Chapter 2
Development of the Rice Econometric Model with Endogenous Water in Lao PDR (REMEW-LAO)

2-1. Introduction
Laos is a rice producing country in Southeast Asia where 64% of total food supply came from the staple crop in 2003. However, seasonal production is highly variable due to the low share of irrigated fields, i.e., about 10% in 2004. Laos covers 236,800 square kilometers and had a population of only 5.87 million in 2007, so the country is relatively land abundant. However, upland areas in Laos are experiencing population growth pressure and the productivity of shifting cultivation is declining. Stable water supply for wet season and upland rice cultivation is necessary for food security and farm management stabilization. The evaluation of water supply changes on rice yields and the resulting market responses from fluctuations in production are an essential theme of agricultural development in Laos. This chapter describes the supply and demand of rice in Laos, which is named Rice Econometric Model Endogenous Water in Lao (REMEW-LAO), focusing on the impacts of fluctuations of water supply on rice production.

2-2. SEDP and policies related to rice production
Following three-year socio-economic development plan from 1978 to 1980, 1st five-year socio-economic development plan (SEDP) was put into action in 1981. Under the economic plan, farmers’ incomes were reduced by the following three policies; (1) High inflation rate. The inflation rate was over 50%. The inflation led to an increase in the real exchange rate and it was hard to export agricultural products. (2) High trade protectionism. Terms of trade of agricultural products got weaker against industrial products due to the high tariff rates and import quota placed on agricultural products. (3) Low government procurement price. The government price of rice and coffee were significantly lower than the prices in the black market.

The Lao government introduced the New Economic Mechanism (NEM; Rabop Mai) on the issue in the first SEDP. The NEM was one part of the liberalization policy of culture, politics, and economy (New Thinking; Chintanakan mai) modeled after Perestroika. The main policies are as follows; (1) introduction of a self-support accounting system for national and public cooporations, (2) abolishment of the government procurement price of rice, (3) abolishment of the multiple exchange rate system, (4) liberalization of entry of private companies in production and marketing sectors, (5) streamlining of finance sector, (6) centralization of power for management of national assets and budget implementation, (7) trade liberalization except mineral products and timber.

In the agricultural sector, the government attempted to shrink the difference between the government price and the market price in 1984 and the government marketing board and distribution system of the government were abolished in 1987. Furthermore, the land tax rate was changed from a uniform rate to a variable rate depending on yields of agricultural products.

A committee consisted of Ministers and representatives of the party decided to make the transition from a strictly socialist economic system to one which includes faces of a market economy and to reform the land owner system in 1988. The reform guarantees farmers longterm use, alienation, and inheritance of land. Thus, farmers have defacto land ownership under state regulations. The independence of each farmer put an end to the favorable terms for cooperatives and state-owned farms. Participation in cooperatives became voluntary and the state-own farms were partly privatized.

The NEM reformed macro economic conditions and trade policies as follows; (1) sharp devaluation of the currency (kip) in September 1987 and abolishment of the multiple exchange rate system in July 1988, (2) moving the central bank interest closer to that of real rate, (3) abatement of printing money. These economic reforms and changes in agricultural policies increased the terms of trade by 40% from 1985 to 1989.

The 6th five-year SEDP is now in operation. The world economy is recovering and official development assistance (ODA) and foreign direct investment (FDI) are increasing. However, the high oil price had led to further hardship among the low income population. Following the situation, the SEDP set the following directions: (1) producing high value added goods, (2) increasing competitiveness and exploiting comparative advantages under the frameworks of ASEAN and WTO, (3) strengthen the linkage between economic
development and social development such as poverty reduction, (4) advancing a market economy under the socialism system.

The government also has outlined a strategic vision from 2000 to 2020. The main target is to increase per capita GDP and it will reach up to US$885 and stepping out the category of least developing country. The main targets of agricultural sector are as follows: (1) increasing the self-sufficiency rate of food and confirmation for food security, (2) export promotion of commercial agricultural products, (3) stabilizing slash-and-burn agriculture.

In the strategic vision, agricultural land is divided into the Mekong river basin advanced market economy and the sloping region with a more closed economy. In the Mekong river basin, diversification and intensification of agriculture will be advanced and high value-added products will be promoted. In the sloping region, slash-and-burn methods are to be traded for fixed agriculture systems to increase the stability of producer livelihoods, increase of productivity, improve the socio-economic conditions, and protection of natural resources will be accomplished.

Organizations related to irrigation are important for this study. There are two types organizations. The Water Use Association (WUA) is a formal farmers' association, and it manages irrigation plans and maintains irrigation facilities. Furthermore, the association purchases materials, provides finance, and works in marketing. Public assets such as pump, head works, canals, and constructions were devolved from the government.

The Water Use Group (WUG) is organized in locations where irrigation project supported by the Department of Irrigation (DOI) and Provincial Agriculture and Forestry Service (PAFS) exists. Irrigation facilities are maintained and managed by farmers' group while facility ownership is maintained by the government.

Distribution of rice and meats was restricted before 2002 and prices were controlled by the government. Previously, certificates issued by the local government were necessary for movements of these products. Now, there are no restrictions of the distributions.

Crop selection had been restricted and farmers had to follow instructions of the provincial government such as requiring farmers to cultivate rice in irrigated fields. The restriction on crop selection was also abolished in 2002.

2-3. Model

A supply and demand model for rice which includes a water supply variable affecting regional yields is developed. Planted area, yield, and production for each province, areas of province close to a small river basin, can be analyzed with the model.

The supply and demand model for rice in Laos consists of yield functions, planted area functions, production identities, supply identities, a consumption function, an import function, and a price linkage function. The yield and area functions for wet season are estimated for all provinces and monthly evapotranspiration (ET) is used as an explanatory variable which is a proxy for available water supplies. The generalized forms of these functions are as follows:

Yield function of wet season rice:
\[ YL' = f_{ri} (T, ET_{May}', \ldots, ET_{Nov}'), \] (2-1)

Area function of wet season rice:
\[ AL' = f_{Al} (AL_{i}, FP_{i}, ET_{May}'(i), \ldots, ET_{Nov}'(i)), \] (2-2)

Production of wet season rice:
\[ QL' = YL'AL', QL = \Sigma YL'AL' \] (2-3)

Yield function of dry season rice:
\[ YI' = f_{ri} (T, ET_{Nov}'), \] (2-4)

Area function of dry season rice:
\[ AI' = f_{Al} (AI_{i}, FP_{i}, ET_{Nov}'(i), \ldots, ET_{May}'(i)), \] (2-5)

Production of dry season rice:
\[ QI' = YI'AI', QI = \Sigma YI'AI' \] (2-6)

Yield function of upland rice:
\[ YU' = f_{ri} (T, ET_{May}'), \] (2-7)

Area function of upland rice:
\[ AU' = f_{Al} (AU_{i}, FP_{i}, ET_{May}'(i), \ldots, ET_{Nov}'(i)), \] (2-8)

Production of upland rice:
\[ QU' = YU'AU', QU = \Sigma YU'AU' \] (2-9)

Total production:
\[ Q = QL + QI + QU \] (2-10)

Total supply:
\[ QS = Q + IMP - STC \] (2-11)

Demand function:
\[ QS/POP = f_{S} (RP, GDP/POP) \] (2-12)

Imports function:
\[ IMP = f_{mp} (WP \cdot EXR, Q) \] (2-13)

Price linkage function:
\[ FP = f_{p} (RP) \] (2-14)

where T is time trend, ET-May through ET-Nov are evapotranspiration values for May through November, YL, AL, and QL are yield, planted area, and production of wet season rice, i is the number of provinces, YI, AI, and QI are yield, planted area, and production of dry season rice, YU, AU, and QU are yield, planted area, and production of upland rice, Q is total production, IMP is imports, STC is the annual change in stocks, POP is population, GDP is gross domestic products, WP is the world price of rice (Thailand, 5% broken, FOB), EXR is the exchange rate, FP is the producer price of rice, and RP is the retail price of rice. All are specified as linear functions.
Chapter 2
Development of the Rice Econometric Model with Endogenous Water in Lao PDR (REMEW-LAO)

Figure 2-1. Flowchart of wet season rice production sector

Figure 2-2. Flowchart of supply and demand sector

Figure 2-1 and Figure 2-2 represent models for the wet season rice production sector and the overall supply and demand sector respectively. The model structures for irrigated and upland rice production sectors are same as those of the wet season rice production sector.

2-4. Data

The time series data for production and planted area for each province was provided by the Department of Planning in the Ministry of Agriculture and Forestry of Laos. The farm price for rice was obtained from FAO-STAT and the retail price of rice was obtained from the National Statistics Center of the Committee for Planning and Cooperation of Laos. The prices used represent a national average price for Laos. CPI, GDP, and population are from the Asian Development Bank and the exchange rate and the world price of rice are data from the IMF. The estimation period for functions (1) through (14) is from 1980 to 2000 which starts in the earliest available year for CPI and ends in the last year of available ET values. The estimation period includes the turning point of the Laotian economy because the trend of rice production in the statistics showed that the shock of the economic liberalization on the rice
production was small.

The historical ET values are calculated by Ishigooka et al., 2005 and the calculation method is based on the Penman-Monteith equation (Allen et al., 1998). The climatic data for the calculation are 0.5 degree grid data and these are averaged for each province.

2-5. Estimation results of all functions

There are 17 provinces in Laos, and yield and planted area functions of wet season rice are estimated for all provinces.

Irrigated area is a small share of the total rice area in Laos, therefore, yield and area functions are estimated for only two provinces, Vientiane municipality and Savannakhet province. Yield and area of the other provinces are averaged and aggregated to the north region, central region excluding the two provinces, and south region.

These functions of upland rice are estimated for 15 provinces. There are no data of upland rice for Vientiane municipality and Champasak province.

The estimated method is ordinary least square method (OLS) and time trends and some dummy variables are used for extreme climate or economic events.

2-5-1. Yield functions

2-5-1-1. Yield function of wet season rice (lowland rice)

2-5-1-1-1. Yield Function of Lowland Rice in Vientiane Mun.

\[ YLH01 = + 1.41350 + 0.15216 \times \text{TREND} - 0.09906 \times \text{T90} + 0.76697 \times \text{ET01MAY} - 1.67357 \times \text{ET01OCT} + 0.94395 \times \text{ET01NOV} \]

\[ \text{AdjR}^2 = 0.9504 \quad \text{D.W.} = 1.728 \]

2-5-1-1-2. Yield Function of Lowland Rice in Luangnamtha

\[ YLH02 = + 5.66198 + 0.21550 \times \text{TREND} - 0.22559 \times \text{T90} - 0.70205 \times \text{ET03MAR} + 0.33729 \times \text{ET03APR} - 1.22712 \times \text{D91} \]

\[ \text{AdjR}^2 = 0.9276 \quad \text{D.W.} = 2.366 \]

2-5-1-1-3. Yield Function of Lowland Rice in Phongsaly

\[ YLH03 = + 2.38594 + 0.14034 \times \text{TREND} - 0.11489 \times \text{T93} + 0.28520 \times \text{ET02MAY} + 0.66032 \times \text{ET02JUN} - 0.55528 \times \text{ET02JLY} - 0.66466 \times \text{ET02OCT} + 0.43447 \times \text{D845} - 0.92268 \times \text{D93} - 0.70954 \times \text{D956} \]

\[ \text{AdjR}^2 = 0.9876 \quad \text{D.W.} = 2.505 \]
2-5-1-1-4. Yield Function of Lowland Rice in Oudomxay

\[ YLH04 = -7.63351 + 0.22887 \times \text{TREND} - 0.24624 \times T90 - 0.38784 \times \text{ET04AUG} + 1.33188 \times \text{ET04SEP} - 0.46867 \times D924 \]

\[ \text{AdjR}^2 = 0.9375 \]

2-5-1-1-5. Yield Function of Lowland Rice in Bokea

\[ YLH05 = +0.11707 + 0.73508 \times \text{ET05MAY} - 1.52907 \times \text{ET05JUN} + 2.80079 \times \text{ET05JL} + 1.41703 \times \text{ET05AUG} - 0.87729 \times D924 \]

\[ \text{AdjR}^2 = 1.822 \]

2-5-1-1-6. Yield Function of Lowland Rice in Luangprabang

\[ YLH06 = -6.55499 + 0.24501 \times \text{TREND} - 0.20084 \times T86 \]

\[ \text{AdjR}^2 = 0.8762 \]

2-5-1-1-7. Yield Function of Lowland Rice in Huaphanh

\[ YLH07 = +9.51059 + 0.61266 \times \text{TREND} - 0.55814 \times \text{T84} + 0.79665 \times \text{ET07MAY} - 2.83517 \times \text{ET07JLY} + 1.41746 \times \text{ET07MAR} + 0.474911 \times \text{ET07NOV} \]

\[ \text{AdjR}^2 = 0.9226 \]

2-5-1-1-8. Yield Function of Lowland Rice in Xayabury

\[ YLH08 = -31.07729 - 0.41746 \times \text{ET08MAR} + 1.23084 \times \text{ET08JUN} + 2.00308 \times \text{ET08SEP} + 4.74911 \times \text{ET08NOV} \]

\[ \text{AdjR}^2 = 0.8762 \]

2-5-1-1-9. Yield Function of Lowland Rice in Xiengkhuang
YLH09=  
 4.37166
(1.16)  
+ 0.38932*TREND
(7.41)  
- 0.33745*T84
(-6.09)  
+ 1.22831*ET09MAR
(4.86)  
- 1.94472*ET09JUN
(-6.09)  
+ 1.32462*ET09SEP
(2.13)  
- 1.42360*ET09OCT
(-2.83)  
NYLH09=  
TREND  
T84  
ET09MAR  
ET09JUN  
ET09SEP  
ET09OCT  
AdjR^2=0.9121  
D.W.=-2.473

2-5-1-1-10. Yield Function of Lowland Rice in Vientiane

YLH10=  
0.12911
(0.03)  
+ 0.43839*TREND
(8.24)  
- 0.38372*T84
(-2.68)  
+ 1.48876*ET10MAY
(5.80)  
- 2.21065*ET10JUN
(-4.56)  
+ 2.08830*ET10SEP
(3.41)  
- 1.19108*ET10OCT
(-2.28)  
- 0.53829*SHIFT00
(-2.99)  
AdjR^2=0.9205  
D.W.=-1.824

2-5-1-1-11. Yield Function of Lowland Rice in Borikhamxay

YLH11=  
-4.10774
(-1.64)  
+ 0.49191*TREND
(2.46)  
- 0.40897*T82
(-2.02)  
- 0.29632*ET11MAR
(-2.68)  
+ 0.39164*ET11APR
(4.58)  
- 1.43455*ET11JUN
(-2.68)  
+ 1.24675*ET11LY
(2.01)  
+ 1.10256*ET11OCT
(3.08)  
- 0.50009*D93
(-3.29)  
AdjR^2=0.9394  
D.W.=-1.862

2-5-1-1-12. Yield Function of Lowland Rice in Khammuane

YLH12=  
14.51833
(3.66)  
+ 0.50015*TREND
(6.09)  
- 0.45942*T84
(-5.32)  
- 0.40583*ET12MAR
(-2.81)  
+ 1.02754*ET12MAY
(5.45)  
- 2.37920*ET12JUN
(-4.47)  
- 1.41696*ET12OCT
(-2.19)  
- 1.51262*D88
(-5.99)  
- 0.79501*D93
(-3.76)  
AdjR^2=0.8804  
D.W.=-2.593

2-5-1-1-13. Yield Function of Lowland Rice in Savannakhet
Chapter 2
Development of the Rice Econometric Model with Endogenous Water in Lao PDR (REMEW-LAO)

$$Y_{LH13} = 4.27109 + 0.35008 \times \text{TREND}$$
$$- 0.30109 \times T84$$
$$+ 0.76054 \times ET13MAY$$
$$- 1.45541 \times ET13JLY$$
$$- 1.71606 \times DB88$$
$$- 0.46290 \times D93$$
$$\text{AdjR}^2 = 0.9437$$

$$D.W. = 2.052$$

2-5-1-1-14. Yield Function of Lowland Rice in Saravane

$$Y_{LH14} = 18.84528 + 0.51017 \times \text{TREND}$$
$$- 0.47213 \times T84$$
$$- 2.90249 \times ET14JLY$$
$$- 1.13524 \times ET14SEP$$
$$- 1.10894 \times DB88$$
$$\text{AdjR}^2 = 0.8636$$

$$D.W. = 1.495$$

2-5-1-1-15. Yield Function of Lowland Rice in Sekong

$$Y_{LH15} = -6.57882 + 0.39730 \times T9294$$
$$+ 0.40307 \times ET15MAR$$
$$+ 1.41744 \times ET15JUN$$
$$- 1.28748 \times ET15JLY$$
$$\text{AdjR}^2 = 0.9199$$

$$D.W. = 2.768$$

2-5-1-1-16. Yield Function of Lowland Rice in Champasack

$$Y_{LH16} = -7.46465 + 0.58777 \times DB846$$
$$+ 0.71947 \times SHIFT00$$
$$\text{AdjR}^2 = 0.958$$

$$D.W. = 2.585$$

2-5-1-1-17. Yield Function of Lowland Rice in Attapeu

$$Y_{LH17} = -3.21988$$
2-5-1-2. Yield Function of Irrigated Rice in Savannakhet

\[
YIH13 = -0.95591 + 0.14845 \times T82 - 0.67468 \times E13DEC(t-1) - 0.85887 \times D81 - 0.62802 \times D857
\]

AdjR^2 = 0.9276  \quad \text{D.W.} = 1.894

YIH13: Yield of Irrigated Rice in Savannakhet

T82: Time Trend from 1982 to 2000, 0 otherwise

E13DEC: Evapotranspiration of December in Savannakhet

D81: Dummy Variable, 1 in 1981, 0 otherwise

D857: Dummy Variable, 1 in 1985 to 1987, 0 otherwise

2-5-1-2-3. Yield Function of Irrigated Rice in North Region

\[
YIH = 7.66036 + 0.10050 \times TREND - 2.34302 \times ENOVC(t-1) - 0.72572 \times ENDEC(t-1) - 0.32143 \times ECTAPR
\]

AdjR^2 = 0.9276  \quad \text{D.W.} = 2.541

YIH: Yield of Irrigated Rice in North Region

TREND: Time Trend from 1980 to 2000

ENOVC: Evapotranspiration of November in North Region

ENDEC: Evapotranspiration of December in North Region

ECTAPR: Dummy Variable, 1 in 1998, 0 otherwise

2-5-1-2-4a. Yield Function of Irrigated Rice in Central Region (including 01 and 13)

\[
YIH = -10.94278 + 0.13108 \times TREND + 2.78103 \times E1CNOV(t-1) - 0.72572 \times ETCDEC(t-1) - 0.32143 \times ETCAPR
\]

AdjR^2 = 0.9276  \quad \text{D.W.} = 2.414

YIH: Yield of Irrigated Rice in Central Region

TREND: Time Trend from 1980 to 2000

E1CNOV: Evapotranspiration of November in Central Region

ETCDEC: Evapotranspiration of December in Central Region

ETCAPR: Dummy Variable, 1 in 1998, 0 otherwise
Chapter 2
Development of the Rice Econometric Model with Endogenous Water in Lao PDR (REMEW-LAO)

2-5-1-2-4b. Yield Function of Irrigated Rice in Other Central Region (Excluding 01 and 13)

\[
\begin{align*}
\text{YIHC} &= -37.82907 + 0.56928 \cdot \text{TREND} + 9.56978 \cdot \text{ETCNOV}(t-1) - 7.87553 \cdot \text{ETCDEC}(t-1) + 3.92656 \cdot \text{ETOCJAN} \\
&\quad - 0.96686 \cdot \text{ETSAPR} - 0.92542 \cdot \text{ETSMAY} - 1.49482 \cdot \text{ETSJUN} - 0.62043 \cdot \text{D801} \\
&\quad + 0.97119 \cdot \text{D97} \\
\text{AdjR}^2 &= 0.9647 \\
\text{D.W.} &= 2.510
\end{align*}
\]

YIHC Yield of Irrigated Rice in Other Central Region
TREND Time Trend from 1980 to 2000
ETCNOV Evapotranspiration of November in Other Central Region
ETCDEC Evapotranspiration of December in Other Central Region
ETCJAN Evapotranspiration of January in Other Central Region
ETSMAY Evapotranspiration of May in Other Central Region
D801 Dummy Variable, 1 in 1980 to 1981, 0 otherwise
D97 Dummy Variable, 1 in 1997, 0 otherwise

2-5-1-3. Yield function of upland rice

2-5-1-3-1. Yield Function of Upland Rice in Phongsaly

\[
\begin{align*}
\text{YUH02} &= +2.97859 + 0.03296 \cdot \text{TREND} + 0.89710 \cdot \text{ET02APR} \\
&\quad - 0.62043 \cdot \text{D89} \\
\text{AdjR}^2 &= 0.8681 \\
\text{D.W.} &= 2.382
\end{align*}
\]

YUH02 Yield of Upland Rice in Phongsaly
TREND Time Trend from 1980 to 2000
ET02APR Evapotranspiration of April in Phongsaly
ET02JUN Evapotranspiration of June in Phongsaly
D89 Dummy Variable, 1 in 1989, 0 otherwise

2-5-1-3-2. Yield Function of Upland Rice in Luangnamtha

\[
\begin{align*}
\text{YUH03} &= +5.78085 + 0.03275 \cdot \text{TREND} - 0.46538 \cdot \text{ET03JUN} \\
&\quad - 0.50637 \cdot \text{D93} \\
\text{AdjR}^2 &= 0.8681 \\
\text{D.W.} &= 2.382
\end{align*}
\]

YUH03 Yield of Upland Rice in Luangnamtha
TREND Time Trend from 1980 to 2000
ET03JUN Evapotranspiration of June in Luangnamtha
D93 Dummy Variable, 1 in 1993, 0 otherwise
YUH03 Yield of Upland Rice in Luangnamtha

<table>
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AdjR^2 = 0.9299

D.W. = 1.902

YUH04 Yield of Upland Rice in Oudomxay

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AdjR^2 = 0.9064

D.W. = 2.270

YUH05 Yield of Upland Rice in Bokea

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AdjR^2 = 0.8474

D.W. = 2.422

YUH06 Yield of Upland Rice in Luangprabang

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<tr>
<td>D98</td>
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</table>

AdjR^2 = 0.8474

D.W. = 2.422

YUH07 Yield of Upland Rice in Huaphanh

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<th>Term</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-Value</th>
<th>p-value</th>
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<tr>
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</tbody>
</table>

AdjR^2 = 0.8474

D.W. = 2.422
Chapter 2
Development of the Rice Econometric Model with Endogenous Water in Lao PDR (REMEW-LAO)

\[
\begin{align*}
YUH07 &= \text{Yield of Upland Rice in Huaphanh} \\
\text{TREND} &= \text{Time Trend from 1980 to 2000} \\
ET07JUN &= \text{Evapotranspiration of June in Huaphanh} \\
ET07OCT &= \text{Evapotranspiration of October in Huaphanh} \\
D803 &= \text{Dummy Variable, 1 in 1980 to 1983, 0 otherwise} \\
D94 &= \text{Dummy Variable, 1 in 1994, 0 otherwise} \\
\end{align*}
\]
\[
2-5-1-3-7. \text{Yield Function of Upland Rice in Xayabury}\]
\[
YUH08 = + 8.44733 \\
\text{(5.79)} \\
+ 0.04492 \times \text{TREND} \\
\text{(10.38)} \\
-0.98298 \times \text{ET08JUN} \\
\text{(-4.48)} \\
-0.70610 \times \text{ET08AUG} \\
\text{(-3.13)} \\
-0.31016 \times \text{D87} \\
\text{(-3.01)} \\
+ 0.49883 \times \text{D89} \\
\text{(4.87)} \\
-0.36290 \times \text{SHIFT99} \\
\text{(-4.06)} \\
\end{align*}
\]
\[
\text{AdjR}^2 = 0.8858 \\
\text{D.W.} = 2.464
\]

\[
YUH08 = -15.73220 \\
\text{(-5.65)} \\
+ 0.02125 \times \text{TREND} \\
\text{(8.44)} \\
+ 0.58315 \times \text{ET09MAR} \\
\text{(4.90)} \\
+ 1.22050 \times \text{ET09JLY} \\
\text{(4.14)} \\
-0.65885 \times \text{ET09AUG} \\
\text{(-3.64)} \\
+ 1.59956 \times \text{ET09SEP} \\
\text{(5.71)} \\
+ 0.49705 \times \text{ET09OCT} \\
\text{(2.19)} \\
+ 0.57695 \times \text{ET09NOV} \\
\text{(3.52)} \\
\end{align*}
\]
\[
\text{AdjR}^2 = 0.9394 \\
\text{D.W.} = 2.182
\]

\[
YUH09 = -1.35070 \\
\text{(-0.87)} \\
+ 0.09258 \times \text{TREND} \\
\text{(28.61)} \\
+ 0.27683 \times \text{ET10MAR} \\
\text{(2.67)} \\
\]
\[
\text{AdjR}^2 = 0.9394 \\
\text{D.W.} = 2.182
\]
YUH11 Yield of Upland Rice in Borikhamxay
TREND Time Trend from 1980 to 2000
ET11MAY Evapotranspiration of May in Borikhamxay
ET11AUG Evapotranspiration of August in Borikhamxay
ET11OCT Evapotranspiration of October in Borikhamxay
ET11NOV Evapotranspiration of November in Borikhamxay
D845 Dummy Variable, 1 in 1984 to 1985, 0 otherwise
D93 Dummy Variable, 1 in 1993, 0 otherwise
D95 Dummy Variable, 1 in 1995, 0 otherwise

2-5-1-3-11. Yield Function of Upland Rice in Khammuane
YUH12= + 1.37801
(1.03) + 0.01286*TREND
(4.59) + 0.20949*ET12MAR
(5.23) + 0.57628*ET12JLY
(3.64) + 0.49061*ET12AUG
(3.00) - 1.15021*ET12OCT
(-5.65) - 0.28656*D812
(-5.14) - 0.34834*D83
(-4.53) + 0.34027*D87
(4.50)

AdjR^2=0.9779 D.W.=1.827

YUH13 Yield of Upland Rice in Savannakhet
TREND Time Trend from 1980 to 2000
ET13APR Evapotranspiration of April in Savannakhet
ET13MAY Evapotranspiration of May in Savannakhet
ET13AUG Evapotranspiration of August in Savannakhet
ET13SEP Evapotranspiration of September in Savannakhet
ET13OCT Evapotranspiration of October in Savannakhet
D90 Dummy Variable, 1 in 1990, 0 otherwise
D99 Dummy Variable, 1 in 1999, 0 otherwise

2-5-1-3-13. Yield Function of Upland Rice in Saravane
YUH14= + 2.59027
(1.11) + 0.02284*TREND
(3.41) - 1.56756*ET14JUN
(-3.57) + 1.28597*ET14JLY
(2.27) - 0.32862*D812
(-2.72) - 0.77331*D88
(-5.08) - 1.16783*D98
(-7.68)

AdjR^2=0.8382 D.W.=1.679

YUH15 Yield of Upland Rice in Sekong
TREND Time Trend from 1980 to 2000
ET15AUG Evapotranspiration of September in Sekong
D812 Dummy Variable, 1 in 1981 to 1982, 0 otherwise
D88 Dummy Variable, 1 in 1988, 0 otherwise
D98 Dummy Variable, 1 in 1998, 0 otherwise

2-5-1-3-14. Yield Function of Upland Rice in Sekong
YUH15= + 5.54098
(2.75) + 0.04253*TREND


Chapter 2

Development of the Rice Econometric Model with Endogenous Water in Lao PDR (REMEW-LAO)

(7.08)
-0.31172*ET15MAR
(-3.22) [-0.416]
-0.97624*ET15JUN
(-2.90) [-1.520]
+0.89644*ET15JLY
(2.56) [1.399]
-0.70735*ET15AUG
(-2.34) [-1.109]
+0.19795*D847
(3.30) [1.399]
-0.69819*D88
(-6.83) [-1.109]
+0.25297*D934
(3.43) [1.399]

D.W. = 2.403

YUH15 Yield of Upland Rice in Sekong
TREND Time Trend from 1980 to 2000
ET15MAR Evapotranspiration of March in Sekong
ET15JUN Evapotranspiration of June in Sekong
ET15JLY Evapotranspiration of July in Sekong
ET15AUG Evapotranspiration of August in Sekong
D847 Dummy Variable, 1 in 1984 to 1987, 0 otherwise
D88 Dummy Variable, 1 in 1988, 0 otherwise
D934 Dummy Variable, 1 in 1993 to 1994, 0 otherwise

2-5-1-3-15. Yield Function of Upland Rice in Attapeu

YUH17 = -5.55920
(-2.63)
+0.03612*TREND
(8.74)
-0.32121*ET15MAR
(-2.99) [-0.410]
-0.93452*ET15JUN
(-3.21) [-1.480]
+1.05715*ET15JLY
(2.91) [1.673]
+0.90497*ET17SEP
(4.19) [1.415]
+0.67149*ET17OCT
(2.92) [1.067]
-0.26188*D873
(-6.52) [-0.53853*D98
(-5.86)

AdjR²=0.8782 D.W.=2.178

YUH17 Yield of Upland Rice in Attapeu
TREND Time Trend from 1980 to 2000
ET17MAR Evapotranspiration of March in Attapeu
ET17JUN Evapotranspiration of June in Attapeu
ET17JLY Evapotranspiration of July in Attapeu
ET17SEP Evapotranspiration of September in Attapeu
ET17OCT Evapotranspiration of October in Attapeu
D873 Dummy Variable, 1 in 1987 to 1993, 0 otherwise
D89 Dummy Variable, 1 in 1989, 0 otherwise
D98 Dummy Variable, 1 in 1998, 0 otherwise

2-5-2. Planted area functions

2-5-2-1. Area function of wet season rice (lowland rice)

2-5-2-1-1. Area Function of Lowland Rice in Vientiane Municipality

APLO1 = -48.09605
(9.43)
+0.07999*APLO1(t-1)
(0.98)
+7.66162*[FPR(t-1)/CPI(t-1)/100]
(2.01) [0.048]
+0.10197*T87
(8.67)
-0.12314*ET01JUN(t-1)
(-2.55) [-0.263]
-0.09390*ET01AUG(t-1)
(-2.32) [-0.189]
-18.76004*D95
(-11.55)

AdjR²=0.9303 D.W.=2.179

APLO1 Planted Area of Lowland Rice in Vientiane Mun.
FPR Farm Price of Laos Rice (thousand kip per kg)
CPI Consumer Price Index (1995=100)
T87 Time Trend from 1987 to 2000, 0 otherwise
ET01JUN Evapotranspiration of June in Vientiane Mun.
ET01AUG Evapotranspiration of August in Vientiane Mun.
D95 Dummy Variable, 1 in 1995, 0 otherwise

2-5-2-1-2. Area Function of Lowland Rice in Phongsaly

APLO2 = -0.92726
(-1.25)
+0.10490*APLO2(t-1)
(1.79)
+1.46287*[FPR(t-1)/CPI(t-1)/100]
(2.82) [0.074]
+0.07483*T83
(6.69)
-0.01077*ET02APR(t-1)
(-5.47) [-0.129]
+0.01071*ET02MAY(t-1)
(4.82) [0.206]
+0.01852*ET02SEP(t-1)
(3.54) [0.334]
+0.01779*ET02OCT(t-1)
(4.41) [0.297]
+0.01335*ET02NOV(t-1)
(2.39) [0.181]

AdjR²=0.9546 D.W.=2.438

APLO2 Planted Area of Lowland Rice in Phongsaly
FPR Farm Price of Laos Rice (thousand kip per kg)
CPI Consumer Price Index (1995=100)
2-5-2-1-3. Area Function of Lowland Rice in Luangnamtha

\[ APL03_3 = 12.29642 + 0.58906 \times APL03(t-1) + 0.03624 \times [FPR(t-1) \times CPI(t-1)/100] - 0.03092 \times D845 - 0.05309 \times ET03MAR(t-1) - 0.04042 \times ET03MAY(t-1) - 0.05092 \times ET03JUN(t-1) + 3.06307 \times D83 - 1.91123 \times D912 \]

\[ \text{Adj}R^2 = 0.9105 \quad D.W. = 2.151 \]

2-5-2-1-4. Area Function of Lowland Rice in Oudomxay

\[ APL04 = 6.86317 + 0.14939 \times APL04(t-1) + 3.40601 \times [FPR(t-1) \times CPI(t-1)/100] - 0.38599 \times T8083 + 0.32116 \times T92 + 0.02644 \times ET04APR(t-1) + 4.27495 \times D86 - 3.05029 \times D92 \]

\[ \text{Adj}R^2 = 0.9951 \quad D.W. = 2.591 \]

2-5-2-1-5. Area Function of Lowland Rice in Bokeo

\[ APL05 = -1.28032 + 0.04186 \times APL05(t-1) + 3.13786 \times [FPR(t-1) \times CPI(t-1)/100] - 0.38599 \times T8083 + 0.33410 \times T8492 + 0.66956 \times T93 + 0.01554 \times ET05MAY(t-1) + 4.27495 \times D86 - 3.05029 \times D92 \]

\[ \text{Adj}R^2 = 0.9951 \quad D.W. = 2.591 \]

2-5-2-1-6. Area Function of Lowland Rice in Luangprabang

\[ APL06 = 5.97910 + 0.02512 \times APL06(t-1) + 0.79977 \times [FPR(t-1) \times CPI(t-1)/100] - 0.01411 \times ET04MAR(t-1) + 0.00577 \times ET04APR(t-1) + 4.27495 \times D86 - 3.05029 \times D92 \]

\[ \text{Adj}R^2 = 0.9337 \quad D.W. = 2.431 \]
Chapter 2
Development of the Rice Econometric Model with Endogenous Water in Lao PDR (REMEW-LAO)

2-5-2-1-7. Area Function of Lowland Rice in Huaphanh

\[
\text{APL07} = 4.39814 + 0.03812 \times \text{APL07}(t-1) + 0.035263 \times \left[\frac{\text{FPR}(t-1)}{\text{CPI}(t-1)/100}\right] - 0.86662 \times \text{T8083} + 0.56311 \times \text{T93} - 0.03679 \times \text{T8083}(t-1) + 0.04708 \times \text{T8083}(t-1) + 0.03810 \times \text{T8083}(t-1) - 1.29900 \times \text{D84} + 1.09874 \times \text{D97}
\]

\[
\text{Adj}R^2 = 0.9629 \quad \text{D.W.} = 1.926
\]

2-5-2-1-8. Area Function of Lowland Rice in Xayabury

\[
\text{APL08} = 31.23140 + 0.64936 \times \text{APL08}(t-1) + 9.70013 \times \left[\frac{\text{FPR}(t-1)}{\text{CPI}(t-1)/100}\right] - 0.13111 \times \text{T8083}(t-1)
\]

\[
\text{Adj}R^2 = 0.9629 \quad \text{D.W.} = 2.325
\]

2-5-2-1-9. Area Function of Lowland Rice in Xiengkhuang

\[
\text{APL09} = 13.86744 + 0.07501 \times \text{APL09}(t-1) + 9.59941 \times \left[\frac{\text{FPR}(t-1)}{\text{CPI}(t-1)/100}\right] - 0.37718 \times \text{T8083} - 0.44761 \times \text{T93} - 0.03997 \times \text{T8083}(t-1) + 3.10659 \times \text{D86}
\]

\[
\text{Adj}R^2 = 0.7559 \quad \text{D.W.} = 2.416
\]
\[
\begin{align*}
\text{APL10} & = 5.98894 + 0.21849 \times \text{APL10(t-1)} + 7.77065 \times \frac{\text{FPR(t-1)}}{\text{CPI(t-1)}} + 2.33176 \times \text{T95} + 0.03180 \times \text{ET11APR(t-1)} - 0.07875 \times \text{ET11NOV(t-1)} + 2.28450 \times \text{D892} + 4.42793 \times \text{D90} \\
\text{AdjR}^2 & = 0.6515 \\
\text{D.W.} & = 1.741
\end{align*}
\]

\[
\begin{align*}
\text{APL11} & = 9.58894 + 0.21849 \times \text{APL11(t-1)} + 7.77065 \times \frac{\text{FPR(t-1)}}{\text{CPI(t-1)}} + 2.33176 \times \text{T95} + 0.03180 \times \text{ET11APR(t-1)} - 0.07875 \times \text{ET11NOV(t-1)} + 2.28450 \times \text{D892} + 4.42793 \times \text{D90} \\
\text{AdjR}^2 & = 0.6515 \\
\text{D.W.} & = 1.741
\end{align*}
\]

\[
\begin{align*}
\text{APL12} & = 132.12505 + 0.09167 \times \text{APL12(t-1)} + 7.77065 \times \frac{\text{FPR(t-1)}}{\text{CPI(t-1)}} + 2.33176 \times \text{T95} + 0.03180 \times \text{ET12MAY(t-1)} - 0.07875 \times \text{ET12SEP(t-1)} + 2.28450 \times \text{D892} + 4.42793 \times \text{D90} \\
\text{AdjR}^2 & = 0.6002 \\
\text{D.W.} & = 2.005
\end{align*}
\]

\[
\begin{align*}
\text{APL13} & = 132.12505 + 0.09167 \times \text{APL13(t-1)} + 7.77065 \times \frac{\text{FPR(t-1)}}{\text{CPI(t-1)}} + 2.33176 \times \text{T95} + 0.03180 \times \text{ET13MAR(t-1)} - 0.07875 \times \text{ET13SEP(t-1)} + 2.28450 \times \text{D892} + 4.42793 \times \text{D90} \\
\text{AdjR}^2 & = 0.6002 \\
\text{D.W.} & = 2.005
\end{align*}
\]

**2-5-2-1-12. Area Function of Lowland Rice in Khammuane**

\[
\begin{align*}
\text{APL12} & = 92.89300 + 0.17637 \times \text{APL12(t-1)} + 24.31869 \times \frac{\text{FPR(t-1)}}{\text{CPI(t-1)}} + 0.18230 \times \text{ET12MAY(t-1)} - 0.53165 \times \text{ET12SEP(t-1)} - 17.80456 \times \text{D83} - 19.82763 \times \text{D96} + 25.52013 \times \text{D92} + 16.40433 \times \text{D99} \\
\text{AdjR}^2 & = 0.4343 \\
\text{D.W.} & = 2.544
\end{align*}
\]

**2-5-2-1-13. Area Function of Lowland Rice in Savannakhet**

\[
\begin{align*}
\text{APL13} & = 132.12505 + 0.09167 \times \text{APL13(t-1)} + 7.77065 \times \frac{\text{FPR(t-1)}}{\text{CPI(t-1)}} + 2.33176 \times \text{T95} + 0.03180 \times \text{ET13MAR(t-1)} - 0.07875 \times \text{ET13SEP(t-1)} + 2.28450 \times \text{D892} + 4.42793 \times \text{D90} \\
\text{AdjR}^2 & = 0.6002 \\
\text{D.W.} & = 2.005
\end{align*}
\]
Chapter 2
Development of the Rice Econometric Model with Endogenous Water in Lao PDR (REMEW- LAO)

D83 Dummy Variable, 1 in 1983, 0 otherwise
D96 Dummy Variable, 1 in 1996, 0 otherwise
SHIFT99 Dummy Variable, 1 from 1999, 0 otherwise

2-5-2-1-14. Area Function of Lowland Rice in Saravane

\[ APL14 = 13.56709 + 0.09541 \times APL14(t-1) + 0.013913 \times ET14AUG(t-1) + 0.01187 \times ET14OCT(t-1) - 0.49593 \times D83 - 4.53109 \times D868 - 13.67612 \times D93 + 11.86392 \times SHIFT09
\]

\[ AdjR^2 = 0.9098 \]

D.W. = 2.660

APL14 Planted Area of Lowland Rice in Saravane
FPR Farm Price of Laos Rice (thousand kip per kg)
CPI Consumer Price Index (1995=100)
T84 Time Trend from 1984 to 2000, 0 otherwise
ET15MAR Evapotranspiration of March in Sekong
ET15APR Evapotranspiration of April in Sekong
ET15AUG Evapotranspiration of August in Sekong
ET15SEP Evapotranspiration of September in Sekong
ET15OCT Evapotranspiration of October in Sekong
D94 Dummy Variable, 1 in 1994, 0 otherwise
D96 Dummy Variable, 1 in 1996, 0 otherwise

2-5-2-1-15. Area Function of Lowland Rice in Champasack

\[ APL16 = 107.91658 + 0.10362 \times APL16(t-1) + 0.57532 \times ET16MAY(t-1) + 0.54152 \times ET16NOV(t-1) - 43.70553 \times D88 - 42.904 \times D96
\]

\[ AdjR^2 = 0.7500 \]

D.W. = 2.615

APL16 Planted Area of Lowland Rice in Champasack
FPR Farm Price of Laos Rice (thousand kip per kg)
CPI Consumer Price Index (1995=100)
ET16APR Evapotranspiration of April in Champasack
ET16MAY Evapotranspiration of May in Champasack
ET16JUN Evapotranspiration of June in Champasack
ET16LY Evapotranspiration of July in Champasack
ET16SEP Evapotranspiration of September in Champasack
ET16NOV Evapotranspiration of November in Champasack
D88 Dummy Variable, 1 in 1988, 0 otherwise
D96 Dummy Variable, 1 in 1996, 0 otherwise

2-5-2-1-17. Area Function of Lowland Rice in Attapeu

\[ APL17 = 2.71396 + 0.81582 \times APL17(t-1) - 1.09821 \times D96
\]

\[ AdjR^2 = 0.7500 \]

D.W. = 2.615

APL17 Planted Area of Lowland Rice in Attapeu
2-5-2-1. Area Function of Irrigated Rice in Vientiane Municipality

\[
\text{API01} = -4.15829 \\
+ 0.666562^*T95 \\
+ 0.91504^*\text{API01(t-1)} \\
+ 5.87563^*[\text{FPR(t-1)}/\text{CPI(t-1)}]/100 \\
- 0.02510^*\text{ET01MAY(t-1)} \\
+ 0.07931^*\text{ET01JUN(t-1)} \\
- 0.06424^*\text{ET01JLY(t-1)} \\
- 0.05530^*\text{ET01OCT(t-1)} \\
- 1.84317^*D83 \\
- 1.73775^*D87 \\
\]

\( AdjR^2=0.9045 \quad D.W.=1.803 \)

2-5-2-2. Area Function of Irrigated Rice in Savannakhet

\[
\text{API13} = -17.02137 \\
+ 1.33120^*T94 \\
+ 0.66973^*\text{API13(t-1)} \\
+ 7.06345^*[\text{FPR(t-1)}/\text{CPI(t-1)}]/100 \\
+ 0.09520^*\text{ET13MAR(t-1)} \\
+ 0.08641^*\text{ET13JLY(t-1)} \\
+ 0.12318^*\text{ET13AUG(t-1)} \\
- 0.07771^*\text{ET13OCT(t-1)} \\
- 5.61707^*D84 \\
+ 4.34852^*D92 \\
\]

\( AdjR^2=0.9629 \quad D.W.=2.641 \)

2-5-2-3. Area Function of Irrigated Rice in North Region

\[
\text{AHN} = -21.03793 \\
+ 1.57140^*T94 \\
+ 0.21623^*\text{AHN(t-1)} \\
+ 1.98217^*[\text{FPR(t-1)}/\text{CPI(t-1)}]/100 \\
\]

\( AdjR^2=0.9338 \quad D.W.=2.216 \)
Chapter 2
Development of the Rice Econometric Model with Endogenous Water in Lao PDR (REMEW-LAO)

(2.99) [0.181] + 0.02820*ETNMAY(t-1) (3.77) [0.981] - 0.07016*ETNJUN(t-1) (-6.63) [-2.317] + 0.04534*ETNJLY(t-1) (3.08) [1.410] + 0.20926*ETNSEP(t-1) (9.91) [6.783] + 0.04481*ETNOCT(t-1) (3.93) [1.405] - 2.03450*D82 (-5.03) - 0.63629*D93 (-2.00) + 0.93235*D96 (2.62) -2.0450*SHJFT00 (-12.42)

AdjR²=0.9992 D.W.=2.156

AIHN  Planted Area of Irrigated Rice in North Region
FPR  Farm Price of Laos Rice (thousand kip per kg)
CPI  Consumer Price Index (1995=100)
T97  Time Trend from 1997 to 2000, 0 otherwise
ETCMAR  Evapotranspiration of March in Central Region
ETCAPR  Evapotranspiration of April in Central Region
ETCAUG  Evapotranspiration of August in Central Region
ETCSEP  Evapotranspiration of September in Central Region
ETCOCT  Evapotranspiration of October in Central Region
ETCNOV  Evapotranspiration of November in Central Region
D82  Dummy Variable, 1 in 1982, 0 otherwise
D93  Dummy Variable, 1 in 1993, 0 otherwise
SHFT00  Dummy Variable, 1 from 2000, 0 otherwise

2-5-2-2-4b. Area Function of Irrigated Rice in Other Central Region
(Excluding 01 and 13)
AIHOC  - 19.65243 (-5.52) + 0.66063*AIHOC(t-1) (8.51) + 5.44282*FPR(t-1)/CPI(t-1)/100 (2.77) [0.375] + 1.67572*T95 (8.67) + 0.06448*ETCMAR(t-1) (4.52) [0.710] - 0.09320*ETCAPR(t-1) (-3.20) [-0.640] + 0.08427*ETNOCT(t-1) (4.92) [2.194] + 0.11465*ETCSEP(t-1) (3.73) [2.861] - 2.26245*D82 (-2.49) + 3.57380*D92 (3.51)

AdjR²=0.9832 D.W.=2.348

AIHOC  Planted Area of Irrigated Rice in Other Central Region
FPR  Farm Price of Laos Rice (thousand kip per kg)
CPI  Consumer Price Index (1995=100)
T95  Time Trend from 1997 to 2000, 0 otherwise
ETCMAR  Evapotranspiration of March in Other Central Region
ETCAPR  Evapotranspiration of April in Other Central Region
ETCSEP  Evapotranspiration of September in Other Central Region
D82  Dummy Variable, 1 in 1982, 0 otherwise
D92  Dummy Variable, 1 in 1992, 0 otherwise

2-5-2-2-5. Area Function of Irrigated Rice in South Region

AdjR²=0.42364*SHIFTOO (-12.42)

AIHC  Planted Area of Irrigated Rice in Central Region
FPR  Farm Price of Laos Rice (thousand kip per kg)
CPI  Consumer Price Index (1995=100)
T97  Time Trend from 1997 to 2000, 0 otherwise
ETCMAR  Evapotranspiration of March in Central Region
ETCAPR  Evapotranspiration of April in Central Region
ETCAUG  Evapotranspiration of August in Central Region
ETCSEP  Evapotranspiration of September in Central Region
ETCOCT  Evapotranspiration of October in Central Region
ETCNOV  Evapotranspiration of November in Central Region
D82  Dummy Variable, 1 in 1982, 0 otherwise
D83  Dummy Variable, 1 in 1983, 0 otherwise

2-5-2-2-6. Area Function of Irrigated Rice in South Region
AIHS = + 0.70014
(0.63)
+ 0.82899*AIHS(-1)
(15.40)
+ 5.13662*[FPR(-1)/CPI(-1)/100]
(5.03) [0.366]
+ 4.50486*T97
(23.84)
+ 0.04696*ETSJLY(-1)
(2.87) [0.650]
- 12.52035*SHIFTOO
(-18.22)

CPI Consumer Price Index (1995=100)

ET01JLY Evapotranspiration of July in Phongsaly
ET01AUG Evapotranspiration of August in Phongsaly
ET01SEP Evapotranspiration of September in Phongsaly

D87 Dummy Variable, 1 in 1987, 0 otherwise
D92 Dummy Variable, 1 in 1992, 0 otherwise

2-5-2-3-2. Area Function of Upland Rice in Luangnamtha

APU03 = + 33.0350
(4.70)
+ 0.39009*APM03(-1)
(3.32)
+ 13.82765*[FPR(-1)/CPI(-1)/100]
(3.15) [0.232]
- 0.12240*ET03APR(-1)
(-5.86) [-0.427]
+ 0.10462*ET03JLY(-1)
(4.79) [0.631]
- 0.21968*ET03JUN(-1)
(-6.33) [-1.282]
- 0.14945*ET03JLY(-1)
(-2.72) [-0.789]
+ 0.08226*ET03APR(-1)
(3.07) [0.440]
- 0.07780*ET03OCT(-1)
(-2.03) [-0.430]
+ 3.72811*D81
(3.14)
- 9.64960*D92
(-8.85)
- 3.05912*D97
(-2.71)

AdjR^2=0.9620 D.W.=2.461

APU03 Planted Area of Upland Rice in Luangnamtha
FPR Farm Price of Laos Rice (thousand kip per kg)
CPI Consumer Price Index (1995=100)

ET03APR Evapotranspiration of April in Luangnamtha
ET03MAY Evapotranspiration of May in Luangnamtha
ET03JUN Evapotranspiration of June in Luangnamtha
ET03JLY Evapotranspiration of July in Luangnamtha
ET03AUG Evapotranspiration of August in Luangnamtha
ET03OCT Evapotranspiration of October in Luangnamtha

D81 Dummy Variable, 1 in 1981, 0 otherwise
D92 Dummy Variable, 1 in 1992, 0 otherwise
D97 Dummy Variable, 1 in 1997, 0 otherwise

2-5-2-3-3. Area Function of Upland Rice in Oudomxay

APU04 = + 136.23768
(4.72)
+ 0.32724*APM04(-1)
(2.32)
+ 31.03572*[FPR(-1)/CPI(-1)/100]
(3.05) [0.244]
+ 0.26452*ET04APR(-1)
(4.05) [0.492]
- 0.29712*ET04JLY(-1)
(-3.34) [-0.877]

AdjR^2=0.9620 D.W.=1.556
Chapter 2

Development of the Rice Econometric Model with Endogenous Water in Lao PDR (REMEW-LAO)

\[ + 0.63946 \times ET04JUN(t-1) \]
\[ + 0.40639 \times ET04AUG(t-1) \]
\[ - 1.09198 \times ET04SEP(t-1) \]
\[ - 1.53653 \times ET04NOV(t-1) \]
\[ + 12.25215 \times D81 \]
\[ - 25.32420 \times D84 \]
\[ + 12.79532 \times D95 \]

\[ AdjR^2 = 0.9382 \]
\[ D.W. = 1.981 \]

\[ APU04 = \]
\[ \text{Planted Area of Upland Rice in Oudomxay} \]
\[ FPR = \text{Farm Price of Laos Rice (thousand kip per kg)} \]
\[ CPI = \text{Consumer Price Index (1995=100)} \]
\[ ET04APR = \text{Evapotranspiration of April in Oudomxay} \]
\[ ET04MAY = \text{Evapotranspiration of May in Oudomxay} \]
\[ ET04JUN = \text{Evapotranspiration of June in Oudomxay} \]
\[ ET04AUG = \text{Evapotranspiration of August in Oudomxay} \]
\[ ET04SEP = \text{Evapotranspiration of September in Oudomxay} \]
\[ ET04NOV = \text{Evapotranspiration of November in Oudomxay} \]
\[ D81 = \text{Dummy Variable, 1 in 1981, 0 otherwise} \]
\[ D84 = \text{Dummy Variable, 1 in 1984, 0 otherwise} \]
\[ D95 = \text{Dummy Variable, 1 in 1995, 0 otherwise} \]

2-5-2-3-4. Area Function of Upland Rice in Bokea

\[ APU05= -0.27824 \]
\[ + 0.87132 \times APM05(t-1) \]
\[ + 5.78557 \times [FPR(t-1)/CPI(t-1)/100] \]
\[ - 0.10363 \times ET05JUN(t-1) \]
\[ + 0.09949 \times ET05AUG(t-1) \]
\[ + 2.50772 \times D90 \]
\[ + 4.58270 \times D94 \]
\[ + 1.83388 \times D96 \]

\[ AdjR^2 = 0.7177 \]
\[ D.W. = 1.998 \]

\[ AP06 = \]
\[ \text{Planted Area of Upland Rice in Luangprabang} \]
\[ FPR = \text{Farm Price of Laos Rice (thousand kip per kg)} \]
\[ CPI = \text{Consumer Price Index (1995=100)} \]
\[ ET06MAR = \text{Evapotranspiration of March in Luangprabang} \]
\[ D90 = \text{Dummy Variable, 1 in 1990, 0 otherwise} \]
\[ D94 = \text{Dummy Variable, 1 in 1994, 0 otherwise} \]
\[ D96 = \text{Dummy Variable, 1 in 1996, 0 otherwise} \]

2-5-2-3-6. Area Function of Upland Rice in Huaphanh

\[ APU07 = -11.21992 \]
\[ + 0.73682 \times APM07(t-1) \]
\[ + 30.61079 \times [FPR(t-1)/CPI(t-1)/100] \]
\[ - 0.12271 \times ET08MAR(t-1) \]
\[ + 0.31127 \times ET08AUG(t-1) \]
\[ - 0.18905 \times ET08NOV(t-1) \]
\[ - 8.78325 \times D82 \]
\[ - 9.45343 \times D93 \]

\[ AdjR^2 = 0.8711 \]
\[ D.W. = 2.257 \]

\[ AP08 = \]
\[ \text{Planted Area of Upland Rice in Xayabury} \]
\[ FPR = \text{Farm Price of Laos Rice (thousand kip per kg)} \]
\[ CPI = \text{Consumer Price Index (1995=100)} \]
\[ ET07MAR = \text{Evapotranspiration of March in Xayabury} \]
\[ ET07AUG = \text{Evapotranspiration of August in Xayabury} \]
\[ D82 = \text{Dummy Variable, 1 in 1982, 0 otherwise} \]
\[ D93 = \text{Dummy Variable, 1 in 1993, 0 otherwise} \]

2-5-2-3-7. Area Function of Upland Rice in Xayabury

\[ + 49.99883 \]
\[ + 0.40417 \times APM08(t-1) \]

\[ + 14.58704 \times [FPR(t-1)/CPI(t-1)/100] \]
2-5-2-3-8. Area Function of Upland Rice in Xiengkhuang

\[
\begin{align*}
APU09 = & 24.95975 + 0.87700 \times APM09(t-1) + 13.25962 \times \frac{FPR(t-1) \times CPI(t-1)}{100} + 0.03386 \times ET09APR(t-1) - 0.32318 \times ET09AUG(t-1) + 5.25945 \times D901 \\
& + 13.34335 \times D99 \\
\text{AdjR}^2 = 0.8739 & & D.W. = 1.895
\end{align*}
\]

2-5-2-3-9. Area Function of Upland Rice in Vientiane

\[
\begin{align*}
APU10 = & -6.08877 + 0.87499 \times APM10(t-1) + 8.19291 \times \frac{FPR(t-1) \times CPI(t-1)}{100} + 0.06845 \times ET10APR(t-1) + 0.09089 \times ET10JUN(t-1) \\
& + 5.08602 \times D99 \\
\text{AdjR}^2 = 0.8363 & & D.W. = 1.927
\end{align*}
\]

2-5-2-3-10. Area Function of Upland Rice in Borikhamxay

\[
\begin{align*}
APU11 = & 7.62728 + 0.45513 \times APM11(t-1) + 5.62442 \times \frac{FPR(t-1) \times CPI(t-1)}{100} - 0.08872 \times ET11JUN(t-1) + 0.09023 \times ET11JLY(t-1) - 0.10883 \times ET11AUG(t-1) + 0.05134 \times ET11NOV(t-1) \\
& + 1.78976 \times D902 + 3.45526 \times D95 + 3.98765 \times SHIFT00 \\
\text{AdjR}^2 = 0.8363 & & D.W. = 1.927
\end{align*}
\]

2-5-2-3-11. Area Function of Upland Rice in Khammuane

\[
\begin{align*}
APU12 = & 7.19583 + 0.72274 \times APM12(t-1) \\
\text{AdjR}^2 = 0.8363 & & D.W. = 1.927
\end{align*}
\]
Chapter 2
Development of the Rice Econometric Model with Endogenous Water in Lao PDR (REMEW-LAO)

(10.64) + 1.72720*[FPR(t-1)/CPI(t-1)/100] (0.64) [0.109] - 0.03275*ET12MAR(t-1) (-3.12) [-0.337] + 0.01783*ET12APR(t-1) (2.36) [0.274] - 0.07627*ET12JLY(t-1) (-3.31) [-1.835] + 8.17571*080 (9.19) 

AdjR$^2$=0.9812 D.W.=2.640

<table>
<thead>
<tr>
<th>APU12</th>
<th>Planted Area of Upland Rice in Khammuane</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPR</td>
<td>Farm Price of Laos Rice (thousand kip per kg)</td>
</tr>
<tr>
<td>CPI</td>
<td>Consumer Price Index (1995=100)</td>
</tr>
<tr>
<td>ET12MAR</td>
<td>Evapotranspiration of March in Khammuane</td>
</tr>
<tr>
<td>ET12APR</td>
<td>Evapotranspiration of April in Khammuane</td>
</tr>
<tr>
<td>ET12JLY</td>
<td>Evapotranspiration of July in Khammuane</td>
</tr>
<tr>
<td>D80</td>
<td>Dummy Variable, 1 in 1980, 0 otherwise</td>
</tr>
</tbody>
</table>

2-5-2-3-12. Area Function of Upland Rice in Savannakhet

APU13= -4.84468 (-3.06) + 0.67045*APM13(t-1) (8.37) + 8.78030*[FPR(t-1)/CPI(t-1)/100] (2.39) [0.247] -0.04793*ET13APR(t-1) (-2.58) [-0.286] + 0.07984*ET13MAY(t-1) (3.59) [0.812] + 2.63452*D81 (2.59) + 2.64344*D912 (3.74)

AdjR$^2$=0.9678 D.W.=2.040

<table>
<thead>
<tr>
<th>APU13</th>
<th>Planted Area of Upland Rice in Savannakhet</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPR</td>
<td>Farm Price of Laos Rice (thousand kip per kg)</td>
</tr>
<tr>
<td>CPI</td>
<td>Consumer Price Index (1995=100)</td>
</tr>
<tr>
<td>ET13APR</td>
<td>Evapotranspiration of April in Savannakhet</td>
</tr>
<tr>
<td>ET13MAY</td>
<td>Evapotranspiration of May in Savannakhet</td>
</tr>
<tr>
<td>D81</td>
<td>Dummy Variable, 1 in 1980, 0 otherwise</td>
</tr>
<tr>
<td>D912</td>
<td>Dummy Variable, 1 in 1991 to 1992, 0 otherwise</td>
</tr>
</tbody>
</table>

2-5-2-3-13. Area Function of Upland Rice in Saravane

APU14= -2.69791 (-0.83) + 0.25820*APM14(t-1) (2.22) + 0.93255*[FPR(t-1)/CPI(t-1)/100] (0.47) [0.034] + 0.08602*ET14JLY(t-1) (2.69) [1.222] + 2.10905*D847 (1.97938) - 3.68058*D88

AdjR$^2$=0.7121 D.W.=2.483

APU14 Planted Area of Upland Rice in Saravane
FPR Farm Price of Laos Rice (thousand kip per kg)
CPI Consumer Price Index (1995=100)
ET14JLY Evapotranspiration of July in Saravane
D847 Dummy Variable, 1 in 1984 to 1987, 0 otherwise
D88 Dummy Variable, 1 in 1988, 0 otherwise
D98 Dummy Variable, 1 in 1998, 0 otherwise

2-5-2-3-14. Area Function of Upland Rice in Sekong

APU15= -5.54303 (-2.57) + 0.45412*APM15(t-1) (3.75) + 4.11123*[FPR(t-1)/CPI(t-1)/100] (2.47) [0.184] - 0.04131*ET15AUG(t-1) (-1.93) [-0.710] + 2.54847*D80 (3.22) + 1.10703*D867 (2.05)

AdjR$^2$=0.8488 D.W.=1.595

APU15 Planted Area of Upland Rice in Sekong
FPR Farm Price of Laos Rice (thousand kip per kg)
CPI Consumer Price Index (1995=100)
ET15AUG Evapotranspiration of August in Sekong
D80 Dummy Variable, 1 in 1980, 0 otherwise
D867 Dummy Variable, 1 in 1986 to 1987, 0 otherwise

2-5-2-3-15. Area Function of Upland Rice in Attapeu

APU17= -3.42351 (-2.19) + 0.23298*APM17(t-1) (2.04) + 2.58664*[FPR(t-1)/CPI(t-1)/100] (2.23) [0.184] - 0.02779*ET17APR(t-1) (-3.32) [-0.368] + 0.07055*ET17JLY(t-1) (4.09) [1.921] - 2.18113*D84 (-3.41) + 1.58899*D86 (2.98) + 1.56754*SHIFT00 (2.94)

AdjR$^2$=0.7121 D.W.=2.483

APU17 Planted Area of Upland Rice in Attapeu
FPR Farm Price of Laos Rice (thousand kip per kg)
CPI Consumer Price Index (1995=100)
ET17APR Evapotranspiration of April in Attapeu
2-5-3. Demand function of rice

\[
QC = + 681.30015 + 6.67679 \times T8086 + 13.41221 \times T8688 + 15.68680 \times T9499 - 282.61797 \times \frac{RP}{(CPI/100)} - 1.66306 \times RGDP/POP + 127.26798 \times D813 + 34.70990 \times D84 - 117.82337 \times D88 - 30.99935 \times D9193
\]

\[\text{AdjR}^2 = 0.8776 \quad \text{D.W.} = 3.051\]

QC: Consumption of Rice per capita
T8086: Time Trend from 1980 to 1986, 0 after 1986
T8688: Time Trend from 1986 to 1988, 0 before 1986, 0 after 1988
T9599: Time Trend from 1995 to 1999, 0 before 1996, 5 after 1999
RP: Retail Price of Rice (Non-glutinous)
CPI: Consumer Price Index
RGDP: Realized Gross Domestic Products
POP: Population
D813: Dummy Variable, 1 in 1981 to 1983, 0 otherwise
D84: Dummy Variable, 1 in 1984, 0 otherwise
D88: Dummy Variable, 1 in 1988, 0 otherwise
D890: Dummy Variable, 1 in 1989 and 1990, 0 otherwise
D9193: Dummy Variable, 1 in 1991 and 1993, 0 otherwise
D978: Dummy Variable, 1 in 1997 and 1998, 0 otherwise

2-5-4. Import function of rice

\[
IMP = 70.08878 - 42.11725 \times WP \times EXR/(CPI/100) + 0.02268 \times Q - 30.15455 \times D80 + 39.71473 \times D81 - 28.38935 \times D858 - 15.39497 \times D893 + 28.89936 \times D98
\]

\[\text{AdjR}^2 = 0.7928 \quad \text{D.W.} = 2.440\]

WP: World Price (Thailand: US$/MT)
EXR: Exchange Rate (Kip/US$)
Q: Total Production
D80: Dummy Variable, 1 in 1980, 0 otherwise
D81: Dummy Variable, 1 in 1981, 0 otherwise
D858: Dummy Variable, 1 in 1985 to 1988, 0 otherwise
D893: Dummy Variable, 1 in 1989 to 1993, 0 otherwise
D98: Dummy Variable, 1 in 1998, 0 otherwise

2-5-5. Price linkage function of rice

\[
FPR = -0.00270 + 0.49901 \times RP
\]

\[\text{AdjR}^2 = 0.9989 \quad \text{D.W.} = 2.217\]

FPR: Farm Price of Rice
RP: Retail Price of Rice (Non-glutinous)

Table 2-1 through Table 2-3 show elasticities of yield of wet season rice, irrigated rice, and upland rice with respect to a time trend and evapotranspirations. Table 2-4 through Table 2-6 show elasticities of planted area of the three types of rice with respect to last year's planted area, last year's farm price, and last year's evapotranspirations.
Table 2-1. Elasticities of yield of wet season rice for evapotranspiration and trend

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Vientiane Mun.</td>
<td>0.152</td>
<td>0.599</td>
<td></td>
<td></td>
<td>-1.223</td>
<td>-0.502</td>
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<tr>
<td>Phongsaly</td>
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<td>Bokeo</td>
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<td>-1.023</td>
<td>1.837</td>
<td>0.934</td>
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<td>Luangprabang</td>
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<td>Xayabury</td>
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<td>Bokeo</td>
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<td>-1.023</td>
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<td>Attapeu</td>
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<td>0.726</td>
<td>0.782</td>
<td>0.745</td>
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</tr>
</tbody>
</table>

Note) Trend is for after 2000

Table 2-2. Elasticities of yield of irrigated rice for evapotranspiration and trend

<table>
<thead>
<tr>
<th>Province</th>
<th>Trend</th>
<th>Nov.</th>
<th>Dec.</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vientiane Mun.</td>
<td>0.122</td>
<td>-0.898</td>
<td>0.488</td>
<td></td>
<td>0.131</td>
<td>-0.112</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Savannakhet</td>
<td>0.148</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.412</td>
<td></td>
<td></td>
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<tr>
<td>North region</td>
<td>0.101</td>
<td>-1.648</td>
<td>0.619</td>
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<tr>
<td>Central region</td>
<td>0.131</td>
<td>1.618</td>
<td>-0.385</td>
<td></td>
<td>-0.171</td>
<td>0.647</td>
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<tr>
<td>Central region²</td>
<td>0.569</td>
<td>1.979</td>
<td>-1.482</td>
<td>0.649</td>
<td>-0.301</td>
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</tr>
<tr>
<td>South region</td>
<td>0.112</td>
<td>0.552</td>
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<td>-0.549</td>
<td>0.526</td>
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</tr>
</tbody>
</table>

Note) Trend is for after 2000, Central region² excludes Vientiane municipality and Savannakhet province

Table 2-3. Elasticities of yield of upland rice for evapotranspiration and trend

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Phongsaly</td>
<td>0.033</td>
<td>0.300</td>
<td>1.129</td>
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<td>-1.456</td>
<td>-0.688</td>
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</tr>
<tr>
<td>Luangnamtha</td>
<td>0.033</td>
<td></td>
<td>-0.633</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Oudomxay</td>
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<td>-1.778</td>
<td></td>
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</tr>
<tr>
<td>Bokeo</td>
<td>0.103</td>
<td>0.540</td>
<td>1.433</td>
<td>-0.771</td>
<td>1.446</td>
<td></td>
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</tr>
<tr>
<td>Luangprabang</td>
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<td>0.193</td>
<td></td>
<td>-1.233</td>
<td>-1.905</td>
<td>-1.326</td>
<td>-1.005</td>
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</tr>
<tr>
<td>Huaphanh</td>
<td>0.037</td>
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<td></td>
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</tr>
<tr>
<td>Xayabury</td>
<td>0.045</td>
<td></td>
<td>-1.271</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Xiengkhuan</td>
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<td>-0.826</td>
<td>2.048</td>
<td>0.641</td>
<td>0.706</td>
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</tr>
<tr>
<td>Vientiane</td>
<td>0.025</td>
<td>0.228</td>
<td>0.089</td>
<td></td>
<td>2.339</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Bokeo</td>
<td></td>
<td>0.365</td>
<td></td>
<td>1.188</td>
<td></td>
<td>-1.861</td>
<td>1.009</td>
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<tr>
<td>Xiangkhouane</td>
<td>0.013</td>
<td>0.247</td>
<td>0.843</td>
<td>0.593</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Savannakhet</td>
<td>0.041</td>
<td>-0.209</td>
<td>0.628</td>
<td></td>
<td>-1.041</td>
<td>1.349</td>
<td>0.697</td>
<td></td>
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</tr>
<tr>
<td>Saravan</td>
<td>0.023</td>
<td></td>
<td></td>
<td></td>
<td>-2.110</td>
<td>1.738</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Sekong</td>
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<td>-0.416</td>
<td></td>
<td>-1.520</td>
<td>1.399</td>
<td>-1.109</td>
<td></td>
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</tr>
<tr>
<td>Attapeu</td>
<td>0.036</td>
<td>-0.410</td>
<td></td>
<td>-1.480</td>
<td>1.673</td>
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</tr>
</tbody>
</table>

Note) Trend is for after 2000
### Table 2-4. Elasticities of planted area of wet season rice

<table>
<thead>
<tr>
<th>Province</th>
<th>Area (t-1)</th>
<th>Price (t-1)</th>
<th>Evapotranspiration (t-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vientiane Mun.</td>
<td>0.080</td>
<td>0.048</td>
<td></td>
</tr>
<tr>
<td>Phongsaly</td>
<td>0.105</td>
<td>0.074</td>
<td>-0.129</td>
</tr>
<tr>
<td>Luangnamtha</td>
<td>0.589</td>
<td>0.084</td>
<td>-0.328</td>
</tr>
<tr>
<td>Oudomxay</td>
<td>0.149</td>
<td>0.102</td>
<td>-0.170</td>
</tr>
<tr>
<td>Bokea</td>
<td>0.042</td>
<td>0.149</td>
<td>0.273</td>
</tr>
<tr>
<td>Luangprabang</td>
<td>0.025</td>
<td>0.024</td>
<td>-0.668</td>
</tr>
<tr>
<td>Huaphanhn</td>
<td>0.038</td>
<td>0.106</td>
<td>-0.452</td>
</tr>
<tr>
<td>Xayabury</td>
<td>0.649</td>
<td>0.155</td>
<td>-0.497</td>
</tr>
<tr>
<td>Xiengkhuang</td>
<td>0.075</td>
<td>0.163</td>
<td>-0.109</td>
</tr>
<tr>
<td>Vientiane</td>
<td>0.269</td>
<td>0.129</td>
<td>0.096</td>
</tr>
<tr>
<td>Borikhamxay</td>
<td>0.218</td>
<td>0.150</td>
<td>0.145</td>
</tr>
<tr>
<td>Khammuane</td>
<td>0.176</td>
<td>0.173</td>
<td>0.497</td>
</tr>
<tr>
<td>Savannakhet</td>
<td>0.092</td>
<td>0.057</td>
<td>-0.201</td>
</tr>
<tr>
<td>Saravan</td>
<td>0.095</td>
<td>0.032</td>
<td></td>
</tr>
<tr>
<td>Sekong</td>
<td>0.444</td>
<td>0.314</td>
<td>-0.734</td>
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<tr>
<td>Champassack</td>
<td>0.104</td>
<td>0.186</td>
<td>-0.201</td>
</tr>
<tr>
<td>Attapeu</td>
<td>0.816</td>
<td>0.253</td>
<td>-0.417</td>
</tr>
</tbody>
</table>

Note) Central region\(^2\) excludes Vientiane municipality and Savannakhet province.

### Table 2-5. Elasticities of planted area of irrigated rice

<table>
<thead>
<tr>
<th>Province</th>
<th>Area (t-1)</th>
<th>Price (t-1)</th>
<th>Evapotranspiration (t-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vientiane Mun.</td>
<td>0.915</td>
<td>0.206</td>
<td>-0.320</td>
</tr>
<tr>
<td>Savannakhet</td>
<td>0.670</td>
<td>0.432</td>
<td>0.940</td>
</tr>
<tr>
<td>North region</td>
<td>0.216</td>
<td>0.181</td>
<td>0.981</td>
</tr>
<tr>
<td>Central region</td>
<td>0.822</td>
<td>0.060</td>
<td>0.219</td>
</tr>
<tr>
<td>Central region(^2)</td>
<td>0.661</td>
<td>0.375</td>
<td>0.710</td>
</tr>
<tr>
<td>South region</td>
<td>0.829</td>
<td>0.366</td>
<td>1.215</td>
</tr>
</tbody>
</table>

Note) Central region\(^2\) excludes Vientiane municipality and Savannakhet province.

### Table 2-6. Elasticities of planted area of upland rice

<table>
<thead>
<tr>
<th>Province</th>
<th>Area (t-1)</th>
<th>Price (t-1)</th>
<th>Evapotranspiration (t-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phongsaly</td>
<td>0.290</td>
<td>0.156</td>
<td>-1.671</td>
</tr>
<tr>
<td>Luangnamtha</td>
<td>0.391</td>
<td>0.232</td>
<td>-0.427</td>
</tr>
<tr>
<td>Oudomxay</td>
<td>0.327</td>
<td>0.244</td>
<td>0.492</td>
</tr>
<tr>
<td>Bokea</td>
<td>0.871</td>
<td>0.250</td>
<td>-1.550</td>
</tr>
<tr>
<td>Luangprabang</td>
<td>0.483</td>
<td>0.160</td>
<td>0.163</td>
</tr>
<tr>
<td>Huaphanhn</td>
<td>0.737</td>
<td>0.318</td>
<td>-0.248</td>
</tr>
<tr>
<td>Xayabury</td>
<td>0.404</td>
<td>0.222</td>
<td>-0.254</td>
</tr>
<tr>
<td>Xiengkhuang</td>
<td>0.877</td>
<td>0.237</td>
<td>-0.165</td>
</tr>
<tr>
<td>Vientiane</td>
<td>0.875</td>
<td>0.238</td>
<td>0.751</td>
</tr>
<tr>
<td>Borikhamxay</td>
<td>0.455</td>
<td>0.166</td>
<td>-0.928</td>
</tr>
<tr>
<td>Khammuane</td>
<td>0.723</td>
<td>0.109</td>
<td>-0.337</td>
</tr>
<tr>
<td>Savannakhet</td>
<td>0.670</td>
<td>0.247</td>
<td>-0.286</td>
</tr>
<tr>
<td>Saravan</td>
<td>0.258</td>
<td>0.034</td>
<td></td>
</tr>
<tr>
<td>Sekong</td>
<td>0.454</td>
<td>0.184</td>
<td>-0.710</td>
</tr>
<tr>
<td>Attapeu</td>
<td>0.233</td>
<td>0.184</td>
<td>-0.368</td>
</tr>
</tbody>
</table>
Chapter 2
Development of the Rice Econometric Model with Endogenous Water in Lao PDR (REMEW-LAO)

2-6. Simulation results

2-6-1. Results of estimation of yield functions

Table 2-1 shows the elasticities of yield of wet season rice with respect to evapotranspiration (ET) evaluated at the average value for yield and ET. The results indicate that if the ET value for May or September increases, the resulting yield will increase, and if the ET value for June increase, the yield will decrease in many provinces. The results suggest that the water supply during the planting and flowering season greatly impacts production.

Table 2-2 shows the elasticities of yield of irrigated rice with respect to ET. If water supply in December increases, yield of irrigated rice in the north region will increase, and if the water supply in January increases, the yield in the south region will increase.

Table 2-3 shows the elasticities of yield of upland rice with respect to ET. The results are similar to those of wet season rice. If the water supply in May increases, yields will increase, and if water supply increases in June, yields will decrease. These results are consistent with the relationship between yield and planting time. If transplanting is delayed by the shift of the rainy season, the growth period will be shortened.

2-6-2. Results of estimation of planted area functions

Table 2-4 shows the elasticities of planted area of wet season rice with respect to farm price and ET. The equation is based on an adaptive expectation model in the case that ET is an expected value. The elasticities of area with respect to farm price are equivalent to the supply elasticities of price. The results indicate that if the water supply increases in September, farmers will decrease planting area. This could be a result of flood damage during the cultivation season which leads to a decrease in farmers’ income. In this case, the low income will make preparation for planting difficult.

Table 2-5 and Table 2-6 show the elasticities of planted area for irrigated rice and upland rice with respect to farm price and ET. The results suggest that if the water supply increases in September, farmers will expand planting area in the dry season, because of the abundant water stock. The results also indicate that if the water supply increases in August in the north region, farmers cultivating upland rice will expand their planting area. The water supply probably induces much plant production in forest region and it will prepare suitable plant area for upland rice cultivation.

2-6-3. Simulation results of supply and demand model

The simulation term is from 2001 to 2015. The assumptions of the simulation are as follows; (1) the forecast growth rate of CPI is the average between 1995 and 2002, (2) the growth rate of real GDP is the average between 1980 and 2002, (3) the growth rate of exchange rate is the average between 1993 and 2002, (4) the growth rate of the population is the average between 1980 and 2002, (5) the linear trend of the yield functions are continued, (6) The trend of area functions are flat except for upland rice which is in decline.

Figure 2-3 through Figure 2-5 show the simulation results for the production of wet season rice, irrigated rice, and upland rice. The production of the wet season rice will increase 273,000 MT (metric tons) from 2005 to 2015. The dry season rice will also
increase 326,000 MT during the period. However, the production of upland rice will be stable at around 290,000 MT during the period.

Figure 2-6 shows the simulation result of the market clearing realized farm price. The realized farm price will increase from 410 kip per MT to 610 kip per MT during the period. The realized farm prices are deflated by CPI with a base year of 1995.

2-7. Conclusion

A supply and demand model of rice in Laos which can analyze production and water supply impacts for each province is developed. The results of the baseline analyses indicate that production of wet and dry season rice steadily increases and that of upland rice remains stable at the current production level. If the cycle of shifting cultivation changes by population growth, the production of upland rice will decrease due to the reduction in the fertility of the upland crop (Evenson, 1994).

The impacts of water supply changes on rice production and market in Lao are analyzed in Chapter 6 along with the other three countries.