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The Profitability of Shallow Tube Well Scheme in Lao People's Democratic Republic

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Summary

The purpose of this paper is to clarify the profitability of the shallow tube well irrigation systems in Ban Hom area, Lao. Farm survey was conducted to evaluate the difference between electric and fuel powered irrigation systems. The shallow tube well system is small scale and invested by farmers. The electric operated systems are used mainly for production of vegetables. On the other hand, the fuel operated systems are used both for rice and vegetables.

The BCR at 10 percent of discount rate is 3.1 in EPS and 1.1 in FPS. The internal rate of return is higher in both STW systems than the interest rate of the agricultural extension credit. An indirect benefit is also observed in the creation of employment for idle family labor mostly in the dry season.

This study clarified the Ban Hom farmers case has shown a great potential for extending more shallow wells into other area of the country. The shallow tube wells are advantageous in the locations close to market and easily access to the road.

1 Introduction

The economy of Laos had an average annual GDP growth rate of about 4.8 percent during the period from 1980 to 1993.

Production was largely for subsistence with a per capita GDP of US $220 in 1992 (World Bank [17]). Since 1980, agriculture has been the principal economic sector accounting for 58 percent of GDP and 85 percent of the labor force. The average GDP growth rate for agriculture was 4.0 percent from 1980 to 1992 .

Since 1986, the government has been reforming economic policy (World Bank [14]). One consequence of which is that the import tax for the irrigation engines and pumps has been set at low level, because small scale irrigation schemes are important to economic improvement.

Such a policy change has encouraged the construction of small scale irrigation systems, such as the pond, tube well and natural gravity irrigation systems.

The objective of this study is to clarify the profitability of the shallow tube well (STW) irrigation systems. Farm survey was conducted to evaluate the difference between electric and fuel powered irrigation systems.

The STW is an innovation which has increased vegetable production in central Laos. The selected site, Ban Hom, is a place where the first STW irrigation system was introduced.

Recently the irrigation management community (Small [13], Dhakal et al. [3], Kikuchi [6]) have argued that (1) publicly managed irrigation schemes have experienced very serious management problems, unlike the schemes sponsored and managed by farmers ; and (2) the low-capital intensive schemes, managed by farmers, produce a high rate of return, but capital intensive schemes, under public management, produce a low rate of return (World Bank [14]). These arguments are investigated in this paper.

2 Irrigation development policy in Lao PDR

To promote self-sufficiency in food production and the reduction in the degradation of the forest due to the slash-and-burn cultivation, the government of Laos has given priority to irrigation development. From 1988 to 1992, the government committed itself to these policies by allocating 32.6–46.2 percent of the total budget expenditure for the ministry of agriculture and forestry to sustainable food production.

Rice is a staple subsistence crop and accounts for about 40 percent of the agricultural GDP of the Laos economy. At present, total rice production in an average year ranges from between 1.4 and 1.6 million tons, and all of it is consumed domestically. But drought and flood in major rice producing areas could quickly bring about a rice shortage in Laos. In an average year, rice production could meet domestic requirements if distribution problems could be overcome. Only less than 5 percent of total rice production is traded within the country (IRRI [5]).

Over 80 percent of the cultivated land is used for rice production ; one third of this rice is produced in upland fields through slash-and-burn, or swidden, cultivation. In 1993, total rice production was 1,250,000 tons. 74 percent of the rice was produced in the lowlands ; 22.6 percent of that was produced in the uplands and only 3.6 percent of that was produced in irrigated land. Rice grown during the rainy season is called wet rice. Terrace farming is not practiced on hillsides and rice is cultivated only in narrow valley where there are few population clusters. In north and central Laos, most wet rice farming is dependent entirely on rainfall, the water being held in the fields by crude dikes. "Flood rice" has been suggested as a more accurate term in these circumstances (Halpern [4]).

Table 1 shows irrigated area by type of irrigation schemes in Laos. The total area irrigated during the wet season is 137,944 ha. The area of the supplementary irrigated lands managed under the government schemes amounts to approximately 60,000 hectares. Nearly 20,000 ha is irrigated during the dry season. All of these irrigated lands are used for rice production (Rasphone [12]). The low-value crops, which are produced in a "low-input low-output" system, are characteristic of agricultural production in this country (World Bank [14] p. 69–70).

There are traditional irrigation schemes that are managed by farmers. Lao's farmers have tried to control water entering paddy fields by diverting stream and catchments, creating holding ponds, and by using other methods. These traditional structures are possible to construct whenever there are small streams close to the rice fields and sufficient elevation for gravity flow. The weir structures are made of brushwood and are technically simple to construct, but these structures are impermanent and labor intensive. The construction cost of a weir is around US $200–400 per hectare, while the

Table 1 Type of irrigation schemes and its command area in Lao P. D. R.

Type of structure	Number	Area ha	Average ha/unit
Weirs	286	32,290	112.9
Weirs (reservoirs)	61	19,733	323.5
Pumping station	93	7,460	80.2
Traditional weirs	5,600*	64,169	11.5
Lakes, Ponds, Shallow wells and Tube wells	3,500*	4,292	1.2
Flood protection gates	43	10,000	232.5
Total		137,944	

Source : Ministry of Agriculture and Forestry 1993
*Estimated

cost per hectare of the government-managed schemes is approximately US $3,500.

3 The spread of shallow tube wells in Ban Hom

3.1 A General profile of the study area and the selection of sample farms

The case study area, Ban Hom, is located 14 km south of Vientiane along Mekong River. It is very close to the agricultural market of metropolitan area. The road to Vientiane is partly paved (9 km) and another 5 km is graveled.

Rice is the main crop and the irrigation canal system managed by the government is available for wet-season rice. Ban Hom consists of eight villages. Four villages of those wards were selected for our study area ; Ban Savang, Ban Phosy, Ban Pafang and Ban Chomthong. Shallow tube well development is most advanced in Ban Savang. The total cultivated area is 538 ha, including 389 ha of rain-fed paddy fields and 148 ha of irrigated paddy fields. The total number of households in the four villages is 704. The number of the non-farm households was only 50 in 1996. Accordingly, the average farm household has 5.3 persons. Average cultivated land per farm is 0.7 ha.

Ban Hom people have been known as the assiduous and tolerant, waking up early and coming back home late, as the native proverb says "*Payyiabma Mayiabkhiet* (go and step on a dog ; return and step on a frog)." The tube well operated by electric pump for home use was introduced to the study area in 1989. In 1992, one farmer constructed a shallow tube well with a five horse-power fuel pump for dry-season rice cultivation and vegetable cultivation. He visited his relatives in the villages of Thailand close to the border and saw some families using a tube well run by electricity for home use. A manual-drilling technician from this area had introduced this type of tube well in 1993. The construction cost of this system is cheaper than that of other systems. The STW by electric pump diffused immediately for the vegetable cultivation. Impressed by what he saw, the farmer brought this new technology back to Ban Hom. The electric pump STW was adopted immediately by other farmers throughout the village for vegetable cultivation. One hundred thirty shallow tube wells are used in Ban Hom today.

We noticed that most of the STWs were located along the Mekong river in the south-western region of the village (Figure 1). This well area is located on both sides of the residential area. We divided the well area of the village into two regions, the north (upper) and the south (lower), for the purposes of our discussion. Paddy fields made up most of the northern region which was irrigated by two pumping stations, called *Hatdokkeo* and *Chiampang,* which drew water from Mekong river.
Four of the thirty surveyed households were located in the upper region, which was virtually all paddy fields irrigated by two pumping stations. These pumping stations, the *Hatdokkeo* and the *Chiampang,* both drew water from the Mekong river. The farmers of these four households in the north used irrigation water from the shallow tube wells when the surface water supply was insufficient. Two farmers also used the wells for vegetables production during both the rainy and dry seasons at some higher levels of elevation (non paddy fields). But STWs have not increased in this area.

The lower part of the village has no paddy fields and is called *Xuanh,* which means garden or land used for vegetables, maize, tobacco and so forth. The soil is alluvial sandy loam, which is appropriate for vegetables. The fertile soil of this region is the result of the annual flooding of the Mekong river. Before the spread of these wells, this area had been irrigated by a small pond located next to the flood protection dike, during the dry season, from December through February. There were no paddy fields in the lower part of the village. The main products were vegetables, maize and tobacco.

We interviewed 30 tube well owners. Each owner had one tube well. The land holding size

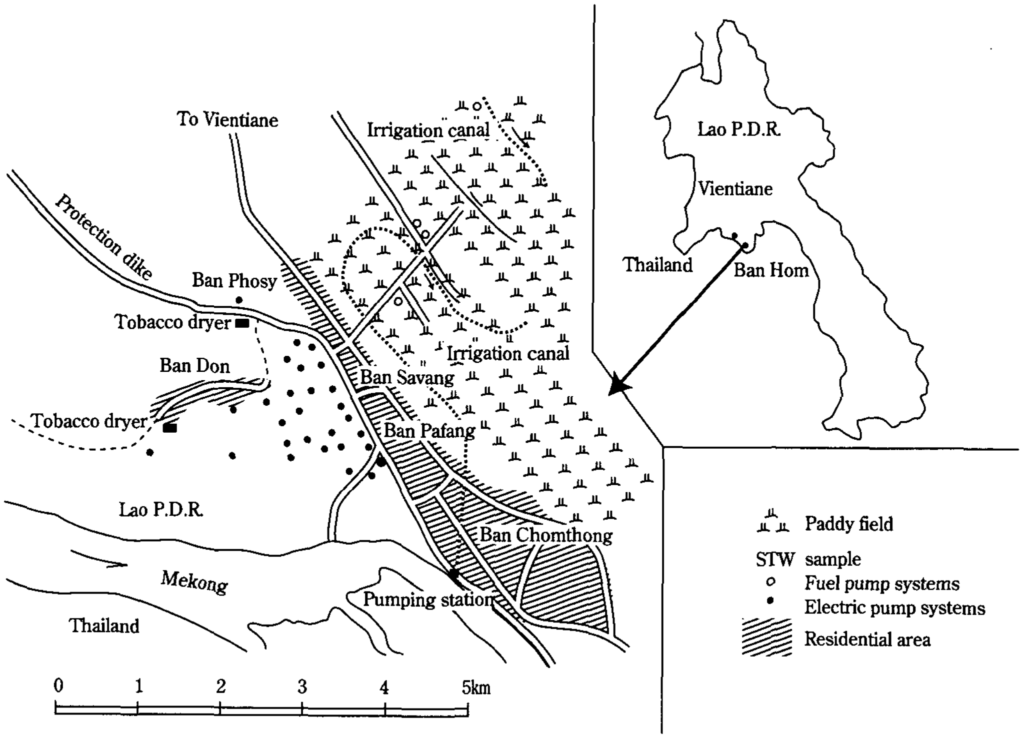


Figure 1　Study area map

varied from 0.12 ha to 4.4 ha, with an average of 1.47 ha. The land irrigated by shallow tube well varied from 0.12 ha to 1.5 ha, with an average of 0.6 ha. These statistics show that this well is an appropriate technology for the small scale farming.

Four of the wells in the south were run by fuel pump and total command area was 5.75 ha. This command area comprised 2.2 ha of upland, 3.55 ha of paddy usable during the wet season, and 1.56 ha of paddy usable during the dry season. The rest of the pumps were electric. The total command area of the electric pumps comprised 12.26 ha. The main crops in this area were green vegetables, coriander, caraway, green onion, lettuce and peppermint. During the interview, we collected the plot wise data[1], which is related to the 1995 crop year.

3.2 Cropping pattern and vegetable production

Laos has a typical warm humid tropical climate. The dominant climate is tropical monsoon. There are two distinct seasons, the rainy and wet season and the cold and dry seasons. The wet period lasts from May through October and the dry one from November through April. About two-thirds of the 100–150 rainy days in a year occur during the rainy season, with the amount of precipitation outside the wet season only 20 percent of the total annual rainfall.

The rice crops in both the paddy fields and the upland clearing are of course dependent on this rainfall pattern. The average rainfall for the country is 1953 mm per year. In each region, the distribution of rainfall is different in the peak period from June to September. However, approximately 200 mm per month is needed to maintain flooded-paddy or deep-water rice production.

Figure 2 shows the cropping calendar. By late May, the rain has begun to soften the ground. Wet rice is rain-fed lowland rice cultivated during rainy season. Cultivation starts with a seedling. The young seedlings are ready for transplanting after four to six weeks. The rice matures in 150, 120, or 90 days, according to the rice variety. Usually all harvesting is complete by December. After harvesting monsoon rice, the farmers continue to grow irrigated rice and tobacco or vegetables. Tobacco[2] and vegetables are a cash crop. The tobacco transplanting takes place in late October and early November and the first tobacco leaves are harvested in the early January with all being completed by the end of April.

In the areas where irrigation is possible, seedling for the second rice are started in early December. The transplanting starts in early January and ends in the middle of February. The harvesting period lasts from the late April to early May.

Upland crops are the most important cash crop in this region. There are a wide variety of vegetables, including peppermint, coriander, caraway, green onion, green leaf vegetables, garlic, lettuce,cabbage, tomato, corn and celery. Although from mid August to late September part of the upland area is flooded, vegetables are produced throughout the whole year. While almost all of the vegetables are sold to the Vientiane Municipality markets, The rest are sold in the close provinces.

4 Physical characteristics of STW irrigation schemes

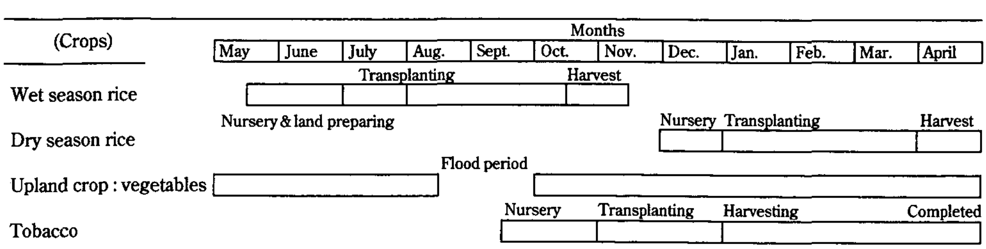
The shallow tube wells in Ban Hom are of two types. One is the fuel operated system (FPS) and the other is electric pump operated system (EPS). The average command area is 1.44 ha for FPS and 0.47 ha for EPS. The physical and technical characteristics of these wells in Ban Hom at the time of our survey are shown in Figure 3 and Table 2. The FPS consists of a hold, a conveyance system (conduction pipe), a distribution system (hose) and a fuel pump. Temporary small ditches are made to distribute irrigation water to the plots. The EPS consists of a hold, a conveyance system, a distribution system, an electric pump or dynamo pump and an electric grid.

The fuel pump engine is 5 horse power in average, usually the fuel pump engine has a 5 horse power engine, whereas the electric pump[3] is 3 hp. The life span is 10 years for the fuel pump and six years for the electric pump. The average of the depth hold is 12.2 meter for FPS and 14.4 meters for EPS respectively. The length of the conduction pipe varies depending upon the irrigated area and the location of the well. The average length is 135 meters for FPS and 153 meters for EPS, respectively.

5 Cost benefit analysis of STW scheme

5.1 Investment Cost of STW

For the farms we surveyed, the investment



Source : Field survey 1996

Figure 2 The seasonal cropping pattern in Ban Hom.

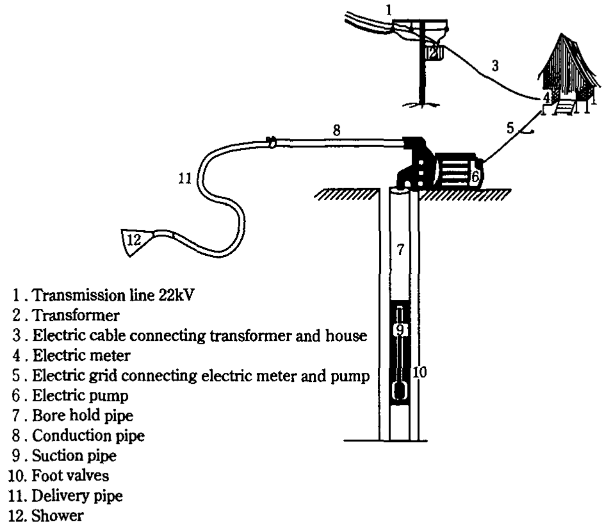


Figure 3 Tube well, pump and electric system

Table 2 Physical and technical characteristics of shallow tube wells in *Ban Hom*, 1995

Characteristics	Units	Fuel operated	Electric operated
Number of sample	no.	4	26
Average horse power	hp	5	3
The life cycle	year	10	6
Average command area in rainy season	ha	1.437	0.47
wet season rice	ha	0.887	0
— in dry season	ha	0.94	0.47
dry season rice	ha	0.39	0
Average depth	m	12.2	14.4
Average length of conduction pipe	m	135	153
Average length of the electric grid	m	—	143
Average electricity consumption	kW/month	—	208
Average gasoline consumption	l/day	3	—

Source : Field survey data, 1995

cost of the shallow tube well irrigation consisted of two parts : The initial investment cost, and the operation and maintenance costs (O & M). The relevant costs were calculated based on the farm survey results.

Table 3 shows the initial investment cost, which included the hold, pump, electric grid, conduction pipe and hose. An average construction cost per hectare was 727,000 Kips for EPS and 331,000 Kips for FPS. The bore hold cost of FPS was 74 percent that of EPS. The low cost of the FPS was the cause of its initial popularity. The cost of the pump was calculated to include the sum of the expenses for the pump, as well as for the suction pipe and foot valves. The price of fuel pump was five times higher than that of electric pump. Even so, the operating cost per hectare using the electric pump was only 1.6 times higher than that when using the fuel pump. The electric cable connects the electricity meter to the electric pump, and varies in length from 10 meters to 600 meters. The cost for the cable included the necessary

Table 3 Average initial investment costs of shallow tube wells operated by fuel and electricity in *Ban Hom,* 1995

Items	Fuel pumps		Electric pumps			
	Kips/unit	Kips/ha	Kips/unit	Kips/ha		
	(a)	(b)	(c)	(d)	(a)/(c)%	(b)/(d)%
Bore holds	129,204	89,913	173,738	369,657	74	24
Pump	209,627	145,878	41,704	88,732	502	164
Electric grid	0	0	37,572	79,940	–	–
Conveyance system (PVC pipe)	109,626	76,288	53,876	114,629	203	67
Hose	28,591	19,896	35,041	74,555	82	27
Total	477,048	331,975	341,931	727,513	140	46

Source : Field survey data, 1995

Table 4 Average operation and maintenance (O & M) costs of the shallow tube wells in *Ban Hom,* 1995

	Fuel pump operated systems		Electric pump operated systems	
Cost items	Kips/unit	Kips/ha	Kips/unit	Kips/ha
Repairing	–	–	3,910	8,320
Spare part	749	521	5,444	11,582
Lubricant	1,549	1,078	153	326
Electric power	–	–	18,624	39,625
Miscellenous	3,023	2,104	4,037	8,589
Gasoline	134,652	93,704	–	–
Mobile	9,796	6,817	–	–
Total	149,769	104,224	32,168	68,442

Source : Field survey data, 1995

switches,and bamboo electric poles and was calculated to be 35,000 Kips per unit and 79,000 Kips per ha on average.

The cost of the fuel conveyance systems included the conduction pipe (PVC pipe).The price of this conduction pipe was 2.18 times higher than that of the EPS. Because the size of the pipe was bigger, the price per unit was greater. Almost all PVCs imported from Thailand in 1992 were expensive, costing 130 Baths (4,810 Kips) per unit. The average length of the conduction pipe was longer for EPS, because 30 percent of the farmers who adopted the EPS installed their tube wells nearby their home. The average cost of conduction pipe per unit was cheaper because the price of PVC pipe was cheaper (Since 1993, PVC pipes have been produced in Laos). The cost of conduction pipe per hectare was 114,000 Kips for EPS and 76,000 Kips per hectare for FPS. Almost all of the farmers surveyed preferred PVC pipe,because the conveyance loss of PVC was less than that of the irrigation canals. PVC conveyance systems were also able to conserve cultivated land because these pipes were laid directly on the path trail.

EPS was mainly used to irrigate vegetable beds in Ban Hom. The length of the hoses connecting the conduction pipe varied from 50 to 100 m in length, depending on the distance between the pump and the vegetables beds. On the contrary, FPS was used for both rice and vegetable production, and both were located near the pump. The distribution cost (hose) per hectare was 74,555 Kips for EPS, and 19,896 Kips for FPS, respectively.

The O & M costs for EPS included the expenses for repairs, lubricant, electric spare parts and others. The O & M costs for FPS included repairs, spare parts, lubricant, gasoline, mobile oil and others (Table 4). These costs amount to 68,000 Kips and 104,000 Kips per hectare, respectively. The operation cost was higher for FPS than for EPS because gasoline was more expensive than the electric power at the time of our survey.

We estimated the electricity cost for EPS by comparing the expenditure for the electricity before and after the introduction of the electric tube well. We calculated the average daily consumption of gasoline to estimate the annual consumption of gasoline, including mobile oil and lubricants. The price of gasoline was 250 Kips per liter, whereas electric power price was 8 Kips for 0–100 kW, 15 Kips for 101–200 kW, and 25 Kips for over 200 kW. The cost of gasoline accounted for 90 percent of the O & M cost for FPS, while that of the electric power accounted for only 58 percent of the O & M cost for EPS. Thus, the cost of gasoline has a critical influence on the profitability of FPS.

5.2 Cost and return of crop production

Most of the farmers surveyed were responsive to the price of vegetables and they planned the production schedule according to their market information. The farmers sometimes even discarded the vegetables when the price dropped too low. The vegetables were bought by the *talat* (market) vendors[4)] or contractors. The vendors are almost all women known as Mekha who live in the local village. They make direct contact with the farmers in the fields or at home and even harvest by themselves when they buy vegetables.

The index of land productivity was estimated from the total sales to the vendors. It was difficult to ask the farmer which and how many vegetables they grow, because they grow various kinds of vegetables continuously in each small parcel of land, in order to avoid the risk of price fluctuation. The home consumption of vegetables was approximately 0.5–1.0 percent of the total value of vegetable production and therefore neglected. The total cash income is an alternative way of estimating the value of production.

The estimated results are shown in Table 5. Implementation of the shallow tube well irrigation systems in Ban Hom dramatically increased profits for these farmers. Before adopting this new irrigation system, the revenue earned by the farmers was negligible-Vegetable production by EPS was the most profitable-four times that of the wet rice area and two times that of production by FPS. EPS was so profitable because the farmers used this system for the irrigation of vegetables, which are almost always sold at a profit, whereas the fuel pump system was mainly used to irrigate rice and vegetables.

The variable costs of production consist of seed and seedling materials, fertilizer, chemical inputs and labor. Fixed costs include land rent and interest of capital. The important variable cost is family labor. The period of engagement in upland crops cultivation was substantially longer than that of the rice production. After harvesting the rice, all family members engaged in gardening. FPS labor input per hectare and its estimated cost was 330 man days and 385,000 Kips ; EPS labor input per hectare and its estimated cost were 606 man days and 707,000 Kips.)

Although the farmers often produce their own seed and seedling materials, the cost of these materials is still the second largest in the total cost of production. Vegetable seed material cost 393,000 Kips (cost associated with EPS), whereas rice seed material, which is less expensive, cost only 180,000 Kips (cost associated with FPS)

The contribution to revenue of land ownership is evaluated using the average land rent in each area. The rent was higher in the EPS area than in the FPS area. The contribution of owning capital is assumed to be zero, because the construction facilities used by the farmers were negligible. In addition, none of the farmers owned farm machinery such as tractors.

The total cost per hectare was 1,773,000 Kips for EPS and 851,000 Kips for FPS respectively. Revenue minus cost is net revenue. Details are shown in Table 5.

Table 5 Average profit of crops production in the command area of shallow tube in *Ban Hom*

(Kips/ha)

Items	Before STW irrigation schemes	Shallow tube well: Fuel pump	Shallow tube well: Electric pump	**Wet season rice	***Dry season rice (Irrigated rice)
Average revenue (1)	450,000	1,172,870	2,388,091	534,782	613,191
Yield (t/ha)	–	–	–	3.06	3.5
Average cost (2)	436,618	851,177	1,773,759	339,637	551,695
Seed material	72,500	180,609	393,654	20,209	35,186
Fertilizer	35,000	66,157	131,668	23,496	75,585
Pesticides & Insecticides	13,750	28,452	80,220	–	–
Rice bran	15,600	36,870	98,124	–	–
Family labor	268,896	385,009	707,202	131,700	116,700
Hired labor	0	2,609	2,447	74,726	134,468
(Average labor input, man-day)	(226)	(330)	(607)	(100)	(100)
Buffalo power	15,625	–	2,855	25,638	4,680
Tractor	–	37,500	65,824	28,625	74,468
Land rent	–	81,597	214,286	17,874	51,489
Interest repayment (10%)	15,247	32,374	77,479	17,369	34,864
Water fee	–	–	–	–	24,255
Average profit* (3)	13,382	321,693	614,332	195,145	61,496
Average profit/unit	(6,290)	(452,272)	(288,736)	(173,093)	(23,983)

Source : Field survey data, 1995

Notes : * Average profit (3) is average revenue (1) subtracted by average cost (2).

** Under and outside command area of government managed irrigation schemes.

*** Under command area of government managed irrigation schemes.

Average cost does not include STW initial investment and O & M costs. Own land rent evaluated using average land rent.

6 Calculation of BC ratio and internal rate of return

The benefit of STW irrigation investment is the change of the profit (net revenue) of production, which is derived by subtracting the average cost from the average revenue. The profit made on vegetable production prior to EPS installment was negligible since this profit was the residuals of home consumption. The profit made on rice production prior to FPS adoption was calculated as the sum of wet rice profits plus dry rice, irrigated by irrigation canal. Therefore, the benefit foregone was assumed to be the average revenue of rice production during the wet and dry seasons.

The net benefit was higher in EPS than in FPS. The net benefit of FPS per hectare was 321,000 Kips-half that of EPS. The profit pre-STW was only 13,000 Kips, because most of the cultivated area had been left fallow before these wells were constructed. The net benefit per hectare increases from 13,000 Kips to 614,000 Kips using EPS.

Benefit of FPS = Profit of FPS − Profit of wet season rice − Profit of dry season rice

Benefit of EPS = Profit of EPS − Profit before STW

The investment cost is the sum of initial investment and O & M. The life span of each item is assumed as follows : STW, 10 years ; engines, 10 years ; dynamo, 6 years ; electric grid, 10 years ; conduction pipes, 10 years ; horses, 3 years. The salvage value of the capital cost is assumed at 10 percent for fuel pumps and 5 percent for electric pumps. The engine repair cost is assumed at 10 percent of the engine cost every 6 years. The overhauling of dynamo is needed every 6 years and the hose is replaced every 3 year.

The discount rate was set at 10 percent that is prevailing agricultural credit interest by Extension Agricultural credit system, for calculating the benefit cost rate (BCR). The internal rate of return is estimated by a trial and error procedure until the positive and negative of net present value is found[5].

Table 6 shows that both tube well systems are profitable. The cost-benefit ratio at a 10 percent discount rate for EPS and FPS is 3.1 and 1.1 re-

Table 6 The benefit cost ratio (BCR) and internal rate of return (IRR) of the studied shallow tube wells irrigation schemes in *Ban Hom*

Tubewell type	BCR at 10%	IRR %
Electric pump operated	3.07	77.02
Fuel pump operated	1.14	18

Source : Table 3, 4 and 5

Note : Calculated per unit

A. Benefit-cost ratio (BCR),

$$\sum_{t=0}^{10}\frac{B_t}{(1+r)^t}\Big/\sum_{t=0}^{10}\frac{C_t}{(1+r)^t}$$

B_t : Benefit=Profit in Table 5.

r : Discount rate (10%).

t : Duration of times (10 years).

C_t : Initial investment and O & M cost (Table 3 and 4).

B. Internal rate of return (IRR) λ

$$\sum_{t=0}^{10}\frac{NB_t}{(1+\lambda)^t}=0$$

NB_t : Net benefit

$NB_t=B_t-C_t$

spectively. The internal rate of return is 18 percent and 77.0 percent, respectively for the FPS and EPS. The internal rates of return for both FPS and EPS exceed the 10 percent interest rate, which indicates that both EPS and FPS are more profitable than any other kind of investment.

Before the diffusion of tube wells, most family labor was unemployed during the dry season. If we consider the family labor input for irrigated cultivation, the widespread adoption of tube wells has an indirect benefit. When the marginal productivity of labor increases from zero to positive, the new shallow tube well program is adopted.

7 Concluding remarks and policy implications

The shallow tube well irrigation system in Ban Hom is a small scale scheme. In which farmers can invest individually. The shallow tube wells were adapted at first in paddy fields where not enough water can be irrigated to grow rice during the dry season. The use of these wells has since spread rapidly throughout the upland.

The crops cultivated by these farmers have been changed from rice to cash crops and consequently, land productivity has increased drastically. The investment in shallow tube well irrigation systems using electric pumps is more profitable than that of using fuel pumps in terms of BCR and internal rate of return. These systems gained popularity after the economic liberalization in Laos. The economic policy change affected also irrigation policy. The government is encouraging farmers and farmers' groups to participate in the management of irrigation systems (MAF [10]).

The government invested a great deal in natural gravity irrigation systems, constructing weirs and pumping irrigation systems from the Mekong and its tributary. The irrigation canal construction cost per hectare was approximately $3,500 U.S. The investment cost of the government irrigation system was five times higher than that of the STW system in Ban Hom. The maintenance and upkeep of farmer-implemented STWs is much better than that of the government irrigation system (Coward [2]).

The advantage of the shallow tube wells is that they provide water for the production of crops throughout the year. If the price of vegetables should fluctuate, farmers can adjust their production depending on the price signals of the previous year.

The shallow tube well irrigation schemes for upland crops are advantageous in locations close to market places and accessible to local road. These wells also make it possible for the farmer to grow other profitable crops, the demand for which is increasing, such as potatoes, maize, and so forth.

Evidence shows that the electric pump system is more profitable than the fuel pump system. The BCR at 10 percent of discount rate is 3.0 in EPS and 1.1 in FPS. The internal rate of return (IRR) is found to be higher in both STW systems than the interest rate of the agricultural extension credit. An indirect benefit is also observed in the creation of employment for idle family labor throughout the year with the production of vegetables in the irrigated fields.

This study has shown that systems operated by electric pump are more cost efficient than those operated by fuel pump. Because electricity and gasoline influence the operation cost greatly, electric operated pump systems are advantageous. The price of electricity is cheaper than that of gasoline. On other hand, fuel pumps are used to irrigate rice field. The price of rice will influence how beneficial the fuel pump operated systems are.

The physical conditions in Laos have a high potentiality for the development of hydroelectric power (MAF [8]). Both making use of this potential, and increasing the number of EPS irrigation schemes, are critical to the agricultural development in this country. These hydroelectric power stations (dams) will provide underground water to the tube wells.

The extension of shallow tube well schemes should be an integral and equally-funded part of the national project, which includes the reduction of forest degradation and drug control. Institutional credit should be established for farmers who intend to invest in irrigation. An electric power grid should be supplied for irrigation purposes by the government. A comprehensive ground water survey should be made by the organizations concerned about the efficient utilization of the tube wells.

A new irrigation development policy that encourages the participation of farmers, agricultural groups, community groups and the private sector is essential for irrigation development in Laos. This study clarified that the Ban Hom farmers' initial investment in STWs has created a great potential for extending more shallow tube wells into other areas of the country.

We would like to suggest that the most important factor is infrastructure, specifically the road network, in the promotion of shallow tube well irrigation systems. Roads to the market play an important role for STW irrigation extension. Roads connect the middlemen or mekha to the producer. The producers can sell their products directly to the market as well.

Well-maintained roads help reducing the cost of transportation, operation and maintenance (O & M), and energy, and consequently, reduce the costs to the producers and consumers.

NOTES

1) The lancl holding of the paddy field parcel is known in Laos the *Phanh*. The surface measurement is hectare. The *phanh* ranges from large to small in size, and is divided into plots. Around the plot a dike is established to keep water for rice cultivation and to create a pathway, but land used for vegetable cultivation is called *Tone* (parcel). The surface measurement is *Lai* or hectare.

2) Tobacco is one of the primary cash crops in Ban Hom. Although seedlings are sometimes sown in small seed beds by farmers in mid-September, they are most often prepared in a tobacco-dryer factory. Three years ago seedlings had been given at no cost to the farmers who produced tobacco for the factory but in 1995 the factories began selling the seedlings at the price of one for a Kip. During the time of our survey, the areas used for tobacco cultivation were almost all close to the Mekong River, from which water is more easily provided by low-lift pumps. Water was sold by the pump's owners; the prices per 1000 hold of tobacco differed depending upon the distance of the cultivated area from the pump: 2000 Kips, 2500 Kips, and 3000 Kips for closer areas, middle and further areas, respectively. The category for the tube well area is 3000 Kips per 1000 holds.

3) Electric pumps are fundamental to the operation of the tube well system in Ban Hom. The capacity of electricity consumption is 750W with 220–240V type of electricity, and surface installed by suction pipe ϕ 2 inches.

4) Who would transport the most of the vegetables to the *Khapachams* retailers and some to the *feu* restaurants. Farmers also bring the vegetables to markets. In addition some vegetables were sold door-to-door by stroller sellers. The customers and restaurants bought vegetables at nearby markets called talat.

5) In detail, see Lee, F. et. al., [7] p. 65.

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