Economic Constraints to the Intensification of Rainfed Lowland Rice in Laos

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INTRODUCTION

Rice production in the rainfed lowlands of Laos faces a number of constraints at the farm level, including poor soil fertility, droughts and floods, and various pests and diseases (Schiller et al. 2001; Linquist and Sengxua 2001; Fukai and Ouk 2012). Furthermore, factors beyond the farm boundary such as rising input costs, fluctuating output prices, and uncertain trade policy continue to limit farmers' incentive to intensify production beyond that required to achieve household self-sufficiency. Hence, in recent years, household labour and capital have been redirected into a

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range of other farm and non-farm activities rather than into intensifying rice production (Manivong et al. 2014). With high levels of yield- and price-risk and limited opportunities for consumption smoothing through market mechanisms (credit and insurance), households adopt income-smoothing strategies by adopting Low-Input production systems and income diversification, most notably through migration of family members to earn wages.

While the constraints are numerous, lowland rice production systems have been evolving over the past two to three decades (Chaps. 5 and 6). The traditional farming system that relied on draught animal power, traditional varieties, and organic fertilisers now accounts for a very small proportion of the country's lowland rice area, with widespread adoption of mechanised land preparation, improved varieties, and low levels of inorganic fertilisers. Despite the achievements of these "green revolution" technologies in terms of increased output, lowland rice production remains an economically marginal activity, providing limited economic incentive for farmers to intensify production beyond household consumption needs.

This poses a challenge for the Government of Laos (GOL) that seeks to keep the price of rice affordable for urban consumers (and net buyers of rice in rural areas), while providing incentives for farmers to intensify production to achieve food security (and even export) objectives. Attempts to maintain national food security, equated by policy-makers with rice self-sufficiency, have included the setting of official yield targets that are high relative to the current situation (4 t/ha for the rainfed wet season [WS] crop and 5 t/ha for the irrigated dry-season [DS] crop), as well as ad hoc trade restrictions prompted by seasonal shortfalls and price spikes. However, in many cases the strategies fail basic economic viability tests at the household level and have created further market uncertainty.

The limited intensification of lowland rice systems reflects the relative resource endowments and livelihood objectives of farm households. Induced innovation theory predicts that farming systems will respond both to changes in resource endowments and to growth in product demand, with new technologies developed and adopted that facilitate the substitution of relatively abundant and low-cost factors for those that are relatively scarce (Hayami and Ruttan 1985). In practice, this depends on the extent to which farmers' circumstances and national government policies align, and the ability of farmers to influence research and development priorities. In considering the economic and institutional constraints to improved fertility management, Pandey (1999) classifies rice production

systems using a matrix of population density and the stage of economic development (as indicated by income levels). He argues that in situations with low population density and low income levels (in which he includes Laos), farms tend to be subsistence-oriented, with limited demand for improved nutrient management technologies that increase yields and returns to land. Such technologies will only be adopted if they also help save labour, the relatively scarce resource. He further argues that in order to stimulate the demand for yield-increasing technologies, policies need to focus on improving the profitability of rice production. This may include the development of export markets and improved market infrastructure, factors that lie outside the farm boundary. Nevertheless, in rainfed regions, production risk will continue to influence the demand for fertility management technologies.

In this chapter, we aim to explain farmers' decisions regarding the intensification of rainfed lowland rice systems in the context of current resource endowments, product demand, and production and market risk. We first describe the current rice production system in two major lowland provinces in central and southern Laos—Savannakhet and Champasak. We demonstrate that while the rainfed production system remains largely subsistence-oriented, farmers have selectively adopted a range of new technologies and continue to respond to changing incentives. However, to date this has largely involved the adoption of Low-Input, more labour-efficient, and more stable production systems rather than commercially oriented, High-Input, and high-yield systems. We use activity budgeting and sensitivity analysis to explore the economic performance of several input scenarios, ranging from farmers' practice to input levels required to achieve GOL policy targets. This analysis can be used to reassess aspects of rice policy for the rainfed lowlands in Laos.

METHODS

Savannakhet and Champasak are two of the most important rice-producing provinces in Laos. In 2009, they accounted for around 40% of the national WS harvested area and a similar proportion of total production (Ministry of Planning and Investment 2010). A diagnosis and assessment of farming systems in these two provinces was undertaken in several phases of field-work, including key informant interviews with district agricultural staff, village group discussions, household surveys, and household case studies.

The fieldwork was conducted along transects reflecting different farm types, from irrigated lowlands through rainfed lowlands to uplands. However, only data from lowland villages are considered here; upland villages surveyed in the east of Savannakhet have been excluded from the analysis. Thus for present purposes the study region included six villages in Outomphone, Phalanxai, and Phin Districts in Savannakhet and six villages in Phonethong and Sukhuma Districts in Champasak (see Fig. 5.1 in Chap. 5). A household survey was carried out with 30 randomly selected households in each village, making 360 households in all. Information was sought regarding household composition and assets, cropping practices, livestock practices, off-farm and non-farm employment, migration and remittances, forest collection and hunting activities, access to water, access to credit, group membership, information sources, and rice security. More detailed case studies were conducted with 13 households in Savannakhet and 18 households in Champasak.

Survey and case-study data were supplemented with project and historical agronomic trial results in order to construct model budgets for various input scenarios. These include data from fertiliser response trials conducted by the International Rice Research Institute (IRRI) and the National Agriculture and Forestry Research Institute (NAFRI) over more than a decade (Linguist and Sengxua 2001, 2003; Haeefe et al. 2010). Official yield data were not used as these tend to overestimate actual farm yields (Pandey 2001), presumably a reflection of the pressure to show progress in achieving policy targets. In 2013, the model budgets were presented to a farmer focus group for validation and updating with input and output prices relevant to the 2012 wet season. Sensitivity analysis, threshold analysis, and risk analysis (using the @Risk software package) were conducted for each scenario.

STATUS OF LOWLAND RICE FARMING IN THE STUDY VILLAGES

The cultivation of rice remains an important livelihood activity for the majority of households in the lowland regions of Laos and creates the platform on which other activities and household decisions are based. Decisions regarding labour utilisation and migration, livestock management, and even religious and cultural festivals, are all made with reference to the paddy production cycle. Around 96% of surveyed households cultivated rice in WS 2010. Household access to paddy lands varied within and

Table 10.1 Status of rice-growing in surveyed villages, 2010 ($n = 360$)

<i>District and village</i>	<i>% of hh^a growing rice</i>	<i>Mean hh^a size</i>	<i>Mean WS cultivated area (ha)</i>	<i>Mean WS yield (kg/ha)</i>	<i>Mean % of production sold</i>
Outomphone	100	6.6	2.5	1466	9.7
Nagasor	100	6.1	2.1	1618	8.2
Phonegnanang	100	7.0	3.0	1314	11.2
Phalanxai	98	6.2	1.9	1572	3.8
Phanomxai	100	6.8	1.3	1987	2.1
Phontan	97	5.7	2.6	1157	5.5
Phin	88	7.2	1.2	1740	7.2
Khamsa-e	87	7.3	1.2	2545	14.1
Geangxai	90	7.0	1.1	965	0.5
Phonethong	97	7.0	2.8	1582	24.5
Phaling	97	7.3	2.4	1718	22.3
Oupalath	97	7.0	2.4	1933	27.0
None Phajao	97	6.8	3.5	1100	24.1
Soukhuma	98	6.3	1.8	1996	22.6
Boungkeo	100	6.7	1.4	2219	26.2
Khoke	100	6.5	1.7	2109	24.1
Nongbua					
Hieng	93	5.8	2.4	1645	17.1
<i>Mean</i>	<i>96</i>	<i>6.7</i>	<i>2.1</i>	<i>1689</i>	<i>15.3</i>

^ahh = household

between villages, from less than a hectare to over 10 ha, with an average across all villages of around 2 ha (Table 10.1). There was a similar proportion of households with 1 ha or less (33%), 1–2 ha (34%), and over 2 ha (33%). Beyond farm size, other factors such as soil type, position in the toposequence, and access to water sources all affected the productivity of the land, even before any management decisions were overlayed. The stability of the livelihood platform thus varied between households and seasons.

WS 2010 was considered by farmers and researchers to be a drier than a normal year, with reported yields (calculated from farmers' estimates of cultivated area and production) somewhat lower than in previous years (Table 10.1). Droughts and floods are a common occurrence in the region, with large areas impacted by these climatic shocks. According to Schiller et al. (2006), over a period of 37 years (1966–2002) the Central Region (which includes Savannakhet) was affected by extreme events in

32 years, while the Southern Region (which includes Champasak) was affected in 22 years. These events have a profound impact on household rice self-sufficiency, given that many operate close to a subsistence threshold. Nevertheless, this means that the 2010 yields were not greatly different from the normal run of seasons. It is significant that they were below official yield data for the same season and well below the official target of 4 t/ha.

Households produced limited surplus rice for sale in WS 2010, averaging only 15% across the 12 villages (Table 10.1). Only 40% of surveyed households who were growing rice sold any rice, with the rest either producing rice exclusively for home consumption or buying rice to cover a deficit. However, sellers included some households that had access to irrigation water for the subsequent DS crop (particularly in Boungkeo and Phaling in Champasak).¹ The proportion of households selling rice, just self-sufficient, and buying rice varied significantly between the villages, as shown for the six Champasak villages in Fig. 10.1. There was also a group of households that sold rice immediately after harvest to pay off debt and re-entered the market later in the year as buyers to make up shortfalls. These households received low paddy prices when they sold their rice after

Fig. 10.1 Household rice status in Champasak for 2010, by district and village

harvest and incurred higher prices when they re-entered the market to make purchases.

The household's rice status is a function of the number of household members (or, strictly, the number of people who share the harvest); the area of paddy land available for cultivation; and the yield of the rice crop (Table 10.1). Given that yields fluctuate between years and many households are close to subsistence levels, the household's rice status is likely to change from year to year. Hence households formulate their livelihood strategy each year depending on crop performance. For example, the migration patterns of young people in some case-study households were determined by the performance of the WS rice crop and whether cash income would be required to make up shortfalls.

The average household size in the survey was 6.7 members, but this is complicated by household dynamics throughout the year. Members of the household may migrate for periods of the year and not consume from the household's rice stock. On the other hand, sometimes the rice harvest is shared beyond the immediate household, including relatives who have moved away from the village. Similarly, there are other social obligations involving sharing rice with others, including offerings to monks. Acknowledging these nuances, it is useful to take as a benchmark the national criterion for self-sufficiency, which is 350 kg of paddy (i.e., unmilled rice) per household member per year.

Figure 10.2 shows the yield required for an average household to achieve self-sufficiency for a range of paddy areas. The "self-sufficiency curve" indicates the large difference in required yield as the land size varies. For example, a household with 2 ha of paddy land only requires a yield of around 1.2 t/ha to achieve household self-sufficiency, while a household with only 1 ha would require a yield of close to 2.5 t/ha. The scatter plot presents the yield and area combinations for WS 2010. Self-sufficient households tend to track the "self-sufficiency curve", suggesting that households are trading off yield and paddy area, pursuing higher yields only when farm size is limited. As expected, most net purchasers of rice fall below the "self-sufficiency curve" in Fig. 10.2 and most net sellers are above the curve (remembering that actual family sizes vary between points). Some households remain net purchasers of rice, despite relatively large paddy areas, due to low yields, while other households achieve relatively good yields but, due to area constraints, still fail to meet household requirements.

Fig. 10.2 Yield-area combinations by household rice status

The “market-oriented curve” in Fig. 10.2 shows the yield-area combinations enabling the average household to sell 50% of production, and the “market entry curve” shows the combinations for sales of 20% of production, reflecting an incipient market orientation. There were few households above the “market-oriented curve”, especially in Savannakhet. As indicated in Fig. 10.2, a large proportion of households selling rice in 2010 were from Champasak, reflecting the higher average yields in 2010 in that province. Again, the scatterplot shows that the opportunity for a household to meet these market criteria varies considerably with paddy area. Households with 3 ha or more could achieve a 50% surplus with 2 t/ha or less, while the few market-oriented households with less than 2 ha were achieving yields of 3–4 t/ha.

In general, the data suggest that currently the majority of households remain largely subsistence-oriented (with respect to rice farming) and are willing to trade-off yields with paddy area to meet household requirements, limiting the incentive for intensification. Even in cases where households have access to irrigation water allowing double cropping, significant areas of the land were left fallow as rice prices fell to the extent that only 3 ha of DS rice were planted in Phaling village in 2012 compared to around 50 ha for the survey year in 2010.

ADOPTION OF MODERN TECHNOLOGY

While there are many physical and biological constraints that continue to limit rice productivity in the rainfed lowlands, the farming system has by no means remained static over the past two decades. The traditional production system that relied on draught animal power for land preparation, traditional varieties, and organic fertilisers has almost completely disappeared from the landscape. Indeed, only 11 households from the 347 households surveyed that were growing rice had not adopted any of the three main technologies—mechanised land preparation, improved varieties, or inorganic fertilisers. The current status of adoption of these technologies is summarised below.

Mechanisation

Economic growth in Laos and neighbouring countries has created considerable employment opportunities away from the farm. Migrating to Thailand is a well-established livelihood strategy for young people from lowland households; 43% of households surveyed in Champasak had at least one member working in Thailand (Manivong et al. 2014). In Outomphone, Savannakhet, 42% of households had at least one family member working in Thailand, with the incidence falling away as distance from the border increased. At the same time, employment opportunities within Laos, both in urban areas (including the construction and service sectors) and rural areas (such as working in rubber plantations) is also drawing labour away from traditional, semi-subsistence agriculture. This is not only impacting on the availability of household labour, but also increasing the cost of hiring labour, especially during peak periods such as transplanting and harvesting. Wage rates varied from LAK 25,000 to 50,000 per day depending on location, season, and activity. However, even in the remote Phin District, the wage rate for transplanting was reported to have reached LAK 50,000 per day (USD 6.25).

Mechanisation of rice production in Laos remains in its infancy, but with labour becoming increasingly scarce, changes are rapidly occurring as technology spills across the borders (Table 10.2). Around 75% of survey households utilised two-wheel tractors for land preparation rather than relying on draught animal power (mainly buffaloes). The ownership of two-wheel tractors had expanded to over 60% of households, while only 21% of households continued to use draught animal power exclusively. As

Table 10.2 Mode of land preparation by paddy area and district

<i>Land preparation method (% of households in each category)</i>				
	<i>Buffalo</i>	<i>Own tractor</i>	<i>Hired tractor</i>	<i>Buffalo and hired tractor</i>
Land preparation by paddy area				
Small (<i>n</i> = 113)	21	57	16	4
Medium (<i>n</i> = 121)	19	69	7	4
Large (<i>n</i> = 113)	23	67	6	4
All (<i>n</i> = 347)	21	64	10	4
Land preparation by district				
Outomphone (<i>n</i> = 60)	18	78	2	0
Phalanxai (<i>n</i> = 59)	19	56	20	3
Phin (<i>n</i> = 53)	9	85	6	0
Phonethong (<i>n</i> = 87)	47	43	3	5
Soukhuma (<i>n</i> = 88)	6	69	16	8
All (<i>n</i> = 347)	21	64	10	4

Table 10.2 shows, the area of paddy land owned did not have a major impact on adoption. Moreover, adoption had extended into some more remote areas where rice productivity remained low and almost no surplus rice was produced. While the technology is not divisible like seed or fertiliser, the extent of adoption is not surprising given the versatility of the tractors and the extent of labour saved in both production and non-production activities, for example, transport to regional centres. However, in one village in Phonethong District (None Phajao) ownership of two-wheel tractors remained low compared to all other villages.

Other forms of mechanisation were less common, with the first transplanter, drill seeders, and harvesters only beginning to be utilised in the past few years and only in small areas. It is expected that their use will continue to expand as labour becomes increasingly expensive. Currently, in order to minimise cash outlays, households tend to extend the period of transplanting and utilise the declining household labour resource rather than hire labour or transplanters (with obvious trade-offs in terms of yield).

Improved Varieties

As shown in Chaps. 5 and 6, the adoption of improved varieties has been the single most important factor in achieving significant productivity increases since the 1990s. The first improved varieties were released in

Fig. 10.3 Cumulative adoption of improved varieties by paddy area

Laos in the 1970s, and over the past two decades there has been widespread adoption. Indeed, the majority of households now grow at least one improved variety that has come out of breeding programmes in Laos or neighbouring countries,² with the area of traditional cultivars contracting. The adoption of improved varieties has occurred at similar rates among different farm size classes (Fig. 10.3). The impact of various projects can be seen in years (such as 2000) where significant jumps in adoption occurred.

Fertiliser Use

Soil fertility has long been recognised as one of the major constraints to rice production in Laos. The soils throughout the main lowland rice-growing areas in the central and southern plains have been described as generally infertile, highly weathered, and old alluvial deposits that comprise a series of low-level terraces with an elevation of about 200 metres above sea level (Lathvilayvong et al. 1996). Previous studies have identified nitrogen (N) as the most limiting nutrient in all regions of the country. In much of the Central and Southern Regions phosphorus (P) deficiency is also acute. Potassium (K) is the least limiting of the three tested nutrients

in the central region, yet the need for K inputs is expected to increase as production is increased through double cropping or as rice yields increase through changes in management (Schiller et al. 2001).

The use of both organic and inorganic fertilisers has long been promoted in Laos. Linquist and Sengxua (2001) developed broad fertiliser recommendations based on fertility management research throughout the country. They recognised that the rainfed lowlands constitute a risky environment for crop production, hence their recommendations required relatively low investment and used nutrients with maximum efficiency rather than aiming for maximum yields. The recommendations were also based on the three fertilisers that were readily available.

For the first year of application, the recommendation is to apply 60-x-25 kg/ha of elemental nitrogen (N), phosphorus (P), and potassium (K), with the P rate varying according to soil texture. The rate of N recommended is lower than that required for maximum yields and reflects farmer risk in the rainfed environment. Higher rates of 90–120 kg/ha of N usually result in higher yields but only under good growing conditions. The recommended rate of P is 8.5 kg/ha in sandy soils, 13 kg/ha in sandy loam soils, and 19–26 kg/ha in loams and clay loams. In the second and subsequent years, the recommendation is modified to account for P that was not removed by the crop. These recommendations have been used in the scenario analysis presented in the following section.

The use of inorganic fertilisers by farmers in the lowland rainfed environment has historically been low. Surveys by Villano and Pandey (1998) for the 1996 WS crop in Champasak and Saravan Provinces found that 66% of households were using some chemical fertilisers and 48% of the area was fertilised. Of those applying fertilisers, about 54% did so to both the seedbed and the main field, 16% only to the main field, and 30% only to the seedbed.

The use of small amounts of inorganic fertilisers had expanded to around 80% of surveyed households in 2010. A range of fertility management strategies was used, including only applying fertilisers to seedlings and various combinations of basal applications and topdressing. Only around 18% of households were applying fertilisers to seedlings plus a basal application to the main field, followed by a topdressing (as recommended). Most households not using inorganic fertilisers were from the two villages in Phin District, Savannakhet. However, the reasons for not using fertilisers were very different between the two villages. The average WS yields in Khamse were the highest across the Savannakhet survey, with households growing longer-duration varieties due to favourable

conditions. Farmers reported that they did not use fertilisers because the land was still fertile, and hence additional (purchased) nutrients were not required. Some households reported that they had experimented with fertilisers in the past but had problems with lodging. On the other hand, Geangxai had the lowest average yields of the survey, with almost no household producing a surplus crop in 2010. Farmers in this village had frequent problems with drought as well as lower cash incomes compared to Khamsa-e. In Champasak the lowest rate of adoption was in the relatively remote village of None Phajao. Similar to Geangxai, this village had some of the lowest rice yields in the survey.

While the percentage of households using inorganic fertilisers has increased significantly, the level of use remains well below the recommended rates. The limited use of fertilisers reflects both the high cost of purchasing inputs, the limited access to credit, the high level of production risk, and market uncertainty should a surplus be produced. Physical access, counterfeit products, and limited knowledge about appropriate rates and timing contribute to the problems. Table 10.3 presents the average

Table 10.3 Average nutrient application rate by village (kg/ha)

<i>District/village</i>	<i>Mean quantity of nutrient applied (kg/ha)</i>		
	N	P ₂ O ₅	K ₂ O
Outomphone	10.2	8.9	1.8
Nagazor	13.1	10.6	2.2
Phonegnanang	7.5	7.2	1.4
Phalanxai	14.4	13.0	1.1
Phanomxai	18.2	17.4	2.1
Phontan	10.9	8.9	0.2
Phin	9.5	6.9	0.0
Geangxai	10.0	6.4	0.0
Khamsa-e	7.3	9.2	0.0
Phonethong	21.1	10.5	3.2
None Phajao	5.8	5.5	1.7
Oupalath	27.4	13.6	3.1
Phaling	20.8	9.5	3.8
Soukhuma	15.9	15.3	1.7
Boungkeo	21.8	22.5	2.5
Hieng	7.1	8.1	0.1
Khoke Nongbua	17.0	13.3	2.3
All	15.3	11.8	1.9

N-P₂O₅-K₂O rates for each village. The overall average of 15-12-2 kg/ha of N-P₂O₅-K₂O converts to 15-5-1.5 kg/ha of NPK—well below the conservative recommendation developed by Linquist and Sengxua (2001) of 60-[8/26]-25 kg/ha NPK, with the P rate varying according to soil texture. It should be noted that these average amounts assume that farmers spread the fertilisers equally across their paddy fields. In practice, farmers tend to vary their application rates based on previous crop performance and perceived risk.

THE ECONOMICS OF INTENSIFYING FERTILISER USE FOR RAINFED RICE

To help understand the adoption patterns for fertiliser use, enterprise budgeting scenarios were developed for a hectare of WS rainfed rice based on household survey data and field experimental results. These representative budgets were first developed using average values for prices and yields, then sensitivity analysis was applied to allow for variability in these two key parameters. A range of indicators was used to capture farmers' decision criteria with regard to input use, including net returns to land (NR), with imputed costs for household labour deducted; net returns to household resources (NRHR), with no costing of household labour or land; and net returns to household resources per day of household labour (NRHL). When presenting the representative budgets to groups of farmers, these three indicators were assessed in terms of their usefulness for evaluating activities. Farmers preferred the NR measure to the NRHR measure as it explicitly placed a value on their own labour, but they also found the NRHL measure an easy way to compare the returns they received to the wage rate at different times of the year and for different household members.

Fertiliser-yield Scenarios

The four budget scenarios represented successively greater intensification as indicated by increasing fertiliser rates and yields.

Scenario 1 (No-Input)—Yield estimates were based largely on experimental results in which no inorganic fertiliser is added to the transplant crop. The household survey suggests that this represents around 30% of households. Both survey and experimental results show wide variation

in the yields obtained where no inorganic fertiliser is used due to factors such as the indigenous soil fertility, soil-water balance properties, and other management practices. An average yield of 1.5 t/ha was assumed.

Scenario 2 (Low-Input)—This was based on the current Low-Input system that many households practice. It assumes again that households use inorganic fertilisers to establish seedlings but then apply one bag (50 kg) of 16-20-0 as a basal application, followed by a topdressing of one bag of urea. This results in a rate of 31-10-0 kg/ha of N-P₂O₅-K₂O. An average paddy yield of 2 t/ha was assumed.

Scenario 3 (Medium-Input)—This was developed using the current broad recommendation of 60-30-30 kg/ha of N-P₂O₅-K₂O (or 60-13-25 kg/ha of NPK). This is applied through a basal application of 15-15-15 (200 kg/ha) with the remaining N coming via topdressing with urea. The yield assumption was based on adjusted experimental results (allowing for the well-known yield loss when moving from small to large plots). Again, experimental results have shown a range of responses to applied nutrients according to location. An average yield of 3 t/ha was assumed.

Scenario 4 (High-Input)—This was based on recent experimental work in the two provinces where a high rate is used in an attempt to achieve the government target yield of 4 t/ha. The recent trials had site-specific application rates with no replications and therefore it was necessary to develop an average treatment with a rate of NPK of 120-60-60 kg/ha, resulting in a yield of 3.75 t/ha, based on experimental results from the 2011 and 2012 wet seasons.

Other key assumptions are presented in Table 10.4, including the values used for sensitivity analysis. Sensitivity analysis was conducted on the

Table 10.4 Assumptions for budget scenarios

<i>Parameter</i>	<i>Base assumption</i>	<i>Sensitivity analysis</i>
Farm-gate price (LAK/kg)	2000	1200 and 3300
Fertiliser price (LAK/bag)		
16-20-0	230,000	250,000
46-0-0	220,000	250,000
15-15-15	250,000	300,000
Wage rate (LAK/day)	30,000	40,000

USD 1 = LAK 8000

farm-gate price of paddy based on the high 2010 price and the 2012 price in Champasak which was extremely low. The farmer focus group also considered this to be the lowest price that traders would offer before not coming to purchase rice at all. Threshold analysis was conducted on the farm-gate price of paddy to achieve various criteria. The labour required for each scenario was only varied for harvesting, threshing, and hauling, which are related to crop yield. The variation in labour for fertiliser application is minor and typically occurs during other operations.

Enterprise Budgets for the Four Scenarios

All four scenarios confirm the low profitability of rice farming in the rain-fed lowlands of Laos, and the challenge facing farmers and government alike if they are to intensify the production system (Table 10.5). The gross return (GR) was calculated as the total market value of production, regardless of how much was sold. The total variable cost (VC) included all physical inputs and labour (but not land), with imputed market values used for non-cash costs. The net return (NR) was the GR minus VC, with all

Table 10.5 Economic analysis of fertiliser-input scenarios for a hectare of WS rice

	<i>No-Input</i>	<i>Low-Input</i>	<i>Medium-Input</i>	<i>High-Input</i>
Fertiliser (kg/ha, N-P ₂ O ₅ -K ₂ O)	0-0-0	31-10-0	60-30-30	120-60-60
Average yield (t/ha)	1.5	2.0	3.0	3.75
Gross returns (GR) (LAK/ha)	3,000,000	4,000,000	6,000,000	7,504,000
Variable cost (VC) (LAK/ha)	3,272,000	3,944,000	5,024,000	6,632,000
NR (LAK/ha)	-272,000	56,000	976,000	872,000
NRHR (USD/ha)	2,352,000	2,848,000	4,096,000	4,232,000
NRHL (LAK/day)	26,857	30,645	39,365	37,710
Marginal NR (USD/ha)		336,000	912,000	-112,000
Marginal rate of return (MRR)		50%	84%	D
Price of paddy rice (LAK/kg) needed for ...				
NR > 0	2206	1967	1658	1757
NRHL = LAK 50,000/day	3517	2994	2388	2387
MNR > 0		1295	1121	2152
MRR > 50%		1995	1755	3316
MRR > 100%		2733	2328	4543

Note: Labour cost = LAK 30,000/day; paddy price (P_r) = LAK 2,000/kg; USD 1 = LAK 8,000; D = dominated scenario

labour (household and hired) costed at the assumed value of LAK 30,000/day (USD 3.75).

For the No-Input scenario, the NR was negative. However, there was a positive result for the net return to household resources (NRHR), which does not involve deducting household labour costs. When NRHR was calculated as a ratio to the household labour input, the net return to household labour (NRHL) was below the wage rate of LAK 30,000/day. That is, while there were positive returns to household-owned resources (land, labour, and durable capital), these were not sufficient to provide a return greater than the opportunity cost of household labour.

The Low-Input scenario produced a positive NR and hence an NRHL slightly above the opportunity wage. Thus there was a positive marginal net return (MNR) to moving from the No-Input to the Low-Input scenario, with a marginal rate of return (MRR) of 50% on incremental investment (including household labour).

The Medium-Input scenario provided a further increase in NR and an NRHL above the opportunity wage by LAK 9000 (over USD 1). Moving from the Low- to the Medium-Input scenario provided an MRR of 84%. Thus many farmers who currently practise a Low-Input system could benefit economically from adopting the broad recommendations of the Medium-Input system, with about double the fertiliser rate and a 50% yield increase.

However, a further movement to the High-Input scenario saw the NR to land and labour both fall, although the NRHL remained just above LAK 30,000/day. Hence the MRR to this degree of intensification was negative and the scenario was deemed to be dominated (D).

Threshold and Sensitivity Analysis

Threshold analysis was conducted on the farm-gate price of paddy rice (P_r) to determine at what price (a) the NR would become positive, (b) the NRHL would be 50,000 kip/day, and (c) the MRR for moving to the next scenario would be positive, 50%, or 100%. The results, shown in the last lines of Table 10.5, indicate that, if the paddy price decreased to below LAK 1967/kg, the NR for a Low-Input system will become negative, but as long as the price is above LAK 1295/kg there is still some gain relative to applying no fertiliser at all. The threshold prices for realising positive returns to the Medium- and High-Input scenarios were in the achievable range, but the price would have to be very high indeed (>LAK 4500/kg)

for the move from Medium-Input to High-Input to offer an acceptable rate of return of 100%.

In 2010 the price of fertilisers varied between locations, particularly for compound fertiliser such as 16-20-0 and 15-15-15 in more remote areas. By 2012, the price of urea had also increased across the two provinces. Furthermore, fuel prices had increased and wage rates continued to rise, adding to farmers' cash outlays. The impact of higher costs on the economic indicators is summarised in Table 10.6. The increase in input prices reduces the NR such that all scenarios produce a negative result. Increased fertiliser and fuel costs reduce the NRHL so that the Medium- and High-Input scenarios are barely above the previous opportunity wage (LAK 30,000), but are now below the new, higher opportunity wage. A move from No-Input to Low-Input still somewhat improves the NRHR, but only achieves an MRR of 30%. Similarly, a further increase to the Medium-Input scenario improves the NRHR, but again falls short of an acceptable MRR.

The incentives for intensification worsened in 2011 and 2012 when the farm-gate price fell to as low as LAK 1200/kg. At this price the NRHL would be less than half the initially assumed opportunity wage rate of LAK 30,000/day (Table 10.7). On the other hand, during the price spike in 2010 when farm-gate prices reached LAK 3300/kg in some regions, the returns to labour from intensification strategies looked much more promising. However, farmers in group interviews did not have high expecta-

Table 10.6 Sensitivity analysis of fertiliser costs and wage rates

	<i>No-Input</i>	<i>Low-Input</i>	<i>Medium-Input</i>	<i>High-Input</i>
Fertiliser (kg/ha of N-P ₂ O ₅ -K ₂ O)	0-0-0	31-10-0	60-30-30	120-60-60
Variable cost (LAK/ha)	4,184,000	4,952,000	6,336,000	8,264,000
NR (LAK/ha)	-1,184,000	-952,000	-336,000	-768,000
NRHR (LAK/ha)	2,320,000	2,768,000	3,824,000	3,728,000
NRHL (LAK/day)	26,514	29,785	36,779	33,185
MRR		30%	44%	D
Price of paddy rice (LAK/kg) needed for ...				
NR > 0	2884	2525	2118	2215
NRHL = LAK 50,000/day	3539	3039	2482	2530
MRR > 50%		2335	2153	4011
MRR > 100%		3200	2856	5496

Note: Labour cost = LAK 40,000/day; paddy price (P_r) = LAK 2,000/kg; USD 1 = LAK 8,000; D = dominated scenario

Table 10.7 Sensitivity analysis for low and high paddy prices

	<i>No-Input</i>	<i>Low-Input</i>	<i>Medium-Input</i>	<i>High-Input</i>
Farm-gate price of paddy of LAK 1200/kg				
NR (USD/ha)	-2,248,000	-2,400,000	-2,616,000	-3,616,000
NRHR (USD/ha)	1,256,000	1,320,000	1,544,000	872,000
NRHL (LAK/day)	14,309	14,215	14,856	7,795
Farm-gate price of paddy of LAK 3300/kg				
NR (USD/ha)	552,000	1,400,000	3,368,000	3,864,000
NRHR (USD/ha)	4,056,000	5,120,000	7,528,000	8,360,000
NRHL (LAK/day)	46,349	55,086	72,404	74,443

Note: Labour cost LAK 40,000/day; input prices based on Table 10.6; USD 1 = LAK 8000

tions that prices would again be at this level in the coming season and hoped for a return to prices around LAK 2000/kg.

Optimal Farmer Strategies

Given these results, what strategy should a farm-household adopt? A move from the No-Input to Low-Input system improves the net return to land and labour; however, the NR would remain negative under 2012 conditions. Furthermore, the MRR of the change is only 50%, falling to 30% if the higher costs are assumed. Previous studies (CIMMYT 1988) have suggested an MRR of at least 100% is required before adoption is likely, although 50% may be sufficient for relatively small system changes. Assuming household self-sufficiency is an important objective, the small amount of fertiliser involved in moving to the Low-Input system may raise some households with small areas of paddy above their subsistence requirement, with returns to labour and capital treated as less important. For example, an average No-Input household with 1.2 ha could move from being 75% self-sufficient, with an output of 1800 kg, to 100% self-sufficient, with an output of 2400 kg, by adopting the Low-Input package (Fig. 10.2).

Under the 2010 price conditions, a move from the Low-Input system to the Medium-Input system provides a positive NR per hectare and an NRHL above the wage rate. This move provides an MRR of 84% (or a 71% return if moving directly from the No-Input to the Medium-Input system). The threshold analysis on paddy price suggests that this scenario is likely to provide positive NR and MNR for most price scenarios, and a

small increase in the price would deliver an MRR greater than the CIMMYT (1988) rule-of-thumb. This outcome holds even allowing for an increased price of fertilisers. However, the increase in the cost of labour to LAK 40,000/day pushes this scenario into negative NR unless the paddy price is above LAK 2118/kg.

It is very unlikely that a household would adopt the High-Input scenario, given that returns to both land and labour decline compared to the Medium-Input case. Nevertheless, a land-scarce household may be forced to adopt this strategy if achieving household self-sufficiency remains the dominant objective, given that the returns to labour remain above the wage rate. However, households with acute land constraints are also less likely to have the capital to make the necessary investment.

Given that labour use does not increase much with increased fertiliser application, rising wage rates are not projected to impact greatly on WS fertility management decisions, though they will affect the overall economic performance of all scenarios. On the other hand, for households with access to irrigation that enables cultivation of a DS rice crop, the question of wage rates becomes more important, given that self-sufficiency may be achieved in the WS, allowing labour to move off-farm and earn relatively high returns in the DS. Several case-study farmers were making this decision and not growing a DS crop; rather they made their irrigable land available to households with smaller paddy areas who had not yet achieved self-sufficiency in the WS.

CONCLUSION

The survey evidence from Central and Southern Laos shows that farm-households in the rainfed lowlands continue to manage rice production systems that are largely subsistence-oriented. The adoption of new technologies, especially improved varieties, has been important in helping households meet self-sufficiency objectives and has enabled some to produce a small surplus. Despite this, rice production remains an economically marginal activity that is under increasing pressure from rising costs, particularly for labour. Rural livelihoods in the study area have become increasingly diversified, with households allocating labour to a range of alternative farm and non-farm activities. However, rice production continues to be the platform on which these other livelihood activities are based. The development and adoption of technologies that enable households to

achieve self-sufficiency in a labour-efficient and cost-effective manner are important to improving household welfare in this context.

The budget models show that, given their resource endowments and the high degree of production and market risk they encounter, households in the rainfed lowlands have been rational in adopting a Low-Input system rather than intensifying rice production to achieve government yield and production targets. As the costs of labour continue to increase, technologies that improve labour productivity and enable labour to move off-farm are likely to be adopted more readily than technologies that seek to intensify production. In the same way, the development and adoption of improved varieties that are well adapted to abiotic and biotic stresses and reduce risks in specific environments can potentially improve the profitability and stability of the rainfed lowland system. Moreover, improving the efficiency of fertiliser application through site-specific recommendations may be more important than increasing absolute fertiliser rates.

While the improvements in profitability that these technologies bring may induce some intensification, we argue that the strategy of diversifying livelihoods while maintaining a largely subsistence-oriented rice production system is likely to persist, given the current economic trends. While this may not help lift rice production to reach national targets, it is likely to improve the livelihood outcomes of the numerous households living in this marginal environment.

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NOTES

1. WS rice remained largely rainfed in these villages unless subsidies were given for irrigation fees during drought years.
2. Thai varieties such as RD6 were common in lowland areas of Savannakhet.

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