IMPROVING RICE PRODUCTION AND COMMERCIALIZATION IN CAMBODIA

FINDINGS FROM THE FARM INVESTMENT CLIMATE ASSESSMENT

ASIAN DEVELOPMENT BANK

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Acknowledgments

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Executive Summary

In 2010, Cambodia outlined a plan aimed at developing its rice sector into a major rice-exporting country. The rice sector was chosen due to comparative advantages in land, perceptions of significant unmet potential, and ability of sectoral growth to accelerate poverty reduction and improvements in the welfare of the poorest and least well-off in Cambodia. By early 2014, Cambodia had made significant progress in increasing its rice exports. Nevertheless, much remains to be done. This study uses a new farm investment climate assessment (ICA) survey to identify key areas of the investment climate that are important for increasing rice production and commercialization of small farms. The investment climate is captured by a variety of measures that reflect potential constraints to farm enterprise growth and performance. By analyzing the link between investment climate and farm outcomes of production efficiency, commercialization, sales, changes in farm size, and investments in irrigation helps to provide an added perspective on potential policies and reforms. As the majority of farms in Cambodia are small, improving the investment climate for these farms are integral to having more inclusive growth.

Key findings of the report are as follows:

(i) Production efficiency is constrained by the absence of domestic milling, low rates of irrigation, and uncertified farm land.

(ii) Higher levels of commercialization, rice sold, and value of sales can arise from improving irrigation and domestic milling.

(iii) Improvements in farm size dynamics and allocative efficiency of land, where land is reallocated from farms with lower productivity to those with higher productivity, are related to increased milling and financing.

(iv) Farm size tends to increase in areas with better legal environments and decrease with greater opportunities from nonfarm activities, while farm size tends to increase in areas with better physical infrastructure.

(v) Investments in irrigation are associated with increased access to extension services, enhanced input markets, availability of domestic milling and better physical infrastructure.

(vi) Providing input price subsidies for nonhigh-yielding seeds and inorganic fertilizer may have positive short-run returns in production.

Abbreviations

ADB	Asian Development Bank
CDRI	Cambodian Development and Research Institute
CSES	Cambodian Socioeconomic Survey
FAO	Food and Agriculture Organization
ha	hectare
HH	household
IC	investment climate
ICA	investment climate assessment
IFC	International Finance Corporation
INGER	International Network for Generic Evaluation of Rice
IRRI	International Rice Research Institute
kg	kilogram
KHR	Cambodian riel
log	natural logarithm
RDTA	Regional Development Technical Assistance
SD	standard deviation
SRI	system of rice intensification
TE	technical efficiency
WB	World Bank

I. Introduction

Cambodia's economic development has been impressive, posting solid economic growth and dramatic reductions in poverty over the last decade.[1] Growth in the agriculture sector, and particularly the rice sector, has played a crucial role in Cambodia's development. In 2012, agriculture employed more than half of all workers and accounted for more than one-third of value added (World Bank 2013). During 2007–2012, yearly net production value of agriculture and rice paddy grew by 8.1% and 6.8% respectively (FAOSTAT 2014).[2] Cambodia's evolution into a net rice exporter after many years of net rice importation is largely attributable to gains in rice production and commercialization. While Cambodia exported 378 thousand tons of rice in 2013, it is still considered a small player in the worldwide rice export market. There are strong indications that rice production in Cambodia is far below potential as it has much lower yields and production value compared to other countries in the region (Figure 1).

In 2010, the Cambodian government designated the rice sector as a strategic area for development in its Policy Paper on the Promotion of Paddy Production and Rice Export (Royal Government of Cambodia 2010). The rice sector was identified as an area where Cambodia has a potential comparative advantage as it has significant amounts of fertile land, high levels of agricultural employment, and production that is well below potential. The policy paper outlined specific reforms and measures to address issues perceived as significant hurdles for Cambodia to achieve its ambitious goal of becoming one of the world's major rice exporter. The measures ranged from investments in infrastructure and input supply, to developing value-added output markets for milled rice processing. Policy reforms were also identified that could ensure and enforce quality standards.

Despite identification of a large set of measures and reforms to undertake for the rice sector, there has been limited systematic and rigorous analytical work conducted to guide and prioritize government investments and policy reforms. Which proposed investment climate policies and reforms may have the largest effects on rice commercialization, sales and production?[3] How may reforms affect farms of different sizes, especially small farms? These questions have remained largely unanswered due to the absence of adequate data

[1] Economic growth was 5.4% between 2007 and 2012, and poverty fell from 53% in 2004 to 20.5% in 2011 (World Bank 2013).

[2] Computed using values in 2004–2006 international dollar constant terms. Agriculture value added in contrast grew 4.6% (World Bank 2014).

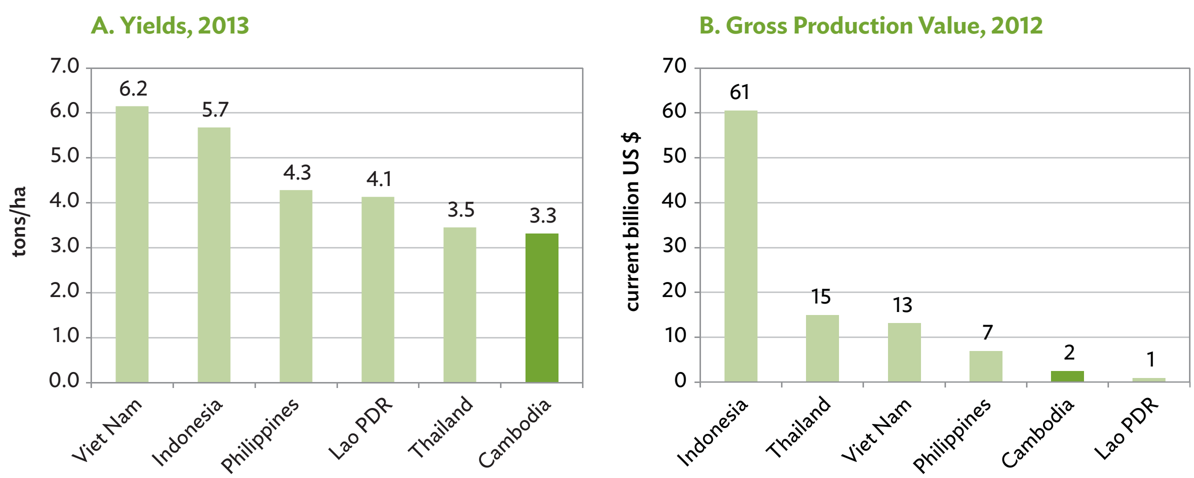
[3] Marketed surplus is a commonly used term to represent the percentage of total rice produce sold. This study considers commercialization as a binary variable because modeling in this case assumes that a farmer makes a decision prior to planting whether he wants to sell some portion of his produce or not. This in turn informs investment choices.

that capture aspects of the investment climate and farm performance in the rice sector. This study provides some answers to these questions by undertaking statistical and econometric analysis on data from a farm investment climate assessment (ICA) conducted in Cambodia. It provides a systematic way to prioritize policies and reforms that can reduce constraints farmers face in generating greater growth in the rice sector, which in turn can accelerate poverty reduction and sustainable agricultural development.

This farm ICA is one of the first known ICAs that have attempted to understand specific constraints to development and growth of small-scale farms engaged in rice production. It focuses on small farms, as more than 90% of farms in Cambodia operate on less than 4 ha of land. Historically, ICAs have covered primarily larger formal enterprises in urban areas or rural nonfarm enterprises. ICAs are essential tools in helping identify key constraints to firm growth which can inform governments on crucial reforms and investments. These studies typically analyze entrepreneur perceptions and measure obstacles faced in business operations, which are then linked to quantitative level data on firm outcomes. For this study, subjective perceptions on constraints to agricultural production and objective measures capturing access to irrigation, extension services, and financing, among others, were collected on the farm investment climate. Farm outcomes were captured by detailed data on rice input levels, production efficiency, commercialization, sales, changes in farm size, and investments in irrigation (Table 1).

The remainder of the report is organized as follows: Section II provides a background on the Cambodia farm ICA and investment climate. Section III presents the conceptual framework, which links the investment climate to commercialization and rice production decisions of farms. Section IV discusses the results of the analysis of the effects of the investment climate on farm outcomes. Section V outlines the major policy implications. Section VI concludes with some final remarks.

Figure 1: **Rice Paddy Production of Selected Asian Countries**



Lao PDR = Lao People's Democratic Republic.
Source: FAOStat Online Database. http://faostat.fao.org (accessed 23 September 2014).

Table 1: **Variables in the Cambodian Farm Investment Climate Assessment Survey**

Farm Household	
Investment climate perceptions	
	Constraints to agricultural production (yield, climate patterns, etc.)
	Top three major constraints to agricultural production
	Belief on whether business disputes can be resolved
	Informal payments needed
Investment climate objective	
	Land irrigated, land certified, electricity from grid, awareness of extension services, usage of extension services, access to credit, loans accessed in the last year
Production inputs	
	Land holdings, quantity and cost of seed, organic fertilizer, inorganic fertilizer, pesticide, other agricultural expenses
Production outcomes	
	Quantity of rice or crops produced, value of rice and crop production, yield, commercialization (farm sold some rice), quantity of rice sold, value of rice sold
Demographics	
	Farm manager education, gender, age, household size, etc.
Other variables	
	Nonfarm income, asset ownership
Commune	
Investment climate objective	
	Type of road infrastructure available, distance to nearest provincial town, distance to nearest miller, availability of miller in commune

Source: ADB.

II. Farm Investment Climate Assessment

A. Survey Rationale and Design

The farm ICA aimed to capture constraints to agricultural production faced by small farms in Cambodia. The survey was conducted from June to August 2013 in the three provinces of Battambang, Kampong Thom, and Takeo. These provinces are located around the Mekong and Tonle Sap rivers and are part of the main rice-growing areas in Cambodia. This survey covered crop production in the May–December 2012 wet season and the January–March 2013 dry season.[4]

While there has been increased attention to understanding constraints to investment of nonfarm enterprises in the rural sector, little work has assessed the investment climate for farm enterprises (e.g., Kinda and Loening 2010). Prior attempts to assess constraints to investments in rural Cambodia have relied mostly on provincial business environment scorecards that cover nonfarm enterprises (IFC and The Asia Foundation 2009). While the Cambodian socioeconomic surveys (CSES) are useful for analyzing some constraints to farm investments, these were not specifically designed to capture the full set of agricultural operations and changes in farm size that are important for rice production and commercialization.[5]

This farm ICA aims to fill this gap by providing a more complete picture of the issues and constraints that Cambodian farmers face in investing in technologies and inputs that can improve rice production and commercialization. The farm ICA was comprised of detailed commune profiles and associated household surveys. The commune profile collected general information on the history of the commune, demographic profiles, access to credit, farm size, input and output markets, and infrastructure. The household questionnaire captured characteristics of the farm, including acquisition history and current land ownership, utilization of inputs and production outputs, and investments in capital and land. Perceptions on major investment climate constraints hindering rice production relating to access to infrastructure, finance, government relationships, and the legal framework were also gathered.

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4 Rainfall especially in September 2012 was significantly higher than the average in many of the previous years (World Food Programme 2013).

5 Yu and Fan (2011), for example, used the CSES 2004 and 2007 to analyze the impact of irrigation and input usage on rice production in Cambodia. However, as irrigation is only an indicator variable and inputs did not capture seed or pesticide usage, the production estimates may contain significant bias. The model also ignored sample selection issues in dry season production functions because rice cultivation typically only occurs during this season when irrigation is available.

B. Sampling Strategy

The farm ICA surveyed 750 farm households covering 18 communes in three of the 24 provinces in Cambodia, namely, Battambang, Kampong Thom, and Takeo (Figure 2).[6] These provinces are among the highest rice producers in the country. Battambang is located in the northwest Tonle Sap, and ranked third in production with 0.785 million tons of rice paddy. Bordering Thailand, Battambang contains a major national highway and is a main hub connecting the region. Kampong Thom is located in the southern part of the Tonle Sap region and is ranked sixth in production with 0.549 million tons of paddy. Besides rice production, Kampong Thom is one of the major wild and aquaculture fish producers in the country. Takeo, situated at the lower Mekong delta and bordering Viet Nam in the southwest, is ranked second in production with 1.105 million tons of paddy. Takeo is closely linked to Phnom Penh through a good road system. While the provinces have similar patterns and ranks in rice area and harvesting values, Battambang and Kampong Thom have low to mediocre yields with 2.96 and 2.76 tons per hectare, respectively. Takeo has one of the highest yields among all the provinces at 3.87 tons per hectare (CAMInfo 2013). Takeo had a poverty rate that was near the average poverty rate of 25.8% for Cambodia in 2010, while Battambang and Kampong Thom had poverty rates that were over the average levels of poverty in the country at 28.7%, and 32.7%, respectively (ADB 2012).

Within each of the three provinces, six communes were selected based on average farm size and seed type used by the majority of farms in the commune (Table 2). These characteristics were chosen as they are expected to proxy for different levels of agricultural investments, production, productivity, and rice commercialization. Communes were categorized as above average or subaverage, using a cut-off of 1.5 ha, which is the average farm size across the three provinces based on the socioeconomic survey 2012. Communes were further categorized as domestic noncertified, domestic certified, or foreign seed users if more than 50% of farms in the commune used that seed type. These broad seed categories aimed to capture quality and seed type differences.[7] These categories were used for initial sampling purposes, but seed varieties are later used to recategorize seeds into groups that better reflect differences in yields and commercialization value.

Following consultations by the survey team with local commune authorities, villages within communes were selected to match the commune selection criteria. On average, two villages per commune comprised the sample quotas. Around 40 farm households were interviewed in each commune. Minimum quotas were imposed for the type of household surveyed, which differed by commune type (Table 3). These quotas aimed to ensure that different farm size–seed type comparisons could be conducted. Sampling weights derived from a screener questionnaire capturing farm size–seed type distributions combined with farm

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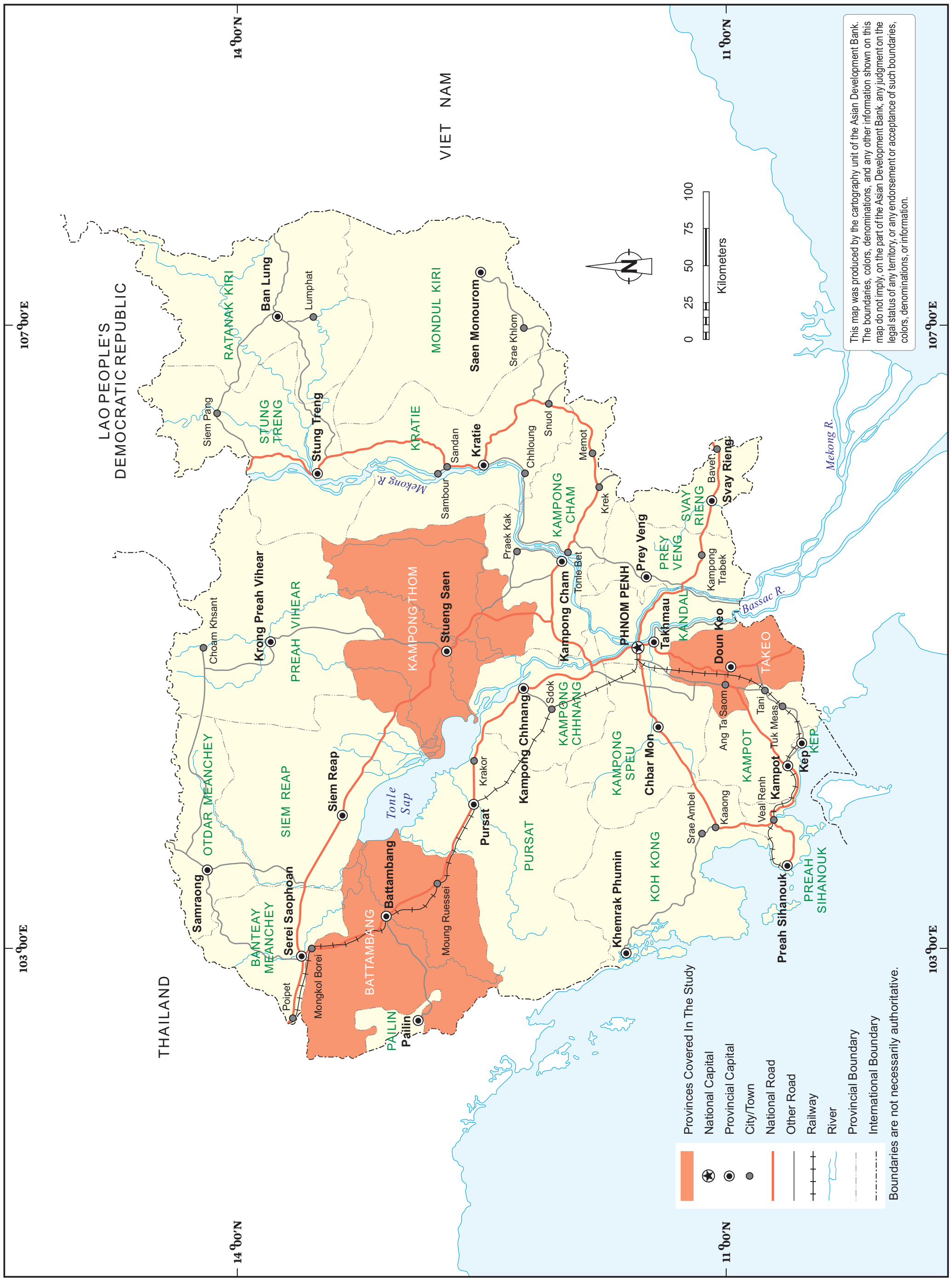
6 These provinces were selected because of involvement of the Asian Development Bank and World Bank, their importance as major rice-growing regions, and their geographic location.

7 Domestic noncertified seed includes Neang Khun, Phkar Malis, Kor Horm, and Sor Kronhan. Domestic certified seed includes Phka Romdoul, Rign Chhey, and Car 1. Foreign seed includes Namkhongbon (Vietnam-504), Phkar Khney Thai, IR 66, Rice OM, and Phkar Malis Thai. These seed types are recategorized in later analyses into high-yielding and standard seed varieties based on the International Rice Research Institute's International Network for Genetic Evaluation of Rice (INGER) Rice Varietal Releases Around the World Database (IRRI 2014).

Figure 2: **Cambodia Map**



Source: Nations Onine Project (http://www.nationsonline.org/oneworld/mapcambodia-administrative-map.htm).

Table 2: **Selection of Communes per Province**

Mean Farm Size	Type of Rice Seed Used by More than 50% of Households		
	Domestic Noncertified	Domestic Certified	Foreign
≤ 1.5 hectares	1	1	1
> 1.5 hectares	1	1	1

Source: ADB estimates.

Table 3: **Minimum Quotas for Household Sampling in Commune**

Panel A: Primary rice seed in commune is domestic noncertified

Farm Size	Rice Seed Used by Household		
	Domestic Noncertified	Domestic Certified	Foreign
≤ 1.5 hectares	5	5	10
> 1.5 hectares	5	5	10

Panel B: Primary rice seed in commune is domestic domestic certified or foreign

Farm Size	Rice Seed Used by Household	
	Primary	Other
≤ 1.5 hectares	5	5
> 1.5 hectares	5	5

Source: ADB estimates.

household population counts therefore are used to obtain representation of the population at the commune level.[8]

C. Farm and Farm Household Characteristics

Most farms are small, with 1.6 ha of land owned. Land rentals and share cropping bring cultivated land to 2.2 ha (Table 4). Farm households are highly concentrated on rice production as it accounts for 93% of the value of agricultural production. Few farms own any mechanized equipment for rice cultivation or harvesting. However, over 90% of farmers rent equipment such as threshers, rice mills, and drying machines for postharvest processes.[9] Although many households are engaged in rice production, 88% of farm households have diversified into nonagricultural activities and nonfarm income accounts for 44% of all income (Table 4).

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8 The weight W in commune c, with seed type t, and farm size, f is $W_{ctf} = \dfrac{p_c\left(\dfrac{s_{ctf}}{s_c}\right)}{d_{ctf}}$ where d is the number of farms, s is number of farms in screener sample, and p represents the total population of farm households in commune c.

9 The survey cannot differentiate between quality or level of mechanization of the mills and drying machines.

Table 4: Farm and Farm Household Characteristics

	All		Battambang		Kampong Thom		Takeo	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Raw Observations				751				
Land owned (ha)[1]	1.63	1.48	1.93	1.6	1.69	1.62	1.15	0.98
Land operated (ha)[2]	2.22	3.02	2.33	1.89	3	4.83	1.25	1.07
Crop prod value ('000 KHR)[3]	18,141	128,563	22,893	108,829	23,053	194,912	6,343	36,535
Rice prod value ('000 KHR)	4,086	7,205	3,561	3,141	5,687	11,741	3,206	4,608
Rice to crop prod value	0.93	0.21	0.87	0.28	0.97	0.14	0.98	0.12
Crop sales indicator	0.69	0.46	0.75	0.43	0.63	0.48	0.66	0.47
Crop sales ('000 KHR)	3,141	7,732	2,813	4,558	4,817	12,508	1,905	3,625
Rice sales indicator	0.65	0.48	0.69	0.47	0.59	0.49	0.66	0.47
Rice sales ('000 KHR)	2,696	7,362	1,837	2,592	4,719	12,491	1,866	3,608
Crop sales of prod value	0.44	0.63	0.47	0.55	0.46	0.88	0.4	0.38
Rice sales of prod value	0.38	0.37	0.35	0.34	0.41	0.41	0.39	0.38
Rice prod (tons)	5.4	11.65	4.36	3.65	8.82	20.07	3.4	4.77
Rice expenses ('000 KHR)	3,007	7,229	2,041	1,924	5,540	12,482	1,810	2,726
Rice cultivation single season	0.75	0.43	0.84	0.37	0.62	0.49	0.76	0.43
Cult equip owned[4]	0.6	0.49	0.54	0.5	0.63	0.48	0.65	0.48
Cult equip used[4]	0.99	0.1	0.99	0.11	0.98	0.13	1	0.02
Cult mech equip owned[5]	0	0.05	0	0.06	0	0.06	0	0
Cult mech equip used[5]	0.1	0.3	0.13	0.34	0.14	0.35	0.01	0.1
Harv mech equip owned[6]	0.01	0.11	0.01	0.11	0.01	0.09	0.02	0.13
Harv mech equip used[6]	0.9	0.31	0.97	0.18	0.98	0.16	0.71	0.45
Farm mngr female	0.14	0.34	0.13	0.33	0.12	0.32	0.17	0.38
Farm mngr age	45	11	45	12	45	11	44	11
Farm mngr educ primary	0.92	0.28	0.9	0.3	0.94	0.25	0.92	0.27
Farm mngr educ lower sec.	0.08	0.28	0.1	0.3	0.06	0.25	0.07	0.26
Farm mngr educ upper sec.	0	0.02	0	0	0	0	0	0.04
Total inc per cap ('000 KHR)[7]	2,014	2,430	1,793	1,638	2,015	2,832	2,329	2,871
Nonfarm inc in total inc	0.44	0.31	0.37	0.3	0.48	0.31	0.49	0.3
Poverty incidence	0.56	0.5	0.58	0.49	0.6	0.49	0.49	0.5
HH size	5.4	1.81	5.4	1.79	5.74	1.85	5.06	1.74
Car owned	0.01	0.09	0.01	0.11	0	0	0.01	0.09
Motorcycle owned	0.38	0.49	0.28	0.45	0.4	0.49	0.51	0.5

cap = capita, cult = cultivation, educ = education, equip = equipment, ha = hectare, harv = harvest/postharvest, HH = household, inc = income, KHR = Cambodian riel, mech = mechanical, mngr = manager, prod = production, SD = standard deviation, sec = secondary.

1 Plots owned and operated.

2 Plots owned and operated, rented in, or used for free.

3 Production value = total crop sales multiplied by average commune crop price, multiplied by quantity of crop produced but not sold, summed over all crops. For rice crops, price of dry paddy was used. As rice quantity is reported as wet paddy, an 85% conversion factor was used to obtain dry rice quantities.

4 Cultivation equipment includes hand tractor, plough, harrow, water pump.

5 Cultivation mechanized equipment includes tractor, intercultivator, drum seeder.

6 Harvesting and postharvesting equipment include thresher, miller, combine harvester, and drying machine.

7 Total income divided by household size. Total income is the sum of production value minus the total expenses from paid labor and material inputs bought; livestock and poultry sales; net sales from other farm activities; nonfarm income.

Source: ADB estimates.

Table 5: **Rice Production by Season of Subsistence and Commercialized Farmers**

	All		Battambang		Kampong Thom		Takeo	
	Sub	Comm	Sub	Comm	Sub	Comm	Sub	Comm
	Mean							
	Dry Season (January–March 2013)							
Farms cultivating rice	0.01	0.12	0.01	0.02	0.01	0.27	–	0.04
Yields (tons/ha)	2.56	3.41	2.52	3.82	2.66	3.15	–	4.02
Prod value per ha ('000 KHR)[1]	2,516	2,403	2,651	2,975	2,192	1,928	–	3,659
Cultivated area (ha)	0.51	3.98	0.49	0.94	0.55	5.1	–	1.95
Land irrigated of total	0.93	0.98	0.9	0.87	1	1	–	1
	Late Wet Season (September–December 2012)							
Farms cultivating rice	0.21	0.32	0.09	0.21	0.26	0.19	0.33	0.67
Yields (tons/ha)	1.85	2.22	1.88	2.28	1.29	1.94	2.37	2.3
Prod value per ha ('000 KHR)[1]	2,101	1,830	2,162	1,759	1,262	1,604	2,881	2,050
Cultivated area (ha)	1.08	1.99	1.53	2.54	1.1	1.7	0.65	1.46
Land irrigated of total	0.21	0.27	0.18	0.24	0.08	0.25	0.36	0.31
	Early Wet Season (May–August 2012)							
Farms cultivating rice	0.07	0.19	0.06	0.17	0.09	0.18	0.08	0.21
Yields (tons/ha)	1.94	2.62	1.78	2.54	1.67	2.4	2.8	3.04
Prod value per ha ('000 KHR)[1]	2,117	1,963	2,116	1,824	1,555	1,521	3,209	2,808
Cultivated area (ha)	0.86	2.01	1.02	2.09	0.94	2.83	0.39	0.74
Land irrigated of total	0.33	0.66	0.34	0.55	0.18	0.77	0.6	0.71

Comm = commercialized, ha = hectare, KHR = Cambodian riel, prod = production, Sub = subsistence.

[1] See Table 3, footnote 3.

Source: ADB estimates.

Rice cultivation occurs mostly in the late wet season with far fewer farms cultivating in the dry season (56% versus 13%). Farms that do cultivate in the dry season are largely irrigated, have higher yields, cultivate larger areas, and are more commercialized than those cultivating in the wet season (Table 5). As more than 75% of farms cultivate in a single season, and yields during the wet season are much lower than in the dry season, there is significant potential to increase the intensity of land use and the levels of production. There also is substantial potential to increase commercialization as one-third of farm households only produce rice for subsistence purposes. Increasing the intensity of land use, production, and commercialization therefore could potentially help to reduce the high rate of poverty incidence (59%) among farm households.[10]

D. Farm Investment Climate

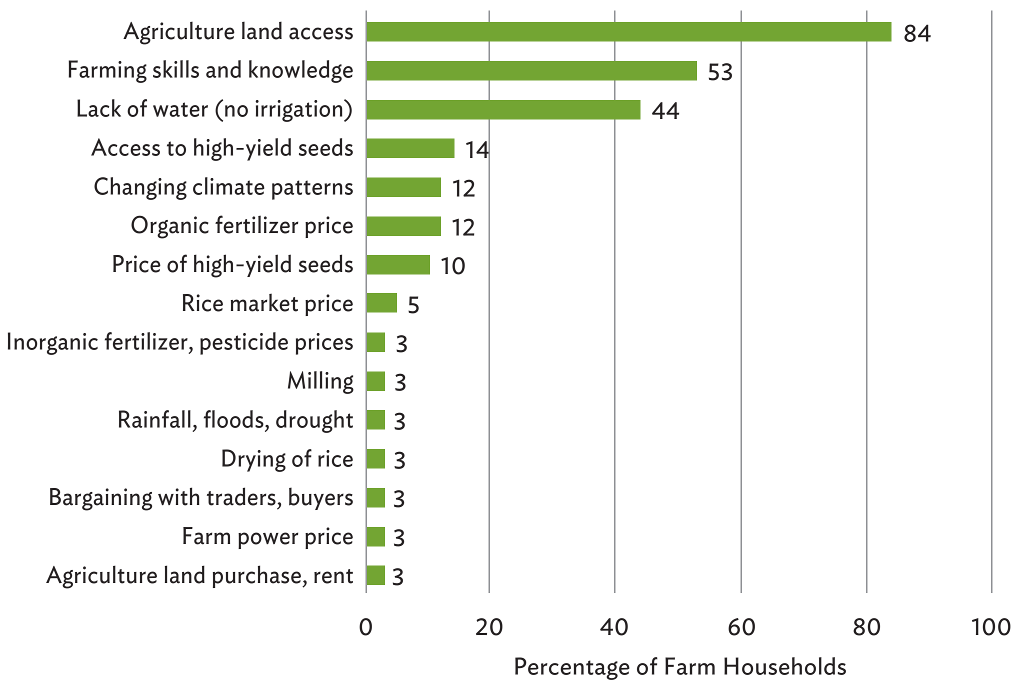
The farm investment climate is captured through a wide variety of measures that reflect areas where government intervention and policy reforms may contribute to improving production

[10] The 2009 (adjusted to 2013) yearly per capita income poverty line is KHR1.4 million ($339).

and the productivity of investments in small farms.[11] Perception-based measures provide insights into constraints that farmers perceive are the most relevant and difficult challenges to improving agricultural production. When farmers are asked what problems they perceived are the most problematic constraints to agricultural production, a high proportion of farmers indicated land access, farming skills and knowledge, lack of water or irrigation, followed by access to high-yielding seeds and changing climate patterns (Figure 3). When asked to rank major issues in agriculture production a high proportion of farmers cited weather shocks, irrigation, price of inorganic fertilizer and pesticides, changing climate patterns, financial capital, and rice price volatility were cited as major issues by a higher proportion of farmers (Figure 4).

Perception-based measures, however, are subject to bias arising from a farmer's education and skills, gender, and strategic priorities for agricultural development. Objective measures are often complementary and provide an alternative basis for understanding which areas of the investment climate are problematic. Table 6 includes a combination of objective and perception-based measures related to the investment climate. The simple indicators show that over 30% of farmers still operate land without legal titles and less than 50% have

Figure 3: **Most Problematic Constraints to Agricultural Production**

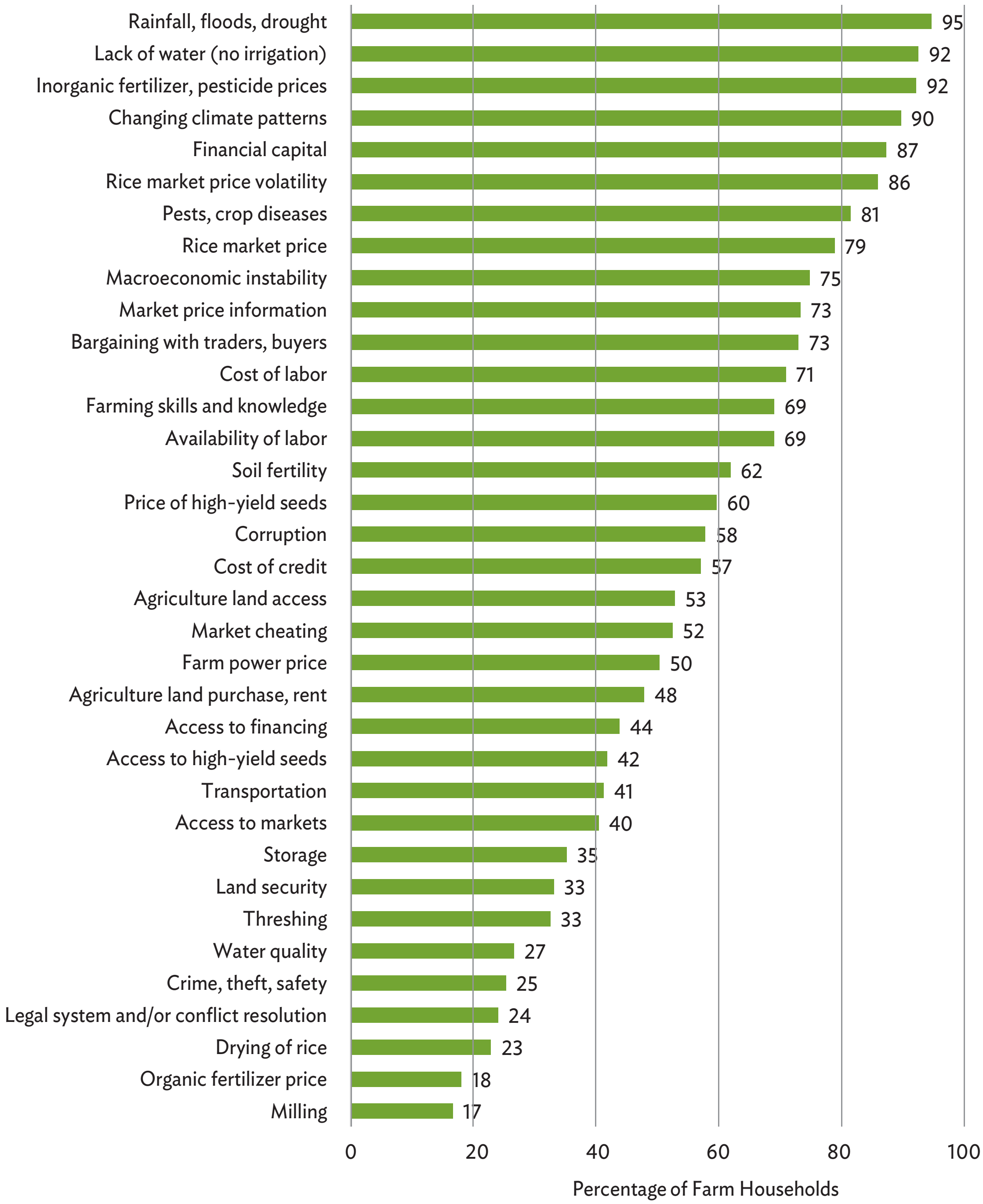


Note: Based on responses as to whether an item is in the top 3 most difficult problems for agricultural production.

Source: ADB estimates.

[11] General investment climate measures have been shown to be significantly related to firm performance (Dollar et al. 2005, Kinda et al. 2011, Kinda and Loening 2010). This report is driven by the line of inquiry and approaches set out by papers and surveys in the firm investment climate literature, rather than that of the more traditional agricultural economics literature.

Figure 4: **Farmers' Ranking of Major Issues in Agricultural Production**



Note: Based on responses as to whether an item was considered a major problem for agricultural production .
Source: ADB estimates.

Table 6: **Investment Climate Farm Indicators**

	All	Battambang	Kampong Thom	Takeo
	Mean			
	Land Security			
Operates unsecured land	0.37	0.44	0.38	0.25
Proportion of farm area certified	0.71	0.65	0.69	0.80
Operates legally certified land	0.69	0.79	0.63	0.61
Legally certified land of total farm	0.38	0.28	0.44	0.45
	Skills and Knowledge Development			
Agricultural advice from government entities	0.09	0.11	0.05	0.13
Agricultural advice from books, internet, media	0.54	0.53	0.51	0.60
Agricultural advice from supplier, millers, traders	0.20	0.16	0.26	0.20
Plan to take course to improve farming skills	0.26	0.26	0.28	0.24
Aware of SRI methods	0.09	0.08	0.05	0.13
Usage of SRI methods	0.09	0.09	0.07	0.13
Computer used for farm business	0.01	0.01	0.00	0.01
	Irrigation			
Irrigation indicator	0.47	0.43	0.49	0.50
Land irrigated of total	0.34	0.28	0.38	0.39
Land irrigated of total: dry season	0.21	0.15	0.37	0.11
Land irrigated of total: wet season	0.31	0.27	0.32	0.37
Land irrigated of total (late wet season)	0.31	0.27	0.32	0.37
	Input Markets			
Usage of regular seed	0.76	0.70	0.81	0.80
Usage of old high-yielding seed	0.13	0.22	0.01	0.13
Usage of new high-yielding seed	0.41	0.42	0.46	0.35
Purchase seeds	0.12	0.18	0.08	0.08
Purchase organic fertilizer	0.10	0.05	0.03	0.25
Purchase inorganic fertilizer	0.86	0.80	0.87	0.92
Purchase pesticides	0.56	0.77	0.50	0.32
Hire agricultural labor	0.50	0.56	0.37	0.54
Cooperative member	0.07	0.06	0.02	0.12
	Output Markets			
Regular rice sold of total sold	0.61	0.51	0.73	0.64
Old high-yielding rice sold of total sold	0.09	0.19	0.00	0.03
New high-yield rice sold of total sold	0.30	0.30	0.27	0.33
Sold rice to trader	0.88	0.80	0.94	0.96
Sold rice to cooperative	0.02	0.02	0.03	0.01
Sold rice to miller	0.12	0.24	0.01	0.02
Rice sold to trader of total sold	0.86	0.76	0.93	0.94

continued on next page

Table 6 *continued*

	All	Battambang	Kampong Thom	Takeo
	Mean			
Rice sold to consumer of total sold	0.03	0.05	0.02	0.02
Rice sold to cooperative of total sold	0.02	0.02	0.03	0.01
Rice sold to miller of total sold	0.09	0.18	0.01	0.02
Rice sold at farm gate	0.07	0.04	0.05	0.11
Rice sold within village	0.62	0.68	0.56	0.59
Rice sold outside village	0.02	0.04	0.01	0.00
Contract farming indicator	0.00	0.00	0.00	0.00
Storage equipment owned	0.31	0.31	0.29	0.33
Storage equipment used	0.33	0.35	0.31	0.34
Storage equipment owned	0.31	0.31	0.29	0.33
Storage equipment used	0.33	0.35	0.31	0.34
	Physical Infrastructure			
Transportation costs indicator	0.36	0.41	0.31	0.33
Transportation costs (in '000 KHR)	52	52	70	33
Electricity from grid	0.40	0.53	0.05	0.58
	Financing			
Bank/MFI loan	0.37	0.33	0.48	0.32
Credit-constrained	0.18	0.17	0.15	0.21
	Legal Environment			
Not confident in business dispute resolution	0.10	0.09	0.11	0.11
Informal payments commonly used	0.72	0.69	0.82	0.64
	Production Uncertainty			
Crop damage from flooding	0.03	0.02	0.02	0.06
Crop damage from drought	0.03	0.04	0.02	0.02
Crop damage from pests	0.05	0.06	0.06	0.03
25% crop destruction perceived likely	0.72	0.77	0.69	0.69
25% crop destruction perceived uncertain	0.19	0.12	0.24	0.25
50% crop destruction perceived likely	0.29	0.36	0.22	0.25
50% crop destruction perceived uncertain	0.33	0.23	0.48	0.31
Risk aversion	0.89	0.89	0.90	0.89

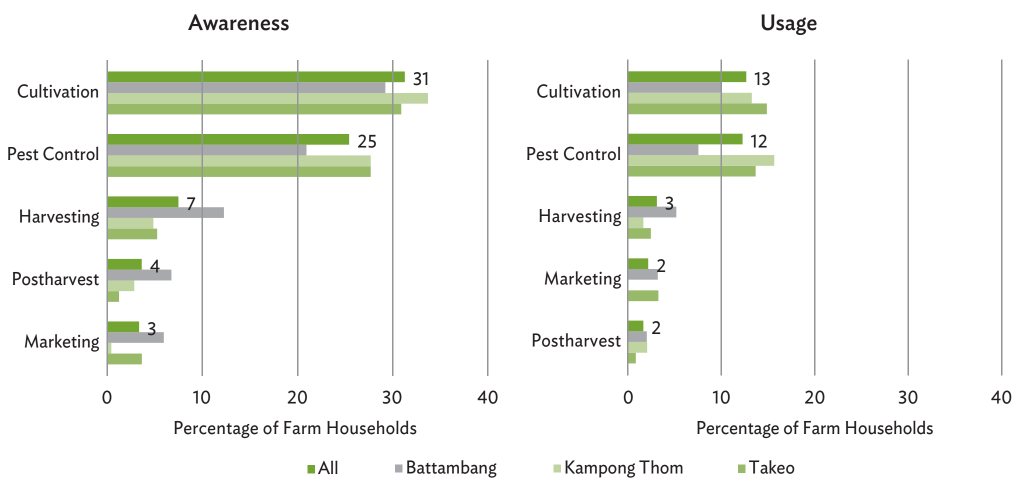
KHR = Cambodian riel, MFI = microfinance institute, SRI = system of rice intensification.
Source: ADB estimates.

land that is irrigated. Most farmers sell rice to traders with only a small percentage selling to millers or cooperatives. They also face a high degree of uncertainty in production as 70% believe it is likely that at least 25% of their crop will be destroyed in the next cropping season. Many farmers live in communes with limited facilities and infrastructure. Only one of the 18 communes surveyed has an asphalt road and only seven of the 18 communes have any domestic milling facility. None of the communes contain a joint drying facility.

Consistent with perceptions that skill development is a potential constraint, only 9% of farmers can identify practices related to the system of rice intensification, a series of cultivation practices that are promoted as raising yields through labor-intensive investments. Moreover, while extension services are useful channels through which government can improve skills, the extension services that farmers are aware of and utilize are low. Only 44% of farmers are aware of extension services available in their commune, about half of whom actually utilize these services (Figure 5). Few farmers have made any changes to their farming practices, reflecting limited investments in skill and knowledge development for agriculture. Only 32% of farmers introduced a new seed variety, and 18% utilized a better land preparation technology. Farmers appear to invest more in new nonfarming businesses, with 49% indicating they had started a nonagricultural business in the last 2 years (Figure 6). Cambodian farmers generally appear to lack critical skills and knowledge for improving rice production. Skill limitations have left Cambodian farmers exposed to greater risks as a limited number of farmers are found to adjust their crop variety or planting dates in response to extreme weather conditions—adjustments that could significantly mitigate production risks (Thomas et al. 2013).

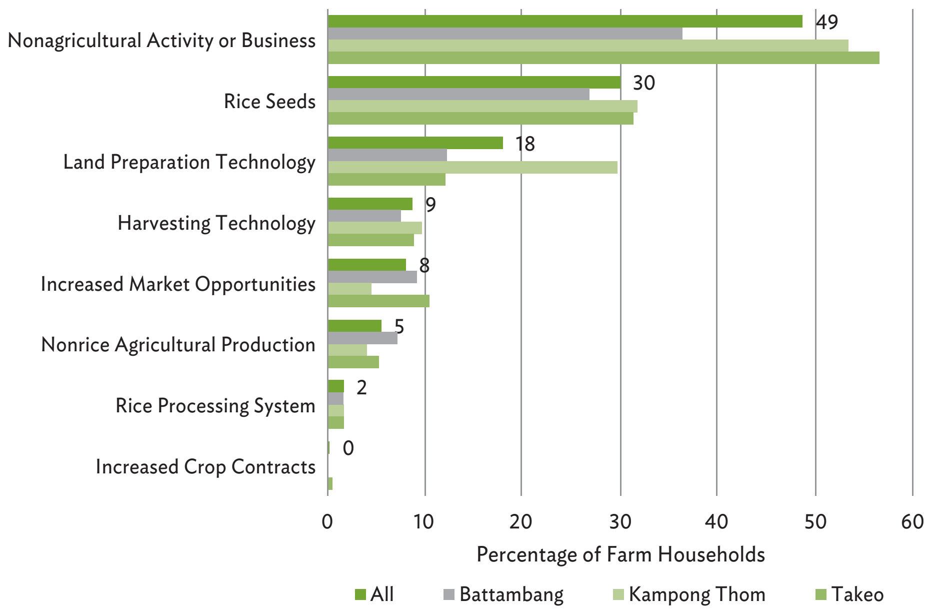
While land access is perceived to be a major challenge to agricultural production, access to finance that can be used to purchase more land is not a major issue as only 18% of farms are identified as credit-constrained. Even beyond the farm sector, Cambodia has relatively well-functioning financial markets, which are ranked 42 out of 189 countries in Doing Business

Figure 5: **Awareness and Usage of Agricultural Extension Services**



Source: ADB estimates.

Figure 6: **New Investments Made in the Last 2 Years**



Note: The items are new activities or strategies undertaken by the household in the last 2 years .
Source: ADB estimates.

indicators. Farmer perceptions reflect a limited amount of exposure to the legal environment. Over 90% of farmers indicate that business disputes can be resolved and only 25% consider the legal system and conflict resolution to be important for agricultural production. Still the broader legal environment may have negatively affected the nonfarm sector, as Cambodia is ranked 162 and 163 out of 189 countries in enforcing contracts and resolving insolvency, respectively. There is also clear indication that the legal system has hurt agribusiness development in the input supply and rice output markets (World Bank 2013). The indicators of the investment climate are reflective of a number of areas that can be improved and may be constraining production and commercialization in the farm sector.

E. Differences among Provinces

Kampong Thom has the highest average area of land operated, crop value of production, and total rice sales (Table 4). It also has the highest percentage of farmers growing rice over multiple seasons. Yet, Kampong Thom has substantially lower yields, value of production per hectare, and proportion of farms commercializing rice production compared to other provinces (Table 5). Takeo, which has much smaller farms, has much higher yields. A large part of the differences in production can be explained by differences in nonfarm income. Takeo has significantly higher levels of nonfarm income, has better infrastructure, and has a strategic advantage as it is located close to Phnom Penh and borders Viet Nam. It is the only province containing a commune with an asphalt road (Table 7). Battambang has the advantage of having a greater number of domestic millers. Both Takeo and Battambang have much higher rates of electrification. In light of these differences, Kampong Thom may potentially have more to gain from government improvements in the investment climate for rice production.

Table 7: **Investment Climate Commune Indicators**

Variable	All	Battambang	Kampong Thom	Takeo
Sample communes	18	6	6	6
Proportion of households connected to electricity	0.4	0.4	0.0	1.0
Average distance to provincial town (kilometers)	27	15	5	49
		Counts		
Cooperative	9	4	1	4
Asphalt road	1	0	0	1
Joint drying facility	0	0	0	0
Large domestic miller (none)	13	4	5	4
Large domestic miller (one)	2	0	0	2
Large domestic miller (two or more)	3	2	1	0
Domestic miller (none)	11	3	5	3
Domestic miller (one)	1	0	0	1
Domestic miller (two or more)	6	3	1	2

Note: Large domestic millers have milling capacity of 10 tons or more per hour.
Source: ADB estimates.

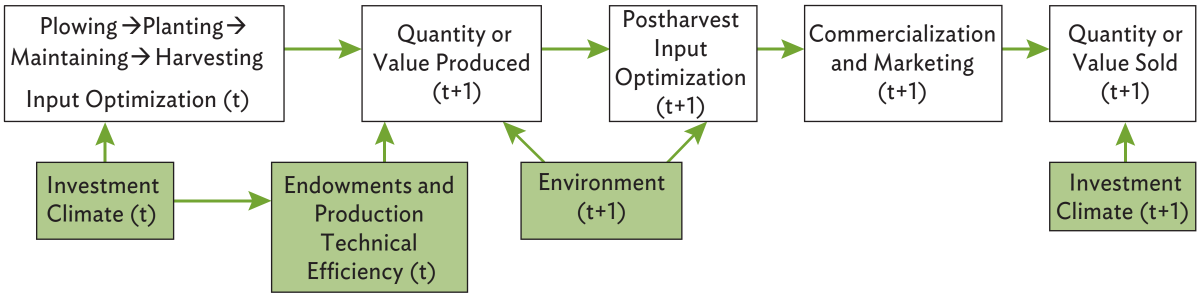
III. Methodology

A. Conceptual Framework

Figure 7 outlines a framework for understanding the potential investment climate effects on rice production and commercialization. In this framework, farmers optimize their inputs in rice production given current investment climate conditions, asset and skill endowments, and expected probability of environmental shocks. These factors result in a level of paddy production that farmers may decide to commercialize as wet paddy, dried paddy, or milled rice. The investment climate at the time of selling affects demand from output markets, costs to accessing markets, and expected price to be received in output markets, which in turn may affect both the decision to commercialize, and the marketed surplus or amount that the farmer decides to commercialize.[12]

Commercialized farmers have much higher yields, land area planted, irrigation, and dry season cropping compared to noncommercialized farmers (Table 5). Commercialized farmers are also more likely to purchase inputs through the market economy (Figure 8). The close link between rice production and rice sales indicates that raising production is

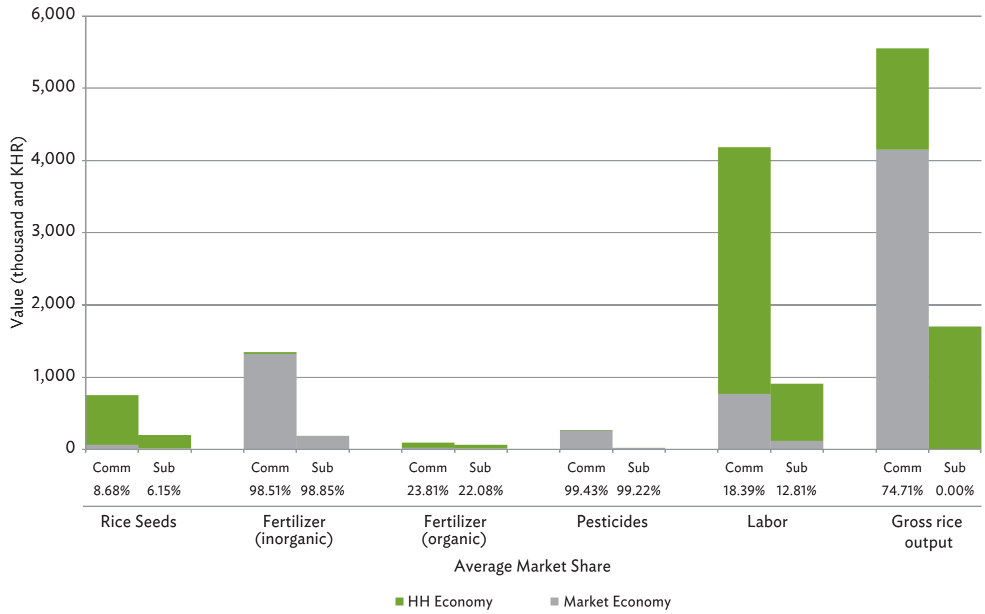
Figure 7: **Rice Production and Commercialization**



t = time.
Source: ADB estimates.

12 A model where farmers were strategically oriented and evaluated returns to commercialization at the same time they made their input decisions was considered. However, the literature and data suggest that small farmers on the margin are not strategic actors and simply take certain price conditions and endowments as given and make production decisions accordingly, rather than based on expected returns to commercialization at the time they make their input decisions.

Figure 8: **Market Integration for Noncommercialized and Commercialized Farmers**



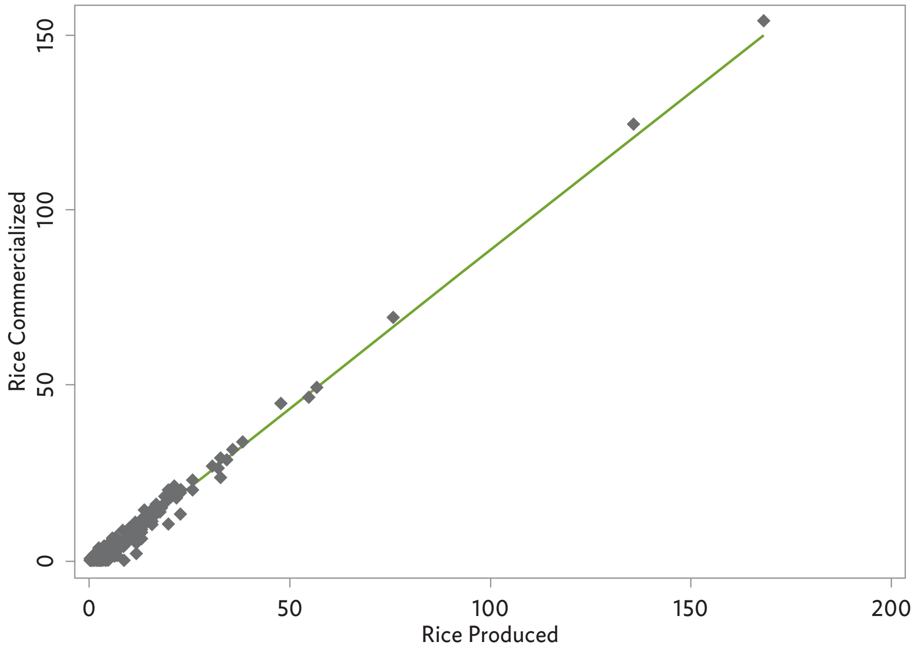
Comm = Commercialized, Sub = subsistence.
Source: ADB estimates.

a crucial factor toward increasing commercialization and marketed surplus (Figure 9). This framework provides the basis for the empirical models that estimate the effects of changes in the investment climate on farm household input choices, rice production and production technical efficiency, rice commercialization, and quantity and value of rice sold. Production technical efficiency captures a farmer's ability to transform existing inputs into rice production output. The subsequent empirical analysis helps to identify the important aspects of the investment climate that are needed for prioritizing future reforms and investments.

B. Farm Investment Climate Variables

This study focuses on eight aspects of the farm investment climate that may affect agricultural production and commercialization. These are (i) land certification (ii) irrigation (iii) skills, (iv) input markets, (v) output markets, (vi) financial markets, (vii) physical infrastructure, and (viii) legal environment. The first five reflect aspects that a significant proportion of farmers perceive as the most problematic for agricultural production (Figure 3). The last three are included to capture areas of the investment climate that are commonly discussed for policy reforms. While many investment climate indicators exist, this selected set of variables is the focus of this analysis as sample size constraints make it difficult to empirically analyze a larger set. These eight aspects are identified as the most relevant indicators for understanding farm production constraints and potential farm sector reforms in Cambodia.

Figure 9: **Relationship between Quantity of Rice Commercialized and Quantity of Rice Produced** (tons)



Source: ADB estimates.

Each area of the investment climate is represented by a single variable or index. Objective measures of the investment climate are used where possible as they are less contingent on unobserved differences in perceptions and conditions, and provide a clearer basis for understanding the types of investments that are needed. Most investment climate indices were constructed at the commune level. This reduces some concerns that estimates are biased by reverse causality and individual level omitted variables. For investment climate measures composed of multiple variables, the first principal component from principal component analysis was.[13] This reduces variable identification problems in regression analysis that arise from using a smaller sample size and multicollinearity.[14]

Table 8 summarizes the list of variables that are used to capture the investment climate. Land access is measured using the proportion of farm households that have secure rights. Unsecured rights may decrease the chance that viable rental markets can exist. It can also reduce incentives for households to make longer-term investments in their land if it is potentially taken over before it is possible to recoup investments. Irrigation is measured by the percentage of a farm's land that is irrigated. This measure is based on an indicator

[13] This technique uses variations in a set of related variables to construct weights that result in a new set of variables that are orthogonal or unrelated to each other. It provides a more systematic way to construct indices based on a set of variables.

[14] There is still correlation between the different indices, but it is not as high as the correlation of variables within indices. Correlations of indices are generally below 0.5.

Table 8: **Key Investment Climate Variables**

Variable Name	Level	Description	Mean	Eigenvector	Simulated Change
Land certified	Household	Proportion of land area certified	0.70		0.1
Irrigation	Household	Proportion of land area irrigated	0.36		0.1
Skills	Household	Awareness of extension services: cultivation	0.31	0.453	+1 SD
		Awareness of extension services: harvesting	0.07	0.552	
		Awareness of extension services: postharvesting	0.03	0.498	
		Awareness of extension services: marketing	0.03	0.346	
		Awareness of extension services: pest control	0.26	0.349	
Input market	Commune	Proportion of high-yielding rice cultivated	0.28	(0.451)	+1 SD
		Quantity to price ratio of high-yielding rice	0.14	(0.335)	
		Quantity to price ratio of inorganic fertilizer	4.91	0.617	
		Quantity to price ratio of pesticides	0.00	0.551	
Milling	Commune	Number of large millers in commune	0.50		[0–1]
Infrastructure	Commune	Percent of households with electricity	0.53	0.707	+1 SD
		Asphalt road in commune	0.05	0.707	
Financing	Commune	Proportion with bank/MFI loan	0.33	0.707	+1 SD
		Proportion not credit constrained	0.79	0.707	
Legal	Commune	Proportion perceiving legal system/conflict resolution as problematic	0.49	0.349	–1 SD
		Proportion perceiving crime, theft, safety as problematic	0.25	0.581	
		Proportion perceiving market cheatings as problematic	0.24	0.572	
		Proportion perceiving corruption as problematic	0.58	0.412	
		Proportion perceiving business disuptes difficult to resolve	0.11	(0.048)	
		Proportion perceiving informal payments needed	0.71	0.193	

( ) = negative.
Note: Variables based on multiple indicators were created using pricincipal component analysis.
Source: ADB estimates.

of whether farmers can irrigate their plot, but does not necessarily capture differences in quality of irrigation that may occur due to different types of irrigation systems and access to water. Irrigation is an essential component to ensure that farmers can crop during the dry season, and helps to better regulate water inputs, which are essential for improved yields. An indicator of a farmer's awareness of different types of extension services in the commune is used to capture the supply of services provided to farmers to enhance agricultural skill and knowledge development. Extension services are useful channels through which the government can enhance diffusion and adoption of new seed technologies, farming techniques, and commercialization (e.g., Gebremedhin et al. 2009). Input markets are captured by the quantity of inputs purchased and the price of inputs, as better markets should have greater consumption and lower input prices. Output markets are captured by the number of large domestic millers in the commune. Large millers are believed to stabilize output market prices by providing a more stable source of demand for rice. Financing is captured by an index comprised of the proportion of households in the commune that obtained loans, and the proportion of farmers that are identified as credit-constrained, meaning they wanted to borrow more for agriculture than what was offered through formal loan markets. Better financing conditions are expected to enable entrepreneurs to make productive investments that can allow their firms to grow or start a new business. Physical infrastructure is an index based on the proportion of households with electricity and the availability of asphalt roads in the commune. Better physical infrastructure is expected to reduce transaction costs and improve the ability of entrepreneurs to access markets (Ouma et al. 2010). Finally, the legal environment is an index comprised of the proportion of farmers in each commune who perceive one of six aspects of the legal system as problematic for agricultural production.

These indicators are not perfect. Some bias exists because variations in the observed levels of variables are potentially driven by locational conditions or farm conditions that are not exogenous. For example, skill and knowledge development represented by awareness of extension services may be provided by governments in areas that are poorer and are identified as having lower levels of production efficiency. Financing and irrigation may reflect a farm's own investments rather than governmental investments, which occur because unobserved locational characteristics drive farmers to invest more in rice production, but also improves the value of production (Sherlund et al. 2002). There are also potential limitations with the indicators to capture heterogeneity and differences in quality especially in the case of irrigation and inputs. In the absence of better data, it is not possible to completely resolve these issues. Still, the investment climate areas are expected to capture areas where policymakers and local governments have the capability to invest in infrastructure and implement reforms.

IV. Investment Climate Effects

Identifying aspects of the investment climate that are related to input levels, commercialization, production, and production technical efficiency are important in identifying and prioritizing policies and investments. However, as the analysis is restricted to a single year of observation capturing the dynamic nature of investment decisions that occur over time and controlling for unobserved and time-invariant characteristics associated with locations and farm characteristics is not possible. Thus, the analysis cannot fully establish causality of investment climate effects on farm outcomes. In particular, environmental production conditions could lead to overestimation in factors related to technical efficiency in production (Sherlund et al. 2002). However, to control for some of the conditions that are associated with regional characteristics and locational conditions related to fertility of land and proximity to other countries and markets, province-level indicators are included in the regression analysis. Different models are used to examine various outcome variables, but while interrelated, are not estimated simultaneously. The estimates from the empirical models are used to simulate expected changes in outcomes that are related to changes in the investment climate (Table 8). Only changes in the investment climate that are statistically significant with a probability < 0.1 with the outcome of interest are discussed and highlighted.

A. Input Usage

The intensity of inputs utilized can lead to higher returns to production and greater commercialization. Using high yielding seed varieties may also have increased commercialization potential or market value. A tobit model is used to investigate the intensity of input usage and expenditures (Appendix Part A, Appendix Table A.1). As some inputs and expenditures are nonessential to the production process, the tobit model adjusts for censoring in quantities utilized as many farmers may not utilize some types of inputs. Both seeds and labor quantities should be nonzero as they are essential to the rice production process, but may have zero expenses as they can be generated by the household. On the other hand, fertilizer and herbicides are not used by a handful of farmers, but are important for enhancing yields. In addition to aspects of the investment climate, the models include controls for household and farm characteristics that factor into the intensity of input usage. For example, the inclusion of cultivated area captures potential economies or diseconomies of scale, while farm characteristics such as household size, farm manager education, and amount of income received from nonfarm activities captures aspects of skill and competing demands that may constrain the level of inputs that can be generated or employed.

The effect of the investment climate varies by type of input. Increased irrigation and improvements in input markets are associated with decreased intensity of labor inputs and labor expenses per hectare as they are indicative of technologies whose usage are less labor-intensive. Milling, input markets, infrastructure, and legal environment improvements are associated with increased labor expenses per hectare. Increased irrigation is associated with higher levels of seed usage, inorganic fertilizer and pesticide usage and expenses per hectare. Physical infrastructure improvements are related to increased intensity of seed and pesticide usage, but are not significant factors in expenses. This result can occur if physical infrastructure reduces transaction costs allowing for reduction in input prices. Improved input markets are associated with increased usage and expenses of inorganic fertilizer and pesticides. Presence of milling is associated with higher usage of inorganic fertilizer and expenses and with decreases in organic fertilizer expenses. Improved input markets raise the amount and expenses of inorganic fertilizer and pesticides used, as well as the expenses dedicated toward organic fertilizer. There is also evidence that improved rates of land certification are associated with a rise in inorganic fertilizer usage, and a decrease in seed expenses. However the reason such relationships may occur is less clear.

The trade-offs and substitution effects that occur between different inputs due to changes in the investment climate make it difficult to draw conclusion from the input analysis on aspects of the investment climate that are important for raising rice production and commercialization. Therefore, examining the investment climate effects on production and commercialization provides a way to understand the exact implications of altering the investment climate.

B. Rice Production Technical Efficiency

The investment climate can alter the intensity of input usage and a farmer's level of rice production efficiency by encouraging adoption of better technology, more efficient management practices and techniques, and optimized use of inputs for rice production. These factors in turn affect the level of production. Improvements in the investment climate that are associated with farms that are closer to the technological frontier of rice production and therefore are more efficient is investigated using a technical efficiency model. This model assumes that the production function is Cobb-Douglas and is a factor of land, seed, fertilizer, and pesticide inputs in addition to a technological efficiency component. A farmer's endowments such as education and household size, as well as the investment climate, comprise the technological efficiency component (Appendix Part B, Appendix Table A.2). Because input quantities enter the model in log terms, inputs with zero values are undefined. Zero values therefore are represented by a dummy indicator and replaced with zero in the log term. While production efficiency data is typically analyzed on a seasonal basis to improve estimates on effects of input usage (e.g., Yu and Fan 2011, Wokker et al. 2014), input values were aggregated over multiple seasons. This introduces more seasonal bias into input value estimates, but better captures time-invariant investment climate effects on yearly production efficiency.

The technical efficiency model indicates that using more inputs—excluding labor inputs—is associated with higher production levels and value. Increased land certification, area irrigated, milling, and financing are significant factors associated with increased quantity and value of rice production technical efficiency. In contrast, reducing legal problems, improvements in input markets and increased extensions services are associated with decreased technical efficiency. The legal environment potentially enhances returns to nonfarm activities more than farm activities resulting in lower technical efficiency. The surprising finding that more extension services are associated with lower technical efficiency may arise if such services are targeted to areas that are poorer and have lower yields. The negative relationship of input market development meanwhile may be explained by counteracting factors not controlled for in the regression analysis and representing more general factors of the investment climate. None of the household characteristics such as education are significant in the regressions. Farms that increase in size or used a higher percentage of high yielding seeds have higher values of production technical efficiency.

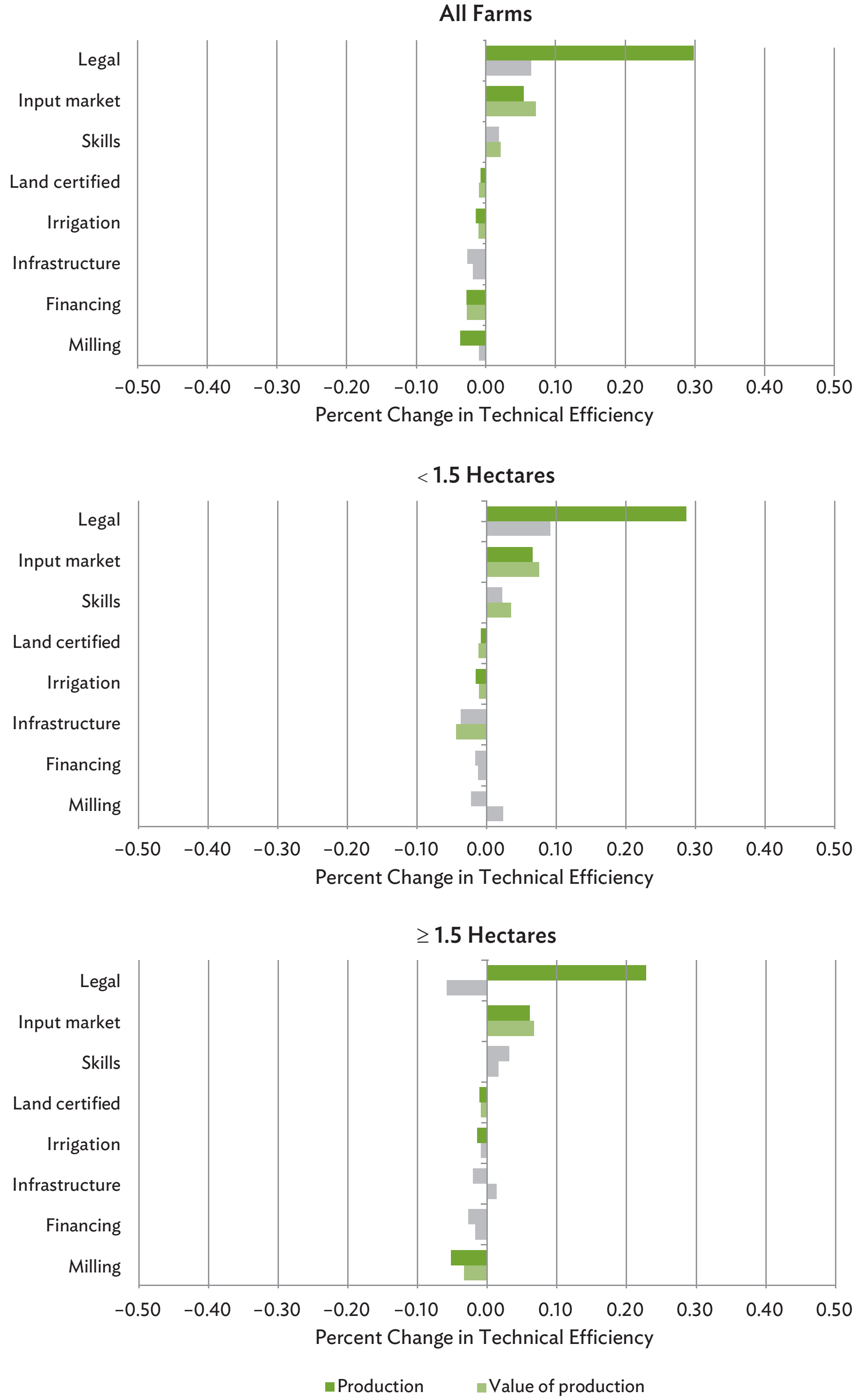
Smaller farms tend to have fewer agricultural assets and have greater exposure to risks because of inability to diversify their crops and cropping patterns. To examine whether the investment climate has differential on production technical efficiency of different sized farms, technical efficiency models are run on farms operating land with ≤ 1.5 ha and those operating land with > 1.5 ha (Figure 10, Appendix Table A.2). Irrigation and land certification play a highly important role in production technical efficiency of above average and sub-average farms. However, irrigation is only important in the value of production technical efficiency for sub-average farms. On the other hand, large miller presence is associated with greater production technical efficiency of above average farms, but not sub-average farms. The legal environment is associated with reduced technical efficiency of all farms. Skill development is associated with lower value of production technical efficiency in the case of small farms, but not large farms. Increased land size is associated with improvements in value of production technical efficiency of small farms, while it has a negative relationship with large and may be indicative of a nonlinear relationship between farm size and efficiency. The results indicate that there are some differences in the relationship of the investment climate with technical efficiency depending on farm size that potentially should be considered when trying to design more optimal policies for enhancing development of smaller farms.

C. Commercialization and Rice Sales

Despite the close link between production and rice sales the technical efficiency models cannot completely capture the effects of the investment climate on rice commercialization and sales which are essential for improving farm incomes. To capture outcomes that are more associated with farm incomes, a probit model is used to examine the probability of commercialization while a tobit model is used to examine rice quantity and value of sales. These models include investment climate factors, farm characteristics, and input and output market prices. The tobit specification corrects for the inability to observe the extent of the shortfall in rice production of rice farmers who have not commercialized (Appendix Part C, Appendix Table A.3).

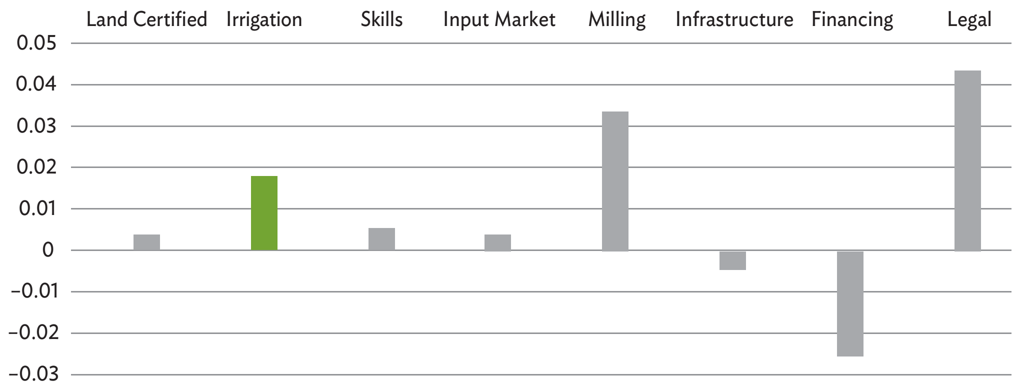
The probability of commercialization increases with improvements in irrigation. Access to storage facilities and greater farm manager education are related to increased probabilities of commercialization (Figures 11 and 12). However, increased farm size is related to

Figure 10: **Investment Climate Effects on Technical Efficiency**



Source: ADB estimates.

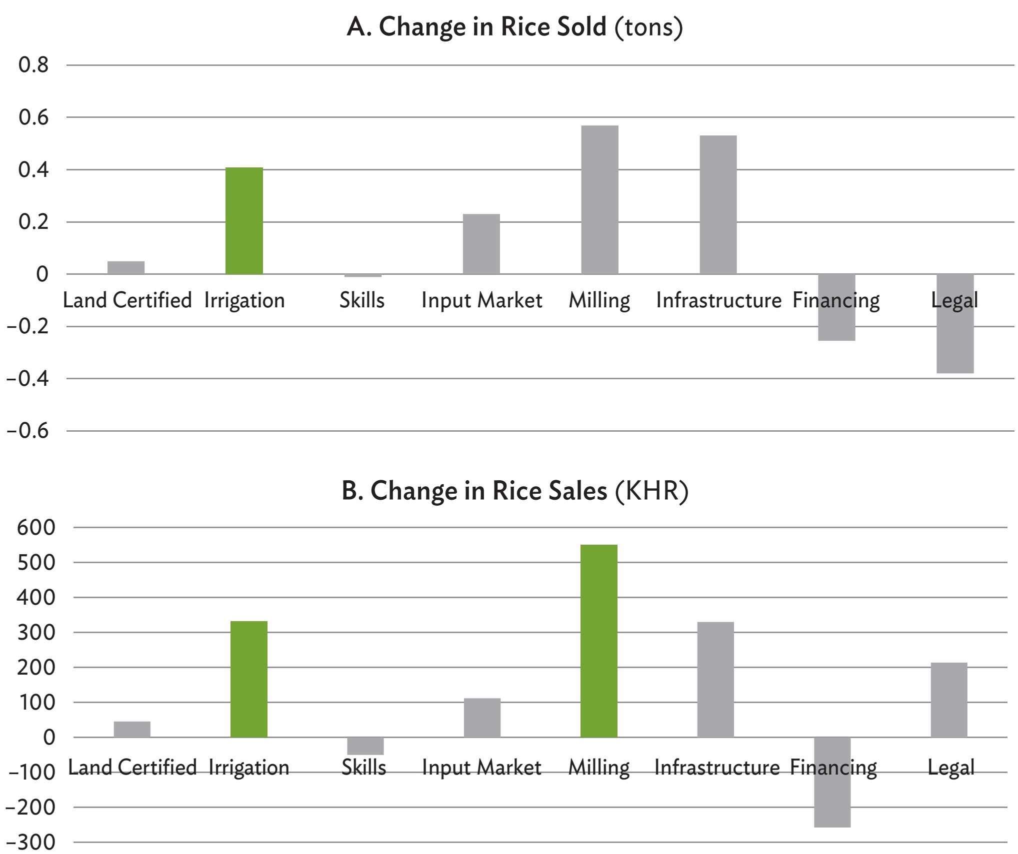
Figure 11: **Investment Climate Effects on Commercialization**



Note: Estimates based on probit model of commercialization. Highlighted column is statistically significant with $p < 0.1$.

Source: ADB estimates.

Figure 12: **Investment Climate Effects on Rice Sold**



KHR = Cambodian riel.

Note: Estimates based on tobit model of rice sold or sales. Highlighted columns are statistically significant with $p < 0.1$.

Source: ADB estimates.

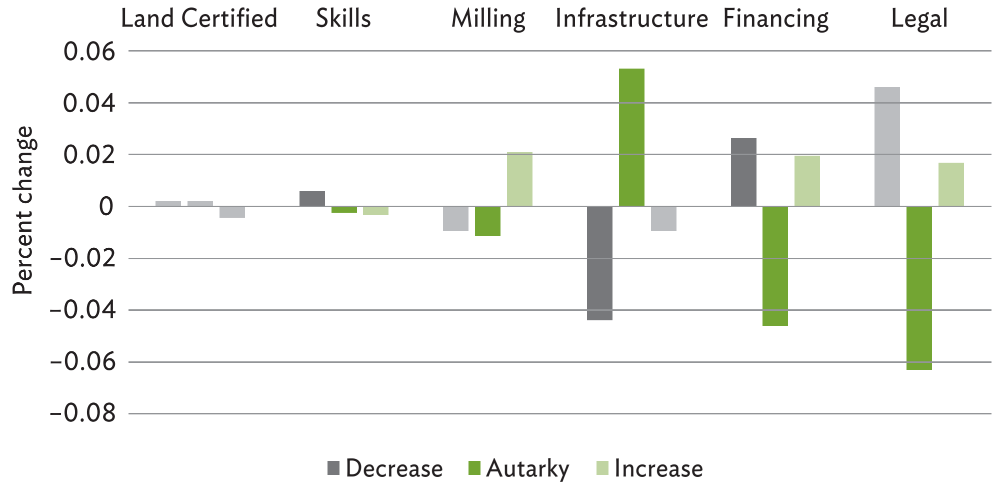
decreased probability of commercialization. This may reflect that farmers with farm growth had lower levels of commercialization and have remained largely in subsistence farming. Larger households are associated with lower levels of commercialization since they tend to keep more rice for consumption purposes. The investment climate has a similar relationship with the quantity and value of rice sold. However, domestic miller presence is associated with higher value of rice sales and use of rice storage is associated with lower total quantity and value of rice sold. This may reflect that storage availability is useful for keeping rice for off-season consumption and reducing the amount of rice bought. Increases in land size are associated with lower levels of rice sales and production after controlling for current farm size and may indicate catch up in production of small farms compared to large farms.

D. Land Investments

Farm size, as measured by area of land cultivated or operated, is the most important determinant of increased rice production, value of production, commercialization and sales. To increase land cultivated or operated is reliant on primarily land acquisition, via rental or ownership, or land irrigation investments that permit multiple season cropping to increase the cultivated area. The investment climate can play an important role in land investments that alter farm size and improve irrigation. Since the data only covers transfers out of land owned since 2008, it is not possible to investigate changes in land cultivated or operated that are associated with rentals. However, as land owned covers a large portion of all farm land cultivated and operated, understanding these changes are important for understanding increases in production and commercialization. Factors influencing changes in land ownership between 2008 and 2013 are examined using a standard linear regression and a multinomial logit regression (Appendix Part D, Appendix Table A.4).

The linear model indicates that the presence of large millers in the commune is the primary factor inducing increases in land ownership pointing to the importance of domestic output market development. Farm manager age is also significant and related to decreased land ownership potentially representing the desire of younger populations to reduce engagement in agricultural production activities and increase their engagement in nonfarm activities. However, the linear model assumes that various investment climate effects have the same symmetric effect on increases in land ownership as they do on land reductions. In reality, some aspects of the investment climate may raise the relative returns to agricultural production compared to nonfarm activities inducing increases in land ownership while others may lower relative returns to agricultural production and induce decreases in land ownership. Moreover, both purchase and selling of land requires transaction costs which are not incurred if a farm decides to simply retain the land they own. The multinomial logit model shows that investment climate does have potentially asymmetric effects on changes in land ownership. Greater nonfarm income and more educated farmers tend to reduce land ownership. Improvements in infrastructure is associated with a decreased probability of land ownership reductions, while improved financing increases the probability of reductions. At the same time, presence of large millers, better financing, and improvements in the legal environment are highly important for land acquisitions (Figure 13). Financing in particular is highly important in potentially enhancing farm size dynamics which can occur if land holdings shift from less skilled farmers to more skilled farmers.

Figure 13: **Investment Climate Effects on Probability of Land Change**



Source: ADB estimates.

A linear regression model and probit model is used to examine investments in irrigation and the probability of renting land for cultivation (Appendix Part E, Appendix Table A.5). Access to extension services is related to greater investments in irrigation. Input markets, domestic milling, and physical infrastructure are also significant factors associated with greater irrigation. The results are indicative that the investment climate has an important role in ensuring that essential investments in land are made that can enhance productivity over the longer term.

E. Short-Term Policies for Enhancing Input Usage

Short-term policies can increase the usage of important inputs leading to improved production. This section examines the potential effects of one-time financing and price subsidies for inputs on expected increases in rice production.

1. One-Time Financing

Since land is expensive, financing for land would provide little returns in the short run relative to the costs. Providing direct financing to all farms for inputs could induce immediate increases in production. Utilizing quantity, unit cost data, and coefficient estimates from the technical efficiency regressions the effect of a $100 investment in a particular input on the rice production of a farm is considered. Pesticide and seed investments yield the highest returns from a $100 investment with an estimated increase in production of 27% and 18%, respectively (Table 9).

2. Price Subsidies

Input price subsidies is an alternative method to increase production rather than outright input purchases. Utilizing quantity, unit cost data, estimates from tobit models on

Table 9: **Simulated Production Increase from $100 Investment in Inputs**

Input	Qty Unit	Mean Qty	Unit Cost (KHR)	Qty Input Bought with KHR402.7K ($100)	% Change Qty Input	CoeffEst TE Prod	CoeffEst TE Value of Prod	% Change in Prod	% Change in Value of Prod
Seeds	kg	478.8	1,262	319	67	0.271***	0.248***	18.1	16.5
Inorganic fertilizer	kg	345.1	2,678	150	44	0.209***	0.187***	9.1	8.1
Organic fertilizer	kg	764.7	151	2,667	349	0.015**	0.017**	5.2	5.9
Pesticides	liters	4.5	45,366	9	196	0.125***	0.142***	24.5	27.8
Labor	mandays	157.9	14,052	29	18	0.027	(0.07)	0.5	(1.3)

( ) = negative, coeffest = coefficient estimate, KHR = Cambodian Riel, prod = production, qty = quantity, TE = technical efficiency.
Source: ADB estimates.

quantity of inputs bought and estimates from the technical efficiency regressions a $0.25 price subsidy for each input is considered. The subsidy for nonhigh–yielding seeds are estimated to increase value of production by 9.4%, while the subsidy for inorganic fertilizer is expected value of production by 2.4% (Table 10). Much smaller increases occur for pesticides, while estimates for high-yielding seeds and organic fertilizer are not precisely estimated. Given that the average rice production value is KHR4,086,000 the percentage increase in production for nonhigh-yielding seeds suggests that the added value may result in a KHR384,084 increase in value of production, and inorganic fertilizer would result in a KHR93,978 increase in value of production. Given that the expenditure subsidies would expect to cost on average KHR154,000 for high-yielding seeds and KHR35,000 for inorganic fertilizer, both are expected to have higher returns than the expected costs. Nevertheless, subsidies can potentially crowd out commercial fertilizer demand, and targeting subsidies to the poorest households may better maximize and potentially control costs related to subsidy provisions (Ricker-Gilbert et al. 2010).

Table 10: **Simulation of Input Price Change on Production**

	Qty Unit	Mean Qty	Unit cost (KHR)	CoeffEst of input price on input qty bought	Additional Input Bought due to KHR1000 Price Subsidy ($0.25)	% Change Qty Input	CoeffEst TE Prod	CoeffEst TE Value of Prod	% Change in Prod	% Change in Value of Prod
Standard seeds	kg	415	1,487	(0.157)*	157	37.8	0.271***	0.248***	10.25	9.38
High-yielding seeds	kg	415	2,074	(0.006)	6	1.4	0.271***	0.248***	0.39	0.36
Inorganic fertilizer	kg	284.0	3,447	(0.036)***	36	12.7	0.209***	0.187***	2.65	2.37
Organic fertilizer	liters	873.0	4,797	(0.313)	313	35.9	0.015***	0.017***	0.54	0.61
Pesticides	mandays	3.3	68,842	(0.0002)***	0.2	6.1	0.125***	0.142***	0.76	0.87

( ) = negative, coeffest = coefficient estimate, KHR = Cambodian Riel, prod = production, qty = quantity, TE = technical efficiency.
Source: ADB estimates.

F. Discussion

One of the surprising results of the analysis was that access to extension services had a negative correlation with production technical efficiency and otherwise was insignificant with the exception of investments in irrigation. There are several potential explanations. First, extension services are selectively provided to areas that are more concentrated on agriculture, and have lower incomes and skills resulting in the implication that access to extension services is related to lower efficiency. Second, extension service provision is narrowly focused on cultivation and pesticide practices which do not develop skills needed to link farmers to markets and enhance rice commercialization and sales. Third, extension services may have little impact on improving various outcomes due to the quality and applicability of extension training. For example, if cultivation practices are focused on labor-intensive practices or require significant monetary investments on the part of the farmer, implementing these practices may not be an optimal choice for farmers even if they result in higher levels of production.

The absence of storage facilities is potentially driving some farmers to sell their rice. This would indicate that some of the measures of selling and value of production are upward biased as farmers without storage would need to sell their rice at a low price when production is high only to later buy rice in the off season at a high price. The data does not capture expenditures on rice, which enable differentiation between farmers who are net rice sellers from those who are net rice buyers. This means the set of factors that are significant for all sellers are potentially different from those that are net sellers and are in rice production more for business purposes rather than for sustaining consumption (e.g., Bellamare and Barrett 2006, Key et al. 2005, Stephens and Barrett 2011, Zanello 2012). Such a distinction is not possible in the context of the data and may introduce some measurement error into the estimates. Nevertheless, the estimates still provide some supporting evidence on the constraints faced in agricultural production and land investments.

The legal environment and financing are negatively related to cross-sectional technical efficiency, but the regressions supported their importance in improving the reallocation of land and inputs in changes in land ownership. If land is reallocated to more productive farmers, these factors could be highly important toward improving efficiency and total rice production if land continues to be used for agricultural activities.

V. Policy Implications

Various aspects of the investment climate are found to have an important role in rice production, commercialization, and farm size dynamics. To improve the investment climate, however, requires undertaking significant investments in institutions, reforms, and public infrastructure. The estimates derived from the analysis are potentially useful for deriving estimates of the benefits of various investments that can be weighed against expected costs.[15] Such analysis requires identifying weaknesses in legal frameworks and institutions as well as physical investments and is outside the scope of this report. Nevertheless, some important recommendations for improving the investment climate for rice production and commercialization can be drawn from the analysis and are discussed below.

1. Build and enhance quality of physical infrastructure

Physical infrastructure is important in enhancing commercialization, production, and production technical efficiency potential and ensures farm land retention. Due to the reliance of input and output market development on physical infrastructure, namely electricity and quality roads, this is considered a first order priority for investments and development (Mu and Van de Walle 2011). The development of high-quality physical infrastructure reduces transactional costs required for market operations. Constant electricity supply ensures that important machinery that relies on electricity such as in milling and fertilizer industries does not sit idle, while lower electricity prices directly reduces operational costs. Improved road quality and creation of market hubs that are closer to communes can decrease transportation costs required to deliver goods to markets; these in turn can lead to lower agricultural input prices and higher prices received for rice sales, resulting in farms receiving greater returns to agricultural production.

Low-quality infrastructure exists in many communes as only one of the 18 communes had asphalt roads, and only 40% of farms had electricity supplied from the grid. In particular, Kampong Thom potentially faces the greatest infrastructure constraints with no asphalt roads in any of the 6 communes studied and only 5% of households receiving electricity from the grid. Coordinated efforts by the Ministry of Public Works and Transport; Ministry of Rural of Development; Ministry of Industry, Mines and Energy; and Electricity Authority of Cambodia may be needed to ensure that the building of physical infrastructure results in improved market development. This may help in targeting areas where infrastructure is

[15] To utilize estimates, both a measure of changes in investment climate variables and expected costs required to induce these changes would be needed.

limited, and where upside returns of building infrastructure to promote rice production may be significant.

2. Facilitate domestic milling capacity and develop storage facilities

Presence of large millers in a commune is a significant factor related to improved rice production technical efficiency and rice sales. The development of domestic rice milling is essential for Cambodia to capture value addition in paddy production and export. A competitive domestic rice milling market combined with storage facilities can ensure that better prices are received by small farms for rice production by allowing farmers to have greater flexibility in the timing and location of their sales.

Domestic milling in Cambodia, however, is underdeveloped. Some 60% of communes do not have any domestic miller and more than 89% of farmers sell their rice to traders in their village. This has contributed to a high number of farmers working with the same buyer for 3 years or more; and over 70% citing rice price volatility, rice market price, market information, and bargaining position with traders and buyers to be major problems for agricultural production. There exists a limited number of domestic millers in the country despite recent growth in domestic milling and lack of financial constraints (Paavo 2013). Domestic rice milling capacity is estimated at only one-third of the paddy produced, with a majority of paddy informally exported to Thailand or Viet Nam for processing. The existing domestic millers are reported to operate at only 25% of capacity during the low season partially due to inadequate availability of storage facilities (CDRI 2013). However, only 31% of farmers own storage facilities and no joint storage facilities were available in any of the communes.

Competition from foreign traders combined with an absence of support programs to link millers to small farms could be a major hurdle in increasing the presence and competitiveness of domestic milling industries. In the short term, developing contract farming can help to strengthen links between domestic millers and farmers to better ensure stable demand for rice, while increasing the potential for domestic millers to operate at full capacity. However, contract farming remains nascent, as less than 1% of all farmers have engaged in contract farming. The Ministry of Agriculture, Forestry and Fisheries, the Department of Agro-Industry, and the contract farming coordination committee need to have coordinated efforts to develop institutions to enforce contracts, help engage farmers and millers in understanding the benefits, and develop and foster the linkages for contract farming. Providing tax breaks or other concessions and the development in physical infrastructure including storage facilities can provide more profitable opportunities that induce entry of new domestic millers.

3. Increase investments in irrigation and institutions for water management

Irrigation and water management are essential for crop production. Quality irrigation can increase cropping intensity, making crop cultivation possible over multiple seasons (Tong et al. 2011). Better water management can increase production efficiency providing resiliency to changing climate patterns and inadequate rainfall.

Irrigation in Cambodia is problematic, as 44% of farmers indicating that it is one of the major constraints affecting agricultural production. Only 46% of farms operate land with any irrigation and only 20% of farm land is irrigated in the dry season while 31% is irrigated in the wet season. Irrigated land in the wet season is likely to have more limited impacts on production than dry season irrigation—a 10% increase in water is estimated to increase yields by only 0.6% increase in the wet season (Wokker et al. 2014). The low rates of irrigation reflect an absence of government investment in developing irrigation canals, and the high price and low returns to farms investing in pump irrigation and tube wells. While shallow and hand-pumped tube wells are one of the cheaper options that are open to farmers to irrigate their land, this relies heavily on having available groundwater at a depth of 6 meters or less. Without sufficient management, these options become less viable and sustainable as a guaranteed source of water (International Water Management Institute 2013). Attempts have been made to implement participatory irrigation management schemes, however, success rates have been low with many failing to maintain or improve irrigation canals. The Provincial Departments of Water Resources and Meteorology can increase its interactions with communities to increase the prevalence of irrigation by building key irrigation canals, training farmers on the construction of simple small-scale irrigation canals that decrease reliance on pumping water, and educating them on the benefits and optimal usage of irrigation. In the longer term, substantial capital investments may be needed to continue upgrading institutions, and building canals and water storage to improve the quality and quantity of irrigation.

4. Prioritize land titling for farmers

Land security is important in improving rice production efficiency and is essential for agricultural production. Without explicit land asset transfers, farmers must either purchase or rent land to increase their cultivated area. When land rights and contracts are not secure and enforced, land purchase and rental markets may be thin. Without land security, there may be less willingness to invest in land improvements that can enhance agricultural productivity. Nearly 84% indicate that access to agriculture land is a main constraint to increasing production. In Cambodia, 30% of farming land still does not have valid land certificates or rental agreements and about 40% do not hold explicit national or local government land titles. While access to agricultural land is exacerbated by absence of land rental markets that hinder farm production (Jin and Jayne 2013), a number of farmers are able to rent land for cultivation (9%). Low levels of wealth and income that make it difficult to purchase or rent land therefore are likely the greater constraint to land access.

Potential land grabs and forced evictions may have created a state of uncertainty that has potentially deterred many farmers from making long-term investments in agricultural production or land enhancements that could significantly improve agricultural productivity (Deininger and Jin 2006). The Ministry of Agriculture, Forestry and Fisheries can work with the Ministry of Land Management, Urban Planning and Construction to designate land for long-term agricultural use, improve land security rights for farmers through increased titling of land for small farmers, and provide additional assistance for these farmers to help them understand and advocate for their rights to land titles.

5. Improve the quality and breadth of extension services

Extension services can have an important role in developing skills to build, maintain, and use infrastructure. It is also an important channel for encouraging farmers to adopt new agricultural technologies and techniques that can increase production and market potential and minimize risks. Prior studies have found extension services to have a significant role in increasing productivity and market participation of small farmers (e.g., Gebremedhin et al. 2009). As more technologies become accessible and are introduced into the Cambodian economy, retraining and improving knowledge may become increasingly important (Reimers and Klasen 2013).

However, agricultural skill in Cambodia are low and it is seen as a major constraint by farmers to agricultural production. While there was no evidence that extension services have any positive effect on production, commercialization and sales potential it points to the potential ineffectiveness of existing extension services. Most extension services are narrowly focused on crop cultivation despite indications of high levels of demand for postharvesting and marketing extension services.[16] Expansion of current extension services is unlikely to be effective and significant investments may need to be implemented to improve breadth and focus of the extension services that are provided. The Department of Agricultural Extension, Ministry of Rural Development, and Cambodian Agricultural Research and Development Institute can coordinate their efforts to develop a more comprehensive program to ensure that important seed technologies are adopted that have significant commercialization potential, and that value of production is improved.

6. Improve regulation of input markets

Greater usage of inputs is highly important to increased levels of production and quality inputs may have a role in improving production technical efficiency. High proportion of farmers perceive inputs to be a major problem as 24% of farmers indicated that access to or price of high-yield rice varieties were among the top three problems for agricultural production while another 15% indicated prices of organic fertilizer, commercial fertilizer, or pesticides.[17] Supply of seeds by the Cambodian Agricultural Research and Development Institute, the primary organization distributing high-quality seeds to farmers in Cambodia, is estimated at only 20%–25% of seed demand (De Carteret 2013). There remain an insufficient

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16 Cultivation practices may also currently emphasize labor-intensive practices such as the system of rice intensification. Such cultivation techniques may not lead to improved welfare even if yields increase (Takashi and Barrett 2014). Farmer field schools have also typically focused on cultivation practices, but there has been mixed evidence on their ability to increase yields (Feder et al. 2004, Godtland et al. 2004).

17 These are perception-based data. While farmers can potentially obtain access to high-yield varieties through self-multiplication of seeds, it may reflect farmers who actually want to purchase high-yield varieties in their local market. Data show that eight of 18 communes surveyed had no indicative price for high-yield varieties, which may be due to absence of existing markets for these seeds. The survey did not ask about the last year of seed replacement and views on ideal replacement rates that would better differentiate whether low purchases rates actually represent a true market failure or a gap in farmer knowledge of seed management practices. It also did not cover missing markets, or whether certain seed varieties were potentially accessible. The survey did not assess the level of uncertainty that farmers face in quality of seed, fertilizer, and pesticides, which may better reflect informational failures and lack of regulation in input markets.

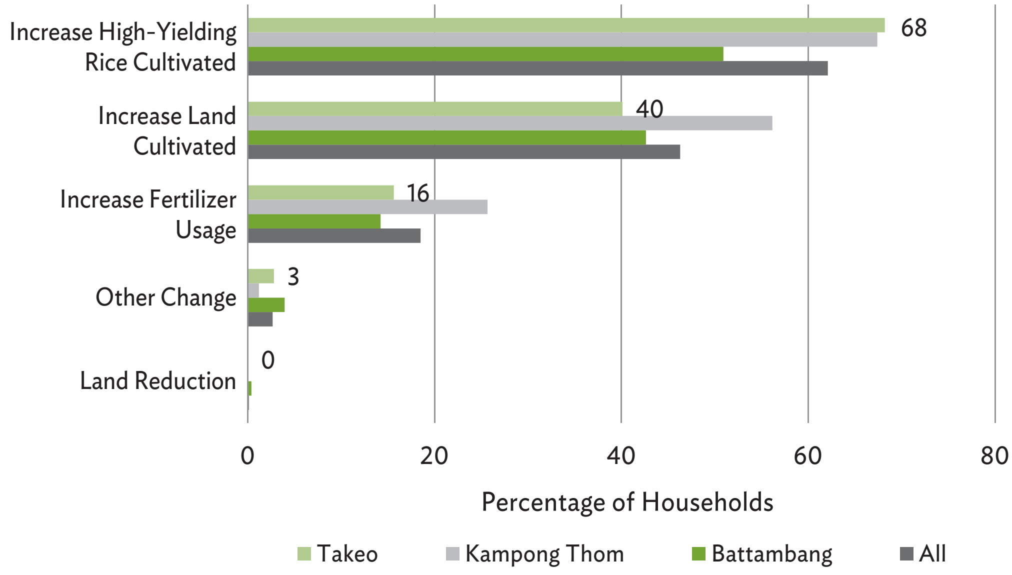
number of domestic seed producers, in part, because sub-laws needed for implementation and enforcement of the Seed Management and Plant Breeder's Rights Laws of 2008 that aimed to regulate seed production, trading, import, export, and quality control have largely remained undefined. Institutions and regulations in the fertilizer and pesticide market are even less developed, and there are reports of widespread mislabeling and distribution of poor quality fertilizers and pesticides (CDRI 2013, Yu and Diao 2011).

Greater input usage of nonhigh-yielding seeds and inorganic fertilizer is related to significantly higher levels of production and significant effects on production can occur through explicit transfers of inputs or price subsidies. Improving institutions regulating input markets can also help resolve inefficiencies in input markets that have led to sub-optimal levels of usage in input by reducing uncertainty over the quality of inputs marketed. Coordination between the Ministry of Agriculture, Forestry and Fisheries together with the Bureau of Agricultural Material Standards, Department of Agronomy and Agricultural Land Improvement, and Cambodian Agricultural Research and Development Institute is potentially important for enhancing and enforcing laws and arriving at a common understanding of what constitutes quality inputs. This is an important first step that should come before the development of policies to try and induce greater private sector participation in the provision of inputs.

VI. Final Remarks

Many of the recommendations for improving rice production and commercialization require developing and strengthening institutions and policy frameworks that ensure effective implementation. Such developments are likely to only occur over the long-term with significant government commitment and may present considerable challenges given that various areas of the investment climate typically requires significant coordination among many ministries. In the near-term, there is a need to identify models, frameworks and procedures that are effective at ensuring improved service delivery over the longer-term. It may also be important to build markets for crop insurance as many farmers are exposed to a high degree of risk in agricultural production and are extremely risk adverse. Crop insurance coverage could help incentivize farmers to make greater investments in agricultural production especially through the usage of high-yielding seeds and expansion of land cultivated (Figure 14). However, legal frameworks to regulate these markets are currently insufficient resulting in market failure in provision.

Figure 14: **Stated Changes in Rice Cultivation Due to Crop Insurance**



Note: Household responses to the question of how they would change cropping practices if they had crop insurance.

Source: ADB estimates.

Increasing dissemination of information on input and output markets; recommending techniques for farming; and helping to reduce uncertainty by encouraging certain practices in agricultural operations, may provide important and low-cost improvements that can have immediate effects on production and commercialization (Zanello 2012). There are also potentially important modalities such as cooperatives and farmer groups which can improve extension service delivery, create market linkages, and help maintain small-scale infrastructure. As both input and output market development are significant factors affecting production a deeper understanding of the constraints producers in these markets face are an important component to improving production and commercialization potential of farms. Given the lack of diversity and presence of these producers in many communes there is a need to develop an understanding of the entry barriers faced in addition to constraints faced in operation. The constraints these producers face are likely to be considerably different than those faced by small farms. There is also a need to develop a better understanding for the dynamic nature of investments both in agriculture and nonfarm businesses that may have long-term effects on production and commercialization. Developing these areas of research are essential for developing a more precise and effective plan to improve the investment climate for rice production and commercialization.

APPENDIX
Econometric Methods

A. Investment Climate Effects on Intensity of Input Usage

The investment climate may have an effect on the intensity of inputs used in rice production as it can affect returns to agricultural production versus investing in other activities, and can reduce transaction costs. A farm household, i, in commune, r, is assumed to have utility for input use U_{ir}^{I} such that:

$$U_{ir}^{I} = \underbrace{\lambda + \beta p_r^I + \alpha L_{ir} + \gamma X_{ir} + \mu IC_r' + \delta + \varepsilon_{ir}}_{\theta} \quad (1a)$$

Inputs per hectare is assumed to be a function of input price, p_r^I, land endowments, L_{ir}, household characteristics, X_{ir}, and investment climate factors. IC_r' and δ are province-level indicators. However, optimal input choice is only observed when quantities utilized are greater than zero. Many households are observed to utilize zero levels of inputs or have zero input expenses and therefore may experience disutility from using certain types of inputs, either because of the costs or time required to use the input, or because they are regarded as nonessential to rice production. For example, the application of fertilizer and pesticides may increase production under proper usage, but are not necessary to produce rice. Many households may also have zero expenses for inputs because of the ease in generating these inputs through the household economy. Labor, seeds, and organic fertilizer are all easily procured and generated by the household and do not require market purchases. In particular, the optimal level of inputs per hectare is essentially a latent variable that is observed only when there is positive utility or value from using the input. That is, we only observe I_{ir} where:

$$I_{ir} = \begin{cases} I_{ir}^{*} \ldots if \ldots U_{ir}^{I} > U_{ir}^{0} \\ 0 \ldots if \ldots U_{ir}^{I} \le U_{ir}^{0} \end{cases} \quad (2a)$$

A tobit model is utilized to examine the intensity of input usage and correct for input quantities and input expenses which are truncated at zero. The tobit model corrects for censoring and selection in the distribution of input usage values to reduce bias in coefficient estimates in equation (1a) due to censoring. The tobit model is estimated through maximum likelihood estimation. The coefficient estimates can then be used to examine changes in predicted input levels due to changes in the investment climate such that:

$$E[I_{ir}^{*}] = \Pr[I_{ir}^{*} > 0] * E[I_{ir}^{*} \mid I_{ir}^{*} > 0] = \Phi\left(\frac{\theta}{\sigma}\right)\left[\theta + \sigma\lambda\left(\frac{\theta}{\sigma}\right)\right] \quad (3a)$$

where $\lambda = \Phi/\ \Phi$ is the inverse mills ratio representing the standard normal density over the normal cumulative distribution function, σ is the estimated standard error of ε_{ir}. The inverse mills ratio corrects for selection in the observed distribution.

B. Investment Climate Effects on Technical Efficiency of Rice Production

The examination of investment climate effects on technical efficiency of rice production starts with a common assumption, i.e., rice production can be represented by a Cobb-Douglas production function (e.g., Kompas et al. 2012, Wokker et al. 2014, Yu and Fan 2011) for each household, i, in region, r, such that:

$$Y_{ir} = A_{ir} L_{ir}^{\alpha} H_{ir}^{\beta} M_{ir}^{\delta} \quad (4a)$$

In this equation, production is a function of land area cultivated, L_{ir}; labor inputs, H_{ir}; and material inputs such as fertilizer, seeds, and pesticides, M_{ir}. Technical efficiency A_{ir} can then be specified as:

$$A_{ir} = e^{v_{ir} - u_{ir}} \quad (5a)$$

In equation (5a), v_i is a symmetric component that follows a standard normal distribution and u_i is a truncated half normal error term representing technical efficiency. It is assumed that u_i can be parameterized as:

$$u_{ir} = \lambda + \gamma X_{ir} + \mu IC_r + \delta + \eta_{ir} \quad (6a)$$

This assumes that technical efficiency is a factor of land endowments and household characteristics, X_{ir}; the investment climate IC_r; and an unobserved error term, η_{ir}. λ is a constant term associated with the current level of productivity, which is standard across farm households. By taking logs and rearranging terms, a linear estimating equation is obtained. It is assumed that this term is a nonnegative i.i.d. random variable where $u_i > 0$ corresponds to a shortfall in output from the maximum value of the stochastic production frontier (Kilic et al. 2009, Deninger et al. 2006. Under the assumptions, $\eta_{ir} \sim N(0, \sigma_u^2)$ implying that $u_i \sim N(\lambda + \gamma X_{ir} + \mu I_r, \sigma_u^2)$, which is truncated at zero. By substituting the technical efficiency component into the above equation and taking logs the estimating equation becomes:

$$\ln Y_{ir} = \alpha \ln L_{ir} + \beta \ln H_{ir} + \delta \ln M_{ir} + \varepsilon_{ir} - (\lambda + \gamma X_{ir} + \mu IC_r + \eta_{ir}) \quad (7a)$$

This is estimated as a single equation using maximum likelihood estimation. In the equation, agriculture production is measured as tons of rice produced and value of rice produced. The main coefficients of interest that are to be estimated are α, β, δ, and μ, which represent the elasticity of agriculture production with respect to land, labor, and material inputs, respectively. μ represents the impact the investment climate on production after controlling for current levels of inputs and household-specific factors. For land characteristics, percent area irrigated and relative shares of the type of land that a farmer owns are included as an indicator of when and what type of crops can be grown. For household characteristics, the household size and farm manager's skills, age, and education, which proxies for skills, are included. Gender is also included to capture differences in investment behavior that may affect production. The investment climate factors capture a variety factors including market integration, which was analyzed by Tipraqsa and Schreinemachers (2009) in relation to agriculture production.

In estimation, production is aggregated over all seasons as this enables better understanding of the general effects of the investment climate that occurs when a household can crop in multiple seasons. This potentially introduces error into estimates on inputs in relation to rice production, whereas focusing on a single season without correcting for endogeneity in the decision to plant in a certain season creates bias in the estimates of interest. While an attempt was made to use standard log-linear production functions with a Heckman correction it was found that the sample size was too small to obtain convergence for the estimates of interest.

C. Investment Climate Effects on Rice Commercialization and Marketed Surplus

While production and rice sales appear to be closely linked, the investment climate nevertheless may still have a different contribution or effect on actual rice commercialization, sales quantity, and sales value. To understand how the investment climate may effect farmer's integration into output markets as suppliers for commercialized production and export, it is also important to explicitly examine the investment climate effects on commercialization and sales through a separate set of models. This analysis improves the understanding of contributions of the investment climate to generating growth in agricultural income, and may be essential to increased investments in agricultural production.

To analyze the effects of investment climate on the probability of commercialization, a standard probit model is run, which assumes that there is a latent unobserved utility or returns from commercialization U_{ir}^{S} such that:

$$S_{ir} = \begin{cases} 1 \ldots if \ldots U_{ir}^{S} > U_{ir}^{N} \\ 0 \ldots i \ldots U_{ir}^{S} \leq U_{ir}^{N} \end{cases} \tag{8a}$$

The probability that commercialization S_{ir} occurs is then:

$$\Pr(S_{ir} = 1) = \Phi(\delta + \varsigma^{y} \ln p_{r}^{y} + \alpha \ln L_{ir} + \rho X_{ir} + \mu IC_{r}) \tag{9a}$$

The latent value from commercialization is assumed to be a factor of the expected market price of rice, p_{r}^{y}; land endowments, L_{ir}; which influence production outputs; household characteristics, X_{ir}; and investment climate effects, IC_{r}, which vary by commune, r. The error term v_{ir} is assumed have a mean zero and standard normal distribution with variance one.

This model can then be extended to examine the effects on total rice sold or rice sales where there is truncation in amount sold, S_{ir}^{y*} at 0. The tobit model is then used to correct for this truncation as it is not possible to observe the shortfall in farm's utility or production to generating actual sales. The latent variable of amount sold can then be represented as:

$$S_{ir}^{y*} = \delta + \varsigma^{y} \ln p_{r}^{y} + \alpha \ln L_{ir} + \rho X_{ir} + \mu IC_{r} + v_{ir} \tag{10a}$$

The expected value of sales then can be represented to an equation similar to (3a).

D. Investment climate and land growth

Understanding changes in land growth and consolidation can potentially help to understand aspects of the investment climate that are potentially associated with land dynamics. It provides some evidence in correlations in the absence of panel data. A standard linear regression is utilized to examine change in land with respect to household characteristics X_{ir} and investment climate characteristics IC_r; which is expressed as:

$$\Delta L_{ir} = \alpha + \delta X_{ir} + \beta IC_r + \delta + \varepsilon_{ir} \tag{11a}$$

This regression assumes that both the investment climate and household characteristics are largely time-invariant over the period changes of 2008–2012.

As it is useful to differentiate between households that are increasing or decreasing their farm size versus those that remain, the same, a multinomial logit is also used to examine how investment climate characteristics affect a farm's probability to increase, decrease, or retain the same land size over the time period of observation. That is:

$$CL_{ir} = \begin{cases} 1 \ldots if \ldots U^{\Delta L_{ir}>0} > U^{\Delta L_{ir}<0}, U^{\Delta L_{ir}>0} > U^{\Delta L_{ir}=0} \\ 0 \ldots if \ldots U^{\Delta L_{ir}=0} > U^{\Delta L_{ir}>0}, U^{\Delta L_{ir}=0} > U^{\Delta L_{ir}<0} \\ -1 \ldots if \ldots U^{\Delta L_{ir}<0} > U^{\Delta L_{ir}>0}, U^{\Delta L_{ir}<0} > U^{\Delta L_{ir}=0} \end{cases} \tag{12a}$$

In this model, a farm is assumed to have some latent unobserved value for changing their farm size compared to keeping them the same. An unordered logit model captures farm size changes as transaction costs arise from sales or purchase of land compared to maintaining current farm size. The model includes different farm household characteristics and aspects of the investment climate as these may cause different effects on increases and decreases of land holdings for existing farmers.

E. Investment Climate and Land Investments

The investment climate may serve as an important factor in driving important land investments that can subsequently enhance production. Two models are run. The first analyzes the probability that a farmer invests in land leveling on one of their plots. This analysis follows a similar framework to the commercialization decision seen in equation (8a) with irrigation investments excluded from the model. The second model analyzes the proportion of farm land that is irrigated. This model uses a standard linear regression framework and similar right hand side variables to those detailed in equation (11a).

Appendix Table A.1: **Relationship between Quantity of Input per Hectare and Commercialization Probabilities** (Tobit regressions)

	Person-days of Labor	Seeds	Inorganic Fertilizer	Organic Fertilizer	Pesticide
Land certified	−17.063 [13.920]	−0.631 [9.573]	24.089* [12.693]	209.175 [353.808]	−0.018 [0.240]
Irrigation	−23.381* [13.078]	71.328*** [15.024]	56.335*** [18.519]	−396.021 [367.657]	2.468*** [0.862]
Skills	11.226 [9.073]	−1.250 [2.561]	−3.455* [1.800]	195.158 [231.165]	0.028 [0.072]
Input market	−16.247*** [3.310]	6.287 [5.222]	14.556** [6.703]	−91.134 [146.783]	1.047*** [0.310]
Milling	5.219 [6.029]	−1.825 [4.558]	23.636** [10.349]	14.162 [152.782]	0.200 [0.158]
Infrastructure	−9.593 [8.866]	11.803** [5.632]	−0.035 [12.388]	−19.614 [136.987]	0.717* [0.374]
Financing	11.810 [7.997]	−4.474 [5.520]	3.718 [7.831]	284.748* [150.917]	−0.667** [0.336]
Legal	22.851 [23.227]	−71.147*** [13.805]	−20.969 [58.104]	1,383.656** [597.813]	−1.591 [1.195]
Cultivated area	−6.131** [2.828]	−1.521* [0.917]	1.087 [1.283]	−181.231* [98.751]	0.029 [0.034]
Household size	1.099 [3.263]	−0.640 [2.669]	−4.466* [2.647]	−142.870 [101.339]	−0.056 [0.061]
Farm mngr female	−22.714* [13.114]	−12.094* [6.906]	−8.094 [16.458]	−634.588 [477.998]	−0.734* [0.391]
Farm mngr high educ	11.381 [23.264]	29.603 [22.435]	7.231 [13.827]	−763.002** [370.528]	0.430 [0.407]
Nonfarm income	−1.214 [0.927]	0.039 [0.928]	−0.315 [0.602]	−10.152 [26.832]	−0.037 [0.024]
Constant	45.125 [28.466]	175.453*** [28.531]	113.163*** [31.703]	−2,222.694*** [759.018]	3.370*** [0.908]
Sigma	149.805*** [23.564]	100.914*** [17.148]	88.934*** [6.681]	2,502.250*** [610.709]	2.784*** [0.997]
Observations	751	751	751	751	751

continued on next page

Appendix Table A.1 *continued*

	Labor Expense	Seed Expense	Inorganic Fertilizer Expense	Organic Fertilizer Expense	Pesticide Expense
Land certified	36.553 [56.588]	−114.236** [54.211]	42.184 [34.401]	−10.585 [100.295]	6.880 [11.497]
Irrigation	−173.852* [93.270]	50.048 [51.037]	177.300*** [55.020]	98.919 [78.284]	114.210*** [38.591]
Skills	55.107 [47.101]	18.318 [15.639]	−2.577 [8.934]	−23.898 [24.053]	0.314 [1.941]
Input market	−112.064*** [37.583]	18.185 [23.026]	35.573** [17.844]	96.519*** [36.831]	44.984*** [14.704]
Milling	73.193** [29.786]	1.370 [26.296]	62.194** [28.468]	−49.615 [34.527]	13.455 [8.773]
Infrastructure	119.711** [58.195]	23.507 [33.056]	−16.748 [34.792]	42.445 [55.404]	23.042 [16.346]
Financing	41.193 [38.959]	−1.713 [41.553]	11.570 [19.759]	−124.374** [55.131]	−23.078 [16.442]
Legal	436.125** [187.180]	−86.242 [134.204]	−64.600 [166.144]	851.653*** [268.835]	−75.187 [55.533]
Cultivated area	14.476*** [4.810]	5.304 [3.421]	2.656 [3.562]	−34.965 [23.945]	0.292 [1.181]
Household size	−59.462*** [22.153]	−14.249 [12.908]	−9.586 [8.811]	−33.096** [13.452]	−1.197 [3.353]
Farm mngr female	−37.914 [105.531]	−103.922* [59.769]	−7.102 [43.810]	−163.516 [147.766]	−38.349** [19.410]
Farm mngr high educ	−55.098 [65.380]	42.699 [46.004]	23.437 [42.053]	144.877 [132.854]	39.886 [26.452]
Nonfarm income	6.849 [7.605]	8.368** [4.218]	−1.451 [2.582]	4.641 [9.454]	−0.962 [1.213]
Constant	−89.493 [164.339]	−265.861** [124.879]	204.200* [104.502]	−1.897 [271.068]	78.469** [35.707]
Sigma	547.978*** [144.409]	281.718*** [29.178]	257.609*** [21.418]	442.693*** [77.880]	112.643*** [24.023]
Observations	751	751	751	751	751

educ = education, ha = hectare, mngr = manager.

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

Note: Robust standard errors in brackets. Province-level indicators, unit prices of inputs included in outcome equation, and farm manager age are included, but not shown.

Source: ADB estimates.

Appendix Table A.2: **Technical Efficiency Models**

Variables	Production: All	Production: Area Operated < 2 ha	Production: Area Operated ≥ 2 ha	Value of Production: All	Value of Production: Area Operated < 2 ha	Value of Production: Area Operated ≥ 2 ha
Land certified	0.086** [0.041]	0.096* [0.053]	0.116* [0.063]	0.137*** [0.048]	0.162** [0.066]	0.140* [0.075]
Irrigation	0.165*** [0.051]	0.176*** [0.067]	0.158** [0.075]	0.142** [0.060]	0.151** [0.069]	0.141 [0.104]
Skills	−0.022 [0.014]	−0.025 [0.017]	−0.034 [0.022]	−0.030* [0.016]	−0.051** [0.020]	−0.025 [0.024]
Input market	−0.062*** [0.019]	−0.072*** [0.024]	−0.066** [0.032]	−0.103*** [0.023]	−0.111*** [0.026]	−0.103** [0.040]
Milling	0.043** [0.019]	0.025 [0.025]	0.059** [0.025]	0.014 [0.023]	−0.034 [0.033]	0.051* [0.030]
Infrastructure	0.031 [0.025]	0.042 [0.034]	0.023 [0.029]	0.026 [0.026]	0.063* [0.036]	−0.021 [0.033]
Financing	0.032* [0.017]	0.018 [0.026]	0.030 [0.024]	0.039* [0.022]	0.018 [0.026]	0.027 [0.032]
Legal	0.329*** [0.102]	0.311** [0.146]	0.231* [0.126]	0.093 [0.111]	0.135 [0.172]	−0.089 [0.155]
Land operated	0.342*** [0.040]	0.342*** [0.064]	0.314*** [0.072]	0.299*** [0.047]	0.298*** [0.068]	0.295*** [0.097]
Labor inputs	0.027 [0.025]	0.046* [0.028]	0.011 [0.035]	−0.007 [0.032]	0.019 [0.038]	−0.024 [0.048]
Seeds qty	0.271*** [0.041]	0.241*** [0.061]	0.215*** [0.058]	0.248*** [0.048]	0.203*** [0.061]	0.219*** [0.072]
Inorganic fertilizer qty	0.209*** [0.028]	0.161*** [0.036]	0.315*** [0.035]	0.187*** [0.034]	0.140*** [0.040]	0.283*** [0.054]
Organic fertilizer qty	0.015** [0.007]	0.027*** [0.008]	0.009 [0.010]	0.017** [0.008]	0.030*** [0.010]	0.011 [0.010]
Pesticides qty	0.125*** [0.024]	0.118*** [0.033]	0.115*** [0.035]	0.142*** [0.029]	0.109*** [0.042]	0.140*** [0.042]
No inorganic fertilizer usage	0.612*** [0.148]	0.198 [0.171]	1.390*** [0.220]	0.569*** [0.168]	0.211 [0.177]	1.262*** [0.295]
No pesticide usage	−0.154*** [0.055]	−0.176** [0.089]	−0.132* [0.069]	−0.138** [0.058]	−0.150** [0.074]	−0.108 [0.087]
High yielding seeds	−0.040 [0.054]	0.036 [0.058]	−0.125 [0.082]	0.119** [0.051]	0.137** [0.062]	0.093 [0.078]
Change in land size	−0.029 [0.024]	0.038 [0.048]	−0.056** [0.022]	−0.017 [0.023]	0.099* [0.056]	−0.044* [0.023]
Household size	−0.006 [0.012]	0.016 [0.015]	−0.019 [0.016]	0.009 [0.014]	0.036** [0.017]	−0.012 [0.019]
Farm mngr female	−0.040 [0.050]	−0.141** [0.063]	0.030 [0.074]	0.004 [0.054]	−0.133** [0.063]	0.131 [0.082]
Farm mngr high educ	0.064 [0.061]	0.025 [0.086]	0.063 [0.071]	0.036 [0.068]	0.025 [0.089]	0.014 [0.091]
Nonfarm income	0.000 [0.003]	0.002 [0.005]	0.002 [0.004]	−0.002 [0.004]	0.005 [0.006]	−0.002 [0.005]
Constant	−1.260*** [0.211]	−1.080*** [0.322]	−1.418*** [0.304]	12.519*** [0.276]	12.689*** [0.360]	12.254*** [0.481]
ln(sigma2v)	−2.951*** [0.194]	−3.258*** [0.401]	−3.212*** [0.312]	−2.355*** [0.185]	−2.541*** [0.205]	−2.326*** [0.342]
ln(sigma2u)	−0.893*** [0.156]	−0.892*** [0.234]	−0.926*** [0.192]	−1.069*** [0.201]	−1.076*** [0.235]	−1.309*** [0.408]
Observations	751	386	365	751	386	365

educ = education, ha = hectare, mngr = manager, qty = quantity.

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

Notes:

1. Robust standard errors in brackets. Province-level indicators are included but not shown.
2. High education refers to secondary education or higher. Land operated, labor inputs, seed quantity, inorganic fertilizer, organic fertilizer, inorganic fertilizer, pesticides and nonfarm income all enters in logs.

Source: ADB estimates.

Appendix Table A.3: Commercialization and Marketed Surplus

Variables	Probit (marginal effects) (1) Commercialization	Tobit Marketed Surplus (1) Rice Sold	Tobit Marketed Surplus (3) Rice Sales
Land certified	0.052 [0.055]	0.488 [0.875]	458.503 [755.152]
Irrigation	0.257*** [0.088]	4.073*** [0.785]	3,323.827*** [644.325]
Skills	0.007 [0.017]	−0.011 [0.162]	−49.836 [102.634]
Input market	0.006 [0.028]	0.230 [0.388]	112.408 [256.886]
Milling	0.046 [0.032]	0.568 [0.393]	550.266** [241.893]
Infrastructure	−0.006 [0.029]	0.530 [0.398]	330.313 [297.347]
Financing	−0.034 [0.028]	−0.256 [0.273]	−257.177 [251.708]
Legal	−0.067 [0.173]	0.381 [1.491]	−214.226 [1,158.118]
High yielding seeds	0.067 [0.065]	0.270 [0.615]	493.717 [417.509]
Change in land size	−0.049** [0.021]	−1.507** [0.690]	−1,121.340** [493.249]
Storage access	−0.017 [0.055]	−0.737 [0.552]	−580.488 [424.890]
Land area operated	0.318*** [0.044]	3.381*** [0.363]	2,351.900*** [241.785]
Household size	−0.053*** [0.016]	−0.673** [0.262]	−493.028*** [188.339]
Farm mngr high educ	0.132** [0.061]	1.004* [0.608]	688.348 [572.504]
Nonfarm income	−0.003 [0.006]	−0.045 [0.061]	−46.377 [45.087]
Constant		−2.215 [2.020]	−1,343.083 [1,342.150]
Sigma		5.344*** [0.599]	4,054.257*** [420.839]
Observations	751	751	751

educ = education, mngr = manager.

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

Note: Standard errors in brackets. Probit model. Province-level indicators, and farm manager age and gender included, but not shown. Land area operated and nonfarm income enter in logs.

Source: ADB estimates.

Appendix Table A.4: **Change in Land Size**

	Ordinary Least Squares	Multinomial Logit				
		Coefficient Estimates (Reference = No change)		Marginal Effects		
	Change in Land Size	Decrease	Increase	Decrease	No Change	Increase
Land certified	−0.144 [0.133]	0.084 [0.357]	−0.538 [0.372]	0.030	0.017	−0.047
Skills	−0.026 [0.027]	0.069 [0.119]	0.020 [0.062]	0.008	−0.004	−0.004
Milling	0.088*** [0.028]	−0.244 [0.181]	0.228** [0.115]	−0.013	−0.010	0.023
Infrastructure	0.089 [0.055]	−1.251** [0.575]	−0.105 [0.111]	−0.104	0.105	−0.002
Financing	0.044 [0.036]	0.412** [0.169]	0.353*** [0.118]	0.030	−0.049	0.019
Legal	0.152 [0.180]	−1.018 [1.104]	−0.735* [0.412]	−0.048	0.064	−0.016
Household size	−0.010 [0.015]	−0.057 [0.083]	0.030 [0.070]	−0.006	0.013	−0.007
Farm mngr female	−0.054 [0.142]	0.180 [0.795]	−0.684* [0.391]	0.027	−0.063	0.036
Farm mngr age	−0.008** [0.003]	0.042** [0.018]	−0.011 [0.014]	0.004	0.001	−0.005
Farm mngr high educ	0.057 [0.061]	0.875** [0.401]	0.198 [0.392]	0.080	−0.135	0.055
Nonfarm income	−0.034 [0.025]	0.148*** [0.041]	−0.036 [0.023]	0.005	0.002	−0.007
Province: Kampong Thom	0.387** [0.135]	−1.350*** [0.485]	0.364** [0.171]	−0.073	0.040	0.033
Province: Takeo	−0.005 [0.102]	0.122 [0.481]	−0.332 [0.358]	0.031	−0.013	−0.018
Constant	0.874** [0.374]	−5.992*** [0.854]	−0.333 [0.766]			
Observations	751	751	751			
R-squared	0.097					

educ = education, mngr = manager.
*** p<0.01, ** p<0.05, * p<0.1.
Note: Robust standard errors in brackets. Province-level indicators included but not shown. Nonfarm income enter in logs.
Source: ADB estimates.

Appendix Table A.5: **Land Investments**

	Probit (Marginal Effects)	Ordinary Least Squares
	1	2
Variables	Land Rented In	Area Irrigated
Land certified	−0.079** [0.037]	0.077 [0.064]
Skills	0.006 [0.008]	0.024** [0.011]
Input market	0.038** [0.015]	0.089*** [0.026]
Milling	0.022 [0.026]	0.090** [0.038]
Infrastructure	0.001 [0.010]	0.136*** [0.021]
Financing	0.006 [0.024]	−0.048 [0.049]
Legal	−0.126*** [0.039]	0.162 [0.134]
Change in land size	0.015 [0.019]	0.036* [0.019]
Household size	0.012 [0.008]	−0.021** [0.009]
Farm mngr female	−0.101*** [0.029]	−0.003 [0.054]
Farm mngr age	0.003* [0.002]	−0.001 [0.001]
Farm mngr high educ	−0.064 [0.044]	0.057 [0.055]
Nonfarm income	−0.002 [0.002]	0.002 [0.003]
Constant		0.368*** [0.106]
Observations	751	751
R-squared		0.240

educ = education, mngr = manager.

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

Note: Robust standard errors in brackets. Province-level indicators included but not shown. Nonfarm income enters in logs.

Source: ADB estimates.

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Improving Rice Production and Commercialization in Cambodia

Findings from the Farm Investment Climate Assessment

Cambodia has a potential advantage in agricultural production due to significant amounts of fertile land and high levels of agricultural employment, but rice production and commercialization remain well below potential. This study uses a farm investment climate assessment to provide evidence on key areas where government investments and policy reforms can lead to higher levels of rice production and commercialization in small farms. Improving output markets through domestic milling and increasing the area irrigated are found to be related to increased production efficiency, commercialization, rice sold, and value of sales. In contrast, access to finance, agricultural skill development, improvements in the legal environment, and increased physical infrastructure have no observable relationship with production and commercialization. Nevertheless, these aspects do have importance in potentially improving allocative efficiency in land where land holdings shift from less skilled and less productive farms into the hands of more productive ones. Since increased farm size is one of the most important factors for raising the levels of farm production and commercialization, investment climate factors that induce reallocation of land may potentially have greater value over the long term than those that only affect short-term production.

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