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Abstract

We focus our study on the agrarian transition in Lao People's Democratic Republic (Lao PDR), a country overwhelmingly dependent on agriculture. Close to 80% of a population lives in rural areas and most are near-subsistence farmers engaged in rice-based agriculture. The large role agriculture plays can hardly be overlooked. Given the paucity of evidence, this paper provides a research on the determinants of agricultural efficiency and rural development by analyzing the marked differences between the upland and the lowland farming of the country.

Our original contribution is to explore the association between farmer education and the adoption of modern agricultural practices in Lao PDR. We find that the returns to farmer education are strongly positive, particular for a completion of primary cycle. Moreover, a better educated farmer is more likely to use new technology, and to have market access and off-farm activities. Despite the large public investment in irrigation, its role is very limited. The research suggests that the support policy on farmer education will be decisive not only for the success of the agrarian transition process but also the long term development of the country.

Keywords: Returns to Education, Farm Efficiency, Agrarian Transition, Lao PDR
JEL Categories: O13, O15, Q12

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1. Introduction

Landlocked in Southeast Asia, Lao People's Democratic Republic (Lao PDR) is a small country overwhelmingly dependent on agriculture. Since economic transition in China and, to a lesser extent, Vietnam are relatively well documented, we focus our study on the agrarian transition in Lao PDR. Such a study is of much interest than the small size of the country might lead one to expect. Lao PDR has a number of specific characteristics, including its limited land area as mainly mountainous landscape, its low population density[3], an ethnically diversified population[4] and very low human capital of farmers. Subsistence farming is still widely characterized by low inputs and low yields, with the result that farming incomes are very low. The other striking characteristics of the Lao agriculture are the widespread use of shifting cultivation practices, traditional production systems (slash-and-burn) especially in the uplands, predominantly household labor, and private land holdings (small size but equitable distribution).

In mid-2007 close to 80% of a population of 5.87 million lives in rural areas and most are farmers engaged in rice-based agriculture. Agriculture has grown at a robust 4.4% annually averaged over 1990-2006 and this largely contributes to the progress in rural poverty reduction. The large role agriculture plays and the analysis of this crucial sector in Lao PDR can hardly be overlooked. However, the existing empirical analysis of agricultural development in Lao PDR is, to date, very limited. For instance, Bourdet (1995, 2000) review the process of rural reforms and evaluate mainly on the impact of co-operatives on rice production using data of 1980-88. Onphanhdala (forthcoming) examines the effects of several alternatives of farmer education on rice production, using data of 1997/98. The main purpose of this paper, therefore, is to update a research work on the determinants of agricultural performance using the more recent data of 2002/03. Our original contribution is firstly to explore the association between farmer education and the adoption of modern agricultural practices in Lao PDR. Similar to Onphanhdala (forthcoming), this research also analyzes the marked differences between the north (mainly, upland rice) and the center-south (mainly, lowland rice) of the country that call for different approaches to agricultural reform[5]. Hereafter, the words 'north' and 'center-south' are used interchangeably with 'upland' and 'lowland', respectively.

In brief, we find that not only a better educated farmer is more likely to have better farm efficiency, but he is more likely to use new technology, and to have market access and off-farm activities. Despite the

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[3] To compare with neighboring countries: In 2007, Vietnam has a population density of 257 inhabitants/km^2, China: 138, Thailand: 128, Myanmar: 88 and Cambodia: 81, but only 25 for Lao PDR (ADB Key Indicators, 2008).

[4] The main group "*Lao*" accounts for 55% of the total population, and 49 different ethnic minorities constitute for the remaining, e.g. *Khmou* 11% and *Hmong* 8%. These minority populations are mainly found in mountainous borderlands and usually practice forms of slash-and-burn agriculture (NSC, 2006).

[5] All four provinces in which upland rice cropping systems still represents more than 50% of land holdings are located in the north (NSC, 2004).

large public investment in irrigation, its role is very limited. Thus, the support policy on farmer education will be decisive not only for the success of the agrarian transition process but also the long term development of the country.

The rest of the paper proceeds as follows: first, we present the rural reforms and agricultural growth in Lao PDR; second, we briefly review the literature on farmer education and farm efficiency, and empirical models; third, we show data description and the analysis of estimation results; and finally, we end with some concluding remarks.

2. Rural Reforms and Agricultural Growth in Lao PDR

2.1. Historical Backgrounds and Policy Changes

Lao PDR has several points in common with its neighbors China and Vietnam: a few decades of central planned economy and collectivization, followed by a move to a market oriented economy without political liberalization. Rural reforms in former socialist countries are predominantly of two kinds, marketization (a shift from an administrative to a market mechanism) and property rights systems. We concentrate here on property rights reform for the Lao case. Prior to the independence in late 1975, the role of rice production dominated the agricultural sector as it accounted for some 85% of total agricultural land. In 1976, a reform of the property rights system started with the collectivization campaign, but only a few co-operatives had been established. The serious attempts were made to organize the Lao peasants into farm co-operatives, considered necessary to complete the socialist transformation of the agricultural sector and to increase its productivity, resulted in a drastically increase of co-operatives number up to 1,356 in 1978 and 2,452 in 1979. The transformation also included the establishment of state farms, but their role was nevertheless very limited (Bourdet, 1995).

The campaign was extensive but very short-lived. Almost 4,000 co-operatives were established during 1976 and 1988, which is the last year for information on this scope is available. The difficulties of organizing the work collectively and redistributing the harvests led to a drop in rice production. Coupled with low public investment, there was widespread passive resistance and many co-operatives were in name only. After the peak in 1986 when the Lao Revolutionary Party had committed the country to a market oriented economy, the number of co-operatives dwindled to almost nothing. (Bourdet, 1995; Ducourtieux *et al*, 2005)

Since the early 1990s, the Lao government has undertaken substantial land reforms as a core policy: (i) to increase land tenure security to encourage farmer involvement in intensive farming, and (ii) to eliminate slash-and-burn agriculture to protect the environment. Land allocation was introduced experimentally in 1990 in two northern provinces (Luang Prabang and Xayabury). The process was extended to the whole country in 1994 (Ducourtieux *et al*, 2005). Though not officially considered as a policy by the government, resettlement of ethnic minorities has become a central feature of the rural

development strategy in Lao PDR[6]. Today, in all parts of the country, migrations of the highland populations to the plains and the valleys are even more significant than the migrations from rural areas to the main cities. In the agricultural sector, some provinces especially in the South, displacements contribute directly to a reduction of slash-and-burn practices[7], but there is little change in the northern provinces where it is most necessary (Evrard and Goudineau, 2004). The other key strategic initiative of the program is the promotion of stable agricultural practices to replace shifting cultivation. The Lao PDR Agriculture Strategy Study (1998) remains largely valid today and leads to a number of the latter government's strategic visions for the agricultural sector and rural development (World Bank, 2006).

2.2. Key Features of the Agricultural Sector

General characteristics: Rice is the single most important crop, accounting for over 40% of agricultural output. The Lao agriculture is dominated by two main farming systems in broad term: the upland pioneering slash-and-burn cultivation practices in the northern and eastern mountain regions or the so called "upland farming"; and the lowland rotational shifting cultivation along the Mekong River or the so called "lowland farming". Half of the population resides in the lowland areas. About 30% of farmers reside in the upland areas. The remaining are in areas of mixed lowland and upland (World Bank, 2006).

Agriculture has grown strongly, at a 4.4% annual average over 1990-2006, while its share of the national economy has declined from 61% to 43% over this period (ADB Key Indicators, 2008). Though the total area of rice harvested fluctuates quite markedly between years, mainly as a result of climatic conditions, the total rice output has been increasing steadily over the time (see Table 1). The total growth has been fueled in large part by an expansion of land under cultivation (on average 2.25% per year during 1976-2004). In recent years, measures of productivity are improving, based on increases from low levels of such inputs as improved seeds and fertilizers.

Overall, the crop sub-sector is characterized by low use of improved varieties of rice and fertilizers/pesticides; irrigation and double cropping are also quite limited; the extension services remain inadequate due to budget and technical limitations. Relative to the upland, the lowland farming makes more use of agricultural inputs. Most farmers produce glutinous rice rather than ordinary rice. Measured from the income side, however, agriculture is not as dominant as it appears. The low share is due to the low level of access to market. The fact is that only one-third of rice production is for market (NSC, 2004).

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[6] A majority of highland villages (hill tribes) have been resettled downhill over the past ten years. For an example, 1,200 villages and 450,000 people (12% of the rural population) have been relocated to the new creation of 87 special areas, called "Focal Sites" during 1998-2002 (Lao PDR, 1998).

[7] It is worth noting that under specific conditions, e.g. low population density and the fallow period long, slash-and-burn agriculture is a sustainable practice that contributes to the food security of highland people.

Table 1: Rice Production in Lao PDR

(1,000 tons)	1976	1980	1985	1990	1995	2001	2002	2003	2004
Wet Season Rice	456	705	1,023	1,089	1,071	1,620	1,801	1,820	1,976
Irrigated Rice	5	11	28	39	50	436	375	369	342
Upland Rice	202	337	345	381	296	279	240	186	211
Total Rice Output	663	1,053	1,396	1,509	1,417	2,335	2,416	2,375	2,529

Source: Computed from National Statistics Centre, Statistics Book 1975-2005.

Land, productive assets and farm labor: The distribution of agricultural land in Lao PDR is reasonably equitable. There is not much difference between provinces. The Agriculture Census showed that almost farmers own land with the relatively small average land size of 1.62 ha. For the country as a whole, 36% of farmers have less than 1 ha of land; 36% have 1 to 2 ha of land; and 27% have 2 ha or more land (Agriculture Census Office, 2000). More precisely, the harvested area of upland rice increased during 1976 and 1990, but it turns to be decreasing substantially resulted by the resettlement policy of "focal sites". In present, the area of upland farming is roughly one-half of its area in 1990. On the other hand, dry season rice plants have increased sharply in recent years following the large investment in irrigation facilities made in the second half of the 1990s. Irrigated land has almost doubled over the past decade. Two-thirds of the increase in dry season irrigated area over 1996-2001 was due to the public distribution of more than 8,000 irrigation pumps in the three main provinces of Vientiane[8], Savannakhet and Khammouane in the central areas. Since 2001 dry season irrigated rice has declined by 25% from its peak, largely due to technical and economic problems (World Bank, 2006).

On the other hand, the presence of productive agricultural assets is rather scarce. Machinery and fertilizers are widely used in the three major provinces of Vientiane, Savannakhet in the center and Champasack in the south. For example, only a quarter of farmers use machinery, mainly two-wheeled tractors in the lowland farming. A typical farmer owns water buffaloes for providing labor as ploughing, cart, etc. Most farm labor is provided by household members. Only one-fourth of farm households hire outside labor, mainly for clearing land (which is not an education-intensive job). In the north, most farmers employ laborers on the exchange basis. Payment in cash is more common in the center and the south. Furthermore, a part of farmers tend to do off-farm works such as a small family business (Agriculture Census Office, 2000; NSC, 2004).

Flood and other restrictions: Farmers are facing a number of restrictions including lack of irrigation, credits, market access, knowledge, and insects and animal disease. The most serious restriction for rice growers is flood disaster, especially in the center and the south. The recent severe floods that occurred in 1995, 1996 and 2000 resulted in huge damaged rice paddies in the country. It is worth noting

[8] Vientiane Capital is the capital city of Lao PDR, and is not located in Vientiane Province. The term 'Vientiane' generally denotes the capital city and is also applied in this study.

that there was also a flood in 2002 but limitedly affected on the data of rice production in this study. The average damaged area was relatively low at about 7.8%[9].

3. Farmer Education and Farm Efficiency

The majority of human capital literature for developing countries focuses on wage earnings, in spite of the fact that the largest share of the labor force is engaged in self-employed activities. Bowman (1976) argued that education and information relevant to the small farmer might usefully be categorized as "formation of competences" and "transmission of information". Basic competences are best formed through schools. Information – on prices, new seeds or techniques, irrigation methods, and so forth – can be transmitted through a variety of institutional or non-institutional frameworks. Concepts of education and farm efficiency through worker effect, allocative effect, and choice of production technique are well-defined in Welch (1970) and Schultz (1961, 1975). Another concept of productivity, market efficiency, is defined as a farmer's ability to obtain the highest net sale price for his outputs and the lowest net purchase price for his inputs. In more recent work, Kremer (1993) proposed a weak-link production function in which workers of similar skill are matched together. Yang (1997) proposed the alternatives for the appropriate empirical specification of education in the production process[10].

On the empirical work, a number of studies [for example, Huffman (1974), Fane (1975), Wu (1977), Lockheed et al. (1980), Jamison and Moock (1984), Rosenzweig (1995), Singh and Santiago (1997), and Yang (1998)] have analyzed the effects of education on farm efficiency. The large majority of the literature uses either the education level of one individual in the household (usually household head) or the average level of education in the household. Jamison and Lau (1982) surveyed the literature worldwide on education and small farm production. The study points out the positive correlation between education attainment and farm efficiency in 31 out of 37 cases. The effects of education are much more likely to be positive in modern agricultural environments than in traditional ones. Similarly, other studies have also usually found the positive effect of education on farm efficiency, but its effect is often small. Furthermore, Foster and Rosenzweig (1996) and Behrman *et al.* (1999) show that anyone within a household having primary education is an important predictor of adopting new farming technology and profitability during the time of the "Green Revolution" in India. However, recent studies on the effects of education on farming pay more attention to the motivation for investing in human capital. Several studies [for example, Huffman

[9] Asian Disaster Reduction Center, "Lao PDR country report 2003" provides the overview of disasters occurred in Lao PDR including floods.

[10] Jolliffe (2002) estimates the effects of several alternative measures of household education, including head, maximum, minimum and average schooling, on household income for the case of Ghana. Onphanhdala (forthcoming) applies this concept for the case of Lao PDR and finds that the rate of returns to household head schooling (relatively high at 3.78%) gives the lowest value among the alternative measures.

(1980), Fafchamps and Quisumbing (1999), Lanjouw (1999), Yang and An (2002), and Kurosaki and Khan (2004)] found that farmers respond to higher returns to education in the non-farm sector by reallocating labor away from agriculture.

The basic method of analysis in this study follows the model proposed by Yotopoulos (1967), cited in the book of Jamison and Lau (1982) page 19-21. Yotopoulos used a production function for agricultural output as the basic tool to analyze the effect of education on efficiency. Subsequent studies use much the same methodology with variations of either the Cobb-Douglas (or ln – ln) production function or the linear production function to relate output, and to the various inputs. We also apply this method, since most growers in Lao PDR are subsistence farmers, and farm income highly depends on price structures and market access. The studies we have reviewed typically used data from surveys that contain some or all of the following variables used in this study for each farm. The output production model is specified as of:

$$\ln(Y_i) = \alpha_0 + \alpha_1 \ln(T_i) + \alpha_2 \ln(L_i) + \beta_i Sch_i + \gamma X_i + u_i \qquad (1)$$

$$\ln(Y_i) = \alpha_0 + \alpha_1 \ln(T_i) + \alpha_2 \ln(L_i) + \beta_i Edu_i + \gamma X_i + u_i \qquad (2)$$

Y= total rice output (kilograms); *T* = area under cultivation (Ha); *L* = labor input (family labors used); Sch = Heads' years of schooling; *Edu* = Heads' years of educational level dummies; X= other factors including farm experiences, use of fertilizer, machinery and irrigation, market access, and so forth. In equation (1) and (2), the estimated coefficients α_1 , α_2 on the input variables indicate how strongly each input affects the output. The coefficients β give the percentage increase in output in response to a unit change in schooling or educational level.

4. Data Description

This study employs the national household survey data, the so-called Lao Expenditure and Consumption Survey in 2002/03 (LECS 3) conducted by the National Statistics Centre of Lao and Swedish International Development Agency. It covers about 1% of the total population. The data was collected from February 2002 to March 2003, with respect to the 2002 wet season and 2002/03 dry season. LECS 3 provides a number of information that not available in LECS 2 (1997/98) such as use of fertilizers, double cropping, single/mixed field crops, and hired labor.

After clearing the missing data, we finally use the subsample of 4,966 wet season rice farmers: 1,979 from the northern areas for mainly the upland farming, and 2,987 from the central and the southern areas for mainly the lowland farming. Summarizing the data, Table 2 presents the characteristics of the samples including: (formal) schooling years/education levels of the household head, total rice output, land and labor size, and various dummies variables. On average, the schooling years of household heads are about 3.9 years for the north and 4.5 years for the center-south. The higher the education level, the larger the gap between the two regions. Although the levels of farmer education show slightly improvement comparing with 1997/98 (3.5 years for the north and 4.2 years for the center-south), the performance in human capital is still very low. Over one half of household heads and eight out of ten their spouses had not

completed a primary education in 2002/03. For all, roughly 20% of the heads are illiterate, and less than 20% of the heads have schooling over the lower secondary level.

Table 2: Characteristics of Lao Farming, 2002/03

Variables	North	Center-South	All
Wet Season Rice Production (Kgs)	2,198	2,662	2,477
Land Size (Ha)	1.03	1.40	1.25
Farm Labor (Persons)	4.04	4.02	4.03
Schooling of Household Head (yrs)	3.93	4.52	4.29
No Education (%)	*21.73*	*18.78*	*19.96*
Some Primary (%)	*31.78*	*29.60*	*30.47*
Completed Primary (%)	*33.10*	*31.87*	*32.36*
Lower-Secondary or higher (%)	*13.39*	*19.75*	*17.22*
Head Age (Farm Experience, yrs)	41.5	43.9	42.9
Family Size (Persons)	6.48	6.29	6.36
Monthly Household Consumption (kips)	771,325	805,699	792,001
Dummy Variables			
Use of Fertilizer (%)	9.40	40.34	28.01
Use of Machinery (%)	18.80	24.84	22.43
Access to Irrigation (%)	21.53	34.45	29.30
Access to Market (%)	26.23	30.50	28.80
Double Cropping (%)	14.15	17.38	16.09
Mixed field crops (%)	40.58	19.85	28.11
Use of outside labor (%)	24.31	28.02	26.54
Off-farm Activities (%)	13.19	15.13	14.36
Owned Land (%)	91.26	95.48	93.80
Ethnic groups (%)	77.67	40.84	55.52
Rural Area (%)	91.97	88.05	89.61
Observations *N*	1,979	2,987	4,966

Source: Authors' calculation based on LECS 3 (2002/03)

The agricultural incomes are not examined in this study due to the insufficient and often unreliable samples. The characteristics of the total rice output between the uplands and the lowlands are generally described in Section 2.2. More specifically, for the upland farming, Xayaboury province is always the highest rice producer. Savannakhet, Champasack, the capital and Vientiane provinces are major rice producer in the lowlands and the whole country. However, the difference in the productivity among provinces both in the upland and the lowland is relatively small. Since land and labor inputs are quite equally distributed among regions, the improvement of education attainments, the adoption of new technology such machinery and access to market are probably the key factors that explain the increase in the total output.

Over 90% of farm households own private land in both regions. The average family size is six to seven persons. The mean of labor size as reported by occupation of each person in household is four

persons in both regions. The average age of household heads is about 43 years old, which resulted in comparable farm experience. Some 30% of farmers have market access, and nearly 15% of them make double cropping and off-farm activities. On the other hand, there are some striking differences between the north and the center-south. Farming in the north is much less modernization than in the center-south (e.g. use of fertilizers 9% vs. 40%). The Lao farming remains predominantly subsistence in nature as access to irrigation is low at 22% for the uplands and at 35% for the rest. We already include farm land that partly irrigated which they account for over one-half of the total access ratio. Furthermore, the northern farmers are mainly ethnic minorities that often practice mixed field crops compared to farmers in the center-south.

In addition to the restricted information on farm incomes and fertilizer use (in kilograms) mentioned above, the limitations of data also include agriculture extension (skills training), price of each input, and access to financial market. Nevertheless, we include a variable of farmers' wealth measured by consumption levels in the models in order to control the endogeinity problem[11]. It is argued that a farmer with higher income tends to have a higher education attainment and holding productive assets, and these tend to yield a higher production. However, we believe that the Lao farming provides an interesting case study that this kind of endogeinity is very small. Of particular note again, the farm practices are predominantly subsistence; family-based labor; equitable small land distribution; low levels of agriculture extensions and supply of school; and very limited access to credit. Under these circumstances for the Lao case, one can expect to examine near-pure impact of determinant factors on farm efficiency.

5. Estimation Results

5.1. Rice Production Function for Lao PDR

The OLS results of the estimation on rice production are given in Table 3-1 and Table 3-2. The models perform very well with high adjusted R-squares and most estimated variables being statistically significant at least at the 5% level. In short, the results support the view that farmer education is very important in increasing farm efficiency in all regions (see the next session).

First, the estimation results on rice production function using the extended model are shown in Table 3-1 (see Appendix 1 and Appendix 2 for the correlation table among variables of the north case and the center-south case, respectively). The associations between income level and rice production are found

[11] Time allocation between on-farm and off-farm of farmers is also an important endogeinity problem in studying agricultural efficiency. In our case, very few farmers do off-farm jobs even during off-farm season due to very limited non-farm rural income opportunities. Less than 15% of households answered that they do a family business. While younger persons in the households tend to involve in off-farm activities, the major labor forces in farming remain the household heads and their spouses.

to be marginal, and not even statistically significant in the case of upland farming[12]. An important finding is that there are no economies of scale in rice production in Lao PDR since the sum of the coefficients of the land area and the labor force is less than one both for the uplands and the lowlands. As a whole, a 1% increase in unit of land and labor would yield roughly 0.61% and 0.22% more rice output, respectively. The elasticity of land input is fairly low compared to other studies, because of shifting cultivation and soil erosion. The results of no economies of scale in rice production found here are consistent with the finding by Bourdet (1995) and Onphanhdala (forthcoming). On the other hand, an additional year of farm experience shows a marginal impact on output. This suggests that farm experience may not be an important determinant for farm efficiency in the Lao agriculture.

Having access to irrigation system is a very significant factor to increase rice production in other studies[13]. But it is questionable about the effectiveness of large public investment in irrigation for the Lao case. That irrigation facilities have not had much success in the Lao farming is illustrated by their small impact on agricultural performance in the period studied. Holding other things equal, farmers with access to irrigation produce only about 6% to 9% more wet season rice than those without access to irrigation in all regions. The usefulness of irrigation is partly limited during weather conditions with sufficient rainfall. But the poor performance of irrigation system is that farmers lack proper management, they are reluctant due to increasing energy costs (irrigation pumps), and in some cases due to poor civil works. World Bank (2006) reports that most irrigation schemes are small scale and village-based, predominate by utilizing pump-lift from rivers. Many of the schemes are poorly designed and/or poorly constructed, and this is exacerbated by inadequate maintenance. This suggests that irrigation facilities have a powerful control only in dry season rice and there is ample scope for a better redistribution of resources.

With respect to the adoption of new technology, using machinery yielded a large effect ranging from 15% to 25% on rice production. Using fertilizers, on the other hand, may yield only 10% higher production for the upland farming and it is not statistically significant for the lowland farming[14]. Overall fertilizer consumption is on an upward trend, four times over the 1990s, but from very low base levels. On average, fertilizer use has still barely reached 10 kg/ha since 2000 in Lao PDR. In comparison, fertilizer use in Indonesia and Vietnam are 121 kg/ha and 364 kg/ha respectively (World Bank, 2006). Together with use

[12] We also tried excluding log (per capita consumption) term as well, but found it to be barely different. Including this term does not change the significant levels of any variables in the results.

[13] Many studies tend to separate out farmers under irrigated farming since they raise crops significantly positive than those under rain-fed farming. For example, Kurosaki and Khan (2004) found that the irrigation ratios on crops are very high by 1.07 to 1.79 times for the Pakistan case.

[14] For an example, if a correlation between use of machinery and fertilizer is high, we need to apply IV (instrument variable) method. But in our case, the correlations between the two variables are very low at 0.2218 and 0.1811 for the uplands and lowlands, respectively. Thus, we simply apply OLS methods for the estimations.

of machinery, the impacts of agricultural productive assets are more dominant factor on increasing rice production in the upland farming.

Table 3-1: Results of the Estimated Rice Production – Extended Model

Variables	North	Center-South	All
log(Land)	0.6766**	0.5987**	0.6111**
	(0.0198)	(0.0136)	(0.0112)
log(Labor)	0.1476**	0.2570**	0.2152**
	(0.0294)	(0.0246)	(0.0191)
Some Primary Education	0.0716*	0.0033	0.0378
	(0.0311)	(0.0267)	(0.0204)
Completed Primary level	0.1954**	0.1167**	0.1576**
	(0.0301)	(0.0265)	(0.0202)
Lower Secondary or Higher	0.2573**	0.1443**	0.2055**
	(0.0378)	(0.0294)	(0.0232)
Farm Experience (Head Age)	0.0122*	-0.0008	0.0065
	(0.0062)	(0.0050)	(0.0039)
Farm Experience Squared/100	-0.0115	-0.0006	-0.0073
	(0.0067)	(0.0052)	(0.0041)
Use of Fertilizer	0.1009**	0.0014	-0.0043
	(0.0336)	(0.0202)	(0.0169)
Use of Machinery	0.2509**	0.1437**	0.1936**
	(0.0268)	(0.0202)	(0.0163)
Irrigation Access	0.0912**	0.0610**	0.0567**
	(0.0287)	(0.0190)	(0.0156)
Market Access	0.2252**	0.3433**	0.2927**
	(0.0224)	(0.0194)	(0.0148)
Double Cropping	0.1174**	-0.0771**	-0.0003
	(0.0309)	(0.0236)	(0.0195)
Mixed Field Crops	-0.0061	0.0556*	0.0375*
	(0.0217)	(0.0224)	(0.0154)
Use of Outside Labor	0.0778**	0.0800**	0.0777**
	(0.0243)	(0.0193)	(0.0153)
Owned Land	0.1758**	-0.0033	0.0981**
	(0.0369)	(0.0371)	(0.0261)
Ethnic Groups	-0.1445**	-0.0997**	-0.0848**
	(0.0258)	(0.0206)	(0.0156)
Log(per capita consumption)	0.0215	0.0723**	0.0601**
	(0.0214)	(0.0172)	(0.0135)
Constant	6.4929**	6.2316**	6.1332**
	(0.2764)	(0.2256)	(0.1756)
Adjusted R^2	0.579	0.643	0.614
F-test	161.10**	317.90**	465.28**
Observations	1,979	2,987	4,966

Note: Robust Standard errors in parentheses.

*Significant at the 5% and ** at the 1% level.

Furthermore, the study found that market access is the significant dominant on increasing farm efficiency. For example, more market-oriented and commercialized farmers may produce 22% and 35% more output than their counterparts in the north and the center-south, respectively. Farmers using outside labor produce slightly more in all regions. Ethnic minorities tend to have slightly lower rice output than their counterparts in the whole country. This suggests that the difference among 'Lao' and 'Ethnic groups' is small. Surprisingly, farmers residing in the areas of double cropping do not produce more rice in wet season in the center-south. Farmers doing mixed field crops are indifferent with farmers doing single field crop in the north, but slightly higher output in the center-south. Moreover, farmers who do not own land significantly produce lower in the northern areas, but unchanged in the center-south.

Overall, policy makers should implement different approaches to the unique characteristics of the farming system. In particular, the government should be more sensitive to the farmers in the uplands, judging from relatively larger coefficients in many factors than those in the lowlands.

5.2. Agricultural Efficiency and Returns to Farmer Education

As shown in Table 3-2, the results indicate that farmer education has a strong positive effect on farm efficiency. An additional schooling year would result in about 4.85% and 3.12% more rice output for the upland and the lowland farming, respectively. On average, the return to schooling is at 3.67%. We also found that the coefficients of returns to schooling generally increase as educational level rise. For the uplands, the effect of primary education on farm efficiency is remarkable at 29% and the additional gain from lower secondary is at 46%. Similarly, for the lowlands, the impact of primary education (22%) is also high, but the additional return from lower secondary education (29%) is quite small. Although most coefficients for schooling are slightly smaller in 2002/03, these trends remain the same over the period of 1997/08 to 2002/03 as compared with the findings of Onphanhdala (forthcoming).

Since the returns to schooling for wage earners are generally reported to be higher than that of farmers (Psacharopoulos and Patrinos, 2004), it is more interesting to compare the present estimates with other researches based on farmer education and farm efficiency. In the studies with statistically significant positive results, Jamison and Lau (1982) conclude that the rates of return to schooling range from 0.70% to 6.47% with an average of about 2.87%. Although the results of different studies must be compared with caution, the results of this study indicate that the estimated rates of return to education in Lao PDR are the above average. We may even say that they are high considering the generally low levels of education attainment of farmers, whereas the majority of them do not complete a primary education.

In terms of the returns to educational levels, we found that the rates of return per year are particularly high for farmers with a completion of primary level. For both the uplands and the lowlands, the estimated results showed that per year rates of return to primary education are roughly 29% and 22%, respectively. Even if two or three years of foregone earnings while in primary schooling are used in calculating the profitability of investment in schooling, these rates are still the highest. On the other hand,

the rates of return per year to lower secondary education are relatively small positive values of roughly 2% to 6% over the study period. Thus, the most profitable investment to education is the primary level. This result does not contradict previous studies. For an example, Kurosaki and Khan (2004) suggest that the effects of primary education on crop productivity are remarkable but the additional gain from higher education is very small. Once we control for other observable characteristics, however, these coefficients are considerably lower (Table 3-1). Whereas the effects of having some primary education are low, the study found that returns to completed primary level are statistically significant and remain very high.

Table 3-2: Results of the Estimated Rice Production – Basic Model

Variables	North		Center-South		All	
log(Land)	0.7019	0.6993	0.7308	0.7230	0.7175	0.7123
	(0.0202)	(0.0275)	(0.0127)	(0.0173)	(0.0107)	(0.0146)
log(Labor)	0.2006	0.2120	0.2492	0.2330	0.2306	0.2248
	(0.0284)	(0.0366)	(0.0237)	(0.0314)	(0.0182)	(0.0239)
Schooling Years	0.0485	-	0.0312	-	0.0367	-
	(0.0034)		(0.0025)		(0.0020)	
Completed Primary level	-	0.2899	-	0.2162	-	0.2484
		(0.0329)		(0.0292)		(0.0219)
Lower Secondary or	-	0.4621	-	0.2878	-	0.3510
Higher		(0.0448)		(0.0348)		(0.0275)
Constant	7.1194	7.0978	7.0885	7.1058	7.1048	7.1021
	(0.0422)	(0.0539)	(0.0358)	(0.0478)	(0.0273)	(0.0357)
Adjusted R^2	0.483	0.514	0.574	0.571	0.544	0.554
F-test	618.05	297.37	1343.27	541.83	1974.88	852.99
Observations	1,979	1,119 [a]	2,987	1,628 [a]	4,966	2,747 [a]

Note: [a] Only household heads with a completed level of schooling are included.

Robust Standard errors in parentheses. All variables are statistically significant at the 1% level.

In comparison with other studies on returns to education in the different sectors for the Lao case, Onphanhdala and Suruga (2007) use the dataset from the same survey with this study analyzing the returns to schooling for wage earners. They found that an additional year of schooling would increase earnings by 5.2% for private sector in 2002/03. The returns for young workers are considerably higher than for older workers. Although the most profitable investment in education is still the primary level, large earnings premiums are generally received by workers with tertiary education. Along the similar line, Suruga and Onphanhdala (2008) investigate the association between entrepreneurial education and micro/small business. They found that education can increase sales performance by 5.1%, which is considerably higher for rural, ethnics and young entrepreneurs. The advantage to primary education is remarkable, but post-secondary education is found to be over-education in all categories. Although the findings of the two studies and this current research have different concrete insights, all of them clearly demonstrate the high

returns to primary education for the Lao case. Undoubtedly, further efforts attempting to strengthen primary education are needed.

5.3. Farmer Education and Use of New Technology, Market Access, and Off-farm works

In this subsection, we examine whether education can enhance a farmer's ability to use of fertilizer and machinery, market access and off-farm works. Similar to the estimations of rice production, we also include the wealth of farmers as a control variable. The Probit analysis is presented in Table 4-1 and Table 4-2 (estimated Probit coefficients have been transformed into marginal effects evaluated at the mean). The estimates that interest us most are that having a completed primary education has considerably strong impacts on modern agriculture.

Table 4-1: Use of New Technology and Farmer Education

	Use of Fertilizer			Use of Machinery		
	North	Center-South	All	North	Center-South	All
Some Primary Education	0.0110	0.0621*	0.0428*	-0.0007	-0.0045	-0.0026
	(0.0792)	(0.0295)	(0.0207)	(0.0261)	(0.0238)	(0.0177)
Completed Primary Level	0.0245	0.1693**	0.1134**	0.0563*	0.0236	0.0394*
	(0.0193)	(0.0288)	(0.0208)	(0.0266)	(0.0240)	(0.0179)
Lower Secondary or Higher	0.0419	0.2561**	0.2044**	0.2013**	-0.0048	0.0640**
	(0.0265)	(0.0315)	(0.0258)	(0.0408)	(0.0263)	(0.0221)
Log (Land)	-0.0038	0.1249**	0.1113**	0.0234	0.1010**	0.0829**
	(0.0098)	(0.0136)	(0.0100)	(0.0131)	(0.0097)	(0.0075)
Log (Labor)	0.0144**	0.0281**	0.0201**	0.0233**	0.0420**	0.0336**
	(0.0032)	(0.0060)	(0.0040)	(0.0048)	(0.0049)	(0.0035)
Log (per capita consumption)	0.0897**	0.2096**	0.1782**	0.1343**	0.1289**	0.1361**
	(0.0115)	(0.0192)	(0.0132)	(0.0166)	(0.0147)	(0.0111)
Log likelihood	-568.02	-1741.94	-2563.11	-869.53	-1742.99	-2358.53
Observations	1,979	2,987	4,966	1,979	2,987	4,966

Note: Marginal effects after Probit Estimation are shown.

Robust Standard errors in parentheses. *Significant at the 5% and ** at the 1% level.

Table 4-2: Market Access, Off-farm Activities, and Farmer Education

	Market Access			Off-farm Activities		
	North	Center-South	All	North	Center-South	All
Some Primary Education	0.0634*	0.1008**	0.0849**	0.0328	0.0439	0.0392*
	(0.0302)	(0.0283)	(0.0208)	(0.0238)	(0.0228)	(0.0166)
Completed Primary Level	0.1155**	0.1837**	0.1546**	0.0570*	0.0797**	0.0707**
	(0.0305)	(0.0279)	(0.0207)	(0.0243)	(0.0230)	(0.0168)
Lower Secondary or Higher	0.1620**	0.2036**	0.1884**	0.1363**	0.1187**	0.1239**
	(0.0412)	(0.0321)	(0.2519)	(0.0372)	(0.0282)	(0.0223)
Log(per capita consumption)	0.1073**	0.1505**	0.1340**	0.1314**	0.1199**	0.1251**
	(0.0193)	(0.0158)	(0.0124)	(0.0136)	(0.0282)	(0.0087)
Log likelihood	-1101.53	-1742.99	-2848.49	-691.84	-1184.41	-1878.90
Observations	1,979	2,987	4,966	1,979	2,987	4,966

Note: Marginal effects after Probit Estimation are shown.

Robust Standard errors in parentheses. *Significant at the 5% and ** at the 1% level.

It is also interesting to observe that farmer education affects the use of fertilizer in the lowland farming as educational level rises, but it does not have any significant impact for the case of upland farming. Nevertheless, use of fertilizers is very rare in the uplands due to lack of supply and various specific practices of ethnic minorities. Similarly, farmer education makes a different impact on the use of machinery between the two regions. Though the level of holding machinery is a slightly lower in the north as comparison with in the center-south, we do not clearly understand this difference. Having a completed primary education or higher, overall, is an important predictor of adopting modern technology inputs.

In addition, education is likely to enhance a farmer's ability to have market access and off-farm jobs both in the upland and the lowland areas. All coefficients of schooling variables are larger as educational level rises. The impacts of famer education on access to market and off-farm jobs show the similar trend for both regions. For examples, education levels of some primary, completed primary, and lower secondary increase the probability of access to market by 8.5%, 15.5%, and 18.8%, respectively. Similarly, farmers with a higher education attainment are likely to do off-farm jobs by 3.9%, 7.1%, and 12.4% as educational level rises. Overall, in most cases, the coefficients of having a completed primary education are double or more than those for some primary education. These facts, again, suggest the importance of basic education for farmers in Lao PDR.

6. Concluding Remarks

Lao PDR has made commendable progress with agricultural growth and this has contributed to significant rural poverty reduction over the past decades. However, this link has weakened and slowed in

recent years[15]. Upland and lowland agriculture are likely to respond differently. The lowland areas hold the most promise for the intensification, diversification and commercialization of agricultural production. Whereas upland areas pose special challenges for delivering significant gains in agricultural growth, the areas are nevertheless important in the long term as suitable land becomes scarcer and lowland opportunities more fully exploited.

The government needs to focus on improving farmer productivity, linking farmer to markets, and strengthening public expenditures on the agricultural sector. Of particular note, the irrigation investments continue to predominate. However, our findings show that the effect of access to irrigation is obviously low. The principal policy implications of the results presented in this study pertain to the potential social and economic benefits of improving education in rural areas. Today, the education levels in Lao PDR are still very low. One-half of household heads and three quarters of their spouses have not completed a primary education in 2002/03. The findings from this study show that the role of farmers' education is quantitatively important in determining the agricultural performance. The estimated rates of return to schooling for both the upland and the lowland farming are relatively high, particularly for the rates of return to a completion of primary cycle. Therefore, adult literacy campaigns, including women's education with their important role in the agricultural labor force, would generate directly the modernization of agricultural practices and the improvements in well-being in the near future. Indirectly, public investment in education may also be helpful in stabilizing shifting cultivation, diversifying the agricultural sector and maintaining a sustainable use of forest products.

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[15] See a review of rural poverty and agricultural linkages in World Bank (2006).

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Appendix 1: Correlation Table among Variables for the North (upland farming)

	Output	Land	Labor	Education	Experience	Fertilizer	Machinery	Irrigation	Market	Double Cropping	Mixed Fields	Hire Labor	Owned Land	Ethnics	Income
Output	1.0000														
Land	0.6422	1.0000													
Labor	0.2160	0.1940	1.0000												
Education	0.2253	0.0466	-0.0165	1.0000											
Experience	0.1227	0.0924	0.3397	-0.1095	1.0000										
Fertilizer	0.1850	0.0122	0.0680	0.0884	0.0763	1.0000									
Machinery	0.3332	0.0696	0.0829	0.1890	0.0813	0.2218	1.0000								
Irrigation	0.0892	-0.0018	0.0496	-0.1046	0.0433	0.0799	0.0186	1.0000							
Market	0.3494	0.2310	0.0007	0.1343	-0.0166	0.0599	0.1336	-0.0216	1.0000						
Double Cropping	0.1083	-0.0610	0.1026	0.0267	0.0265	0.1475	0.1387	0.2707	0.0348	1.0000					
Mixed Fields	-0.0696	-0.1539	0.1157	0.0149	-0.0031	-0.0299	-0.0262	-0.0722	-0.0201	0.0513	1.0000				
Hire Labor	0.2172	0.1287	-0.0187	0.1477	-0.0025	0.0920	0.1616	-0.0445	0.2567	-0.0340	-0.0196	1.0000			
Owned Land	0.0778	-0.0751	0.0203	0.1024	0.0425	0.0690	0.1214	0.1360	-0.0473	0.0948	0.1319	0.0169	1.0000		
Ethnics	-0.1231	0.0940	0.0590	-0.3324	-0.0453	-0.1932	-0.1892	0.0742	-0.0913	-0.0573	-0.0708	-0.1034	-0.1316	1.0000	
Income	0.1696	-0.0184	-0.1267	0.2739	0.0335	0.2064	0.2266	0.0231	0.1622	0.0781	-0.0612	0.1915	0.1423	-0.2804	1.0000

Appendix 2: Correlation Table among Variables for the Center-South (lowland farming)

	Output	Land	Labor	Education	Experience	Fertilizer	Machinery	Irrigation	Market	Double Cropping	Mixed Fields	Hire Labor	Owned Land	Ethnics	Income
Output	1.0000														
Land	0.7210	1.0000													
Labor	0.2718	0.2232	1.0000												
Education	0.1524	0.0475	-0.0089	1.0000											
Experience	0.1412	0.1827	0.3566	-0.1662	1.0000										
Fertilizer	0.2955	0.2895	0.1157	0.2171	0.1102	1.0000									
Machinery	0.3967	0.3295	0.1979	0.0377	0.1280	0.1811	1.0000								
Irrigation	0.0686	0.0415	0.0662	-0.0672	0.0412	0.0300	0.0707	1.0000							
Market	0.5114	0.3717	0.0852	0.1625	0.0546	0.3105	0.2603	0.0615	1.0000						
Double Cropping	0.0568	0.0518	0.1090	0.0161	0.0551	0.1668	0.1106	0.3481	0.1146	1.0000					
Mixed Fields	-0.0584	-0.1098	0.0738	-0.0185	0.0161	-0.1099	-0.0084	-0.0535	-0.0307	-0.0200	1.0000				
Hire Labor	0.3179	0.2522	0.0450	0.1821	0.0612	0.2193	0.1916	0.0606	0.2894	0.0719	-0.0564	1.0000			
Owned Land	0.0442	0.0501	0.0562	-0.0699	0.0610	-0.0346	0.0468	0.1001	0.0286	0.0019	0.0558	-0.0186	1.0000		
Ethnics	-0.2513	-0.2161	-0.0328	-0.2374	-0.0910	-0.4514	-0.1215	0.0612	-0.2339	-0.1006	0.1550	-0.2015	0.0595	1.0000	
Income	0.2193	0.1308	-0.0858	0.2455	0.0761	0.2687	0.1793	0.0409	0.2061	0.1205	-0.0450	0.2474	-0.0548	-0.2764	1.0000