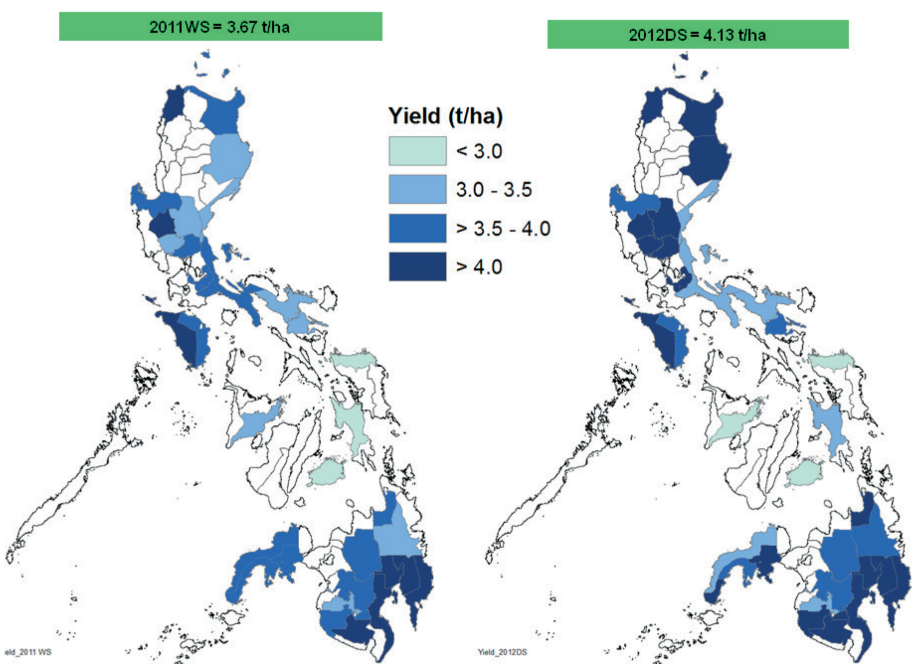


Figure 5.1 Average rice yields in 33 major rice-producing provinces in the Philippines by season,all ecosystems.

Figure 5.2 shows the average yields of irrigated vis-à-vis rainfed farms for all semesters. The maps show that more provinces yielded high (3 t ha^{-1} or more) in their irrigated farms. Most provinces had low rainfed yields (less than 3 t ha^{-1}) but Mindoro Occidental, Tarlac, Ilocos Norte, and Zamboanga del Sur still had high yields. Compostela Valley and Zamboanga Sibugay had higher rainfed yields than irrigated. Six provinces produced greater than 4 t ha^{-1} in both ecosystems.

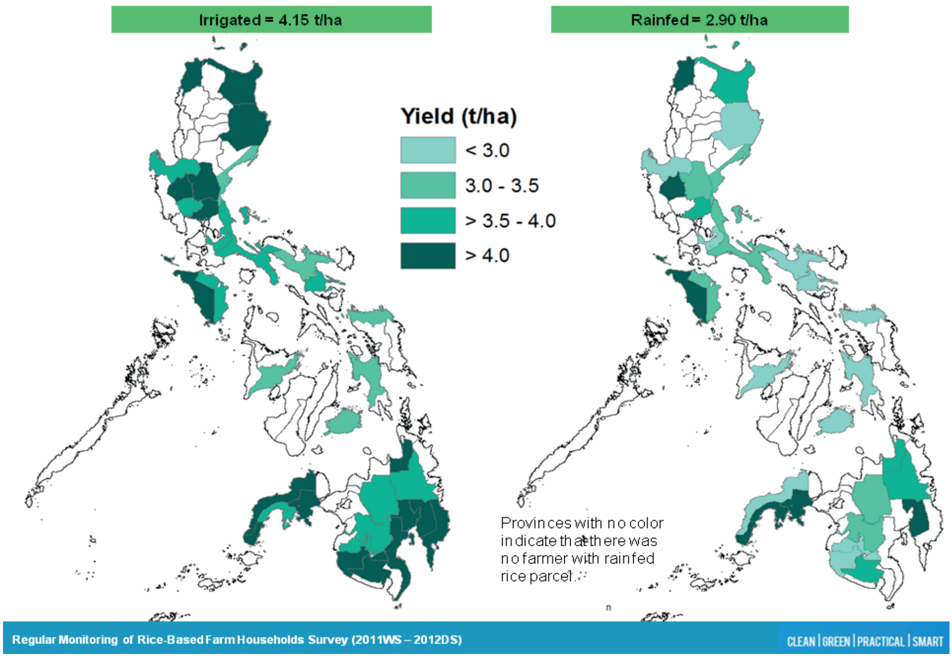


Figure 5.2 Average rice yields in 33 major rice-producing provinces in the Philippines by ecosystem, all semesters.

5.2.2. Area planted in the largest rice parcels

Sample farmers cultivated an average of 1.06 ha (Appendix 4) as their largest parcel during the 2011-2012 cropping. Highest average area was in Maguindanao with 1.70 ha, significantly higher than 1.34 ha in Nueva Ecija. Mindoro Occidental had 1.60 ha, Northern Samar (1.64), and Pampanga (1.54). Smallest areas were Albay (0.52 ha), Bohol (0.43), Ilocos Norte (0.30), Pangasinan (0.76), Quezon (0.76), and Zamboanga del Norte (0.58).

5.2.3. Sources of irrigation

Some 51% of the farmers used the National (NIS) or Communal Irrigation System (CIS) as source of water. Some 28% of them sourced water from small-scale irrigation systems (SSIS) [shallow tubewell, open-dug well, small farm reservoir, small water-impounding project] or natural sources (rivers/streams, free-flowing). The remaining 21% farmers relied on rain.

All farmers in Davao del Sur used NIS or CIS; Bukidnon, Nueva Ecija, Compostela Valley, Davao Oriental, Davao del Norte, and Maguindanao, 71% to 97%; less than 30% in Albay, Bohol, Iloilo, Mindoro Oriental, and Zamboanga Sibugay.

Some 55% to 63% of farmers in Albay, Mindoro Oriental, Pampanga, and Tarlac used SSIS or natural sources. Bohol (61%) and Zamboanga Sibugay (71%) farmers were highly rain-dependent; Agusan del Sur (42%), Iloilo (48%), Northern Samar (48%), Quezon (41%), and Zamboanga del Norte (41%).

5.2.4. Seeds and seeding rates

Figure 5.3 shows that 45% of farmers in all ecosystems adopted high-quality seeds – hybrid (5%), registered (3%), and certified (37%), farmer-saved (41%), and good seeds (14%). Adoption of high-quality seeds was higher in irrigated than in rainfed areas, where farmer-saved seeds were resorted to.

Ilocos Norte (Appendix 4) had the highest adoption of hybrid seeds (33%) in 2011-2012; followed by Cagayan (17%), Nueva Ecija (14%), and Davao del Sur (14%) (Appendix 5). Adoption of registered and certified seeds was highest in Aurora (82%); 61 to 68% in Bulacan, Cagayan, Davao Oriental, Davao del Norte, Isabela, Mindoro Occidental, Nueva Ecija, and Tarlac. Less than 20% of farmers in Albay, Bohol, Camarines Sur, South Cotabato, Sultan Kudarat, and Zamboanga Sibugay used quality seeds.

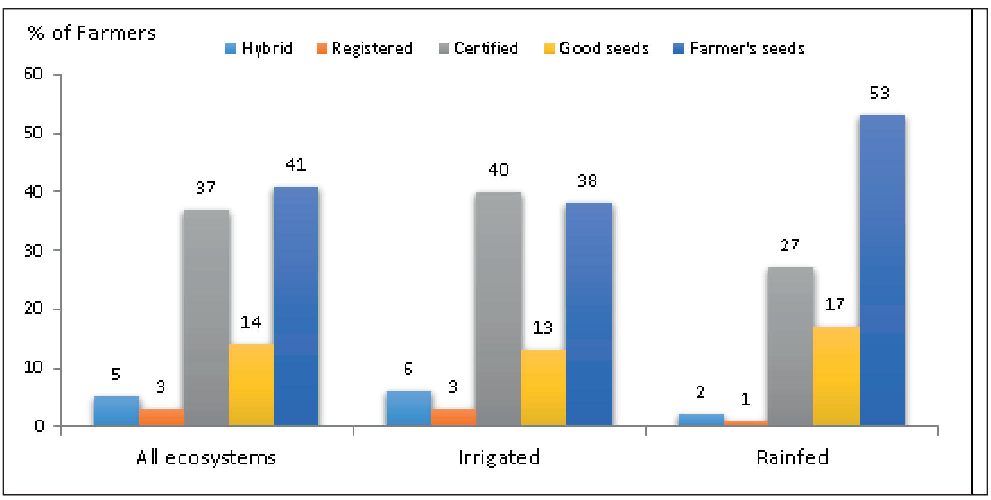


Figure 5.3 Percent of farmers by seed classification and ecosystem, Philippines, 2011-2012.

Farmers in irrigated and rainfed areas used an average of 95 kg of seeds to plant a hectare, higher compared to the 40-80 kg recommended seeding rate for inbreds. This could be due to their adoption of cheaper seed classes and perceived assurance of higher germination with higher seeding rate.

Iloilo (155 kg), Aurora (149), South Cotabato (133), Sultan Kudarat (125), North Cotabato (122), Bukidnon (120), Pampanga (118), Mindoro Oriental (114), and Pangasinan (111) had the highest seeding rates/ha, significantly higher than Nueva Ecija (99 kg). Lowest rates were in Bohol (51 kg) and Cagayan (52 kg). Ilocos Norte averaged 51 kg ha^{-1}, chiefly due to its high adoption of hybrid seeds (Appendix 4).

5.2.5. Amount of N-P-K used

Farmers applied an average of 72 kg ha^{-1} of nitrogen (N), 7 kg of phosphorus (P) and 10 kg of potassium (K). Irrigated farmers averaged 79 kg N, 7 kg P, and 11 kg K, higher than the 48 kg N, 5 kg P, and 6 kg K used by rainfed farmers (Table 5.3).

Table 5.3 Yield and quantity of inputs for rice farming, Philippines, 2011-12.

Item	All ecosystems (n=4,450)	Irrigated (n=3,487)	Rainfed (n=963)
N (kg ha^{-1})	72	79	48
P (kg ha^{-1})	7	7	5
K (kg ha^{-1})	10	11	6

Ilocos Norte also used the most N at 147 kg ha^{-1}; only 102 kg in Nueva Ecija. Mindoro Occidental used 113 kg ha^{-1}; Pangasinan and Tarlac (109); and Davao del Sur (103). Agusan del Sur, Bohol, Northern Samar, and Quezon used the least at 40 kg ha^{-1} or less.

Ilocos Norte used the highest P and K at 16 and 23 kg ha^{-1}; Nueva Ecija at 14 and 21. The other 31 provinces used significantly less P than Nueva Ecija. Except Aurora with 20 kg ha^{-1}, they used significantly less K than Nueva Ecija.

5.2.6. Herbicide and insecticide active ingredients (AI)

Farmers applied 0.33 kg ha^{-1} of herbicide AI and 0.24 kg of insecticide AI. Nueva Ecija applied 0.41 kg of herbicide AI. Agusan del Norte, Compostela Valley, Davao del Norte/ Sur, South Cotabato, Sultan Kudarat, and Zamboanga del Sur used 0.56 to 0.70 kg ha^{-1} herbicide AI. Albay, Bohol, Cagayan, Ilocos Norte, Leyte, Northern Samar, Pampanga, Pangasinan, and Tarlac used the least at 0.20 kg ha^{-1} or less (Appendix 4).

Highest insecticide AI was used in Aurora (0.53 kg ha^{-1}), Davao Oriental (0.77), Davao del Norte (0.42), North Cotabato (0.55), and Zamboanga Sibugay (0.70), significantly higher than Nueva Ecija (0.25). In contrast, Albay, Bohol, Ilocos Norte, Leyte, Northern Samar, and Quezon had less than 0.10 kg ha^{-1} insecticide AI.

5.2.7. Labor requirement and machine-use

Farmers needed 60 labor man-days per hectare (md ha^{-1}) every cropping season from seed management to threshing (Table 5.4). Irrigated farmers had more labor-intensive practices (62 md ha^{-1}) than rainfed farmers (51). With insufficient water, rainfed farmers could not do fertilizer application and irrigation.

Table 5.4 Labor requirement and machine-use in rice farming, Philippines, 2011-12.

Items	All ecosystems (n=4,450)	Irrigated (n=3,487)	Rainfed (n=963)
Hired labor (md ha^{-1})*	**41**	**43**	**35**
Seed management	0.4	0.4	0.2
Land preparation	5	6	5
Crop establishment	14	14	11
Crop care and maintenance	3	3	2
Harvesting & threshing	19	20	17
Operator, family & exchange (md ha^{-1})*	**19**	**19**	**16**
Seed management	1	2	1
Land preparation	5	4	6
Crop establishment	2	2	2
Crop care and maintenance	10	11	6
Harvesting & threshing	0.5	0.4	0.7
Total labor (md ha^{-1})*	**60**	**62**	**51**
Machine (day ha^{-1})**	**10**	**10**	**9**

* md stands for man-day which is equivalent to an eight-hour work day

** one day is equivalent to an eight-hour operation

Fertilizer and pesticide application, irrigation, and drainage were usually done by the operator, family and exchange (OFE) laborers. Harvesting and threshing require the most number of hired and OFE labor man-days (19.5 md ha^{-1}); crop establishment at 16 md. The average machine-use in all ecosystems is 10 day ha^{-1}, which only differs by an eight-hour operation between irrigated and rainfed farmers.

Davao Oriental had the most labor-intensive rice farming with 80 md ha^{-1} (see Appendix 4). Albay, Bohol, Ilocos Norte, Leyte, Mindoro Occidental, Northern Samar, and Zamboanga del Norte needed more than 70 md ha^{-1}, significantly higher than Nueva Ecija at 61 md ha^{-1}. Agusan del Sur, Aurora, Camarines Sur, Iloilo, Mindoro Oriental, North Cotabato, and Pampanga required only 40 to 48 md ha^{-1} of labor.

For land preparation and harvesting-threshing, Camarines Sur, Davao Oriental, Davao del Sur, Maguindanao, Mindoro Occidental/Oriental, North Cotabato, Northern Samar, and Zamboanga del Norte/Sur utilized farm machines for 11 to 13 days ha^{-1} operation. Albay, Bukidnon, Bulacan, Ilocos Norte, Isabela, Laguna, and Pangasinan needed only 6 to less than 8 day ha^{-1} machine utilization.

5.2.8. Cost of production

Farm inputs with the highest cost across ecosystems are labor and power, land rent, and fertilizer, which comprise the highest percent shares to the total production cost (Table 5.5). Irrigated farmers were spending 35% higher than rainfed farmers.

Table 5.5 Cost of production and percent cost share of inputs by ecosystems, Philippines, 2011-12.

Item	Average cost (PhP ha^{-1})			Percent cost share		
	All ecosystems (n=4,450)	Irrigated (n=3,487)	Rainfed (n=963)	All ecosystems	Irrigated	Rainfed
Seeds	2,156	2,241	1,851	5	5	5
Fertilizers	5,851	6,379	3,936	13	14	12
Herbicide	576	575	579	1	1	2
Insecticide	873	884	833	2	2	2
Labor and power	18,964	19,967	15,333	44	43	45
Land rent	10,367	10,856	8,597	24	24	25
Other inputs*	4,661	5,137	2,937	11	11	9
Total cost	**43,448**	**46,039**	**34,066**			

*Other inputs include cost of fungicide and other pesticides, food cost, irrigation and drainage, transportation, land tax, and imputed interest on capital

The estimated unit cost of paddy in irrigated ecosystems is PhP 11.09 kg^{-1}, which is lower than PhP 11.70 in rainfed. Figure 5.4 shows the variation in unit cost across sample provinces. In irrigated areas, majority of provinces had unit cost between Php10.00 and Php12.00; wider variation in rainfed areas. Zamboanga del Sur consistently produced a kilogram of paddy at less than Php10.00 across ecosystems.

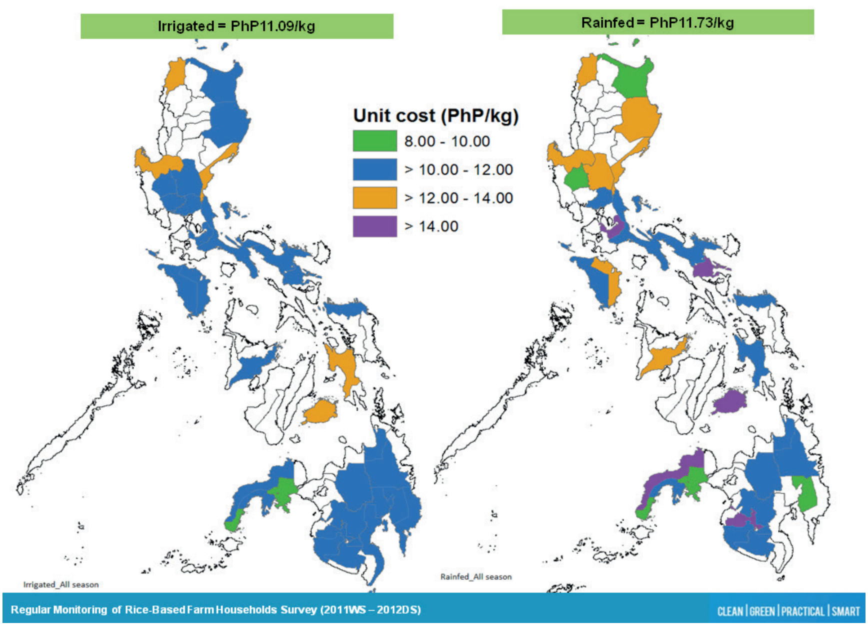


Figure 5.4 Average unit cost in 33 major rice-producing provinces in the Philippines by ecosystem, all semesters.

5.3. Technical efficiency estimates and its determinants

The stochastic frontier production function was fitted assuming that u_i are independently exponentially distributed with variance σ^2_u. Results revealed a significant estimate for σ^2_u that supports the use of a frontier model over the ordinary least squares model (Table 5.6). The gamma parameter ($\gamma = \sigma^2_u \div \sigma^2$) measures the variation in the composite error term that is attributed to the inefficiency component. The estimated gamma shows that 70% of the variation in the composite error term is due to technical inefficiency. This implies that farmers in the 33 provinces are technically inefficient.

Table 5.6 Random error component of the stochastic frontier production model.

ln(production)	Coefficient	Robust Std. Err.	z	P>z	[95% Conf. Interval]	
ln σ^2_v	-2.994	0.057	-52.80	0.000	-3.105	-2.883
ln σ^2_u	-2.135	0.059	-36.14	0.000	-2.251	-2.019
σ_v	0.224	0.006			0.212	0.237
σ_u	0.344	0.01			0.325	0.364
σ^2	0.168	0.006			0.156	0.18
γ	0.704					
Log pseudolikelihood = -1,982.88			Wald chi²(20) = 23,623.31			
Number of observations = 4,450			Prob > chi² = 0.000			

From the frontier production function, the national levels of farmers' technical efficiency (TE) were estimated at mean 74.7%. This implies that the Philippines is producing only 74.7% of the maximum potential production, given the farmers' input combinations.

Figure 5.5 shows the variation in the mean TE estimates across the 33 provinces. Farmers in Nueva Ecija are 73% technically efficient, higher than Aurora, Camarines Sur, Northern Samar, Leyte, Iloilo, Bohol, Maguindanao, and Sultan Kudarat farmers. With the highest TE estimates are Zamboanga Sibugay (82.3%), Compostela Valley (81.2%), Davao del Norte (80.7%), South Cotabato (80.3%), Davao Oriental (80.2%) and Ilocos Norte (80.2%). Aurora (66%), Bohol (66%), and Maguindanao (68%) have the lowest TE estimates.

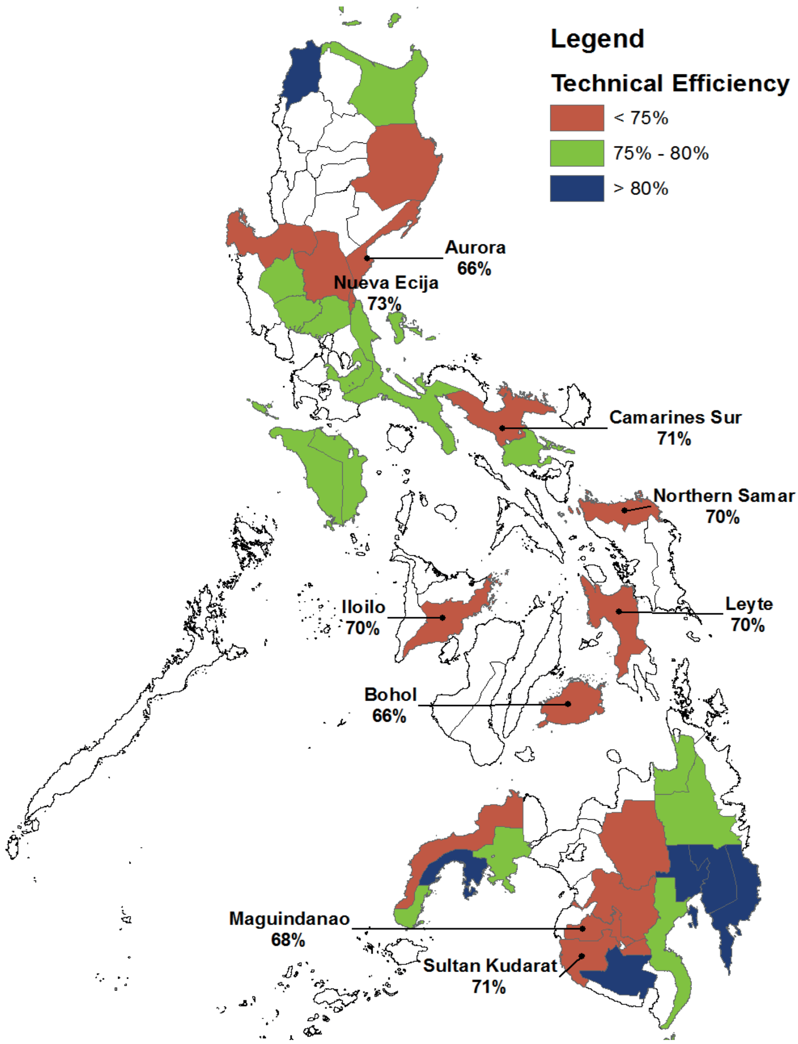


Figure 5.5 Estimated technical efficiency of farmers in 33 major rice-producing provinces in the Philippines, all seasons and ecosystems.

Table 5.7 shows the results of regressing the TE estimates against its possible determinants. The regression model is significant with F-statistics equal to 6.44. However, the adjusted coefficient of determination (R-squared) is only 2.3%, which represents a very small variation in the TE estimates that can be explained by the predictors being considered in this study. This result presents an area for future research on what other highly contributory factors are affecting the TE. For the purpose and limitation of this study, the effects on efficiency of five selected farmer-specific characteristics were assessed.

Table 5.7 Regression estimates for the determinants of technical efficiency.

Variables	Coefficient	Std. error
[*Dependent variable* = TE]		
Farming experience (years)	0.0001	0.0002
Education (1=attained at least high school, 0 otherwise)	0.0167***	0.0061
Training/seminar (1=with training/seminar, 0 otherwise)	0.0173*	0.0097
Organization (1=member, 0 otherwise)	0.0422***	0.0074
Tenurial status (1=owner, 0 otherwise)	0.0101*	0.0057
Traning x Organization	-0.0247**	0.0121
Constant	0.7070***	0.0097
Observations	2,537	
F-statistics	6.44	
Prob > F	0.000	
R-squared	0.023	

*** p<0.01, ** p<0.05, * p<0.1

Results showed that TE of farmers is significantly affected by their education, training participation, organizational membership, and tenurial status. High-school level farmers are more technically efficient than elementary-level farmers. Farmers who participate in rice-related trainings/seminars, and are members of any rice or rice-based farm organization have higher TE than other farmers. Farmers more freely exchange knowledge and ideas about rice farming with fellow members of organizations. They meet with co-farmers and win more access to government support as a group. Moreover, farmers who own the rice parcels they cultivate have higher TE than non-owners. Organizational membership and training participation have significant but negative interaction effect, which tempers their direct effects on TE. This implies that trained farmers could have higher efficiency if they are not members of organizations, and vice versa. Years of farming experience has positive but insignificant effect on farmers' TE.

5.4 Allocative efficiency estimates and its determinants

The stochastic frontier cost function was also fitted assuming exponential distribution of u_i with variance σ^2_u. Similar to the results of frontier production function, the variation in the composite error term that is attributed to the allocative inefficiency component is measured by the gamma parameter ($\gamma = \sigma^2_u \div \sigma^2$). The estimated gamma shows that 54% of the variation in the composite error term is due to allocative inefficiency effects (Table 5.8).

Table 5.8 Random error component of the stochastic frontier cost exponential model.

ln(cost)	Coefficient	Robust Std. Err.	z	P>z	[95% Conf. Interval]	
ln σ^2_v	-3.235	0.056	-58.28	0.000	-3.344	-3.126
ln σ^2_u	-3.099	0.077	-40.01	0.000	-3.251	-2.947
σ_v	0.198	0.006			0.188	0.209
σ_u	0.212	0.008			0.197	0.229
σ^2	0.084	0.003			0.078	0.091
γ	0.539					
Log pseudolikelihood = -653.831				Wald chi²(15) = 25,917.39		
Number of observations = 4,450				Prob > chi² = 0.000		

From the frontier cost function, the national levels of farmers' AE were estimated at mean 81.4%. This implies that the Philippines could have generated the same level of production using only 81.4% of the actual production cost, given the input prices. The potential cost reduction is 18.6%.

Figure 5.6 shows the variation in the average AE estimates across the 33 provinces. Zamboanga del Sur (89%), Ilocos Norte (87%), Albay (85%), and Compostela Valley (85%) have the highest AE estimates; Nueva Ecija (76.9%), Aurora (77.3%), and Bukidnon (78.3%) have the lowest.

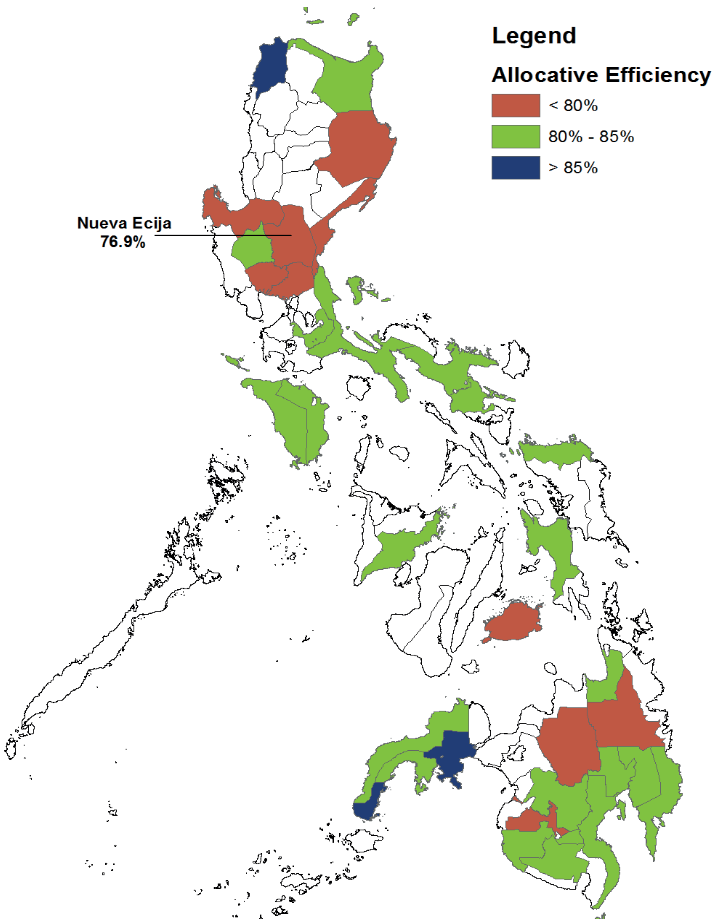


Figure 5.6 Estimated allocative efficiency in 33 major rice-producing provinces in the Philippines, all semesters and ecosystems.

Table 5.9 presents the results of regressing the AE estimates against its possible determinants. Similar to the results of regression for TE determinants, the regression model for AE is significant with F-statistics equal to 5.14. However, the adjusted coefficient of determination (R-squared) is only 1.1%, which indicates a very small variation in the AE estimates that can be explained by the predictors being considered in this study.

Considering the data limitation of this study, results still provide ideas on the effects on AE of five selected farmer-specific characteristics.

Farmers' AE is significantly affected by their organizational membership and tenurial status (Table 5.9). Farmer-members of any rice-based organization had higher AE than other farmers. Farmers who own have less AE than non-owners. Years of farming experience, education, and training did not significantly affect AE of farmers.

Table 5.9 Regression estimates for the determinants of allocative efficiency.

Variables	Coefficient	Std. error
[*Dependent variable* = AE]		
Farming experience (years)	-0.0001	0.0002
Education (1=attained at least high school, 0 otherwise)	-0.0036	0.0042
Training (1=with training, 0 otherwise)	-0.0048	0.0069
Organization (1=member, 0 otherwise)	0.0211***	0.0051
Tenurial status (1=owner, 0 otherwise)	-0.0075*	0.0040
Training x Organization	-0.0029	0.0085
Constant	0.8145***	0.0068
Observations	2,537	
F-statistics	4.99	
Prob > F	0.000	
R-squared	0.011	

*** p<0.01, ** p<0.05, * p<0.1

5.5. Factors affecting yield

Actual yields are inferior to potential yields, hence the need to narrow the gap. Adoption of quality seeds (hybrid or registered/certified seeds) and access to water sources (NIS/CIS or SSIS) contribute most to increased yields (Table 5.10). Rice cropping during semester 1 (January-June) also yields higher than semester 2 (July-December). Improving farmers' TE also contributes significantly to increased yields.

Increases in herbicide and insecticide AI would also lead to yield increment. This implies that chemical pest management may be a positive option as long as the necessity, quantity, timing, and ecological safety of pesticides are taken into account.

Table 5.10 Estimates from the yield-response function.

Variables	Coefficient	Robust Std. Error	% increase in yield	Average input use (kg ha^{-1})	Marginal returns (kg. increase in yield)
[y= Ln(yield in kg ha^{-1})]					
Ln(Seed)	0.0698***	0.0038	0.070%	94.60	2.87
Ln(N)	0.0785***	0.0035	0.079%	72.49	4.20
Ln(P)	0.0177***	0.0022	0.018%	15.26	4.50
Ln(K)	-0.0018	0.0021	-	11.73	-0.58
Ln(Herbicide AI)	0.0178***	0.0014	0.018%	0.33	212.01
Ln(Insecticide AI)	0.0301***	0.0017	0.030%	0.24	486.81
Ln(Labor)	0.1750***	0.0059	0.175%	59.88	11.35
Ln(Machine)	0.0097***	0.0017	0.010%	9.54	3.93
d_NIS/CIS	0.1940***	0.0051	21%		
d_SSIS	0.1040***	0.0054	11%		
d_Hybrid	0.3740***	0.0097	45%		
d_RSCS	0.1110***	0.0041	12%		
d_Season	0.0708***	0.0034	7%		
TE	2.5920***	0.0302	2.6%		
Constant	4.6300***	0.0430			
Observations	4,450				
R-squared	0.958				

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Every increase in labor man and machine-days also significantly boosts yield. This reinforces the importance of dynamic rice crop management practices that emphasize well-puddled and leveled soil, adequate irrigation, sufficient nutrients, and timely reaping and threshing.

As input uses and levels of paddy output differ, the marginal effects of the identified significant factors can change from one province to another. This implies that an additional input can lead to greater increase in yield in one province than in another. The marginal increases in yield due to a unit increase in inputs as well as their values are discussed in the next chapter.

5.6 Factors affecting unit cost

The estimated AE presented in Section 4.4 shows that there is room to further reduce the cost kg^{-1} of production in the Philippines, hence the cost-reducing factors must be determined. Table 5.11 asserts that adoption of quality seeds (hybrid or registered/certified seeds), improved AE of farmers, and an improved yield contribute most to reduced cost kg^{-1}.

Table 5.11 Estimates from the cost-response function.

Variables	Coefficient	Robust Std. Error	% change in cost kg^{-1}	Average input price $unit^{-1}$	Marginal returns (Php change in unit cost)
[y= Ln(unit cost in Php kg^{-1})]					
Ln (Seed)	0.0672***	0.0068	0.067%	Php 32	0.0234
Ln (N)	-0.0164	0.0136	0.016%	Php 59.22	0.0031
Ln (P)	-0.00804	0.0215	-0.008%	Php 87.06	-0.0006
Ln (K)	-0.0001	0.0147	0.0001%	Php 54.83	0.0016
Ln (Herbicide AI)	0.00815***	0.0015	0.008%	Php 5.79	0.0158
Ln (Insecticide AI)	0.00116	0.0018	0.001%	Php 13.10	0.0010
Ln (Land rent)	0.135***	0.0056	0.135%	Php 10,367	0.0001
Ln (Labor)	0.0042	0.0071	0.004%	Php 244	0.0002
Ln (Yield)	-0.314***	0.0183	-0.314%	3,883 kg/ha	-0.0009
d_NIS/CIS	0.0191***	0.0070	0.019%		
d_SSIS	-0.0018	0.0062	-0.002%		
d_Hybrid	-0.203***	0.0192	-0.203%		
d_RSCS	-0.0257***	0.0052	-0.026%		
d_Season	-0.00425	0.0049	-0.004%		
d_machinelp	0.00542	0.0073	0.005%		
d_machineht	-0.0319***	0.0082	-0.032%		
AE	-1.857***	0.0398	-1.857%		
Constant	5.171***	0.1632			
Observations	4,450				
R-squared	0.900				

*** p<0.01, ** p<0.05, * p<0.1

Costs, prices of inputs, levels of paddy output, and the marginal reductions in cost due to the identified significant factors can differ from one province to another. This implies that additional yield can lead to bigger cost reduction in one province than in another. The marginal reduction in cost due to a one-ton increase in output will be discussed in the next chapter.

Table 5.12 compares yields and cost kg^{-1} of production across the 32 provinces relative to Nueva Ecija. These results were derived from the coefficients of dummy variables for 32 provinces in the estimated yield-response and cost-response functions. Holding other factors constant, Compostela Valley had significantly higher yield and lower unit cost than Nueva Ecija. Camarines Sur, Mindoro Occidental, Northern Samar, and Zamboanga del Sur produced paddy at significantly lower cost/kg than Nueva Ecija, but their yields are significantly lower, too. Davao Oriental, Zamboanga del Norte, Bohol, Ilocos Norte, and Pangasinan had significantly higher cost than Nueva Ecija, but their yields are either the same or lower. Leyte, Mindoro Oriental, and Quezon had the same cost kg^{-1} but their yields are significantly lower than Nueva Ecija.

Table 5.12 Comparative yields and costs per kilogram of rice across 33 provinces.

	*Lower cost kg^{-1} than NE	Not significantly different cost kg^{-1} from NE	*Higher cost kg^{-1} than NE
*Higher yield than NE	Compostela Valley		
Not significantly different yield from NE	Agusan del Sur, Aurora, Bukidnon, Cagayan, Isabela, Maguindanao, North/South Cotabato, Pampanga, Sultan Kudarat, Zamboanga Sibugay	Agusan del Norte, Albay, Bulacan, Davao del Norte/Sur, Iloilo, Laguna, Tarlac	Davao Oriental, Zamboanga del Norte
*Lower yield than NE	Camarines Sur, Mindoro Occidental, Northern Samar, Zamboanga del Sur	Leyte, Mindoro Oriental, Quezon	Bohol, Ilocos Norte, Pangasinan

* Significant at 1%, 5%, or 10% level

CHAPTER

6

PROVINCE-SPECIFIC RECOMMENDATIONS IN NARROWING THE YIELD GAPS AND REDUCING THE COSTS

This chapter discusses the yield and cost gaps within each province. The gaps were measured as the differences between the yields (or costs) of the 10^{th} and 90^{th} percentiles. These were used instead of the minimum and maximum due to the chance of outlier values. For each province, the marginal productivity (MP) of an input, defined as the increase in yield brought about by one unit increase in input, was reported. These were calculated using the statistically significant estimated coefficients in the yield response function and the provincial average yield and input uses. Based on this, the input that can best increase the yield of a province was deduced. However, the optimality of increasing the use of an input depends on the marginal value product (MVP) or the value of the incremental output that it generates relative to the additional cost of using the input. Thus, the profit-maximizing change in input is also discussed. Similarly, the marginal reductions in cost per kg due to increase in significant factors were estimated and reported per province.

Luzon Provinces

1. Albay

In the January-June crop period, the yield of the 90^{th} percentile of the sample farmers is 6.11 t ha^{-1} and 1.84 t ha^{-1} for the 10^{th} percentile; resulting in a yield gap of 4.27 t ha^{-1} (Table 6.1.1). For July-December, yields of the 90^{th} and 10^{th} percentiles are 4.98 t ha^{-1} and 1.48 t ha^{-1}, which give a yield gap of 3.49 t ha^{-1}. These yield gaps can still be reduced. Based on Table 6.1.2, applying one more kg of phosphate can lead to a 16-20 kg ha^{-1} increment in yield, which is higher than yield improvement from any other input. Considering the current prices of paddy and fertilizers (i.e. complete and ammonium phosphate) in Albay, additional phosphate applications of 2.90 kg ha^{-1} and 3.41 kg ha^{-1} on the January-June and July-December crops are recommended (Table 6.1.3). An additional man-day of labor can also lead to a yield increment of 7.6-9.6 kg ha^{-1}. However, the wage rate in Albay indicates that farmers are already hiring a profit-maximizing number of workers. Thus, profit will not improve by hiring more farm workers.

Table 6.1.1. Yield and cost gaps in Albay, by season.

Item/	Percentiles		Gaps	
Crop period	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	1,844	6,113	4,269	232
July-December	1,485	4,978	3,493	235
Cost (PhP kg^{-1})				
January-June	6.67	16.63	-9.96	-59.88
July-December	8.21	19.87	-11.66	-58.70

Adoption of hybrid varieties in Albay can raise yield by 1.46- 1.78 t ha^{-1} (Table 6.1.2); certified seeds by 352-434 kg ha^{-1}. Water source also matters in narrowing the yield gap here. Farm areas served by national and communal irrigation systems can yield 688-845 kg ha^{-1} more, about two times higher than those with other sources.

Table 6.1.1 shows that cost gap (i.e. difference between 10th and 90th percentiles) is slightly higher in January-June (60%) than in July-December (59%). Based on Table 6.1.4, a one-ton increase in yield can reduce cost by PhP 0.88 to PhP 1.30 kg^{-1}; climbing to PhP 2.02 to PhP 2.40 kg^{-1} reduction if farmers will use hybrid seeds. The use of combine harvester can cut cost by about PhP 0.40 kg^{-1}; by PhP 0.20 to PhP 0.30 kg^{-1} through use of either certified seeds or water from national and communal irrigation systems (Table 6.1.4).

Table 6.1.2. Marginal productivity of inputs in rice farming in Albay.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	3.89	2.34
Nitrogen (kg ha^{-1})	4.58	4.35
Phosphorus (kg ha^{-1})	20.16	15.66
Herbicide (g ha^{-1})	1.12	0.55
Insecticide (g ha^{-1})	2.35	2.93
Labor (man-day ha^{-1})	9.59	7.60
Machine (machine-day ha^{-1})	5.57	5.84
Large-scale irrigation system	848.73	688.00
Small-scale irrigation system	434.48	352.20
Hybrid seed	1,797.94	1,457.44
Certified inbred seed	465.38	377.25

Table 6.1.3. Profit-maximizing increase in inputs, Albay.

Item	Profit-maximizing increase in input	
	January-June	July-December
Seed (kg ha^{-1})	1.41	1.74
Nitrogen (kg ha^{-1})	1.02	0.94
Phosphorus (kg ha^{-1})	2.90	3.41
Herbicide (g ha^{-1})	1.58	0.76
Insecticide (g ha^{-1})	1.66	1.84
Labor (man-day ha^{-1})	0.53	0.47
Machine (machine-day ha^{-1})	0.09	0.10

Table 6.1.4. Marginal reduction in cost, Albay.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-0.88	-1.30
Large-scale irrigation system	0.21	0.24
Hybrid seed	-2.02	-2.40
Certified inbred seed	-0.27	-0.32
Machine for Harvesting & Threshing	-0.34	-0.40

2. Aurora

Table 6.2.1 shows that the January-June yield of the 90th percentile of the sample farmers is 4.67 t ha^{-1}, which means that 90% of them have yields of or below 4.67 t ha^{-1}. Yield of the 10th percentile is 2.31 t ha^{-1}, meaning 10% of the farmers yielded below this value. Therefore, majority of farmers in Aurora in this crop period had yields between 2.30 and 4.67 t ha^{-1}, or a gap of approximately 2.36 t ha^{-1}. Many farmers still need to increase their yields by 2.36 t ha^{-1} to attain the higher yields possible under their field conditions.

Table 6.2.1. Yield and cost gaps in Aurora, by season.

Item/	Percentiles		Gaps	
Crop period	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June (DS)	2,305	4,668	2,364	103
July-December (WS)	1,664	4,583	2,919	175
Cost (PhP kg^{-1})				
January-June	9.26	19.44	-10.18	-52.36
July-December	10.82	23.61	-12.79	-54.17

But the July-December yields of majority of the farmers fall between 1.66 and 4.58 t ha^{-1}, or a yield gap of 2.92 t ha^{-1} that they need to narrow. This is higher than in January-June because July-December is typhoon season in Aurora.

Aurora farmers can narrow these gaps through the adoption of yield-enhancing technologies (quality seeds and irrigation facilities). They could raise their yields by more than 1 t ha^{-1} by shifting from low-quality to hybrid seeds; by more than 0.5 t ha^{-1} through better access to large-scale irrigation systems (Table 6.2.2). Increases in labor and fertilizer inputs could raise yields efficiently if these are not more than 1 man-day and by 1 kg ha^{-1} of nitrogen and phosphorus (Table 6.2.3).

Table 6.2.2. Marginal productivity of inputs in rice farming in Aurora.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	1.64	1.46
Nitrogen (kg ha^{-1})	4.19	4.47
Phosphorus (kg ha^{-1})	6.93	6.25
Herbicide (g ha^{-1})	0.11	0.13
Insecticide (g ha^{-1})	0.15	0.25
Labor (man-day ha^{-1})	12.10	12.58
Machine (machine-day ha^{-1})	3.16	2.91
Large-scale irrigation system	736.52	678.01
Small-scale irrigation system	377.04	347.09
Hybrid seed	1,560.23	1,436.29
Certified inbred seed	403.85	371.77

The difference between unit costs of the 90th and 10th percentiles is higher in the wet (PhP 12.79 kg^{-1}) than in the dry season (PhP 10.18 kg^{-1}) (Table 6.2.1). This means that farmers had difficulty minimizing cost in July-December owing to less harvest and higher incidence of pests and diseases. Farmers could reduce cost if they increase their yields, and adopt quality seeds and combine harvesters (Table 6.2.4). Highest cost reduction (i.e., PhP 2.58-PhP 2.78 kg^{-1}) will result from the adoption hybrid seeds that yield more than other seeds, resulting in less cost per unit of output.

Table 6.2.3. Profit-maximizing increase in inputs, Aurora.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	0.85	0.76
Nitrogen (kg ha^{-1})	1.08	1.13
Phosphorus (kg ha^{-1})	1.07	1.02
Herbicide (g ha^{-1})	0.21	0.22
Insecticide (g ha^{-1})	0.20	0.18
Labor (man-day ha^{-1})	0.80	0.74
Machine (machine-day ha^{-1})	0.11	0.15

Table 6.2.4. Marginal reduction in cost, Aurora.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-1.30	-1.52
Large-scale irrigation system	0.26	0.28
Hybrid seed	-2.58	-2.78
Certified inbred seed	-0.35	-0.38
Machine for Harvesting & Threshing	-0.43	-0.47

3. Bulacan

Majority of farmers had yields between 3.34 and 6.60 t ha^{-1} in January-June and 2.20 and 5.76 t ha^{-1} in July-December. The yield gap in the latter period is higher (162%) than the former (97%), which poses greater challenges in July-December (Table 6.3.1). The gaps imply that it is possible to increase yields by 3.25 t ha^{-1} in January-June and 3.56 t ha^{-1} in July-December. Table 6.3.2 shows the major factors that could help increase farmers' yields – adoption of hybrid seeds and access to large-scale irrigation system. Hybrid seeds could help farmers produce an additional of 1.7 t ha^{-1} in July-December and 2.2 t ha^{-1} in January-June. From large-scale irrigation system, farmers could increase yields by 0.82 t ha^{-1} (July-December) and 1.06 t ha^{-1} (January-June). Increasing on quantity of seeds, labor, fertilizers, and machine use could also raise yields. For maximum profit, seeds, nitrogen, and phosphorus can only be increased by about 1 kg ha^{-1}, and less than 1 man-day for labor (Table 6.3.3). Using more than this could result in cost inefficiency.

Table 6.3.1. Yield and cost gaps in Bulacan, by season.

Item/	Percentiles		Gaps	
Crop period	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	3,347	6,600	3,253	97
July-December	2,200	5,760	3,560	162
Cost (PhP kg^{-1})				
January-June	7.86	15.75	-7.89	-50.11
July-December	8.95	19.28	-10.33	-53.57

Cost comparison of the 90th and 10th percentiles (Table 6.3.1) shows that the difference is slightly higher in July-December (PhP 10.33 kg^{-1}) than in January-June (PhP 7.89 kg^{-1}). This implies that it is possible to reduce cost through the adoption of quality hybrid seeds, and mechanizing harvesting and threshing operations (Table 6.3.4). High-quality seeds can prime up harvests, while mechanization can reduce cost.

Table 6.3.2. Marginal productivity of inputs in rice farming in Bulacan.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	3.67	3.16
Nitrogen (kg ha^{-1})	4.68	4.53
Phosphorus (kg ha^{-1})	8.65	7.64
Herbicide (g ha^{-1})	0.36	0.30
Insecticide (g ha^{-1})	0.44	0.29
Labor (man-day ha^{-1})	14.72	13.91
Machine (machine-day ha^{-1})	5.75	4.99
Large-scale irrigation system	1,056.56	815.25
Small-scale irrigation system	540.87	417.34
Hybrid seed	2,238.19	1,727.00
Certified inbred seed	579.34	447.02

Table 6.3.3. Profit-maximizing increase in inputs, Bulacan.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	1.42	0.94
Nitrogen (kg ha^{-1})	1.36	1.06
Phosphorus (kg ha^{-1})	1.39	1.17
Herbicide (g ha^{-1})	0.90	0.30
Insecticide (g ha^{-1})	0.65	0.60
Labor (man-day ha^{-1})	0.61	0.54
Machine (machine-day ha^{-1})	0.07	0.06

Table 6.3.4. Marginal reduction in cost, Bulacan.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-0.74	-1.08
Large-scale irrigation system	0.21	0.24
Hybrid seed	-2.09	-2.37
Certified inbred seed	-0.28	-0.32
Machine for Harvesting & Threshing	-0.35	-0.40

4. Cagayan

Yields fall between 2.80 and 6.42 t ha^{-1} in January-June and between 2.25 and 5.28 t ha^{-1} in July-December (Table 6.4.1). This results in yield gaps of more than 3 t ha^{-1} in both seasons, but higher in January-June. Farmers can increase their yields by 3.03 t ha^{-1} in January-June and 3.62 t ha^{-1} in July-December. Table 6.4.2 shows that adoption of hybrid seeds and access to large-scale irrigation system could increase yield. Hybrid seeds could help farmers produce 2.05 t ha^{-1} more in January-June and 1.70 t ha^{-1} more in July-December. From large-scale irrigation system, yields could increase by 1.06 t ha^{-1} (January-June) and 0.82 t ha^{-1} (July-December). For profit maximization and cost efficiency, seeds, nitrogen, and phosphorus can only be increased by about 1 kg ha^{-1} and less than 1 man-day for labor (Table 6.4.3).

Cost comparison of the 90^{th} and 10^{th} percentiles (Table 6.4.1) shows that the difference is slightly higher in July-December (PhP 10.33 kg^{-1}) than in January-June crop (PhP 7.89 kg^{-1}). This implies that it is possible to reduce cost by adopting quality hybrid seeds, and mechanizing harvesting and threshing operations (Table 6.4.4). High-quality seeds can prime up harvests, while mechanization can reduce yield losses.

Table 6.4.1. Yield and cost gaps in Cagayan, by season.

Item/	Percentiles		Gaps	
Crop period	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	2,804	6,428	3,624	129
July-December	2,255	5,285	3,030	134
Cost (PhP kg^{-1})				
January-June	7.42	14.77	-7.34	-49.72
July-December	7.95	15.40	-7.44	-48.34

Table 6.4.2. Marginal productivity of inputs in rice farming in Cagayan.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	7.20	4.38
Nitrogen (kg ha^{-1})	4.42	3.33
Phosphorus (kg ha^{-1})	13.40	9.81
Herbicide (g ha^{-1})	0.51	0.32
Insecticide (g ha^{-1})	1.24	1.25
Labor (man-day ha^{-1})	11.33	9.42
Machine (machine-day ha^{-1})	4.18	3.69
Large-scale irrigation system	966.46	804.69
Small-scale irrigation system	494.75	411.94
Hybrid seed	2,047.33	1,704.63
Certified inbred seed	529.94	441.23

Table 6.4.3. Profit-maximizing increase in inputs, Cagayan.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	0.94	1.29
Nitrogen (kg ha^{-1})	0.93	0.67
Phosphorus (kg/ha)	1.91	1.38
Herbicide (g ha^{-1})	1.33	0.57
Insecticide (g ha^{-1})	0.81	1.01
Labor (man-day ha^{-1})	0.63	0.57
Machine (machine-day ha^{-1})	0.11	0.10

Table 6.4.4. Marginal reduction in cost, Cagayan.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-0.77	-0.98
Large-scale irrigation system	0.20	0.22
Hybrid seed	-2.00	-2.12
Certified inbred seed	-0.27	-0.29
Machine for Harvesting & Threshing	-0.34	-0.36

5. Camarines Sur

Table 6.5.1 shows that yields are between 1.08 and 4.90 t ha^{-1} in January-June and 1.68 and 4.58 t ha^{-1} in July-December. This results in a yield gap higher in January-June (3.82 t ha^{-1}) than in July-December (2.91 t ha^{-1}), which can be reduced. Based on Table 6.5.2, applying one more kg of phosphate can lead to a yield increment of 9.32-11.73 kg ha^{-1} higher than any other input except for labor man-day. Thus, additional phosphate applications of 1.70 kg ha^{-1} in January-June and 1.30 kg ha^{-1} in July-December are recommended in this province considering the current prices of paddy, complete fertilizer, and ammonium phosphate (Table 6.5.3). While an additional man-day of labor can lead to the highest yield increment of about 12 kg ha^{-1}, the wage rate in Camarines Sur indicates that farmers are already hiring the profit-maximizing number of workers.

Table 6.5.1. Yield and cost gaps in Camarines Sur, by season.

Item/	Percentiles		Gaps	
Crop period	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	1,077	4,897	3,820	355
July-December	1,676	4,585	2,909	174
Cost (PhP kg^{-1})				
January-June	7.66	17.60	-9.93	-56.44
July-December	8.24	14.66	-6.42	-43.78

The use of hybrid varieties can also narrow the gap in this province and enhance its yield by about 1.4 t ha^{-1} (Table 6.5.2); certified seeds by 359-363 kg ha^{-1}. Farm areas served by national and communal irrigation systems can improve yields by more than 650 kg ha^{-1}, about twice higher than other water sources.

Table 6.5.2. Marginal productivity of inputs in rice farming in Camarines Sur.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	2.19	2.13
Nitrogen (kg ha^{-1})	4.34	4.28
Phosphorus (kg ha^{-1})	11.73	9.32
Herbicide (g ha^{-1})	0.23	0.27
Insecticide (g ha^{-1})	0.71	0.90
Labor (man-day ha^{-1})	11.62	11.41
Machine (machine-day ha^{-1})	2.54	2.82
Large-scale irrigation system	654.44	662.15
Small-scale irrigation system	335.02	338.97
Hybrid seed	1,386.34	1,402.68
Certified inbred seed	358.85	363.07

Table 6.5.1 shows that cost gap in Camarines Sur is wider in January-June (56%) than in July-December (44%). A one-ton increase in yield can significantly cut the cost by PhP 1.14 to PhP 1.33 kg^{-1} (Table 6.5.4). The use of hybrid seeds can cut the cost by PhP 2.04 to PhP 2.34 kg^{-1} due to more yield. The use of combine harvester can also cut cost by about PhP 0.4 kg^{-1}. PhP 0.20 to PhP 0.32 kg^{-1} cost can be cut through either use of certified seeds or drawing water from national and communal irrigation systems (Table 6.5.4)

Table 6.5.3. Profit-maximizing increase in inputs, Camarines Sur.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	1.41	1.68
Nitrogen (kg ha^{-1})	1.04	0.95
Phosphorus (kg ha^{-1})	1.70	1.30
Herbicide (g ha^{-1})	0.32	0.47
Insecticide (g ha^{-1})	0.60	0.74
Labor (man-day ha^{-1})	0.70	0.68
Machine (machine-day ha^{-1})	0.07	0.07

Table 6.5.4. Marginal reduction in cost, Camarines Sur.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-1.33	-1.14
Large-scale irrigation system	0.24	0.21
Hybrid seed	-2.34	-2.04
Certified inbred seed	-0.32	-0.28
Machine for Harvesting & Threshing	-0.39	-0.34

6. Ilocos Norte

Farmers had yields between 3.76 and 7.12 t ha^{-1} in January-June and 3.42 and 5.97 t ha^{-1} in July-December (Table 6.6.1). This results in yield gaps of 2.55 t ha^{-1} in July-December and more than 3 t ha^{-1} in January-June. Yield gap can be reduced if farmers would shift from low-quality to hybrid seeds that produce an additional yield of more than 2 t ha^{-1} in both seasons. Large-scale irrigation also brings an additional yield (i.e., more than 1 t ha^{-1}) to farmers (Table 6.6.2). Increasing one unit of labor could only increase yield by 10 kg ha^{-1} or more in both seasons making work efficient. To be cost-efficient as well, Table 6.6.3 shows that labor could only be increased up to 0.60 man-day ha^{-1} because the wage rate in this province indicates that farmers are already hiring the profit-maximizing number of workers.

Cost comparison of the 90th and 10th percentiles (Table 6.6.1) shows that the difference is slightly higher in January-June (PhP 6.70 kg^{-1}) than in July-December (PhP 5.97 kg^{-1}). Table 6.6.4 shows that cost reduction is possible if farmers would adopt quality hybrid seeds and mechanize harvesting and threshing operations.

Table 6.6.1. Yield and cost gaps in Ilocos Norte, by season.

Item/ Crop period	Percentiles 10th	90th	Gaps Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	3,760	7,121	3,361	89
July-December	3,424	5,970	2,546	74
Cost (PhP kg^{-1})				
January-June	9.37	16.06	-6.70	-41.69
July-December	10.43	16.40	-5.97	-36.39

Table 6.6.2. Marginal productivity of inputs in rice farming in Ilocos Norte.

Item	Marginal increment in yield January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	8.38	6.29
Nitrogen (kg ha^{-1})	2.42	2.92
Phosphorus (kg ha^{-1})	4.77	6.51
Herbicide (g ha^{-1})	154.33	6.82
Insecticide (g ha^{-1})	3.60	1.18
Labor (man-day ha^{-1})	11.49	10.80
Machine (machine-day ha^{-1})	7.56	5.60
Large-scale irrigation system	1,205.45	1,014.46
Small-scale irrigation system	617.10	519.32
Hybrid seed	2,553.61	2,149.00
Certified inbred seed	660.98	556.25

Table 6.6.3. Profit-maximizing increase in inputs, Ilocos Norte.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	1.00	0.84
Nitrogen (kg ha^{-1})	0.56	0.73
Phosphorus (kg ha^{-1})	0.68	1.08
Herbicide (g ha^{-1})	120.93	1.71
Insecticide (g ha^{-1})	1.50	1.07
Labor (man-day ha^{-1})	0.61	0.66
Machine (machine-day ha^{-1})	0.14	0.13

Table 6.6.4. Marginal reduction in cost, Ilocos Norte.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-0.70	-0.87
Large-scale irrigation system	0.23	0.24
Hybrid seed	-2.27	-2.38
Certified inbred seed	-0.31	-0.32
Machine for Harvesting & Threshing	-0.38	-0.40

7. Isabela

Sample farmers attained yields between 2.66 and 6.87 t ha^{-1} in January-June and 1.03 and 6.09 t ha^{-1} in July-December (Table 6.7.1). The yield gaps are 4.22 t ha^{-1} in January-June and about 5.0 t ha^{-1} in July-December, allowing increased yields under farmers' field conditions.

Table 6.7.1. Yield and cost gaps in Isabela, by season.

Item/	Percentiles		Gaps	
Crop period	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	2,656	6,874	4,218	159
July-December	1,028	6,085	5,057	492
Cost (PhP kg^{-1})				
January-June	7.35	13.14	-5.80	-44.09
July-December	8.16	28.01	-19.85	-70.88

Yield gaps may be reduced through the adoption of high-quality hybrid seeds and the use of irrigation facilities (Table 6.7.2). Hybrid could produce yield increments of 1.5 t ha^{-1} in July-December and 2.19 t ha^{-1} in January-June; certified inbred seeds by 0.39 t ha^{-1} (July-December) and 0.57 t ha^{-1} (January-June). If non-irrigated farmers can gain access to large-scale irrigation facilities, they could harvest an additional of 0.72-1.03 t ha^{-1}. With small-scale irrigation systems, they will have a lower yield increment of 0.37-0.53 t ha^{-1}.

Table 6.7.2. Marginal productivity of inputs in rice farming in Isabela.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	3.72	2.46
Nitrogen (kg ha^{-1})	4.75	3.40
Phosphorus (kg ha^{-1})	7.00	5.29
Herbicide (g ha^{-1})	0.24	0.15
Insecticide (g ha^{-1})	1.02	0.67
Labor (man-day ha^{-1})	16.84	11.69
Machine (machine-day ha^{-1})	5.94	4.18
Large-scale irrigation system	1,033.35	719.85
Small-scale irrigation system	528.99	368.51
Hybrid seed	2,189.02	1,524.92
Certified inbred seed	566.61	394.71

All other factors presented in Table 6.7.2 will produce lower yield increments. Increasing one unit of labor, for example, could increase yield by only 12 kg ha^{-1} in July-December and 17 kg ha^{-1} in January-June, accomplishing more activities in less time. To be cost-efficient, Table 6.7.3 shows that the farmer can only increase labor up to 0.55-0.75 man-day ha^{-1}.

Table 6.7.3. Profit-maximizing increase in inputs, Isabela.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	1.61	1.00
Nitrogen (kg ha^{-1})	1.08	0.73
Phosphorus (kg ha^{-1})	1.05	0.70
Herbicide (g ha^{-1})	0.44	0.34
Insecticide (g ha^{-1})	1.02	0.50
Labor (man-day ha^{-1})	0.75	0.55
Machine (machine-day ha^{-1})	0.12	0.11

Cost difference between the 90th and 10th percentiles (Table 6.7.1) is higher in July-December (71%) than in January-June (44%). To reduce cost under current farmers' field conditions, Table 6.7.4 shows that farmers need to adopt quality hybrid seeds and mechanize harvesting and threshing operations.

Table 6.7.4. Marginal reduction in cost, Isabela.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t/ha)	-0.67	-1.52
Large-scale irrigation system	0.19	0.30
Hybrid seed	-1.86	-2.95
Certified inbred seed	-0.25	-0.40
Machine for Harvesting & Threshing	-0.31	-0.50

8. Laguna

Yields of the 10th and 90th percentiles of farmers in January-June are 2.16 and 5.60 t ha^{-1}; 1.50 and 5.47 t ha^{-1} in July-December (Table 6.8.1). These result in yield gap estimates of 3.44 t ha^{-1} in January-June and 3.97 t ha^{-1} in July-D ecember. To increase yields under farmers' field conditions, one kg more in phosphate application can bring about the highest increment of 16-18 kg ha^{-1} (Table 6.8.2). Given the existing prices of paddy and fertilizers (i.e. complete and ammonium phosphate) in this province, additional phosphate applications of 2.47 kg ha^{-1} in January-June and 2.55 kg ha^{-1} in July-December are recommended (Table 6.8.3). While an additional man-day of labor can lead to about 10 kg ha^{-1} increase in yield, the wage rate in Laguna indicates that farmers are already hiring the profit-maximizing number of workers. Hence, increasing more of this input could lead to cost inefficiency.

Table 6.8.1. Yield and cost gaps in Laguna, by season.

Item/ Crop period	Percentiles		Gaps	
	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	2,160	5,600	3,440	159
July-December	1,500	5,472	3,972	265
Cost (PhP kg^{-1})				
January-June	7.94	18.92	-10.98	-58.04
July-December	8.27	19.91	-11.63	-58.43

The adoption of hybrid varieties in this province can give the highest yield improvement of 1.9 t ha^{-1} (Table 6.8.2); certified seeds by 435-487 kg ha^{-1}. Farm areas served by national and communal irrigation systems can improve yields by 794-887 kg ha^{-1}, about two times higher than those with other water sources.

Table 6.8.2. Marginal productivity of inputs in rice farming in Laguna.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	3.03	2.79
Nitrogen (kg ha^{-1})	4.28	4.14
Phosphorus (kg ha^{-1})	15.86	18.49
Herbicide (g ha^{-1})	0.33	0.23
Insecticide (g ha^{-1})	0.67	0.63
Labor (man-day ha^{-1})	10.38	9.97
Machine (machine-day ha^{-1})	4.85	5.34
Large-scale irrigation system	887.36	793.61
Small-scale irrigation system	454.26	406.27
Hybrid seed	1,879.76	1,681.18
Certified inbred seed	486.56	435.16

Table 6.8.1 shows that the gap in cost (difference between 10th and 90th percentiles) is slightly higher in July-December (58.4%) than in January-June (58%). Based on Table 6.8.4, a one-ton increase in yield can reduce the cost by PhP 0.97 to PhP 1.06 kg^{-1}. The use of hybrid seeds will further cut cost by about PhP 2.30 kg^{-1}. Cost efficiency in this province can be improved by increasing yield through hybrid adoption.

Table 6.8.3. Profit-maximizing increase in inputs, Laguna.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	1.67	1.44
Nitrogen (kg ha^{-1})	0.98	0.85
Phosphorus (kg ha^{-1})	2.47	2.55
Herbicide (g ha^{-1})	0.65	0.63
Insecticide (g ha^{-1})	0.27	0.34
Labor (man-day ha^{-1})	0.43	0.43
Machine (machine-day ha^{-1})	0.05	0.05

Table 6.8.4. Marginal reduction in cost, Laguna.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-0.97	-1.06
Large-scale irrigation system	0.24	0.23
Hybrid seed	-2.32	-2.26
Certified inbred seed	-0.31	-0.31
Machine for Harvesting & Threshing	-0.39	-0.38

9. Occidental Mindoro

The yields of majority of the sample farmers range from 3.32 t ha^{-1} to 6.68 t ha^{-1} in January-June and from 3.24 t ha^{-1} to 5.50 t ha^{-1} in July-December (Table 6.9.1). The yield gap is higher in January-June, pointing to the opportunity for increasing yields under farmers' field conditions. These gaps may be reduced by shifting from planting low-quality to high-quality seeds, especially hybrid that could push yield by about 2 t ha^{-1} in both seasons. A shift from non-irrigated to a large-scale irrigation production system could also improve yield by approximately 1 t ha^{-1} in both seasons (Table 6.9.2). Among production inputs, an increase of one kg in phosphate application can bring about the highest yield increment of about 10 kg ha^{-1} (Table 6.9.2). Given the existing prices of paddy and fertilizers in this province, additional phosphate application of less than 2 kg ha^{-1} for both cropping seasons is recommended (Table 6.9.3).

Table 6.9.1. Yield and cost gaps in Occidental Mindoro, by season.

Item/ Crop period	Percentiles		Gaps	
	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	3,323	6,681	3,358	101
July-December	3,242	5,500	2,258	70
Cost (PhP kg^{-1})				
January-June	8.47	14.11	-5.65	-40.02
July-December	9.01	14.65	-5.65	-38.53

Unit cost was PhP 8.57 to PhP 14.11 kg^{-1} in January-June and PhP 9.01 to PhP 14.65 kg^{-1} in July-December (Table 6.9.1). The cost difference of the 90^{th} and 10^{th} percentiles is the same in both seasons, only slightly different in terms of percent change. The unit cost gap indicates that it is possible to reduce cost under current farmers' field conditions. Table 6.9.4 shows that shifting from low-quality to hybrid seeds could result in approximately PhP 2.00 kg^{-1} reduction in cost through higher yield. Assuming that farmers are incurring PhP 12 kg^{-1} cost, then PhP 2.00 is 17% reduction.

Table 6.9.2. Marginal productivity of inputs in rice farming in Occidental Mindoro.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	3.90	3.15
Nitrogen (kg ha^{-1})	3.62	3.07
Phosphorus (kg ha^{-1})	9.72	9.97
Herbicide (g ha^{-1})	0.50	0.22
Insecticide (g ha^{-1})	1.32	0.47
Labor (man-day ha^{-1})	12.19	11.25
Machine (machine-day ha^{-1})	3.97	4.05
Large-scale irrigation system	1,073.27	964.84
Small-scale irrigation system	549.43	493.92
Hybrid seed	2,273.58	2,043.89
Certified inbred seed	588.50	529.05

Table 6.9.3. Profit-maximizing increase in inputs, Occidental Mindoro.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	0.98	1.13
Nitrogen (kg ha^{-1})	1.02	0.72
Phosphorus (kg ha^{-1})	1.80	1.40
Herbicide (g ha^{-1})	2.65	1.01
Insecticide (g ha^{-1})	2.00	0.76
Labor (man-day ha^{-1})	0.93	0.70
Machine (machine-day ha^{-1})	0.13	0.10

Table 6.9.4. Marginal reduction in cost, Occidental Mindoro.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield ($t\ ha^{-1}$)	-0.69	-0.81
Large-scale irrigation system	0.20	0.21
Hybrid seed	-1.99	-2.09
Certified inbred seed	-0.27	-0.28
Machine for Harvesting & Threshing	-0.33	-0.35

10. Oriental Mindoro

Majority of farmers harvested between 2.42 and 5.52 t ha^{-1} in January-June and 2.12 and 5.22 t ha^{-1} in July-December (Table 6.10.1). Yield difference is higher in July-December, which can be reduced if farmers adopt good-quality seeds and irrigation facilities (Table 6.10.2). Marginal yield increment is higher for hybrid seeds and large-scale irrigation facilities. Yield can be further raised by 14-15 kg ha^{-1} if one unit of labor is increased, and 13-14 kg ha^{-1} for every 1 kg ha^{-1} increase in phosphorus. However, Table 6.10.3 shows that to maintain cost efficiency, the maximum quantity of labor that can be added is only around 0.60 man-day ha^{-1} and for phosphorus is only about 2.00 kg ha^{-1}.

Table 6.10.1. Yield and cost gaps in Oriental Mindoro, by season.

Item/	Percentiles		Gaps	
Crop period	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	2,425	5,522	3,097	128
July-December	2,115	5,219	3,104	147
Cost (PhP kg^{-1})				
January-June	9.04	18.03	-8.98	-49.83
July-December	8.38	17.53	-9.15	-52.19

Majority of the farmers spent PhP 9.04 to PhP 18.03 kg^{-1} in January-June and PhP 8.38 to PhP 17.53 kg^{-1} in July-December (Table 6.10.1), with differences almost the same in both seasons. The unit cost gap suggests it is possible to reduce cost under current farmers' field conditions. Table 6.10.4 reveals that adoption of hybrid seeds could reduce cost by more than PhP 2.00 kg^{-1} through high yield. This spreads the total cost over more output, hence lower unit cost.

Table 6.10.2. Marginal productivity of inputs in rice farming in Oriental Mindoro.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	2.28	2.40
Nitrogen (kg ha^{-1})	4.39	3.84
Phosphorus (kg ha^{-1})	13.71	12.88
Herbicide (g ha^{-1})	0.24	0.15
Insecticide (g ha^{-1})	0.83	0.56
Labor (man-day ha^{-1})	14.38	14.68
Machine (machine-day ha^{-1})	3.13	3.33
Large-scale irrigation system	822.82	813.96
Small-scale irrigation system	421.22	416.69
Hybrid seed	1,743.05	1,724.28
Certified inbred seed	451.18	446.32

Table 6.10.3. Profit-maximizing increase in inputs, Oriental Mindoro.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	1.46	1.13
Nitrogen (kg ha^{-1})	0.98	0.78
Phosphorus (kg ha^{-1})	2.25	2.12
Herbicide (g ha^{-1})	0.59	0.29
Insecticide (g ha^{-1})	1.20	0.66
Labor (man-day ha^{-1})	0.61	0.67
Machine (machine-day ha^{-1})	0.10	0.09

Table 6.10.4. Marginal reduction in cost, Oriental Mindoro.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-1.14	-0.98
Large-scale irrigation system	0.26	0.22
Hybrid seed	-2.51	-2.14
Certified inbred seed	-0.34	-0.29
Machine for Harvesting & Threshing	-0.42	-0.36

11. Nueva Ecija

Table 6.11.1 shows that majority of farmers attained yields between 4.00 and 8.83 t ha^{-1} in January-June and 1.08 and 5.16 t ha^{-1} in July-December, with a yield gap of more than 4.00 t ha^{-1} in both seasons. This means there is a great opportunity to increase yields. Table 6.11.2 shows that yield-enhancing factors are adoption of hybrid seeds and irrigation facilities, and increasing the quantity of labor. Highest incremental yield can be attained if farmers would shift to hybrid rice, followed by the use of large-scale irrigation systems. Increasing one unit of labor could result in 9-19 kg ha^{-1} increase in yield. For maximum profit, the production level of Nueva Ecija farmers can only allow an increase of less than 1 man-day amount of labor (Table 6.11.3).

Table 6.11.1. Yield and cost gaps in Nueva Ecija, by season.

Item/ Crop period	Percentiles 10th	90th	Gaps Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	4,000	8,834	4,834	121
July-December	1,078	5,157	4,079	378
Cost (PhP kg^{-1})				
January-June	6.51	13.01	-6.50	-49.98
July-December	9.76	33.57	-23.81	-70.94

Majority of the farmers spent PhP 6.00 to PhP 13.00 kg^{-1} in January-June and PhP 9.76 to PhP 33.57 kg^{-1} in July-December (Table 6.11.1). The cost difference for January-June is lower. The unit cost gap points out that it is possible to reduce cost under current farmers' field conditions. Table 6.11.4 shows that adoption of hybrid seeds could reduce cost by PhP 1.80 kg^{-1} in January-June and PhP 3.62 kg^{-1} in July-December.

Table 6.11.2. Marginal productivity of inputs in rice farming in Nueva Ecija.

Item	Marginal increment in yield January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	4.77	2.26
Nitrogen (kg ha^{-1})	4.37	2.87
Phosphorus (kg ha^{-1})	6.59	4.90
Herbicide (g ha^{-1})	0.24	0.16
Insecticide (g ha^{-1})	0.85	0.37
Labor (man-day ha^{-1})	18.93	9.49
Machine (machine-day ha^{-1})	6.75	3.53
Large-scale irrigation system	1,346.11	726.54
Small-scale irrigation system	689.10	371.93
Hybrid seed	2,851.57	1,539.08
Certified inbred seed	738.11	398.38

Table 6.11.3. Profit-maximizing increase in inputs, Nueva Ecija.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	0.91	0.82
Nitrogen (kg ha^{-1})	1.16	0.65
Phosphorus (kg ha^{-1})	1.10	0.75
Herbicide (g ha^{-1})	0.65	0.34
Insecticide (g ha^{-1})	1.62	0.56
Labor (man-day ha^{-1})	0.84	0.57
Machine (machine-day ha^{-1})	0.09	0.06

Table 6.11.4. Marginal reduction in cost, Nueva Ecija.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-0.50	-1.85
Large-scale irrigation system	0.18	0.37
Hybrid seed	-1.80	-3.62
Certified inbred seed	-0.24	-0.49
Machine for Harvesting & Threshing	-0.30	-0.61

12. Pampanga

Majority of farmers had yields of 3.18 to 6.49 t ha^{-1} in January-June and 1.49 to 4.91 t ha^{-1} in July-December, with a yield gap of not more than 3.5 t ha^{-1} in both seasons (Table 6.12.1). These gaps may be narrowed if farmers would adopt high-quality seeds and use irrigation facilities (Table 6.12.2). Highest yield increment would be from hybrid seeds at more than 1 t ha^{-1} in July-December and more than 2 t ha^{-1} in January-June. Large-scale irrigation system would give additional yield of more than 0.50 t ha^{-1} in July-December and more than 1 t ha^{-1} in January-June. If farmers would increase labor and phosphorus by one unit, yield could increase by more than 10 kg ha^{-1}. However, farmers must increase phosphorus by only 2-3 kg ha^{-1} and labor by less than 1 man-day to be cost-efficient (Table 6.12.3).

Table 6.12.1. Yield and cost gaps in Pampanga, by season.

Item/	Percentiles		Gaps	
Crop period	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	3,182	6,489	3,307	104
July-December	1,493	4,909	3,417	229
Cost (PhP kg^{-1})				
January-June	6.20	15.50	-9.30	-59.99
July-December	7.45	17.91	-10.47	-58.44

Table 6.12.2. Marginal productivity of inputs in rice farming in Pampanga.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	2.47	2.23
Nitrogen (kg ha^{-1})	4.28	3.04
Phosphorus (kg ha^{-1})	19.62	18.91
Herbicide (g ha^{-1})	0.83	0.41
Insecticide (g ha^{-1})	0.94	0.56
Labor (man-day ha^{-1})	17.79	11.29
Machine (machine-day ha^{-1})	4.92	4.66
Large-scale irrigation system	1,013.09	692.78
Small-scale irrigation system	518.62	354.65
Hybrid seed	2,146.12	1,467.57
Certified inbred seed	555.51	379.87

Majority of farmers spent PhP 6.20 to PhP 15.50 kg^{-1} in January-June and PhP 7.45 to PhP 17.91 kg^{-1} in July-December (Table 6.12.1). The cost difference for January-June is lower but has almost the same percent difference. The presence of a unit cost gap indicates that it is possible to reduce cost under current farmers' field conditions. Table 6.12.4 presents the cost-reducing factors for Pampanga farmers. Adoption of hybrid seeds could cut cost by PhP 2.00 kg^{-1} in January-June and PhP 2.30 kg^{-1} in July-December.

Table 6.12.3. Profit-maximizing increase in inputs, Pampanga.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	1.37	1.16
Nitrogen (kg ha^{-1})	1.23	0.67
Phosphorus (kg ha^{-1})	3.51	2.80
Herbicide (g ha^{-1})	1.47	0.31
Insecticide (g ha^{-1})	1.33	0.54
Labor (man-day ha^{-1})	0.70	0.49
Machine (machine-day ha^{-1})	0.08	0.08

Table 6.12.4. Marginal reduction in cost, Pampanga.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-0.74	-1.24
Large-scale irrigation system	0.20	0.23
Hybrid seed	-2.00	-2.30
Certified inbred seed	-0.27	-0.31
Machine for Harvesting & Threshing	-0.34	-0.39

13. Pangasinan

Table 6.13.1 shows that farmers yielded between 2.64 and 5.52 t ha^{-1} in January-June, and 1.81 and 5.18 t ha^{-1} in July-December. Yields on the 90th percentile are more than 100% higher than those in the 10th percentile, meaning yield gaps are high. This implies that there is big room for farmers to improve yields in both seasons. Table 6.13.2 shows yield may be increased mainly by using high-quality seeds, specifically hybrid. This is followed by large and small-scale irrigation systems, and adoption of certified seeds. Increasing labor quantity can also result in significantly more yield. This means that farmers would gain more than 10 kg/ha yield increment for every 1 unit increase in labor. However, to maintain cost efficiency, labor can only be increased by 0.60-0.67 man-day/ha (Table 6.13.3).

Table 6.13.1. Yield and cost gaps in Pangasinan, by season.

Item/	Percentiles		Gaps	
Crop period	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	2,643	5,520	2,877	109
July-December	1,806	5,175	3,369	187
Cost (PhP kg^{-1})				
January-June	8.04	20.01	-11.96	-59.79
July-December	8.84	21.17	-12.34	-58.26

Table 6.13.1 also shows that farmers had a unit cost of PhP 8.04 to PhP 20 kg^{-1} in January-June and PhP 8.84 to PhP 21.17 kg^{-1} in July-December. The percent cost difference for January-June is almost the same with that in the latter season. The presence of a unit cost gap indicates that it is possible to reduce cost under current farmers' field conditions. Table 6.13.4 shows that adoption of hybrid seeds could result in significant cost reduction of PhP 3-5 kg^{-1}.

Table 6.13.2. Marginal productivity of inputs in rice farming in Pangasinan.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	2.82	2.16
Nitrogen (kg ha^{-1})	2.66	2.75
Phosphorus (kg ha^{-1})	7.36	9.77
Herbicide (g ha^{-1})	0.60	0.42
Insecticide (g ha^{-1})	1.05	0.47
Labor (man-day ha^{-1})	12.39	11.61
Machine (machine-day ha^{-1})	6.02	4.80
Large-scale irrigation system	852.27	783.28
Small-scale irrigation system	436.29	400.98
Hybrid seed	1,805.42	1,659.27
Certified inbred seed	467.32	429.49

Table 6.13.3. Profit-maximizing increase in inputs, Pangasinan.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	1.32	0.64
Nitrogen (kg ha^{-1})	0.61	0.57
Phosphorus (kg ha^{-1})	1.08	1.36
Herbicide (g ha^{-1})	0.73	0.71
Insecticide (g ha^{-1})	1.12	0.61
Labor (man-day ha^{-1})	0.67	0.60
Machine (machine-day ha^{-1})	0.08	0.08

Table 6.13.4. Marginal reduction in cost, Pangasinan.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-2.10	-1.22
Large-scale irrigation system	0.49	0.26
Hybrid seed	-4.81	-2.57
Certified inbred seed	-0.65	-0.35
Machine for Harvesting & Threshing	-0.81	-0.43

14. Quezon

Yields of the 90th and 10th percentiles of farmers were respectively 4.79 and 1.53 t ha^{-1} in January-June, and about 5 and 2.44 t ha^{-1} in July-December (Table 6.14.1). Estimated substantial yield gap in both seasons is higher in January-June (3.26 t ha^{-1}) than in July-December (2.56 t ha^{-1}). Among production inputs, applying one more kg of phosphate can provide the highest yield increment of 15-19 kg ha^{-1} (Table 6.14.2). Phosphate applications of 2.21 kg ha^{-1} in January-June and 2.77 kg ha^{-1} in July-December are recommended in this province considering the current prices of paddy, complete fertilizer, and ammonium phosphate (Table 6.14.3). While an additional man-day of labor can lead to 9-9.75 kg ha^{-1} increase in yield, the wage rate in Quezon indicates that farmers are already hiring the profit-maximizing number of workers.

Table 6.14.1. Yield and cost gaps in Quezon, by season.

Item/ Crop period	Percentiles		Gaps	
	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	1,533	4,788	3,255	212
July-December	2,442	4,998	2,556	105
Cost (PhP kg^{-1})				
January-June	8.56	20.88	-12.32	-59.00
July-December	7.77	14.34	-6.57	-45.83

The use of hybrid varieties can also narrow the yield gap in Quezon and enhance its yield by 1.4 - 1.6 t ha^{-1} (Table 6.14.2); certified seeds by 372-411 kg ha^{-1}. Farm areas served by national and communal irrigation systems can improve yields by 679-750 kg ha^{-1}, about two times higher than those with other water sources.

Table 6.14.2. Marginal productivity of inputs in rice farming in Quezon.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	2.86	2.57
Nitrogen (kg ha^{-1})	7.42	10.04
Phosphorus (kg ha^{-1})	15.03	19.00
Herbicide (g ha^{-1})	0.34	0.25
Insecticide (g ha^{-1})	1.97	2.18
Labor (man-day ha^{-1})	9.01	9.75
Machine (machine-day ha^{-1})	2.94	4.06
Large-scale irrigation system	679.30	750.12
Small-scale irrigation system	347.75	384.00
Hybrid seed	1,439.02	1,589.04
Certified inbred seed	372.48	411.31

The gap in production cost is also wider in January-June (59%) than in July-December (46%) (Table 6.14.1). Table 6.14.4 shows that a one-ton increase in yield can reduce the cost by PhP 0.96 to PhP 1.34 kg^{-1}. If farmers use hybrid seeds, cost reduction climbs to PhP 1.94 to PhP 2.45 kg^{-1}. Thus, cost efficiency in this province can be improved by raising yields through hybrid adoption.

Table 6.14.3. Profit-maximizing increase in inputs, Quezon.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	1.71	2.03
Nitrogen (kg ha^{-1})	1.60	2.21
Phosphorus (kg/ha)	2.21	2.77
Herbicide (g ha^{-1})	0.65	0.76
Insecticide (g ha^{-1})	0.92	1.07
Labor (man-day ha^{-1})	0.39	0.56
Machine (machine-day ha^{-1})	0.04	0.06

Table 6.14.4. Marginal reduction in cost, Quezon.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield ($t\ ha^{-1}$)	-1.34	-0.96
Large-scale irrigation system	0.25	0.20
Hybrid seed	-2.45	-1.94
Certified inbred seed	-0.33	-0.26
Machine for Harvesting & Threshing	-0.41	-0.33

15. Tarlac

Farmers yielded 3.22 to 6.34 t ha^{-1} in January-June and 2.28 to 6.00 t ha^{-1} in July-December (Table 6.15.1). Yield gaps are more than 3 t ha^{-1} but higher percent difference is in July-December. To reduce these yield gaps, Table 6.15.2 suggests that farmers adopt hybrid seeds and large-scale irrigation systems to significantly attain high yield increments. Adoption of certified seeds, small-scale irrigation system, labor, and phosphorus can also produce more yields. For biggest profits, phosphorus can be increased up to only 1.55 kg ha^{-1} in July-December and 1.64 kg ha^{-1} in January-June (Table 6.15.3). Labor can be increased only by 0.54 man-day in July-December and 1.64 man-day in January-June, otherwise production will not be cost-efficient.

Table 6.15.1. Yield and cost gaps in Tarlac, by season.

Item/ Crop period	Percentiles		Gaps	
	10th	90th	Absolute	Percentage (%)
Yield ($kg\ ha^{-1}$)				
January-June	3,227	6,336	3,109	96
July-December	2,284	6,000	3,716	163
Cost ($PhP\ kg^{-1}$)				
January-June	8.49	15.33	-6.85	-44.65
July-December	7.89	16.17	-8.28	-51.20

Table 6.15.2. Marginal productivity of inputs in rice farming in Tarlac.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	3.80	3.53
Nitrogen (kg ha^{-1})	3.30	3.09
Phosphorus (kg ha^{-1})	9.63	11.36
Herbicide (g ha^{-1})	0.50	0.39
Insecticide (g ha^{-1})	2.52	0.79
Labor (man-day ha^{-1})	13.09	13.13
Machine (machine-day ha^{-1})	5.58	4.92
Large-scale irrigation system	1,058.22	882.01
Small-scale irrigation system	541.72	451.52
Hybrid seed	2,241.70	1,868.44
Certified inbred seed	580.25	483.63

Farmers had cost differences of PhP 6.85 and PhP 8.28 kg^{-1} in January-June and July-December (Table 6.15.4). Adoption of hybrid seeds could result in more than PhP 2.00 kg^{-1} reduction in cost in both seasons.

Table 6.15.3. Profit-maximizing increase in inputs, Tarlac.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	2.07	1.10
Nitrogen (kg ha^{-1})	0.87	0.64
Phosphorus (kg ha^{-1})	1.64	1.55
Herbicide (g ha^{-1})	0.60	0.78
Insecticide (g ha^{-1})	1.87	0.56
Labor (man-day ha^{-1})	0.78	0.54
Machine (machine-day ha^{-1})	0.11	0.10

Table 6.15.4. Marginal reduction in cost, Tarlac.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-0.74	-0.88
Large-scale irrigation system	0.22	0.21
Hybrid seed	-2.12	-2.09
Certified inbred seed	-0.29	-0.28
Machine for Harvesting & Threshing	-0.36	-0.35

Visayas Provinces

16. Bohol

Yields of the 10th and 90th percentiles of farmers were 1.47 and 3.86 t ha^{-1} in January-June, and 0.76 and 3.83 t ha^{-1} in July-December (Table 6.16.1). Yield gap is higher in January-June (3.07 t ha^{-1}) than in the other season (2.39 t ha^{-1}). To narrow this gap, Table 6.16.2 suggests applying one more kg each of phosphate and nitrogen can respectively lead to about 6 kg ha^{-1} and 5 kg ha^{-1} yield increments, higher than any other input, except labor use. Given existing prices of paddy, an increase of about 1 kg ha^{-1} in phosphate and nitrogen applications in both cropping seasons is recommended in this province (Table 6.16.3). While an additional man-day of labor can lead to about 6 kg ha^{-1} increase in yield, the wage rate in Bohol like other provinces indicates that farmers are already hiring the profit-maximizing number of workers.

The use of hybrid varieties can also narrow yield gap in Bohol and enhance its yield by more than 1 t ha^{-1} (Table 6.16.2); certified seeds by 271-302 kg ha^{-1}. Farm areas served by national and communal irrigation systems can also improve yields by 495-552 kg ha^{-1}, almost twice higher than those with other sources of water.

Table 6.16.1. Yield and cost gaps in Bohol, by season.

Item/ Crop period	Percentiles		Gaps	
	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	1,467	3,858	2,391	163
July-December	755	3,827	3,072	407
Cost (PhP kg^{-1})				
January-June	11.30	20.77	-9.47	-45.61
July-December	10.57	28.16	-17.59	-62.46

Table 6.16.1 shows that gap in cost is higher in July-December (62%) than in January-June (46%). Based on Table 6.16.4, a one-ton increase in yield can reduce the cost by PhP 1.85 to PhP 2.83 kg^{-1}. This cost reduction further climbs to PhP 2.74 to PhP 3.76 kg^{-1} if farmers will use hybrid technology. The use of combine harvester can also cut cost by PhP 0.46 to PhP 0.63 kg^{-1}. PhP 0.33 to PhP 0.44 kg^{-1} of costs can be reduced by farmers who have access to national and communal irrigation systems, and are users of certified seeds as well (Table 6.16.4).

Table 6.16.2. Marginal productivity of inputs in rice farming in Bohol.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	3.75	2.97
Nitrogen (kg ha^{-1})	5.40	5.12
Phosphorus (kg ha^{-1})	5.54	5.70
Herbicide (g ha^{-1})	1.35	1.47
Insecticide (g ha^{-1})	4.85	3.50
Labor (man-day ha^{-1})	5.55	5.86
Machine (machine-day ha^{-1})	2.71	2.68
Large-scale irrigation system	551.63	494.80
Small-scale irrigation system	282.39	253.30
Hybrid seed	1,168.57	1,048.17
Certified inbred seed	302.48	271.31

Table 6.16.3. Profit-maximizing increase in inputs, Bohol.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	2.25	1.90
Nitrogen (kg ha^{-1})	1.40	1.22
Phosphorus (kg ha^{-1})	0.85	0.91
Herbicide (g ha^{-1})	4.80	2.91
Insecticide (g ha^{-1})	1.75	2.40
Labor (man-day ha^{-1})	0.43	0.42
Machine (machine-day ha^{-1})	0.04	0.05

Table 6.16.4. Marginal reduction in cost, Bohol.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-1.85	-2.83
Large-scale irrigation system	0.28	0.38
Hybrid seed	-2.74	-3.76
Certified inbred seed	-0.37	-0.51
Machine for Harvesting & Threshing	-0.46	-0.63

17. Iloilo

Farmers had yields of 1.48 to 4.37 t ha^{-1} in January-June and 1.54 to 5.24 t ha^{-1} in July-December (Table 6.17.1). Yield gap is higher in July-December (3.70 t ha^{-1}) than in January-June (2.89 t ha^{-1}). Table 6.17.2 shows that an additional man-day of labor can lead to 11-15 kg ha^{-1} increase in yield, higher than from any other input. However, the wage rate in Iloilo indicates that farmers are already hiring the profit-maximizing number of workers, needing no more farm workers. Among other inputs, an increase of one kg in phosphate application can deliver the highest yield increment of 7-8 kg ha^{-1} (Table 6.17.2). Thus, additional phosphate applications of about 1 kg ha^{-1} in both cropping periods are recommended in this province considering the current prices of paddy, complete fertilizer, and ammonium phosphate (Table 6.17.3).

Table 6.17.1. Yield and cost gaps in Iloilo, by season.

Item/ Crop period	Percentiles		Gaps	
	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	1,485	4,371	2,886	194
July-December	1,545	5,240	3,695	239
Cost (PhP kg^{-1})				
January-June	8.95	19.76	-10.80	-54.68
July-December	8.79	16.47	-7.68	-46.65

Hybrid varieties can significantly reduce the yield gap in the province and enhance its yield by 1.27-1.44 t ha^{-1} (Table 6.17.2); certified seeds by 323-373 kg ha^{-1}. Like in other provinces, farm areas served by national and communal irrigation systems can improve yields by 601-680 kg ha^{-1}, almost twice higher than those with other sources of water.

Table 6.17.2. Marginal productivity of inputs in rice farming in Iloilo.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	1.22	1.45
Nitrogen (kg ha^{-1})	2.76	3.08
Phosphorus (kg ha^{-1})	6.84	8.01
Herbicide (g ha^{-1})	0.12	0.17
Insecticide (g ha^{-1})	0.30	0.47
Labor (man-day ha^{-1})	10.81	14.82
Machine (machine-day ha^{-1})	2.50	3.43
Large-scale irrigation system	601.24	680.11
Small-scale irrigation system	307.79	348.16
Hybrid seed	1,273.66	1,440.73
Certified inbred seed	329.68	372.92

Table 6.17.1 shows that gap in production cost (i.e. cost difference between 10th and 90th percentiles) in the province is wider in July-December (55%) than in January-June (47%). A one-ton increase in yield can reduce the cost by PhP 1.23 to PhP 1.56 kg^{-1} (Table 6.17. 4). Hybrid seeds can significantly reduce the cost by PhP 2.25 to PhP 2.52 kg^{-1}, ensuring cost efficiency.

Table 6.17.3 Profit-maximizing increase in inputs, Iloilo.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	0.99	0.71
Nitrogen (kg ha^{-1})	0.62	0.68
Phosphorus (kg ha^{-1})	0.98	1.08
Herbicide (g ha^{-1})	0.20	0.19
Insecticide (g ha^{-1})	0.37	0.43
Labor (man-day ha^{-1})	0.76	0.75
Machine (machine-day ha^{-1})	0.06	0.04

Table 6.17.4. Marginal reduction in cost, Iloilo.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-1.56	-1.23
Large-scale irrigation system	0.26	0.23
Hybrid seed	-2.52	-2.25
Certified inbred seed	-0.34	-0.30
Machine for Harvesting & Threshing	-0.42	-0.38

18. Leyte

Farmers attained yields between 1.66 and 4.75 t ha^{-1} in January-June, and 1.33 and 4.33 t ha-^{1} in July-December (Table 6.18.1). Yield gap estimates of more than 3 t ha^{-1} in the province were almost similar for both cropping seasons. Based on Table 6.18.2, applying one more kg of phosphate can lead to 16-19 kg ha^{-1} increment in yield, higher than from any other input. At profit-maximizing increases in inputs, additional phosphate applications of 2.32 kg ha^{-1} and 2.83 kg ha^{-1} in January-June and July-December crops are recommended (Table 6.18.2). An additional man-day of labor can also lead to a yield increment of about 7 kg ha^{-1}. However, given the current wage rate in the province, hiring more number of workers would only lead to cost inefficiency.

Table 6.18.1. Yield and cost gaps in Leyte, by season.

Item/ Crop period	Percentiles		Gaps	
	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	1,662	4,752	3,090	186
July-December	1,331	4,331	3,001	226
Cost (PhP kg^{-1})				
January-June	9.70	17.87	-8.17	-45.73
July-December	8.79	17.14	-8.34	-48.69

Adoption of hybrid varieties in this province can give the highest yield improvement of 1.30-1.40 t ha^{-1} (Table 6.18.2); certified seeds by 336-361 kg ha^{-1}. Farm areas served by national and communal irrigation systems can improve yields by 612-659 kg ha^{-1}, about two times higher than those with other sources of water.

Table 6.18.1 shows that gap in cost is slightly higher in July-December (49%) than in January-June (46%). Based on Table 6.18.4, a one-ton increase in yield can reduce the cost by PhP 1.39 to PhP 1.46 kg^{-1}. Cost reduction further climbs to PhP 2.29 to PhP 2.58 kg^{-1} if farmers will use hybrid seeds. The use of combine harvester can cut cost by about PhP 0.40 kg^{-1}. On average, PhP 0.23 kg^{-1} and PhP 0.35 kg^{-1} of costs can be reduced by farmers who have access to national and communal irrigation systems, and are users of certified seeds as well (Table 6.18.4).

Table 6.18.2. Marginal productivity of inputs in rice farming in Leyte.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	3.60	3.24
Nitrogen (kg ha^{-1})	4.38	5.18
Phosphorus (kg ha^{-1})	15.59	18.81
Herbicide (g ha^{-1})	0.46	0.44
Insecticide (g ha^{-1})	1.11	1.02
Labor (man-day ha^{-1})	7.10	7.42
Machine (machine-day ha^{-1})	3.67	3.25
Large-scale irrigation system	658.84	612.39
Small-scale irrigation system	337.28	313.50
Hybrid seed	1,395.68	1,297.28
Certified inbred seed	361.26	335.79

Table 6.18.3 Profit-maximizing increase in inputs, Leyte.

Item	Profit-maximizing increase in inputs	
	January-June	**July-December**
Seed (kg ha^{-1})	2.05	1.19
Nitrogen (kg ha^{-1})	1.06	1.18
Phosphorus (kg ha^{-1})	2.32	2.83
Herbicide (g ha^{-1})	0.83	0.71
Insecticide (g ha^{-1})	0.65	0.63
Labor (man-day ha^{-1})	0.54	0.56
Machine (machine-day ha^{-1})	0.05	0.04

Table 6.18.4. Marginal reduction in cost, Leyte.

Item	Marginal reduction in cost kg^{-1}	
	January-June	**July-December**
Yield (t ha^{-1})	-1.46	-1.39
Large-scale irrigation system	0.26	0.23
Hybrid seed	-2.58	-2.29
Certified inbred seed	-0.35	-0.31
Machine for Harvesting & Threshing	-0.43	-0.38

19. Northern Samar

Yield estimates here are between 1.60 and 3.14 t ha^{-1} in January-June, and 0.95 and 3.57 t ha^{-1} in July-December (Table 6.19.1). This shows a higher yield gap in July-Dec (2.62 t ha^{-1}) than in the other period (1.54 t ha^{-1}). Among production inputs, one more kg each of phosphate and nitrogen respectively led to 71-323 kg ha^{-1} and about 20 kg ha^{-1} yield increments, higher than from any other input (Table 6.19.2). Given the existing prices of paddy, an increase of 8.15 and 39.76 kg ha^{-1} in phosphate applications in January-June and July-December is recommended in this province (Table 6.19.3). Additional nitrogen applications of more than 3 kg ha^{-1} in both cropping seasons are also recommended. Proper timing and right amount of insecticide application can also contribute in narrowing the yield gap by as much as 7.54 to 9.53 kg ha^{-1}. An increase of 2.95 g ha^{-1} in insecticide use in January-June and 2.37 g ha^{-1} in July-December is advised. While an additional man-day of labor can lead to about 6 kg ha^{-1} increase in yield, the wage rate in Northern Samar like other provinces indicates that farmers are already hiring the profit-maximizing number of workers, needing no more labor input.

Table 6.19.1. Yield and cost gaps in Northern Samar, by season.

Item/ Crop period	Percentiles		Gaps	
	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	1,600	3,136	1,536	96
July-December	949	3,566	2,617	276
Cost (PhP kg^{-1})				
January-June	9.37	14.21	-4.83	-34.03
July-December	8.53	13.47	-4.94	-36.70

Table 6.19.2. Marginal productivity of inputs in rice farming in Northern Samar.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	2.51	2.01
Nitrogen (kg ha^{-1})	20.03	19.28
Phosphorus (kg ha^{-1})	70.55	322.79
Herbicide (g ha^{-1})	4.62	3.44
Insecticide (g ha^{-1})	7.54	9.53
Labor (man-day ha^{-1})	5.64	5.96
Machine (machine-day ha^{-1})	1.80	2.36
Large-scale irrigation system	486.54	530.10
Small-scale irrigation system	249.07	271.37
Hybrid seed	1,030.68	1,122.96
Certified inbred seed	266.78	290.67

Adoption of hybrid varieties in this province can give the highest yield improvement of more than 1 t ha^{-1} (Table 6.19.2); certified seeds by about 300 kg ha^{-1}. Farm areas served by national and communal irrigation systems can improve yields by 486-530 kg ha^{-1}, almost doubling those with other sources of water.

Table 6.19.1 shows that gap in cost is slightly higher in July-December (37%) than in January-June crop (34%). Based on Table 6.19.4, a one-ton increase in yield can reduce the cost by PhP 1.36 to PhP 1.58 kg^{-1}. This cost reduction further increases to PhP 1.94 to PhP 2.07 kg^{-1} if farmers will use hybrid technology. The use of combine harvester can also cut cost by about PhP 0.35 kg^{-1}. On average, PhP 0.20 and PhP 0.27 kg^{-1} of costs can be reduced by farmers who have access to national and communal irrigation systems, and are users of certified seeds as well.

Table 6.19.3. Profit-maximizing increase in inputs, Northern Samar.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	1.31	1.09
Nitrogen (kg ha^{-1})	3.65	3.24
Phosphorus (kg ha^{-1})	8.15	39.76
Herbicide (g ha^{-1})	6.80	6.25
Insecticide (g ha^{-1})	2.95	2.37
Labor (man-day ha^{-1})	0.40	0.39
Machine (machine-day ha^{-1})	0.09	0.11

Table 6.19.4. Marginal reduction in cost, Northern Samar.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-1.58	-1.36
Large-scale irrigation system	0.21	0.20
Hybrid seed	-2.07	-1.94
Certified inbred seed	-0.28	-0.26
Machine for Harvesting & Threshing	-0.35	-0.33

Mindanao Provinces

20. Agusan del Norte

Table 6.20.1 shows that yield gap here is higher in July-December (5.21 t ha^{-1}) than in January-June (3.54 t ha^{-1}). Based on Table 6.20.2, applying one more kg of phosphate can lead to 16-17 kg increase in yield, higher than from any other input. Given the existing prices of paddy, complete fertilizer, and ammonium phosphate in this province, an increase of 2.63 kg ha^{-1} in phosphate use in January-June and 3.38 kg ha^{-1} in July-December (Table 6.20.3) is recommended. While an additional man-day of labor can increase yield by 10-11 kg ha^{-1}, the wage rate in Agusan del Norte indicates that farmers are already hiring the profit-maximizing number of workers.

Table 6.20.1. Yield and cost gaps in Agusan del Norte, by season.

Item/ Crop period	Percentiles		Gaps	
	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	2,499	6,040	3,541	142
July-December	1,478	6,684	5,206	352
Cost (PhP kg^{-1})				
January-June	8.30	14.47	-6.17	-42.62
July-December	7.24	18.19	-10.96	-60.23

The use of hybrid varieties can also improve yield in Agusan del Norte by as much as 1.8 t ha^{-1}; certified inbred seeds by 467-471 kg ha^{-1}. Water source also matters as yield in areas served by national and communal irrigation systems was higher by 852-860 kg ha^{-1} than those with other sources.

Table 6.20.2. Marginal productivity of inputs in rice farming in Agusan del Norte.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	3.76	3.85
Nitrogen (kg ha^{-1})	7.08	5.99
Phosphorus (kg ha^{-1})	15.62	17.40
Herbicide (g ha^{-1})	0.10	0.10
Insecticide (g ha^{-1})	0.61	0.89
Labor (man-day ha^{-1})	10.24	10.77
Machine (machine-day ha^{-1})	3.17	5.26
Large-scale irrigation system	859.60	852.09
Small-scale irrigation system	440.05	436.20
Hybrid seed	1,820.96	1,805.05
Certified inbred seed	471.34	467.23

The gap in cost is wider in July-December (60%) than in January-June when the cost of the 10th percentile is 42% lower than the 90th percentile. Table 6.20.4 shows that a one-ton increase in yield can reduce cost by PhP 0.8 kg^{-1}. Likewise, the use of hybrid seed can significantly cut the cost by PhP 1.9 kg^{-1}, improving cost efficiency in this province.

Table 6.20.3. Profit-maximizing increase in inputs, Agusan del Norte.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	2.34	2.24
Nitrogen (kg ha^{-1})	1.55	1.21
Phosphorus (kg ha^{-1})	2.63	3.38
Herbicide (g ha^{-1})	0.35	0.48
Insecticide (g ha^{-1})	1.00	0.87
Labor (man-day ha^{-1})	0.67	0.59
Machine (machine-day ha^{-1})	0.08	0.13

Table 6.20.4. Marginal reduction in cost, Agusan del Norte.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-0.82	-0.83
Large-scale Irrigation System	0.20	0.20
Hybrid seed	-1.92	-1.93
Certified inbred seed	-0.27	-0.27
Machine for Harvesting & Threshing	-0.33	-0.33

21. Agusan del Sur

Farmers yielded between 1.95 and 5.71 t ha^{-1} in January-June, and 1.02 and 5.46 t ha^{-1} in July-December (Table 6.21.1). Yield gaps are more than 3.5 t ha^{-1} but highest percent difference is in July-Dec. Table 6.21.2 suggests that farmers adopt hybrid seeds and large-scale irrigation systems to significantly attain high yield increments. Other yield-enhancing technologies are adoption of certified seeds, small-scale irrigation systems, labor, and phosphorus. Profit maximization shows that P rates can be increased up to 1.55 kg ha^{-1} in July-December and 1.64 kg ha^{-1} in January-June (Table 6.21.3). Labor can be increased by 0.54 man-day in July-December and 1.64 man-day in January-June, beyond which production will not be cost-efficient anymore.

Cost differences were PhP 9.00 kg^{-1} in January-June and PhP 22.00 kg^{-1} in July-December (Table 6.21.4). Farmers could reduce cost if they increase their yields, and adopt quality seeds and combine harvesters. Highest cost reduction (i.e., PhP 2.18-PhP 4.43 kg^{-1}) is from adoption of hybrid seeds, resulting in less cost incurred per unit of output.

Table 6.21.1. Yield and cost gaps in Agusan del Sur, by season.

Item/ Crop period	Percentiles		Gaps	
	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	1,953	5,706	3,754	192
July-December	1,020	5,457	4,437	435
Cost (PhP kg^{-1})				
January-June	7.99	16.99	-9.00	-52.98
July-December	9.11	31.43	-22.31	-71.00

Table 6.21.2. Marginal productivity of inputs in rice farming in Agusan del Sur.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	3.07	2.92
Nitrogen (kg ha^{-1})	12.25	9.75
Phosphorus (kg ha^{-1})	30.36	30.73
Herbicide (g ha^{-1})	0.13	0.12
Insecticide (g ha^{-1})	0.35	0.47
Labor (man-day ha^{-1})	13.15	12.64
Machine (machine-day ha^{-1})	4.18	3.62
Large-scale irrigation system	807.02	712.46
Small-scale irrigation system	413.13	364.73
Hybrid seed	1,709.57	1,509.27
Certified inbred seed	442.51	390.66

Table 6.21.3. Profit-maximizing increase in inputs, Agusan del Sur.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	2.05	1.80
Nitrogen (kg ha^{-1})	2.73	2.16
Phosphorus (kg ha^{-1})	5.22	7.45
Herbicide (g ha^{-1})	0.40	0.29
Insecticide (g ha^{-1})	0.45	0.75
Labor (man-day ha^{-1})	0.69	0.66
Machine (machine-day ha^{-1})	0.13	0.10

Table 6.21.4. Marginal reduction in cost, Agusan del Sur.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-1.00	-2.31
Large-scale irrigation system	0.22	0.45
Hybrid seed	-2.18	-4.43
Certified inbred seed	-0.29	-0.60
Machine for Harvesting & Threshing	-0.37	-0.74

22. Bukidnon

Farmers yielded 1.98 to 5.89 t ha^{-1} in January-June and 1.96 to 5.85 t ha^{-1} in July-December (Table 6.22.1), with yield gap higher in July-December (3.89 t ha^{-1}) than in January-June (3.51 t ha^{-1}). Table 6.22.2 shows that an additional man-day of labor can lead to 12-14 kg ha^{-1} increase in yield, which is higher than from any other input. Bukidnon farmers are already hiring the profit-maximizing number of workers. Increase of one kg in phosphate application can also bring a yield increment of 8-9 kg ha^{-1}, hence applications of about 1 kg ha^{-1} in both cropping periods are recommended considering the current prices of paddy, complete fertilizer, and ammonium phosphate (Table 6.22.3).

Hybrid varieties can significantly reduce yield gaps in the province and enhance its yields by about 1.70 ha^{-1} in both cropping periods (Table 6.22.2); certified seeds by about 450 kg ha^{-1}. Farm areas served by national and communal irrigation systems can improve yields by more than 800 kg ha^{-1}, almost doubling those with other sources of water.

Table 6.22.1. Yield and cost gaps in Bukidnon, by season.

Item/ Crop period	Percentiles		Gaps	
	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	1,976	5,487	3,511	178
July-December	1,964	5,852	3,888	198
Cost (PhP kg^{-1})				
January-June	8.85	16.87	-8.01	-47.51
July-December	8.52	19.40	-10.88	-56.06

Table 6.22.2. Marginal productivity of inputs in rice farming in Bukidnon.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	2.40	2.07
Nitrogen (kg ha^{-1})	4.16	4.26
Phosphorus (kg ha^{-1})	8.36	8.69
Herbicide (g ha^{-1})	0.17	0.17
Insecticide (g ha^{-1})	0.31	0.30
Labor (man-day ha^{-1})	12.02	14.34
Machine (machine-day ha^{-1})	4.51	5.56
Large-scale irrigation system	824.60	808.22
Small-scale irrigation system	422.13	413.75
Hybrid seed	1,746.81	1,712.12
Certified inbred seed	452.15	443.17

Table 6.22.1 shows that gap in production cost (i.e. cost difference between 10th and 90th percentiles) is wider in July-December (55%) than in January-June (47%). A one-ton increase in yield can reduce the cost by more than PhP 1.00 kg^{-1} in both cropping periods (Table 6.22.4). Hybrid seeds can significantly reduce cost by PhP 2.30 kg^{-1} in both crops.

Table 6.22.3 Profit-maximizing increase in inputs, Bukidnon.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	1.09	1.54
Nitrogen (kg ha^{-1})	1.10	1.06
Phosphorus (kg ha^{-1})	1.56	1.57
Herbicide (g ha^{-1})	0.87	0.58
Insecticide (g ha^{-1})	0.58	0.59
Labor (man-day ha^{-1})	0.65	0.69
Machine (machine-day ha^{-1})	0.11	0.11

Table 6.22.4. Marginal reduction in cost, Bukidnon.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-1.04	-1.09
Large-scale irrigation system	0.23	0.24
Hybrid seed	-2.30	-2.36
Certified inbred seed	-0.31	-0.32
Machine for Harvesting & Threshing	-0.39	-0.40

23. Compostela Valley

Farmers yielded between 2.95 and 6.60 t ha^{-1} in January-June, and 3.87 and 6.90 t ha^{-1} in July-December (Table 6.23.1). Yield gap estimates of more than 3 t ha^{-1} were almost similar for both seasons. Based on Table 6.23.2, applying one more kg of phosphate can lead to 13-23 kg ha^{-1} increment in yield, higher than from any other input. At profit-maximizing increase in input, additional P applications of 2.12 kg ha^{-1} in January-June and 3.97 kg ha^{-1} in July-December are recommended (Table 6.23.3). An additional man-day of labor only can also lead to a yield increment of 13-15 kg ha^{-1}.

Hybrid varieties can give the highest yield improvement of 2.14-2.44 t ha^{-1} (Table 6.23.2); certified seeds by 555-632 kg ha^{-1}. Farm areas served by national and communal irrigation systems can improve yields by more than 1 t ha^{-1}, about twice higher than those with other sources of water.

Table 6.23.1. Yield and cost gaps in Compostela Valley, by season.

Item/ Crop period	Percentiles		Gaps	
	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	2,954	6,603	3,650	124
July-December	3,866	6,904	3,039	79
Cost (PhP kg^{-1})				
January-June	7.19	16.47	-9.28	-56.36
July-December	7.02	13.94	-6.93	-49.68

Table 6.23.1 shows that gap in cost is higher in July-December (49%) than in January-June (46%). Based on Table 6.23.4, a one-ton increase in yield can reduce the cost by PhP 1.00 kg^{-1}; about PhP 2.00 kg^{-1} if farmers will use hybrid seeds. The use of combine harvester can cut cost by some PhP 0.40 kg^{-1}. On average, PhP 0.20 and PhP 0.30 kg^{-1} of costs can be reduced by farmers who have access to national and communal irrigation systems, and are users of certified seeds, respectively.

Table 6.23.2. Marginal productivity of inputs in rice farming in Compostela Valley.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	3.58	4.29
Nitrogen (kg ha^{-1})	4.60	5.39
Phosphorus (kg ha^{-1})	13.08	22.54
Herbicide (g ha^{-1})	0.13	0.13
Insecticide (g ha^{-1})	0.42	0.39
Labor (man-day ha^{-1})	12.81	15.24
Machine (machine-day ha^{-1})	3.72	5.46
Large-scale irrigation system	1,011.61	1,153.07
Small-scale irrigation system	517.87	590.28
Hybrid seed	2,142.98	2,442.63
Certified inbred seed	554.70	632.26

Table 6.23.3. Profit-maximizing increase in inputs, Compostela Valley.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	1.37	1.07
Nitrogen (kg ha^{-1})	1.08	1.20
Phosphorus (kg ha^{-1})	2.12	3.97
Herbicide (g ha^{-1})	0.67	1.40
Insecticide (g ha^{-1})	0.55	0.79
Labor (man-day ha^{-1})	0.90	0.84
Machine (machine-day ha^{-1})	0.11	0.10

Table 6.23.4. Marginal reduction in cost, Compostela Valley.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-0.75	-0.60
Large-scale irrigation system	0.21	0.19
Hybrid seed	-2.04	-1.87
Certified inbred seed	-0.28	-0.25
Machine for Harvesting & Threshing	-0.34	-0.31

24. Davao del Norte

Majority of farmers harvested 2.23 to 6.45 t ha^{-1} in January-June and 3.37 to 7.40 t ha^{-1} in July-December (Table 6.24.1). Yield difference is higher in July-Dec (4.03 t ha^{-1}) than in Jan-June (3.16 t ha^{-1}). These differences can be significantly reduced if farmers adopt good-quality seeds and irrigation facilities (Table 6.24.2). Marginal yield increment is higher for hybrid seeds (2.17-2.41 t ha^{-1}) and large-scale irrigation facilities (1.04-1.14 t ha^{-1}). Yield can be further increased by 12-15 kg ha^{-1} if one unit of labor is increased, and 16-19 kg ha^{-1} for every 1 kg ha^{-1} increase in phosphorus. Table 6.24.3 shows that to maintain cost efficiency, only around 0.80 man-day ha^{-1} and 3.00 kg ha^{-1} P can be added.

Table 6.24.1. Yield and cost gaps in Davao del Norte, by season.

Item/ Crop period	Percentiles		Gaps	
	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	3,285	6,450	3,165	96
July-December	3,373	7,401	4,028	119
Cost (PhP kg^{-1})				
January-June	9.19	14.25	-5.06	-35.52
July-December	8.52	15.58	-7.06	-45.32

Majority of the farmers incurred a unit cost of PhP 9.19 to PhP 14.25 kg^{-1} in January-June and PhP 8.52 to PhP 15.58 kg^{-1} in July-December (Table 6.24.1). Differences are PhP 5.00 to PhP 7.00 kg^{-1}, with the latter season incurring the higher cost gap. Table 6.24.4 shows that adoption of hybrid seeds could reduce cost by more than PhP 2.00 kg^{-1} as total cost is spread over higher quantity of output.

Table 6.24.2. Marginal productivity of inputs in rice farming in Davao del Norte.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	4.89	4.88
Nitrogen (kg ha^{-1})	5.16	5.40
Phosphorus (kg ha^{-1})	19.42	16.16
Herbicide (g ha^{-1})	0.12	0.15
Insecticide (g ha^{-1})	0.26	0.54
Labor (man-day ha^{-1})	11.81	14.62
Machine (machine-day ha^{-1})	4.24	5.36
Large-scale irrigation system	1,024.74	1,137.31
Small-scale irrigation system	524.59	582.21
Hybrid seed	2,170.79	2,409.25
Certified inbred seed	561.89	623.62

Table 6.24.3. Profit-maximizing increase in inputs, Davao del Norte.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	2.90	2.85
Nitrogen (kg ha^{-1})	1.33	1.38
Phosphorus (kg ha^{-1})	3.28	2.80
Herbicide (g ha^{-1})	1.27	0.57
Insecticide (g ha^{-1})	0.88	1.08
Labor (man-day ha^{-1})	0.77	0.83
Machine (machine-day ha^{-1})	0.11	0.14

Table 6.24.4. Marginal reduction in cost, Davao del Norte.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-0.78	-0.67
Large-scale irrigation system	0.22	0.21
Hybrid seed	-2.15	-2.06
Certified inbred seed	-0.29	-0.28
Machine for Harvesting & Threshing	-0.36	-0.35

25. Davao Oriental

Yields of the 10th and 90th percentiles of farmers in January-June are 3.73 and 6.95 t ha^{-1}, while 3.58 and 7.20 t ha^{-1} in July-December (Table 6.25.1). Yield gap is estimated at 3.22 t ha^{-1} in January-June and 3.62 t ha^{-1} in July-December. Suggesting room for increased yields under farmers' field conditions. One kg more in phosphate application can provide a yield increment of 10-11 kg ha^{-1} (Table 6.25.2). Given the existing prices of paddy and fertilizers (i.e. complete and ammonium phosphate), additional P applications of 1.76 kg ha^{-1} in January-June and 2.03 kg ha^{-1} in July-December are recommended (Table 6.25.3). Only one more man-day of labor can be added for an 11-12 kg ha^{-1} increase in yield, as farmers are already hiring the profit-maximizing number of workers.

Table 6.25.1. Yield and cost gaps in Davao Oriental, by season.

Item/ Crop period	Percentiles		Gaps	
	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	3,735	6,954	3,219	86
July-December	3,578	7,200	3,623	101
Cost (PhP kg^{-1})				
January-June	9.51	15.42	-5.91	-38.34
July-December	9.25	16.75	-7.50	-44.77

Hybrid varieties can give the highest yield improvement of 2.50 t ha^{-1} (Table 6.25.2); certified seeds by 634-641 kg ha^{-1}. Farm areas served by national and communal irrigation systems can improve yields by more than 1 t ha^{-1}, about twice higher than those with other sources of water.

Table 6.25.2. Marginal productivity of inputs in rice farming in Davao Oriental.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	5.01	4.98
Nitrogen (kg ha^{-1})	4.37	4.73
Phosphorus (kg ha^{-1})	9.86	11.20
Herbicide (g ha^{-1})	0.18	0.26
Insecticide (g ha^{-1})	0.23	0.19
Labor (man-day ha^{-1})	12.04	11.49
Machine (machine-day ha^{-1})	4.22	4.84
Large-scale irrigation system	1,168.34	1,155.92
Small-scale irrigation system	598.10	591.74
Hybrid seed	2,474.99	2,448.68
Certified inbred seed	640.63	633.82

Table 6.25.3. Profit-maximizing increase in inputs, Davao Oriental.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	2.73	2.15
Nitrogen (kg ha^{-1})	1.07	0.98
Phosphorus (kg ha^{-1})	1.76	2.03
Herbicide (g ha^{-1})	0.68	0.77
Insecticide (g ha^{-1})	1.00	0.79
Labor (man-day ha^{-1})	0.67	0.62
Machine (machine-day ha^{-1})	0.09	0.11

Table 6.25.1 shows that gap in cost (i.e. cost difference between 10th and 90th percentiles) is higher in July-December (45%) than in January-June (38%). Based on Table 6.25.4, a one-ton increase in yield can reduce the cost by PhP 0.70 kg^{-1}; by more than PhP 2.00 kg^{-1} if farmers will use hybrid seeds.

Table 6.25.4. Marginal reduction in cost, Davao Oriental.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-0.71	-0.74
Large-scale irrigation system	0.23	0.24
Hybrid seed	-2.24	-2.30
Certified inbred seed	-0.30	-0.31
Machine for Harvesting & Threshing	-0.38	-0.39

26. Davao del Sur

Farmers yielded between 3.01 and 6.68 t ha^{-1} in January-June and 2.62 and 7.40 t ha^{-1} in July-December (Table 6.26.1). Yield gap is higher in July-December (4.78 t ha^{-1}) than in January-June (3.61 t ha^{-1}). Table 6.26.2 shows that an additional man-day of labor can lead to 13-14 kg ha^{-1} increase in yield, which is higher than from any other input. Farmers are already hiring the profit-maximizing number of workers, thus no need for more farm workers. One kg more in phosphate application can support a significant yield increment of 11-12 kg ha^{-1} (Table 6.26.2). Additional P applications of about 2 kg ha^{-1} in both cropping periods are recommended considering the current prices of paddy, complete fertilizer, and ammonium phosphate (Table 6.26.3).

Table 6.26.1. Yield and cost gaps in Davao del Sur, by season.

Item/ Crop period	Percentiles		Gaps	
	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	3,066	6,681	3,615	118
July-December	2,619	7,404	4,785	183
Cost (PhP kg^{-1})				
January-June	8.24	12.98	-4.74	-36.50
July-December	7.99	17.88	-9.89	-55.32

Table 6.26.2. Marginal productivity of inputs in rice farming in Davao del Sur.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	3.57	3.65
Nitrogen (kg ha^{-1})	4.03	3.82
Phosphorus (kg ha^{-1})	12.13	11.12
Herbicide (g ha^{-1})	0.17	0.16
Insecticide (g ha^{-1})	0.45	0.44
Labor (man-day ha^{-1})	13.90	12.86
Machine (machine-day ha^{-1})	4.00	3.89
Large-scale irrigation system	1,112.78	1,106.24
Small-scale irrigation system	569.65	566.31
Hybrid seed	2,357.28	2,343.44
Certified inbred seed	610.17	606.58

Hybrid varieties can significantly reduce the yield gap and enhance yields by more than 2.30 t ha^{-1} (Table 6.26.2); certified seeds by around 600 kg ha^{-1}. Farm areas served by national and communal irrigation systems can improve yields by more than 1 t ha^{-1}, almost double those from other sources of water.

Table 6.26.1 shows that gap in production cost (i.e. cost difference between 10th and 90th percentiles) is wider in July-December (55%) than in January-June (37%). A one-ton increase in yield can reduce the cost by less than PhP 1.00 kg^{-1} (Table 6.26. 4); by about PhP 2.00 kg^{-1} with the use of hybrid seeds.

Table 6.26.3. Profit-maximizing increase in inputs, Davao del Sur.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	1.30	1.15
Nitrogen (kg ha^{-1})	1.13	1.07
Phosphorus (kg ha^{-1})	2.09	1.88
Herbicide (g ha^{-1})	1.14	0.81
Insecticide (g ha^{-1})	1.22	0.74
Labor (man-day ha^{-1})	0.92	0.83
Machine (machine-day ha^{-1})	0.09	0.10

Table 6.26.4. Marginal reduction in cost, Davao del Sur.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-0.66	-0.74
Large-scale irrigation system	0.20	0.22
Hybrid seed	-1.96	-2.19
Certified inbred seed	-0.27	-0.30
Machine for Harvesting & Threshing	-0.33	-0.37

27. Maguindanao

Yields of the 10th and 90th percentiles of farmers were 1.65 and 5.06 t ha^{-1} in January-June, and 1.10 and 4.95 t ha^{-1} in July-December (Table 6.27.1), with substantial yield gaps in both seasons. Yield gap is higher in July-December (3.85 t ha^{-1}) than in January-June (3.41 t ha^{-1}). Applying one more kg of phosphate can bring about the highest yield increment of 20-38 kg ha^{-1} (Table 6.27.2). Additional P applications of 2.74 kg ha^{-1} in January-June and 7.00 kg ha^{-1} in July-December are recommended, considering the profit maximization level of inputs (Table 6.27.3). While an additional man-day of labor can lead to 10-11 kg ha^{-1} increase in yield, farmers are already hiring the profit-maximizing number of workers.

Table 6.27.1. Yield and cost gaps in Maguindanao, by season.

Item/ Crop period	Percentiles 10th	90th	Gaps Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	1,650	5,057	3,407	206
July-December	1,100	4,950	3,850	350
Cost (PhP kg^{-1})				
January-June	7.08	18.76	-11.68	-62.26
July-December	8.15	19.22	-11.07	-57.58

Hybrid varieties can also narrow the yield gap in Maguindanao and enhance its yield by 1.42 - 1.55 t ha^{-1} (Table 6.27.2); certified seeds by 367-400 kg ha^{-1}. Farm areas served by national and communal irrigation systems can improve yields by 700-730 kg ha^{-1}, about twice higher than those with other sources of water.

Table 6.27.2. Marginal productivity of inputs in rice farming in Maguindanao.

Item	Marginal increment in yield January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	2.36	2.75
Nitrogen (kg ha^{-1})	4.90	4.71
Phosphorus (kg ha^{-1})	19.54	38.49
Herbicide (g ha^{-1})	0.17	0.16
Insecticide (g ha^{-1})	0.68	0.25
Labor (man-day ha^{-1})	10.78	10.17
Machine (machine-day ha^{-1})	2.60	2.49
Large-scale irrigation system	730.44	669.70
Small-scale irrigation system	373.93	342.84
Hybrid seed	1,547.35	1,418.69
Certified inbred seed	400.52	367.22

The gap in production cost is wider in January-June (62%) than in July-December (58%) (Table 6.27.1). Table 6.27.4 shows that a one-ton increase in yield can reduce the cost by PhP 1.20 kg^{-1}; by PhP 2.25 to PhP 2.40 kg^{-1} if farmers will use hybrid seeds.

Table 6.27.3. Profit-maximizing increase in inputs, Maguindanao.

Item	Profit-maximizing increase in inputs January-June	July-December
Seed (kg ha^{-1})	1.32	1.63
Nitrogen (kg ha^{-1})	1.19	1.12
Phosphorus (kg ha^{-1})	2.74	6.99
Herbicide (g ha^{-1})	0.49	0.60
Insecticide (g ha^{-1})	1.02	0.88
Labor (man-day ha^{-1})	0.73	0.75
Machine (machine-day ha^{-1})	0.07	0.09

Table 6.27.4. Marginal reduction in cost, Maguindanao.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield ($t\ ha^{-1}$)	-1.21	-1.25
Large-scale irrigation system	0.24	0.23
Hybrid seed	-2.37	-2.25
Certified inbred seed	-0.32	-0.31
Machine for Harvesting & Threshing	-0.40	-0.38

28. North Cotabato

Farmers yielded 2.23 to 5.88 t ha^{-1} in January-June and 1.86 to 5.44 t ha^{-1} in July-December (Table 6.28.1), with yield gaps of more than 3.50 t ha^{-1} in both cropping seasons. Hybrid seeds offer additional yields of more than 1.77 t ha^{-1} in January-June and 1.62 t ha^{-1} in July-December (Table 6.28.2); large-scale irrigation adds a yield of 767-834 kg ha^{-1} Adding one unit of labor could increase yield by about 14 kg ha^{-1} in both seasons. Table 6.28.3 shows that up to 0.80 man-day ha^{-1} may be added as farmers are already hiring the profit-maximizing number of workers.

Cost comparison of the 90th and 10th percentiles (Table 6.28.1) shows a lower difference in January-June (PhP 8.92 kg^{-1}) than in July-December (PhP 10.71 kg^{-1}). Table 6.28.4 shows that cost reduction is possible if farmers would adopt hybrid seeds, and mechanize harvesting and threshing operations.

Table 6.28.1. Yield and cost gaps in North Cotabato, by season.

Item/ Crop period	Percentiles		Gaps	
	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	2,233	5,877	3,644	163
July-December	1,864	5,445	3,581	192
Cost (PhP kg^{-1})				
January-June	7.90	16.82	-8.92	-53.02
July-December	8.84	19.55	-10.71	-54.79

Table 6.28.2. Marginal productivity of inputs in rice farming in North Cotabato.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	2.22	2.07
Nitrogen (kg ha^{-1})	4.32	5.03
Phosphorus (kg ha^{-1})	15.34	10.18
Herbicide (g ha^{-1})	0.14	0.13
Insecticide (g ha^{-1})	0.25	0.17
Labor (man-day ha^{-1})	13.23	14.32
Machine (machine-day ha^{-1})	3.19	3.29
Large-scale irrigation system	833.89	767.06
Small-scale irrigation system	426.89	392.68
Hybrid seed	1,766.49	1,624.93
Certified inbred seed	457.24	420.60

Table 6.28.3. Profit-maximizing increase in inputs, North Cotabato.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	1.72	1.42
Nitrogen (kg ha^{-1})	1.04	1.16
Phosphorus (kg ha^{-1})	2.68	1.59
Herbicide (g ha^{-1})	0.48	0.45
Insecticide (g ha^{-1})	0.62	0.31
Labor (man-day ha^{-1})	0.77	0.74
Machine (machine-day ha^{-1})	0.11	0.10

Table 6.28.4. Marginal reduction in cost, North Cotabato.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-1.03	-1.18
Large-scale irrigation system	0.24	0.25
Hybrid seed	-2.31	-2.44
Certified inbred seed	-0.31	-0.33
Machine for Harvesting & Threshing	-0.39	-0.41

29. South Cotabato

Yields of the 10th and 90th percentilse of farmers in January-June are 2.80 and 6.67 t ha^{-1}; 3.04 and 5.86 t ha^{-1} in July-December (Table 6.29.1). Yield gap estimates are 3.96 t ha^{-1} in January-June and 2.82 t ha^{-1} in July-December, suggesting room for increased yields under farmers' field conditions. An increase of one kg in phosphate application can provide the highest yield increment of 24-32 kg ha^{-1} (Table 6.29.2). Given the existing prices of paddy and fertilizers (i.e. complete and ammonium phosphate), additional P applications of 4.06 kg ha^{-1} in January-June and 5.19 kg ha^{-1} in July-December are recommended at the right source, time, and place (Table 6.29.3). One more man-day of labor can lead to about 12 kg ha^{-1} increase in yield, even as farmers are already hiring the profit-maximizing number of workers.

Hybrid varieties can give the highest yield improvement of more than 2 t ha^{-1} in both seasons (Table 6.29.2); certified seeds by more than 500 kg ha^{-1}. Farm areas served by national and communal irrigation systems can improve yields by about 1 t ha^{-1}, about twice higher than those with other sources of water.

Table 6.29.1. Yield and cost gaps in South Cotabato, by season.

Item/ Crop period	Percentiles 10th	Percentiles 90th	Gaps Absolute	Gaps Percentage (%)
Yield (kg ha^{-1})				
January-June	2,803	6,768	3,965	141
July-December	3,045	5,865	2,820	93
Cost (PhP kg^{-1})				
January-June	7.48	13.78	-6.30	-45.72
July-December	8.23	14.74	-6.51	-44.15

Table 6.29.2. Marginal productivity of inputs in rice farming in South Cotabato.

Item	Marginal increment in yield January-June	Marginal increment in yield July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	2.63	2.21
Nitrogen (kg ha^{-1})	5.39	5.02
Phosphorus (kg ha^{-1})	24.10	31.82
Herbicide (g ha^{-1})	0.12	0.14
Insecticide (g ha^{-1})	0.52	0.37
Labor (man-day ha^{-1})	12.07	11.37
Machine (machine-day ha^{-1})	4.29	4.51
Large-scale irrigation system	1,005.46	956.11
Small-scale irrigation system	514.72	489.45
Hybrid seed	2,129.94	2,025.41
Certified inbred seed	551.32	524.26

Table 6.29.1 shows that gap in cost (i.e. difference between 10th and 90th percentiles) is higher in January-June (44%) than in July-December (46%). Based on Table 6.29.4, a one-ton increase in yield can reduce the cost by about PhP 1.00 kg^{-1}; by about PhP 2.00 kg^{-1} if farmers will use hybrid seeds.

Table 6.29.3. Profit-maximizing increase in inputs, South Cotabato.

Item	Profit-maximizing increase in inputs January-June	July-December
Seed (kg ha^{-1})	2.32	1.80
Nitrogen (kg ha^{-1})	1.55	1.38
Phosphorus (kg ha^{-1})	4.06	5.19
Herbicide (g ha^{-1})	0.48	0.57
Insecticide (g ha^{-1})	1.16	0.45
Labor (man-day ha^{-1})	0.97	0.82
Machine (machine-day ha^{-1})	0.09	0.09

Table 6.29.4. Marginal reduction in cost, South Cotabato.

Item	Marginal reduction in cost kg^{-1} January-June	July-December
Yield (t ha^{-1})	-0.71	-0.80
Large-scale irrigation system	0.20	0.21
Hybrid seed	-1.92	-2.07
Certified inbred seed	-0.26	-0.28
Machine for Harvesting & Threshing	-0.32	-0.35

30. Sultan Kudarat

Majority of farmers harvested between 1.28 and 6.49 t ha^{-1} in January-June, and 0.97 and 6.34 t ha^{-1} in July-December (Table 6.30.1), with higher yield difference in July-Dec. These differences can be significantly reduced if farmers to adopt good-quality hybrid seeds, and large-scale irrigation facilities (Table 6.30.2). Yield also grows by more than 13 kg ha^{-1} if one unit of labor is added, and 20-84 kg ha^{-1} for every 1 kg ha^{-1} increase in phosphorus. Table 6.30.3 shows that maximum added labor is one man-day ha^{-1} and 4-15 kg ha^{-1} P.

Table 6.30.1. Yield and cost gaps in Sultan Kudarat, by season.

Item/ Crop period	Percentiles 10th	90th	Gaps Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	1,278	6,494	5,216	408
July-December	975	6,340	5,365	550
Cost (PhP kg^{-1})				
January-June	7.04	20.56	-13.52	-65.78
July-December	8.14	22.21	-14.06	-63.34

Majority of the farmers incurred a unit cost of PhP 7.04 to PhP 20.56 kg^{-1} in January-June and PhP 8.14 to PhP 22.21 kg^{-1} in July-December (Table 6.30.1), with differences almost the same in both seasons. As it is possible to reduce cost under current farmers' field conditions, Table 6.30.4 advises that adoption of hybrid seeds could cut cost by more than PhP 2.00 kg^{-1}.

Table 6.30.2. Marginal productivity of inputs in rice farming in Sultan Kudarat.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	2.23	2.12
Nitrogen (kg ha^{-1})	4.65	4.40
Phosphorus (kg ha^{-1})	20.34	83.78
Herbicide (g ha^{-1})	0.10	0.14
Insecticide (g ha^{-1})	0.46	0.28
Labor (man-day ha^{-1})	13.30	13.89
Machine (machine-day ha^{-1})	4.48	4.79
Large-scale irrigation system	924.63	773.27
Small-scale irrigation system	473.34	395.85
Hybrid seed	1,958.72	1,638.07
Certified inbred seed	507.00	424.00

Table 6.30.3. Profit-maximizing increase in inputs, Sultan Kudarat.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	1.62	1.26
Nitrogen (kg ha^{-1})	1.21	0.96
Phosphorus (kg ha^{-1})	3.48	14.53
Herbicide (g ha^{-1})	0.53	0.48
Insecticide (g ha^{-1})	0.88	0.52
Labor (man-day ha^{-1})	0.92	0.83
Machine (machine-day ha^{-1})	0.10	0.10

Table 6.30.4. Marginal reduction in cost, Sultan Kudarat.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-0.89	-1.10
Large-scale irrigation system	0.23	0.23
Hybrid seed	-2.22	-2.29
Certified inbred seed	-0.30	-0.31
Machine for Harvesting & Threshing	-0.37	-0.38

31. Zamboanga del Norte

Majority of farmers had yields between 1.60 and 5.55 t ha^{-1} in January-June, and 1.89 and 5.98 t ha^{-1} in July-December, with yield gap of about 4 t ha^{-1} in both seasons (Table 6.31.1). These gaps may be narrowed substantially if farmers would adopt high-quality seeds and use irrigation facilities (Table 6.31.2). Highest yield increments from hybrid seeds are 1.50 t ha^{-1} in January-June and 1.76 t ha^{-1} in July-December. Large-scale irrigation system supports an added yield of more than 709 kg ha^{-1} in January-June and 833 kg ha^{-1} in July-December. Additionally, if farmers would increase labor and phosphorus by one unit, yield could increase by less than 10 kg ha^{-1}(Table 6.31.3).

Table 6.31.1. Yield and cost gaps in Zamboanga del Norte, by season.

Item/	Percentiles		Gaps	
Crop period	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	1,600	5,554	3,954	247
July-December	1,888	5,982	4,095	217
Cost (PhP kg^{-1})				
January-June	8.32	22.48	-14.16	-62.98
July-December	8.56	17.46	-8.90	-50.98

Table 6.31.2. Marginal productivity of inputs in rice farming in Zamboanga del Norte.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	2.24	2.66
Nitrogen (kg ha^{-1})	5.19	5.85
Phosphorus (kg ha^{-1})	8.66	9.19
Herbicide (g ha^{-1})	0.33	0.12
Insecticide (g ha^{-1})	0.29	0.35
Labor (man-day ha^{-1})	7.79	9.66
Machine (machine-day ha^{-1})	2.51	3.08
Large-scale irrigation system	709.23	832.76
Small-scale irrigation system	363.07	426.31
Hybrid seed	1,502.42	1,764.11
Certified inbred seed	388.89	456.63

Majority of farmers spent PhP 8.22 to PhP 22.48 kg^{-1} in January-June and PhP 8.56 to PhP 17.46 kg^{-1} in July-December (Table 6.31.1), with cost difference (63%) higher in Jan-June than in the other season (51%). Since, it is possible to reduce cost under current farmers' field conditions, Table 6.31.4 advises that hybrid seeds could cut cost by more than PhP 3.00 kg^{-1} in January-June and PhP 2.33 kg^{-1} in July-December.

Table 6.31.3. Profit-maximizing increase in inputs, Zamboanga del Norte.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	1.39	2.04
Nitrogen (kg ha^{-1})	1.25	1.31
Phosphorus (kg ha^{-1})	1.33	1.50
Herbicide (g ha^{-1})	0.40	0.74
Insecticide (g ha^{-1})	0.29	0.49
Labor (man-day ha^{-1})	0.58	0.68
Machine (machine-day ha^{-1})	0.07	0.05

Table 6.31.4. Marginal reduction in cost, Zamboanga del Norte.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-1.74	-1.04
Large-scale irrigation system	0.34	0.24
Hybrid seed	-3.31	-2.33
Certified inbred seed	-0.45	-0.32
Machine for Harvesting & Threshing	-0.56	-0.39

32. Zamboanga del Sur

Table 6.32.1 shows that farmers yielded between 3.00 and 5.75 t ha^{-1} in January-June and 2.72 and 5.56 t ha^{-1} in July-December. Yields on the 90th percentile are more than 90% higher than those in the 10th percentile, meaning yield gaps are high and the room for farmers to improve yields in both seasons is big. Table 6.32.2 suggests using high-quality hybrid seeds, large and small-scale irrigation systems, and adoption of certified seeds to narrow yield gaps. Farmers would gain 15-18 kg ha^{-1} and 10-11 kg ha^{-1} yield increments for every 1 unit increase in phosphorus and labor, but not more than 3 kg and must be less than one man-day/ha.

Table 6.32.1. Yield and cost gaps in Zamboanga del Sur, by season.

Item/	Percentiles		Gaps	
Crop period	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
January-June	3,001	5,753	2,752	92
July-December	2,723	5,560	2,837	104
Cost (PhP kg^{-1})				
January-June	5.86	11.73	-5.87	-50.05
July-December	6.73	12.52	-5.79	-46.22

Table 6.32.2. Marginal productivity of inputs in rice farming in Zamboanga del Sur.

Item	Marginal increment in yield	
	January-June	July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	4.31	3.66
Nitrogen (kg ha^{-1})	6.93	5.15
Phosphorus (kg ha^{-1})	17.84	15.31
Herbicide (g ha^{-1})	0.12	0.12
Insecticide (g ha^{-1})	0.40	0.32
Labor (man-day ha^{-1})	11.19	10.11
Machine (machine-day ha^{-1})	3.33	3.81
Large-scale irrigation system	942.63	852.68
Small-scale irrigation system	482.55	436.51
Hybrid seed	1,996.85	1,806.31
Certified inbred seed	516.87	467.55

Table 6.32.1 also shows that farmers had a unit cost of PhP 5.86 to PhP 11.73 kg^{-1} in January-June, and PhP 6.73 to PhP 12.52 kg^{-1} in July-December. The percent cost difference for Jan-June (50%) is higher than the other season (46%). While it is still possible to reduce cost under current farmers' field conditions, Table 6.32.4 maintains that hybrid seeds could cut cost by some PhP 2.00 kg^{-1}.

Table 6.32.3. Profit-maximizing increase in inputs, Zamboanga del Sur.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	3.84	3.29
Nitrogen (kg ha^{-1})	1.54	1.13
Phosphorus (kg ha^{-1})	3.28	2.71
Herbicide (g ha^{-1})	0.59	1.30
Insecticide (g ha^{-1})	0.88	0.73
Labor (man-day ha^{-1})	0.99	0.81
Machine (machine-day ha^{-1})	0.11	0.12

Table 6.32.4. Marginal reduction in cost, Zamboanga del Sur.

Item	Marginal reduction in cost/kg	
	January-June	July-December
Yield (t ha^{-1})	-0.62	-0.75
Large-scale irrigation system	0.16	0.18
Hybrid seed	-1.57	-1.72
Certified inbred seed	-0.21	-0.23
Machine for Harvesting & Threshing	-0.26	-0.29

33. Zamboanga Sibugay

The yields of majority of the sample farmers ranged from 2.38 to 5.55 t ha^{-1} in January-June, and 2.46 to 5.30 t ha^{-1} in July-December (Table 6.33.1), with higher yield gap in Jan-June. To increase yields under farmers' field conditions, hybrid seeds could push production by about 2 t ha^{-1} in both seasons. Using the large-scale irrigation system could also raise yield by approximately 1 t ha^{-1} in both seasons (Table 6.33.2). An increase of one unit in phosphate application and labor quantity can significantly contribute 11-14 kg ha^{-1} and about 12 kg ha^{-1}, respectively. Given the existing prices of paddy and fertilizers in this province, additional P applications of about 2 kg ha^{-1} for both cropping seasons are recommended (Table 6.33.3). Considering its wage rate, only around 0.60 man-day ha^{-1} labor can be added to maintain cost efficiency.

Table 6.33.1. Yield and cost gaps in Zamboanga Sibugay, by season.

Item/ Crop period	Percentiles 10th	Percentiles 90th	Gaps Absolute	Gaps Percentage (%)
Yield (kg ha^{-1})				
January-June	2,381	5,548	3,167	133
July-December	2,475	5,300	2,825	114
Cost (PhP kg^{-1})				
January-June	8.46	19.37	-10.91	-56.34
July-December	7.59	15.72	-8.13	-51.70

Table 6.33.1 shows that unit cost ranged from PhP 8.46 kg^{-1} to PhP 19.37 kg^{-1} in January-June, and PhP 7.59 kg^{-1} to PhP 15.72 kg^{-1} in July-December. The cost difference of the 90th and 10th percentiles is higher in Jan-June (56%) than in the other season (52%). Since it is possible to reduce cost under current farmers' field conditions, Table 6.33.4 shows that hybrid seeds could provide PhP 2.00 to PhP 3.00 kg^{-1} reduction in cost.

Table 6.33.2. Marginal productivity of inputs in rice farming in Zamboanga Sibugay.

Item	Marginal increment in yield January-June	Marginal increment in yield July-December
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	3.45	3.67
Nitrogen (kg ha^{-1})	5.75	7.56
Phosphorus (kg ha^{-1})	11.03	13.96
Herbicide (g ha^{-1})	0.41	0.25
Insecticide (g ha^{-1})	0.17	0.17
Labor (man-day ha^{-1})	11.78	12.05
Machine (machine-day ha^{-1})	3.52	3.83
Large-scale irrigation system	854.31	840.94
Small-scale irrigation system	437.34	430.50
Hybrid seed	1,809.75	1,781.44
Certified inbred seed	468.44	461.11

Table 6.33.3. Profit-maximizing increase in inputs, Zamboanga Sibugay.

Item	Profit-maximizing increase in inputs	
	January-June	July-December
Seed (kg ha^{-1})	2.73	2.59
Nitrogen (kg ha^{-1})	1.26	1.72
Phosphorus (kg ha^{-1})	1.82	2.15
Herbicide (g ha^{-1})	0.97	0.81
Insecticide (g ha^{-1})	0.39	0.32
Labor (man-day ha^{-1})	0.64	0.63
Machine (machine-day ha^{-1})	0.13	0.13

Table 6.33.4. Marginal reduction in cost, Zamboanga Sibugay.

Item	Marginal reduction in cost kg^{-1}	
	January-June	July-December
Yield (t ha^{-1})	-1.23	-0.90
Large-scale irrigation system	0.29	0.21
Hybrid seed	-2.82	-2.03
Certified inbred seed	-0.38	-0.28
Machine for Harvesting & Threshing	-0.47	-0.34

CHAPTER

7

SUMMARY AND IMPLICATIONS

This study has estimated technical and allocative efficiencies of major rice bowls in Asia. Farmers in Nueva Ecija, which represents the Philippines, have significantly lower average technical efficiency than other farmers in selected countries in Asia. Filipino farmers are also less able to allocate farm resources efficiently relative to other Asian farmers, except for Indian farmers. This suggests that even with similar production ecosystems (i.e., irrigated environment), Filipino farmers have still a lot of catching-up to do.

A close look at various provinces in PH saw that technical efficiency of farmers in Nueva Ecija is higher than in Aurora, Camarines Sur, Northern Samar, Leyte, Iloilo, Bohol, Maguindanao, and Sultan Kudarat. Farmers in Zamboanga Sibugay, Compostela Valley, Davao del Norte, South Cotabato, Davao Oriental, and Ilocos Norte are more technically efficient than Nueva Ecija farmers. Technical efficiency of farmers in the other covered provinces is not significantly different from Nueva Ecija farmers. Nueva Ecija farmers are likewise among those with lower allocative efficiency, along with Aurora and Bukidnon. Farmers from the other provinces are better in choosing the lower cost combination of technically efficient inputs.

Efficiency estimates using both international and local data confirm that education, training, membership in organizations, and land ownership can positively influence the technical efficiency of farmers. Nevertheless, none of these variables was found to affect allocative efficiency, which necessitates further study.

Technical efficiency was also found to contribute to yield increase but yield increment brought about by improving efficiency was smaller than the effect of high-quality seeds and access to irrigation water. Its effect on yield, however, was bigger than impact of other inputs particularly that of fertilizer. This implies that improvement of efficiency through appropriate timing of nutrient application can have bigger impact on yield than just increasing the amount of applied fertilizer. For example, farmers commonly apply higher doses of nutrients during the early vegetative stage and lower doses during the rapid growth stage of the rice crop. This is the opposite of the nutrient management recommendation of researchers when higher amounts of fertilizer should be applied at the time that the rice crop needs it most.

High-quality seeds of both hybrid and inbred rice varieties and reliable access to irrigation water are among the most influential yield-enhancing factors. While the magnitude of yield increment varies across provinces, the positive effect on yield is quite general. Among the nutrients, the use of higher amount of phosphorus can lead to greater increase in yield. This can be attributed to the positive effect of this nutrient on root development leading to good nutrient uptake and speedy crop growth. Judicious use of plant protection chemicals may also be warranted especially in provinces that have low application but with greater pest and disease incidences.

While increasing other farm inputs can still significantly raise yield, this does not necessarily lead to bigger income. As shown in many provinces, given the prices of these inputs and paddy rice, many farmers are already using near profit-maximizing levels of inputs. This means that the cost of using additional units of input offsets the value of yield benefits that it can bring about. Thus, farmers have no incentive to increase input use to further enhance the yield. To motivate farmers to do so entails making the input prices cheaper relative to paddy price.

It is imperative to note that increasing yield is desirable not only due to bigger production volume but also to its cost-reducing effect. The average across provinces showed that a 1 t ha^{-1} increase in yield can reduce cost by about PhP 0.90 kg^{-1}. Results also indicate that improvement in allocative efficiency can further reduce the cost. Mechanization of harvesting and threshing in particular was also found as cost-reducing.

Aside from wide yield variations across provinces, yield gaps also persist within each province as evidenced by the huge differences between the 10^{th} and 90^{th} percentile yields. This type of gap should be easier to close as farmers within the same province operate in relatively similar agro-climatic conditions. Taking advantage of province-specific recommendations can contribute in narrowing this gap.

Provincial differences matter when it comes to the effects of other farm inputs and input prices on yield and unit cost, respectively. These are vital aspects in considering location-specific interventions. Knowledge of the marginal returns at the national level only may be insufficient in giving rice technology recommendations and interventions at the province level. Hence, it is imperative to assess provincial rice farming conditions, strategize on the right combinations of farm inputs, allocate on the cost-reducing but efficient technologies, and recommend location-specific interventions.

Appendices

Appendix 1. Stochastic Cobb-Douglas production function frontier.

Variable	Coefficient	Standard error
Ln Seed	0.005	0.017
Ln N	-0.005	0.015
Ln P	0.004	0.009
Ln K	0.017	0.008
Ln Herbicide AI	-0.005	0.005
Ln Insecticide AI	0.004	0.004
Ln Labor	-0.004	0.016
Ln Machine	0.005	0.010
Ln Area	0.970***	0.025
Dummy variables		
Hybrid	0.165***	0.042
RS/CS	0.013	0.015
Season	0.157***	0.013
NIS/CIS	-0.004	0.019
China	0.217***	0.042
India	-0.056*	0.029
Indonesia	0.222***	0.039
Thailand	0.137***	0.040
Vietnam	0.376***	0.035
Insig2v	-3.780***	0.095
Insig2u	-3.319***	0.114
Constant	8.737***	0.293
Observations		1,302

*Production per farm as dependent variable

Appendix 2. Cost function frontier.

Variable	Coefficient	Standard error
Ln Seed	0.048***	-0.0134
Ln N	-0.002	-0.0131
Ln P	0.0132	-0.0097
Ln K	0.0163	-0.0129
Ln Herbicide AI	-0.004	-0.0036
Ln Insecticide AI	0.003	-0.0034
Ln Land rent	0.162***	-0.0243
Ln Labor	0.033*	-0.0179
Ln Machine	0.005	-0.0073
Ln Production	0.117***	-0.0173
Ln Area	0.826***	-0.0205
Dummy variables		
Hybrid	0.0946**	-0.0395
RS/CS	0.0249**	-0.0105
Season	0.00431	-0.0095
NIS/CIS	0.0177	-0.0122
China	-0.0131	-0.0471
India	-0.325***	-0.0321
Indonesia	0.201***	-0.0430
Thailand	-0.171***	-0.0273
Vietnam	-0.293***	-0.0228
Insig2v	-4.673***	0.123
Insig2u	-3.247***	0.109
Constant	5.082***	-0.1870
Observations		1,302

*Total cost per farm as dependent variable

Appendix 3. Average farm input-use by ecosystems and cropping seasons, Philippines, 2011-2012.

Item	All seasons			2011 Wet season			2012 Dry season		
	All ecosystems	Irrigated	Rainfed	All ecosystems	Irrigated	Rainfed	All ecosystems	Irrigated	Rainfed
	(n=4,450)	(n=3,487)	(n=963)	(n=2,399)	(n=1,847)	(n=552)	(n=2,051)	(n=1,640)	(n=411)
Area planted	1.06	1.09	0.97	1.06	1.10	0.94	1.06	1.07	1.00
Yield (kg ha^{-1})	3,883	4,152	2,911	3,673	3,884	2,967	4,129	4,453	2,835
Seeds (kg ha^{-1})	95	95	95	97	97	99	92	92	90
N (kg ha^{-1})	72	79	48	72	78	53	73	81	42
P (kg ha^{-1})	7	7	5	6	7	5	7	8	4
K (kg ha^{-1})	10	11	6	9	10	6	10	11	5
Herbicide AI (kg ha^{-1})	0.33	0.34	0.29	0.32	0.33	0.31	0.33	0.34	0.27
Insecticide AI (kg ha^{-1})	0.24	0.25	0.22	0.25	0.26	0.24	0.23	0.23	0.20
Labor (md ha^{-1})	60	62	51	58	61	50	62	64	53
Machine (day ha^{-1})	10	10	9	9	9	8	10	10	10
NIS/CIS user	51%	65%	0%	49%	63%	0%	53%	67%	0%
SSIS/natural source user	28%	35%	0%	28%	37%	0%	27%	33%	0%
Hybrid user	5%	6%	2%	4%	5%	2%	6%	8%	1%
RS/CS user	40%	43%	28%	42%	45%	32%	37%	41%	22%
Technical efficiency	75%	75%	72%	74%	74%	72%	76%	77%	71%

Appendix 4. Average input-use (per hectare) across provinces, all seasons and ecosystems, 2011-12.

Province	Area planted* (ha)	Yield (t)	Seeds (kg)	N (kg)	P (kg)	K (kg)	Herbicide AI (kg)	Insecticide AI (kg)	Labor (man-day)	Machine (day)	NIS/ CIS	SSIS	Hybrid	RS/CS
Nueva Ecija	1.34	4.71	99.10	101.86	14.35	21.18	0.41	0.25	60.56	9.19	74%	24%	14%	63%
Agusan del Norte	1.14	4.00	73.25	48.54	4.29	7.60	0.70	0.16	66.53	9.68	43%	19%	1%	51%
Agusan del Sur	1.49	3.56	82.77	25.40	2.06	5.21	0.51	0.27	48.24	8.83	46%	11%	0%	52%
Albay	0.52	3.59	83.49	62.92	3.56	6.30	0.08	0.04	73.19	6.12	23%	62%	5%	14%
Aurora	1.41	3.30	149	59.91	8.88	19.72	0.49	0.53	46.80	10.54	48%	46%	0%	82%
Bohol	0.43	2.45	51.04	36.47	7.72	14.01	0.03	0.02	75.33	8.80	24%	15%	2%	11%
Bukidnon	1.19	3.81	120	71.10	7.92	9.00	0.40	0.37	50.98	7.42	71%	17%	6%	25%
Bulacan	1.34	4.17	87.26	71.35	9.23	11.60	0.23	0.37	51.34	7.69	57%	8%	9%	63%
Cagayan	1.13	4.14	51.81	84.30	6.37	4.29	0.18	0.10	69.78	10.17	45%	34%	17%	61%
Camarines Sur	1.19	3.07	99.16	55.98	5.22	8.14	0.22	0.12	46.70	11.18	33%	37%	1%	11%
Compostela Valley	0.99	5.06	89.82	79.51	5.29	8.49	0.68	0.38	63.18	10.92	78%	4%	12%	43%
Davao Oriental	0.87	5.43	75.91	93.80	9.16	13.63	0.46	0.77	80.74	11.67	97%	3%	2%	68%
Davao del Norte	1.03	5.05	72.19	75.01	5.09	15.97	0.67	0.42	67.25	10.28	82%	18%	0%	65%
Davao del Sur	0.84	5.18	100.18	103.73	7.90	11.87	0.56	0.35	67.88	12.75	100%	0%	14%	33%
Ilocos Norte	0.30	5.05	50.57	147.07	15.73	23.07	0.01	0.09	79.96	7.86	70%	27%	33%	43%
Iloilo	0.84	3.05	155	80.62	7.10	5.63	0.36	0.23	40.16	9.62	14%	39%	3%	22%
Isabela	1.20	4.10	93.06	78.76	11.72	10.88	0.38	0.15	50.24	7.85	63%	15%	4%	63%
Laguna	1.03	3.92	94.07	73.06	4.08	7.11	0.26	0.18	67.45	7.50	50%	49%	2%	20%
Leyte	0.84	2.97	60.61	49.21	3.09	5.40	0.12	0.08	71.64	8.34	35%	48%	7%	28%
Maguindanao	1.70	3.22	86.61	52.99	2.00	3.60	0.34	0.30	54.37	12.37	75%	4%	0%	27%
Mindoro Occidental	1.60	4.69	96.19	112.93	8.40	13.82	0.29	0.23	70.76	11.30	70%	12%	10%	63%
Mindoro Oriental	1.11	3.82	114	73.12	5.09	9.65	0.36	0.17	46.06	11.49	30%	55%	2%	26%
North Cotabato	1.00	3.72	122	62.52	5.45	5.28	0.49	0.55	47.24	11.15	63%	8%	0%	21%
Northern Samar	1.64	2.36	72.96	9.42	0.38	0.73	0.01	0.01	71.46	11.34	32%	20%	0%	22%
Pampanga	1.54	3.99	118	85.18	3.65	4.63	0.12	0.16	48.33	8.05	44%	56%	1%	57%
Pangasinan	0.76	3.78	111	109.37	7.73	13.54	0.14	0.19	55.54	7.03	45%	42%	4%	51%

Appendix 4. (Continuation)

Province	Area planted* (ha)	Yield (t)	Seeds (kg)	N (kg)	P (kg)	K (kg)	Herbicide AI (kg)	Insecticide AI (kg)	Labor (man-day)	Machine (day)	NIS/ CIS	SSIS	Hybrid	RS/CS
Quezon	0.76	3.34	86.42	30.47	3.50	5.32	0.21	0.05	62.25	9.40	32%	21%	1%	24%
South Cotabato	1.04	4.58	133	69.09	2.95	5.44	0.62	0.32	68.44	10.10	68%	17%	0%	19%
Sultan Kudarat	1.24	3.90	125	67.90	1.99	3.96	0.57	0.35	50.12	8.15	60%	24%	2%	15%
Tarlac	1.04	4.40	84.67	109.13	7.33	13.12	0.18	0.12	58.74	8.28	31%	63%	6%	66%
Zamboanga Sibugay	1.35	3.96	77.74	47.79	5.71	11.91	0.22	0.70	58.18	10.48	6%	22%	0%	18%
Zamboanga del Norte	0.58	3.65	102.56	51.32	7.19	7.23	0.41	0.34	72.11	12.49	47%	13%	2%	23%
Zamboanga del Sur	0.87	4.19	73.62	55.29	4.49	7.00	0.63	0.36	68.89	11.49	53%	25%	1%	38%
PHILIPPINES	1.06	3.88	94.60	72.49	6.66	9.74	0.33	0.24	59.88	9.54	51%	28%	5%	40%

* - Only the largest rice-based parcel was considered in gathering data for input-use.

Appendix 5. Average input-use (per hectare) across provinces, all ecosystems, 2011WS.

Province	Area planted* (ha)	Yield (t)	Seeds (kg)	N (kg)	P (kg)	K (kg)	Herbicide AI (kg)	Insecticide AI (kg)	Labor (man-day)	Machine (day)	NIS/ CIS	SSIS	Hybrid	RS/CS
Nueva Ecija	1.34	3.39	104.96	92.74	12.25	18.77	379.08	276.21	62.57	9.32	67%	28%	4%	73%
Agusan del Norte	1.15	3.98	72.13	52.14	4.05	7.48	687.41	134.75	64.68	7.34	40%	16%	2%	40%
Agusan del Sur	1.50	3.33	79.50	26.79	1.92	5.31	503.83	211.51	46.09	8.92	48%	15%	0%	56%
Albay	0.54	3.21	95.85	57.97	3.63	6.04	104.46	33.01	74.03	5.34	20%	62%	0%	13%
Aurora	1.25	3.17	151.73	55.61	8.97	20.86	434.83	383.61	44.06	10.54	44%	49%	0%	81%
Bohol	0.40	2.31	54.35	35.44	7.18	13.50	28.00	19.87	69.05	8.36	22%	19%	1%	12%
Bukidnon	1.25	3.78	127.30	69.54	7.69	7.99	400.88	372.64	46.08	6.58	69%	15%	3%	26%
Bulacan	1.37	3.81	84.22	66.02	8.82	9.82	228.41	393.62	47.90	7.39	43%	5%	10%	62%
Cagayan	1.08	3.76	59.85	88.50	6.78	3.80	206.31	90.81	69.85	9.87	46%	32%	8%	69%
Camarines Sur	1.21	3.09	101.15	56.77	5.87	8.61	204.76	103.33	47.43	10.64	38%	37%	0%	11%
Compostela Valley	1.03	5.39	87.59	78.47	4.23	7.61	721.33	414.51	61.85	9.57	81%	4%	15%	46%
Davao Oriental	0.90	5.40	75.73	89.53	8.53	13.76	368.75	834.58	82.20	10.81	97%	3%	3%	60%
Davao del Norte	1.04	5.31	76.00	77.20	5.82	18.44	618.36	295.31	63.58	9.61	82%	18%	0%	71%
Davao del Sur	0.81	5.17	98.68	106.20	8.23	11.94	558.74	352.81	70.31	12.89	100%	0%	17%	33%
Ilocos Norte	0.33	4.74	52.59	127.41	12.89	20.13	12.38	121.04	76.76	8.21	55%	40%	32%	42%
Iloilo	0.88	3.18	152.61	80.98	7.02	6.20	327.96	203.50	37.51	8.99	16%	38%	4%	30%
Isabela	1.18	3.36	95.52	77.67	11.24	10.85	394.97	150.15	50.33	7.81	66%	13%	3%	66%
Laguna	1.02	3.71	92.58	70.26	3.55	6.72	292.68	178.43	65.07	6.73	51%	49%	2%	22%
Leyte	0.84	2.86	61.60	43.33	2.69	4.77	115.36	84.19	67.45	8.55	35%	48%	8%	31%
Maguindanao	1.78	3.13	79.31	52.16	1.44	2.58	339.36	369.91	53.83	12.18	72%	7%	0%	27%
Mindoro Occidental	1.55	4.51	99.80	115.29	8.00	13.05	356.97	286.25	70.10	10.78	53%	18%	5%	65%
Mindoro Oriental	1.09	3.80	110.54	77.71	5.23	10.76	438.93	202.73	45.32	11.06	27%	62%	4%	30%
North Cotabato	1.09	3.58	120.75	55.89	6.23	6.58	485.20	624.61	43.77	10.58	64%	6%	0%	21%
Northern Samar	1.46	2.48	85.90	10.08	0.14	0.26	12.83	7.82	72.69	10.17	36%	24%	0%	20%
Pampanga	1.58	3.24	101.31	83.48	3.03	4.55	139.67	175.25	50.15	6.74	39%	61%	0%	69%
Pangasinan	0.77	3.66	118.45	104.60	6.63	12.27	154.36	234.59	55.14	7.40	42%	39%	5%	42%

Appendix 5. (Continuation)

Province	Area planted* (ha)	Yield (t)	Seeds (kg)	N (kg)	P (kg)	K (kg)	Herbicide AI (kg)	Insecticide AI (kg)	Labor (man-day)	Machine (day)	NIS/ CIS	SSIS	Hybrid	RS/CS
Quezon	0.78	3.50	95.14	27.41	3.26	5.38	254.04	48.41	62.87	8.36	42%	15%	0%	22%
South Cotabato	1.05	4.47	140.99	69.77	2.48	6.28	554.73	359.76	68.76	9.61	68%	17%	0%	27%
Sultan Kudarat	1.34	3.61	118.79	64.49	0.76	2.83	451.37	394.10	45.50	7.31	57%	17%	3%	14%
Tarlac	1.09	4.12	81.47	104.77	6.42	11.86	187.73	156.49	54.91	8.12	22%	67%	6%	69%
Zamboanga Sibugay	1.31	3.93	74.72	40.80	4.98	10.46	277.20	685.11	57.05	9.95	4%	29%	0%	25%
Zamboanga del Norte	0.60	3.89	102.06	52.21	7.49	6.24	569.91	332.71	70.48	12.27	42%	12%	2%	30%
Zamboanga del Sur	0.78	3.98	75.90	60.72	4.60	7.13	579.21	377.48	68.92	10.15	52%	23%	0%	38%
PHILIPPINES	1.06	3.67	97.10	72.03	6.36	9.45	324.05	251.16	58.34	9.08	49%	28%	4%	42%

* - Only the largest rice-based parcel was considered in gathering data for input-use.

Appendix 6. Average input-use (per hectare) across provinces, all ecosystems, 2012DS.

Province	Area planted* (ha)	Yield (t)	Seeds (kg)	N (kg)	P (kg)	K (kg)	Herbicide AI (kg)	Insecticide AI (kg)	Labor (man-day)	Machine (day)	NIS/ CIS	SSIS	Hybrid	RS/CS
Nueva Ecija	1.33	6.29	92.05	112.83	16.88	24.08	458.16	223.08	58.14	9.03	82%	18%	26%	51%
Agusan del Norte	1.13	4.02	74.50	44.50	4.55	7.73	714.95	198.60	68.60	12.30	45%	22%	0%	63%
Agusan del Sur	1.48	3.77	85.71	24.15	2.20	5.12	513.36	326.70	50.18	8.74	45%	8%	0%	48%
Albay	0.50	3.96	71.13	67.88	3.48	6.56	63.14	50.83	72.35	6.91	25%	62%	10%	15%
Aurora	1.58	3.44	146.40	64.52	8.78	18.49	553.50	695.87	49.75	10.55	53%	44%	0%	84%
Bohol	0.45	2.58	47.93	37.44	8.23	14.49	33.87	15.98	81.25	9.22	26%	12%	2%	9%
Bukidnon	1.13	3.85	111.79	72.72	8.15	10.04	402.31	369.52	56.06	8.28	73%	19%	9%	23%
Bulacan	1.29	4.93	93.74	82.73	10.09	15.40	246.12	334.74	58.68	8.33	86%	14%	8%	65%
Cagayan	1.18	4.51	43.78	80.10	5.96	4.77	156.80	109.76	69.72	10.48	43%	36%	27%	53%
Camarines Sur	1.16	3.06	97.31	55.24	4.61	7.70	240.08	129.65	46.02	11.68	28%	38%	3%	11%
Compostela Valley	0.94	4.73	92.15	80.59	6.39	9.40	637.49	340.56	64.55	12.32	76%	4%	8%	40%
Davao Oriental	0.85	5.46	76.09	98.07	9.79	13.49	551.72	709.35	79.29	12.53	97%	3%	0%	75%
Davao del Norte	1.02	4.79	68.38	72.82	4.36	13.49	720.20	548.22	70.91	10.95	82%	18%	0%	59%
Davao del Sur	0.87	5.20	101.69	101.26	7.58	11.79	557.24	344.40	65.45	12.60	100%	0%	12%	33%
Ilocos Norte	0.26	5.63	46.89	182.82	20.91	28.42	0.65	47.13	85.77	7.22	97%	3%	36%	45%
Iloilo	0.76	2.81	161.27	79.88	7.27	4.51	416.35	277.86	45.48	10.88	10%	40%	0%	5%
Isabela	1.21	4.83	90.63	79.84	12.20	10.91	364.25	141.98	50.16	7.88	61%	17%	5%	60%
Laguna	1.04	4.14	95.61	75.97	4.62	7.50	223.18	186.83	69.90	8.29	49%	49%	2%	18%
Leyte	0.84	3.08	59.61	55.16	3.49	6.03	119.77	83.16	75.88	8.13	35%	48%	6%	25%
Maguindanao	1.55	3.41	100.82	54.62	3.09	5.59	355.15	151.22	55.41	12.75	82%	0%	0%	26%
Mindoro Occidental	1.68	5.01	89.61	108.64	9.12	15.20	180.21	114.27	71.95	12.25	100%	0%	18%	61%
Mindoro Oriental	1.12	3.84	117.62	68.75	4.96	8.59	281.24	139.16	46.76	11.90	34%	48%	1%	21%
North Cotabato	0.88	3.89	122.72	70.70	4.50	3.68	490.87	463.53	51.53	11.86	62%	10%	0%	21%
Northern Samar	1.78	2.27	63.09	8.91	0.57	1.08	8.76	9.07	70.53	12.23	29%	17%	0%	24%
Pampanga	1.50	4.73	133.46	86.84	4.27	4.71	101.12	151.35	46.54	9.34	50%	50%	2%	44%
Pangasinan	0.73	3.98	98.63	117.37	9.57	15.67	117.73	114.60	56.21	6.41	51%	47%	2%	65%

Appendix 6. (Continuation)

Province	Area planted* (ha)	Yield (t)	Seeds (kg)	N (kg)	P (kg)	K (kg)	Herbicide AI (kg)	Insecticide AI (kg)	Labor (man-day)	Machine (day)	NIS/ CIS	SSIS	Hybrid	RS/CS
Quezon	0.75	3.17	77.56	33.58	3.74	5.27	168.31	48.54	61.62	10.46	22%	27%	2%	27%
South Cotabato	1.03	4.70	124.68	68.38	3.45	4.56	691.19	273.63	68.10	10.62	68%	16%	0%	11%
Sultan Kudarat	1.09	4.32	135.10	72.86	3.76	5.60	737.80	281.97	56.82	9.36	65%	35%	0%	18%
Tarlac	0.96	4.94	90.79	117.46	9.09	15.53	175.92	59.10	66.07	8.59	47%	53%	7%	62%
Zamboanga Sibugay	1.38	3.99	80.63	54.50	6.41	13.29	171.87	723.78	59.26	10.98	8%	16%	0%	12%
Zamboanga del Norte	0.56	3.31	103.28	50.08	6.77	8.60	180.13	339.26	74.37	12.79	53%	14%	2%	14%
Zamboanga del Sur	0.96	4.40	71.35	49.86	4.37	6.86	679.02	334.39	68.87	12.82	55%	27%	2%	37%
PHILIPPINES	1.06	4.13	91.66	73.03	7.02	10.08	328.31	227.15	61.68	10.07	53%	27%	6%	37%

Appendix 7. Yield and cost gaps in China, by season.

Item/ Crop period	Percentiles 10th	90th	Gaps Absolute	Percentage (%)
Yield (kg ha^{-1})				
HYS	6,225	9,000	2,775	45
LYS	5,509	6,592	1,083	20
Cost (PhP kg^{-1})				
HYS	11.04	20.80	-9.76	-46.94
LYS	11.04	17.40	-6.37	-36.59

Appendix 8. Marginal productivity of inputs in rice farming in China.

Item	Marginal productivity of inputs HYS	LYS
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	1.08	0.11
Potassium (kg ha^{-1})	1.15	1.15
Insecticide (g ha^{-1})	0.01	0.05
Labor (man-day ha^{-1})	1.25	1.83
Machine (machine-day ha^{-1})	3.46	4.81
Large-scale irrigation system	4.93	4.03
Hybrid seed	1086.80	888.73
Certified inbred seed	59.92	49.00

Appendix 9. Profit-maximizing increase in inputs, China.

Item	Profit-maximizing increase in input-use HYS	LYS
Seed (kg ha^{-1})	0.04	0.08
Potassium (kg ha^{-1})	0.09	0.12
Insecticide (g ha^{-1})	0.01	0.03
Labor (man-day ha^{-1})	0.03	0.05
Machine (machine-day ha^{-1})	0.01	0.01

Appendix 10. Marginal reduction in cost, China.

Item	Marginal reduction in cost kg^{-1} HYS	LYS
Yield (t ha^{-1})	-1.73	-2.01
Herbicide (g ha^{-1})	-0.05	-0.04

Appendix 11. Yield and cost gaps in India, by season.

Item/ Crop period	Percentiles 10th	Percentiles 90th	Gaps Absolute	Gaps Percentage (%)
Yield (kg ha^{-1})				
HYS	3,267	5,460	2,193	67
LYS	3,576	5,559	1,983	55
Cost (PhP kg^{-1})				
HYS	6.79	14.86	-8.07	-54
LYS	5.52	12.31	-6.79	-55

Appendix 12. Marginal productivity of inputs in rice farming in India.

Item	Marginal productivity of inputs HYS	Marginal productivity of inputs LYS
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	0.11	0.12
Potassium (kg ha^{-1})	2.25	2.09
Insecticide (g ha^{-1})	0.03	0.02
Labor (man-day ha^{-1})	0.31	0.34
Machine (machine-day ha^{-1})	2.40	2.59
Large-scale irrigation system	2.85	3.04
Hybrid seed	629.79	670.63
Certified inbred seed	34.72	36.97

Appendix 13. Profit-maximizing increase in inputs, India.

Item	Profit-maximizing increase in input-use HYS	Profit-maximizing increase in input-use LYS
Seed (kg ha^{-1})	0.04	0.05
Potassium (kg ha^{-1})	1.42	1.14
Insecticide (g ha^{-1})	0.20	0.08
Labor (man-day ha^{-1})	0.02	0.02
Machine (machine-day ha^{-1})	0.01	0.01

Appendix 14. Marginal reduction in cost, India.

Item	Marginal reduction in cost kg^{-1} HYS	Marginal reduction in cost kg^{-1} LYS
Yield (t ha^{-1})	-2.01	-1.71
Herbicide (g ha^{-1})	-0.13	-0.13

Appendix 15. Yield and cost gaps in Indonesia, by season.

Item/	Percentiles		Gaps	
Crop period	10th	90th	Absolute	Percentage (%)
Yield (kg ha^{-1})				
HYS	3,855	7,984	4,129	107
LYS	3,805	6,672	2,867	75
Cost (PhP kg^{-1})				
HYS	11.04	21.23	-10.19	-48
LYS	12.74	24.20	-11.46	-47

Appendix 16. Marginal productivity of inputs in rice farming in Indonesia.

Item	Marginal productivity of inputs	
	HYS	LYS
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	0.53	0.53
Potassium (kg ha^{-1})	2.91	2.73
Insecticide (g ha^{-1})	0.01	0.01
Labor (man-day ha^{-1})	0.39	0.34
Machine (machine-day ha^{-1})	1.32	1.43
Large-scale irrigation system	4.04	3.58
Hybrid seed	890.59	789.22
Certified inbred seed	49.10	43.51

Appendix 17. Profit-maximizing increase in inputs, Indonesia.

Item	Profit-maximizing increase in input-use	
	HYS	LYS
Seed (kg ha^{-1})	0.30	0.27
Potassium (kg ha^{-1})	1.84	1.74
Insecticide (g ha^{-1})	0.05	0.04
Labor (man-day ha^{-1})	0.02	0.02
Machine (machine-day ha^{-1})	0.12	0.09

Appendix 18. Marginal reduction in cost, Indonesia.

Item	Marginal reduction in cost kg^{-1}	
	HYS	LYS
Yield (t ha^{-1})	-2.34	-2.85
Herbicide (g ha^{-1})	-0.63	-0.52

Appendix 19. Yield and cost gaps in Thailand, by season.

Item/ Crop period	Percentiles 10th	Percentiles 90th	Gaps Absolute	Gaps Percentage (%)
Yield (kg ha^{-1})				
HYS	3,648	6,656	3,008	82
LYS	3,881	6,585	2,704	70
Cost (PhP kg^{-1})				
HYS	7.22	13.16	-5.94	-45
LYS	6.79	13.58	-6.79	-50

Appendix 20. Marginal productivity of inputs in rice farming in Thailand.

Item	Marginal productivity of inputs HYS	Marginal productivity of inputs LYS
	(kg paddy/unit change in input)	
Seed (kg ha^{-1})	0.05	0.05
Potassium (kg ha^{-1})	8.55	8.66
Insecticide (g ha^{-1})	0.04	0.04
Labor (man-day ha^{-1})	3.01	2.70
Machine (machine-day ha^{-1})	5.29	3.95
Large-scale irrigation system	3.41	3.51
Hybrid seed	751.67	774.15
Certified inbred seed	41.44	42.68

Appendix 21. Profit-maximizing increase in inputs, Thailand.

Item	Profit-maximizing increase in input-use HYS	Profit-maximizing increase in input-use LYS
Seed (kg ha^{-1})	0.03	0.03
Potassium (kg ha^{-1})	19.47	19.76
Insecticide (g ha^{-1})	0.05	0.05
Labor (man-day ha^{-1})	0.07	0.07
Machine (machine-day ha^{-1})	0.02	0.04

Appendix 22. Marginal reduction in cost, Thailand.

Item	Marginal reduction in cost kg^{-1} HYS	Marginal reduction in cost kg^{-1} LYS
Yield (t ha^{-1})	-1.77	-1.60
Herbicide (g ha^{-1})	-0.22	-0.13

Appendix 23. Yield and cost gaps in Vietnam, by season.

Item/ Crop period	Percentiles 10th	90th	Gaps Absolute	Percentage (%)
Yield (kg ha^{-1})				
HYS	7,533	9,749	2,216	29
LYS	5,009	7,442	2,433	49
ES	4,293	6,512	2,218	52
Cost (PhP kg^{-1})				
HYS	4.25	6.37	-2.12	-33
LYS	5.94	8.49	-2.55	-30
ES	6.3675	10.188	-3.82	-37

Appendix 24. Marginal productivity of inputs in rice farming in Vietnam.

Item	Marginal productivity of inputs HYS	LYS	TS
	(kg paddy/unit change in input)		
Seed (kg ha^{-1})	0.08	0.06	0.05
Potassium (kg ha^{-1})	5.00	3.08	2.82
Insecticide (g ha^{-1})	0.08	0.04	0.05
Labor (man-day ha^{-1})	2.33	1.71	1.67
Machine (machine-day ha^{-1})	4.85	3.71	3.55
Large-scale irrigation system	5.65	4.18	3.76
Hybrid seed	1247.07	922.66	829.41
Certified inbred seed	68.76	50.87	45.73

Appendix 25. Profit-maximizing increase in inputs, Vietnam.

Item	Profit-maximizing increase in input-use HYS	LYS	TS
Seed (kg ha^{-1})	0.05	0.04	0.04
Potassium (kg ha^{-1})	0.95	0.47	0.45
Insecticide (g ha^{-1})	0.09	0.06	0.04
Labor (man-day ha^{-1})	0.05	0.04	0.03
Machine (machine-day ha^{-1})	0.05	0.02	0.03

Appendix 26. Marginal reduction in cost, Vietnam.

Item	Marginal reduction in cost kg^{-1} HYS	LYS	TS
Yield (t ha^{-1})	-0.53	-1.04	-1.23
Herbicide (g ha^{-1})	-0.33	-0.42	-0.45

LITERATURE CITED

Bravo-Ureta BE, Solís D, López VHM, Maripani JF, Thiam A, Rivas T. 2007. Technical efficiency in farming: a meta-regression analysis. Journal of Productivity Analysis. 27(1):57-72.

CountrySTAT Philippines website: Philippine Statistics Authority. 2016. Crops Data. http://countrystat.psa.gov.ph/. December 15, 2016.

DeSilva S. 2011. Access to markets and farm efficiency: A study of rice farms in the Bicol Region, Philippines. [Working Paper]. Levy Economics Institute of Bard College, 687 p.

FAOSTAT: Food and Agriculture Organization of the United Nations. 2016. Crops Data. http://www.fao.org/faostat/en/#data/QC. December 15, 2016.

Food and Agriculture Organization of the United Nations. (2013). FAO Statistical Yearbook 2013: World Food and Agriculture.

Gonzales LA, Sebastian LS, Redona ED, Gonzales VA, Elca CD, Gonzales AA, Lapina GP, Hidalgo FC, Mataia AB, and Alviola PA IV. 2004. Technical and Allocative Efficiencies of Philippine Rice Production. Nueva Ecija: Philippine Rice Research Institute and STRIVE Foundation.

Herdt RW, Mandac AM. 1981. Modern rice technology and economic efficiency of Philippine rice farmers. Economic Development and Cultural Change, 29:375-399.

Hidalgo FC, Flores CEV. 1999. Analysis of technical efficiency of rice production in the Philippines in the presence of El Niño phenomenon. [Unpublished undergraduate thesis]. University of the Philippines, Diliman, Quezon City.

Kalirajan KP, Flinn JC. 1983. The measurement of farm-specific technical efficiency. Pakistan Journal of Applied Econometrics. 2:167-180.

Koirala KH, Mishra AK, Mohanty S. 2013. Determinants of Rice Productivity and Technical Efficiency in the Philippines. In*:* Southern Agricultural Economics Association (SAEA) Annual Meeting. 1-16 pp.

Mariano M, Villano R, Fleming E. 2010. Are irrigated farming ecosystems more productive than rainfed farming systems in rice production in the Philippines?. Agriculture, Ecosystems and Environment, 139:603–610.

Michler JD, Shively GE. 2015. Land tenure, tenure security and farm efficiency: Panel evidence from the Philippines. Journal of Agricultural Economics. 66(1):155-169.

Ogundari K. 2008. Resource-productivity, allocative efficiency and determinants of technical efficiency of rainfed rice farmers: A guide for food security policy in Nigeria. Agricultural Economics– Czech, 54(5):224–233.

Pate NT, Cruz AT. 2007. Technical efficiency of Philippine rice-producing regions: An econometric approach. In*:* 10th National Convention on Statistics. 1-16 pp.

Philippine Rice Research Institute. 1995. Socioeconomic and technology profiles of rice-based farm households in the Philippines. In*:* Philippine Rice R&D Highlights. Nueva Ecija: Philippine Rice Research Institute.

Rola AC, Quintana-Alejandrino JT. 1993. Technical efficiency of Philippine rice farmers in irrigated, rainfed lowland and upland environments: a frontier production function analysis. Philippine Journal of Crop Science. 18(2):59-69.

Sebastian LS, Alviola PA, Francisco SR. 2000. Bridging the rice yield gap in the Philippines. Bridging the rice yield gap in the Asia-Pacific region. MK Papademetriou, FJ Dent, and EM Herath (Eds.). Bangkok: Food and Agriculture Organization of the United Nations Regional Office for the Asia and the Pacific.

Sullano MD, Tan-Cruz A. 2013. Technical Efficiency of Farmers under the Community-based Participatory Action Research (CPAR) Project in Region XI, Philippines: An Application of Structural Equation Modeling. In*:* Philippine Agricultural Economics & Development Association (PAEDA) Biennial Convention.

Tu VH, Trang NT. 2016. Cost Efficiency of Rice Production in Vietnam: An Application of Stochastic Translog Variable Cost Frontier. Asian Journal of Agricultural Extension, Economics & Sociology. 8(1):1-10.

Umetsu C, Lekprichakul T, Chakravorty U. 2003. Efficiency and technical change in the Philippine rice sector: A Malmquist total factor productivity analysis. American journal of agricultural economics. 85(4):943-963.

Velarde O, Pede VO. 2013. Pattern of investment allocation to chemical inputs and technical efficiency: A stochastic frontier analysis of farm households in Laguna, Philippines. In*:* 2013 Conference (57th), February 5-8, 2013, Sydney, Australia (No. 152203). Australian Agricultural and Resource Economics Society.

Villano R, Fleming E. 2004. Analysis of technical efficiency in a rainfed lowland rice environment in Central Luzon Philippines using a stochastic frontier production function with a heteroskedastic error structure. [Working Paper Series] Agricultural and Resource Economics (No. 12906).

AUTHORS' PAGE

IMELDA A. ARIDA is a Science Research Specialist I of the Socioeconomics Division, Philippine Rice Research Institute, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines.
Contact at ia.arida@philrice.gov.ph

JESUSA C. BELTRAN is a Supervising Science Research Specialist of the Socioeconomics Division, Philippine Rice Research Institute, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines.
Contact at jc.beltran@philrice.gov.ph

FLORDELIZA H. BORDEY is a Chief Science Research Specialist and currently acting as Deputy Executive Director for Development of the Philippine Rice Research Institute, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines. Contact at fh.bordey@philrice.gov.ph

WILFREDO B. COLLADO is a Supervising Science Research Specialist of the Agronomy, Soils, and Plant Physiology Division, Philippine Rice Research Institute, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines. Contact at wb.collado@philrice.gov.ph

MARY GRACE C. LAPURGA is a former Science Research Specialist I of the Socioeconomics Division, Philippine Rice Research Institute, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines. She is now working at the National Economic Development Authority.

AILEEN C. LITONJUA is a Senior Science Research Specialist of the Socioeconomics Division, Philippine Rice Research Institute, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines.
Contact at ac.litonjua@philrice.gov.ph

INSIDE COVER