10 Characteristics and economic benefits of small farm ponds in Southern Laos

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Abstract

In rural Lao PDR farm ponds and small reservoirs, allow farmers in rainfed lowland rice-based farming systems to capture rainfall, and to divert and conserve water from other areas and then use to supplementary irrigate short duration dry season crop production or support aquaculture with products destined either for local markets or for home consumption. The South Lao PDR region has a tropical monsoon climate where more than 85% of the rain falls during the months of May-September. Average annual rainfall is 1000-1500 mm. Harvesting rainwater in ponds for agricultural production is commonly practiced to support food security and generate extra income farmers. This study was conducted to provide baseline information on pond characteristics, its multiple-roles in the farm enterprise and the economic benefits derived from its use Savannakheth and Champasack provinces. A household survey was conducted in Savannakhet (Outhoumphone and Champhone Districts) and Champasack (Phonethong and Sukhuma Districts) provinces that included 222 randomly selected households. Seven ponds were used where instruments were installed to measure and record water levels so non productive water losses could be identified and quantified. Cropping systems in the adjacent areas was also monitored for water use. Farms with ponds tend to have better household income largely from crop production and fish culture. On average, total income of farms with ponds ranged from 15-23 million LAK. Farmers with the highest income were in Phonethong district where they generated revenue by selling their dry season crops irrigated by pond water such as vegetable. For the non-pond farms, total farm income ranged from 11 -13.4 million LAK. Rice and off-farm incomes still represent important proportions of total income among farmers ranged (23-28%) and (33-60%), respectively. Ponds owned by sample farmer-respondents in 4 districts varied in size ranging from 1,324 - 2,442 m^2 per household. The water-land ratio (an important indicator of resource allocation for a farmer) was highest in Phonethong (9%) district due to the extent of vegetable irrigation from pond. Farmers with ponds used water from ponds for raising fish, home garden and vegetable growing, rice seedbed irrigation, and source of water for animals. In terms of pond water dynamics, the results of the survey indicated that about 48% of ponds don’t hold water throughout the year. In general, water availability tends to increase with depth of the pond, though other factors may affect water availability of the pond, including total volume, surface area, soil and leakage, cropping systems and utilization for other purposes. The results of the study are vital in identifying management strategies to improve the water use efficiency and water productivity in farm pond through modelling exercise

Introduction

Land and water resource use is central to the challenge of improving food security across the world. Demographic pressures, climate change, and consequent increased competition for land and water are likely to increase vulnerability to food insecurity, particularly in Africa and Asia (FAO and WFP, 2011). Worldwide, water for agriculture is declining (Rijsberman 2006), while population has continued increasing (FAO and WFP 2011). The challenge of providing sufficient food for everyone worldwide has never been greater.

Rainfed agriculture is the predominant agricultural production system in the world, but also hosts the majority of the rural poor. In Laos, agricultural production largely relies on rainfall during monsoon season. However, rainfed production is dependent on erratic rainfall. Unpredictable rainfall may lead to drought or floods which may have devastating effects on crop growth and development. Fluctuating soil moisture availability over the course of a growing season may reduce nutrient uptake and, consequently, yields. The Southern Lao PDR region has a tropical monsoon climate characterized by distinct a wet season (April - November) and dry season (December - March). The average annual rainfall ranges from 1000-1500 mm with more than 85% of the rainfall occurring from May to September. Savannakhet and Champasak provinces, located on the left bank of the Mekong River in southern Lao PDR, are predominantly rainfed lowland rice production areas. Availability and access to water has been identified as major constraints for the rice-based farming systems in these provinces.

The concept of irrigation from ponds for a community-based development is not new. Farmers in some countries in Asia such China, India, Sri Lanka and Thailand, have been using ponds to capture rainfall, store surplus water for agricultural production such as cropping and animal husbandry (Shahbaz Mushtaq *et al*., 2006; Shahbaz Mushtaq *et al.,* 2007; Pandey, 1991; Penning de Vries and Ruaysoonnern, 2010). Supplementary irrigation provided by farm ponds at critical stages of crop growth is a practice which can generate significant increase in crop yields and income (Li et al, 1999). However in Lao PDR, lack of understanding among farmers on the availability, use and management of stored water in the small farm ponds limits the potential benefits of the water resource in the area. Up to now, no research has been yet undertaken which examines the impact of small farm ponds on production and farm income. This paper aimed to investigate the economic benefits and baseline information on the use and management of the farm ponds by farmers in the study area.

Metholology

A household survey was conducted in Savannakhet (Othoumphone and Champhone districts) and in Champassak (Phonthong and Sukhuma districts) to investigate the socio-economic and demographic characteristics (age, level of education, household size, etc.) of farmers using pond irrigation within their farmsteads, and to capture the hydrological and physical characteristics and the multiple-purpose uses of farm ponds. With the village heads and DAFO's assistance, a total of 23 villages were randomly selected in the conduct a field survey. In these villages, individual farm ponds are widely constructed, and farmers are actively using them for productive purposes.

A structured questionnaire was developed and pre-tested before conducting the field survey. Information such as socio-economic conditions, cropping farming patterns, farm inputs and outputs, sources of water and its multiple-purposes, pond characteristics and irrigation, and pond management were collected. About 222 farmer-respondents were randomly selected for household survey with the predetermined criteria (having a pond within a farm and using pond water for cropping; rice as main product in wet season). The farmer-respondents were divided in two groups: farmers with pond farms (188) and farmers with no-pond in their farms (34).

In addition to the household survey, seven (7) farm ponds, and their adjacent crop production areas, in Champassack and Savannaket were selected for detailed monitoring of pond water levels and crop production systems. Automatic water level loggers were installed in the selected ponds in 2011 to monitor fluctuations of pond water levels at an hourly interval, and were regularly downloaded and analysed.

Results and Discussion

Household and farm characteristics

Farmers with ponds had higher average farm sizes in Champhone and Othoumphone districts (Table 1). Size of paddy fields varied from district to district, with Soukhuma having smallest area per household. In all districts, household size was about 6 to 7 members. Farmers produced mostly rice, vegetable and fish within their farms. Soukhuma district farms had the highest rice production (2.5 t/ha) among all districts. Average rice yield in other districts was about 2 t/ha. Rice was largely grown for home consumption in rainfed lowland rice production systems. However, a few farmers with surplus rice sold these on the local market. Vegetables were considered as an important source of additional income in the farm but these were mainly produced in the dry season.

Table 1: Averages of characteristics of the farms in our survey (mean and standard deviation)

Case/feature	Phonthong	Sukhuma	Champhone	Othumphone	Pond farm	No-pond Farms
Total Farm size (ha)[1]	3.0 ± 2.1	2.1 ± 1.1	4.1 ± 3.4	4.5 ± 2.5	3.4 ± 2.3	1.7 ± 1.4
Paddy land (ha)	2.7 ± 1.7	1.9 ± 0.9	3.1 ± 1.9	3.7 ± 2.1	2.9 ± 1.7	1.6 ± 1.0
Household size (heads)	6.2 ± 1.7	6.5 ± 1.4	6.2 ± 1.5	6.9 ± 1.9	6.5 ± 1.6	6.4 ± 1.9
Member aging (15-60)	4.2 ± 2.1	4.7 ± 1.7	4.3 ± 1.3	5.2 ± 1.6	4.6 ± 1.7	3.9 ± 1.9
Rice yield (tons/ha)	1.7 ± 1.0	2.5 ± 2.0	1.9 ± 0.8	2.0 ± 0.9	2.0 ± 1.2	1.9 ± 0.7
Value of livestock (millions LAK*)	3.5 ± 8.7	8.2 ± 8.2	7.9 ± 8.5	13.9 ± 10	8.4 ± 9.0	3.4 ± 6.3
Produce	vegetable, rice, fish	vegetable , rice, fish	vegetable, rice, fish	vegetable, rice, fish	vegetabl e rice, fish	vegetable , rice
Farm income (% of total without livestock)	54	29	47	52	46	28

Note: * LAK is a Lao currency, 1US$ is equal 8,000 LAK (exchange rate in August, 2012).

Livestock was considered important because it was a form savings (particularly cattle). The value of livestock was higher in Outhoumphone and Soukhuma districts compared to other districts because of the availability of extensive grazing areas during the dry season. Livestock sold (mainly pigs, poultry and goats) accounted for the highest proportion of farm income in Phonethong district (12%) (Table 2).

Table 2: Decomposition of 2012 household income* (Pond and non-pond farms)

District	Total income (million LAK)	%Rice	%Livestock	%Agricultural income	% Other income**
Phonethong	22.3 ± 1.1	22	12	33	33
Sukhuma	15.8 ± 1.3	20	5	9	66
Champhone	18.1 ± 1.6	27	3	20	50
Outhoumphone	17.8 ± 1.2	30	6	22	42
Non-pond Farmers	13.1 ± 1.4	26	8	4	62

*Total household income is comprised sales of rice, vegetable, poultry, cattle, pig, goat, fish and non-agricultural revenue in 2011. It means total revenue received in cash.

**It is comprised remittance, regular salary and groceries 'sales (produce sold).

Total income of farmers with ponds ranged from 15-23 million LAK (Table 2). Farmers having the highest income were in Phonethong district where they generated revenue by selling their farm products to Pakse city and to the border traders of Thailand. Farmers sold vegetables produced using water from ponds in both wet and dry seasons respectively, However, some vegetable farmers restored to using groundwater to supplement irrigation during the dry season when pond water was scarce (e.g. Phonethong district).

Rice represented an important proportion of total income (23-28%) among farmers with farm ponds. In many households, rice was considered as a main source of cash especially in emergency case. The percent contribution of agricultural income (excluding rice) to total income of farmers with pond ranged from 12-44%, while non-agricultural income contribution ranged from 33-60%. Soukhuma district has the lowest total income among the 4 districts. Farmers in this district were highly dependent on off-farm income which was mostly derived from remittances from children working outside the district. For non-pond farms, off-farm income represented a greater proportion (65%) of their total household income.

Sources and uses of water in farmsteads

Table 3 and Table 4 show the sources and uses of water in farmsteads "with ponds" and "without ponds". In both cases, the source of water for household use (drinking/cooking) were deep wells, harvested rain stored in jars, especially from June to September, and commercially bottled water sold by the local private companies. Farmers used ponds for raising fish, irrigating home gardens and vegetable gardens, rice fields, and as a source of water for animals. Water drawn from ponds was mostly used by farmers for rice seedbed preparation and as a source of supplemental irrigation during dry spells in the wet season.

Table 3: Percentage of farmstead which uses that source of water for a particular purpose. Sources of water (vertically) and its uses (horizontally) on irrigated farms.

Source and purpose	drinking, cooking	other domestic uses	home garden	vegetable	Livestock	Fish	Rice
Jar (roof)	41	17	2				
Bottle water	65	2					
Tap (piped water)	15	15	2	2	2		
Shallow well	14	7	2	1			
Deep well	72	73	37	15	27	2	2
Public canal	2	2	1	1	1		7
Pond		16	69	20	34	89	46
Run-on water			2	2	1	1	2
Green water			98	69	95	98	99

Table 4: Percentage of farmstead which uses that source of water for a particular purpose. Sources of water (vertically) and its uses (horizontally) on no-pond farms.

Source and purpose	drinking, cooking	other domestic uses	home garden	vegetable	Livestock	Fish	Rice
Jar (roof)	48	26	3		6		
Bottle water	62						
Tap (piped water)	12	15	6		3		
Shallow well	3	3	6				
Deep well	65	68	48	15	29		
Public canal		3	3				6
Pond							
Run-on water			3	3		18	
Green water			94	59	79	18	94

Pond characteristics

Ponds owned by farmer-respondents in 4 districts varied in size, ranging from 1,324 - 2,442 m^2 (Table 5). The water-land ratio (an important indicator of resource allocation by a farmer) was highest in Phonethong (9%) district where ponds supply water for vegetable production. A majority of farmers reported that their ponds have a sandy soil base. They claimed that this is one of the reasons why many ponds in their areas could not hold water throughout the year. In terms of construction, among the 188 farm ponds surveyed, 79% of ponds were constructed, 16% semi-constructed, and 5% are natural ponds. Almost all constructed ponds were excavated by a number of road construction companies operating in the area. The excavation costs were mostly free of charge in exchange for the excavated soil which was hauled away for road construction. This arrangement has been continuing since the early 1990's. Only about 5% of these ponds were constructed and paid by farmers at their own expense. About 34% of ponds were less than 5 years old, 21% were 6-10 years old, and 36% were 10-25 years old.

Table 5: Pond characteristics in the four districts (mean and standard deviation)

	Phonthong district	Sukhuma district	Champhone district	Uthoumphone district
Pond area (m2)*	1,325 ± 1,044	1,039 ± 1,551	2,442 ± 8,265	2,014 ± 2,577
Depth (m)	2.3 ± 1.2	1.9 ± 0.7	1.8 ± 0.6)	2.1 ± 1.0
Storage Capacity (m3)	3,265 ± 3,324	1,798 ± 2,790	4,422 ± 14,267	4,282 ± 6,332
Land-Water ratio**	0.09 ± 0.15	0.05 ± 0.06	0.06 ± 0.10	0.05 ± 0.06
Category***	medium	medium	medium	medium

Note: *Total surface is obtained by multiplying the width and length of a pond measured in the field

**Ratio is the pond surface area over the farm area, e.g. a ratio of 0.1 means the pond size (surface) is 0.1 ha of the farm area of 1 hectare.

***Classification of pond capacity: small pond has a storage capacity is less than 1,000 m^3, medium pond has a storage capacity between 1,000 and 10,000 $m^{3,}$ while large pond has more than 10,000 m^3 (Shahbaz Muzhtaq et al., 2007).

Benefits from ponds and total farm income

Farms without a pond grew fewer vegetables and had no surplus to sell, particularly in the dry season (Table 6). The sale of fish was an extra source of income for farms possessing ponds. Farmers without ponds in their fields were able to engage in the sale of dry season rice because they were located within the command area of a government irrigation system in Champhone district. Rice production in wet season was an important crop/commodity in all cases.

Table 6: Annual income of pond-farms in the four districts and of no-pond farms (million LAK)

Source of income	Phonthong	Sukhuma	Champhone	Uthoumphone	Average pond farms	Average no-pond farms
DS vegetable, sale	5.1	0.4	0.5	1.8	2	0
WS vegetable, sale	2.3	0.2	0.1	1.3	1	0.4
Fish, sale	0.3	0.9	3.3	1.6	1.5	0.0
DS rice, sale	0	0	1.2	0	0.3	0.2
WS rice, sale	5.1	3.5	4.2	6.6	4.8	3.8
Livestock, sales	2.9	0.9	0.6	1.3	1.4	1.2
Farm income (sum)	15.7	5.9	9.9	12.5	11.1	5.9
Off-farm income	7.9	11.5	9.9	9.2	9.6	9.6
Total income	23.6	17.5	19.8	21.8	20.7	15.5

Notes: DS and WS are abbreviated of dry season and wet season, respectively.

Off-farm income accounted for 30-65% of total farm income. This fraction tended to be larger on farms without ponds. Off-farm income consists of payments for part-time or short-time jobs of household members and significant remittances by family members. Nine of ten households had at least 1 family member working in Thailand and sent money to the family.

Farm income per household, including the value of home consumption, was over 10 million LAK (US$1,250) for farms with ponds and less than half of this on farms without ponds.

Water availability and period of drought

About 60% of farmers with ponds reported having enough water during crop production periods (DS and WS) and covering a year (12 months). Only 41 percent of farmstead ponds did not have water available for cropping. Among those ponds that did not have enough water throughout the year, about 70% were already dry in March. These ponds started to be filled up when rainy season begins from the last week of May to early June.

Figure 1 shows the relationship between depth and water availability (possible water volume to cover the dry season crops from November to April) in the 188 farm ponds surveyed. There was no clear relationship between depth and water availability in all cases. The survey data showed that many ponds with shallow water depths (1 to 1.5 m of depth) retained water throughout the year.

Depth of pond

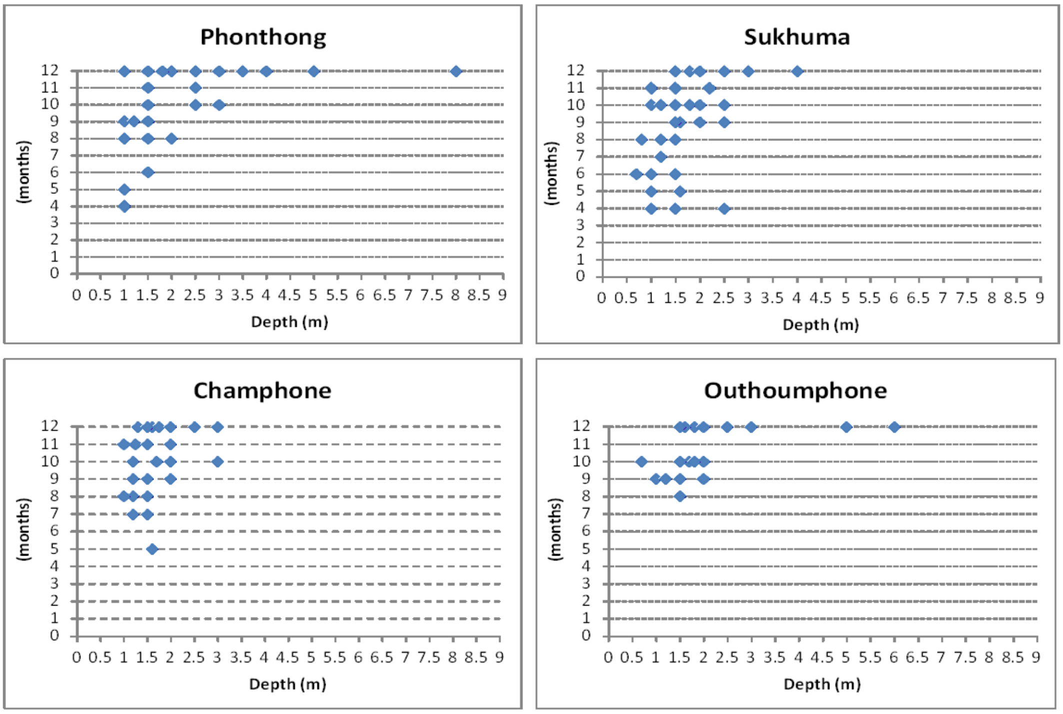

Figure 1: Scatter diagram showing the relationship between depth and water availability of pond.

Figure 2 shows that the higher the storage capacity of the pond, the longer it can store water throughout the year. Most of farmers reported that shallower depths, small sizes of ponds, and high percolation rates were the main factors for lack of water in their pond for whole year.

Capacity of water storage

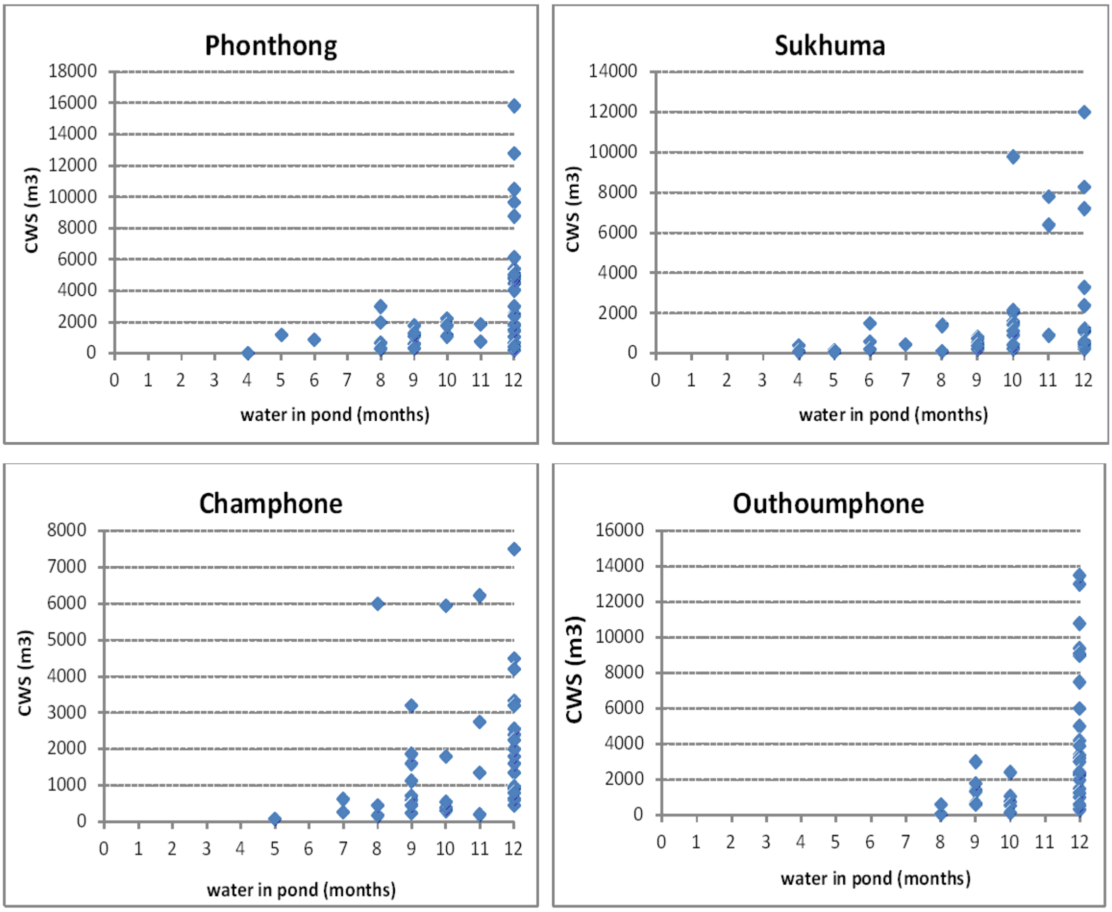

Figure 2: Scatter diagram showing the relationship between water storage capacity and water availability of pond.

Figure 3 shows the water level dynamics in the selected ponds from July 2011. Maximum water depths were attained between mid September to early October. Table 2 shows the average maximum volumes and change in storage (from Jan 1, 2012 to April 30, 2012) in the selected ponds. The rate of change of storage varied depending on the size and use of ponds. From the observation station ponds, large changes in storage volume were found in bigger ponds due to more leakage and evaporation losses, and widely used to irrigate crops in the dry season (e.g. Bak, Oparath and Noneyang villages). On the average, estimated percolation rates in the pond ranged from 4-6 mm/day (data not shown). Soil textural analysis of soils at the bottom of the pond and of the farmers fields adjacent to the ponds show that these are are coarse-textured soils. However, soils at the pond bottom have less sand (67%) compared to soils in adjacent fields (77%).

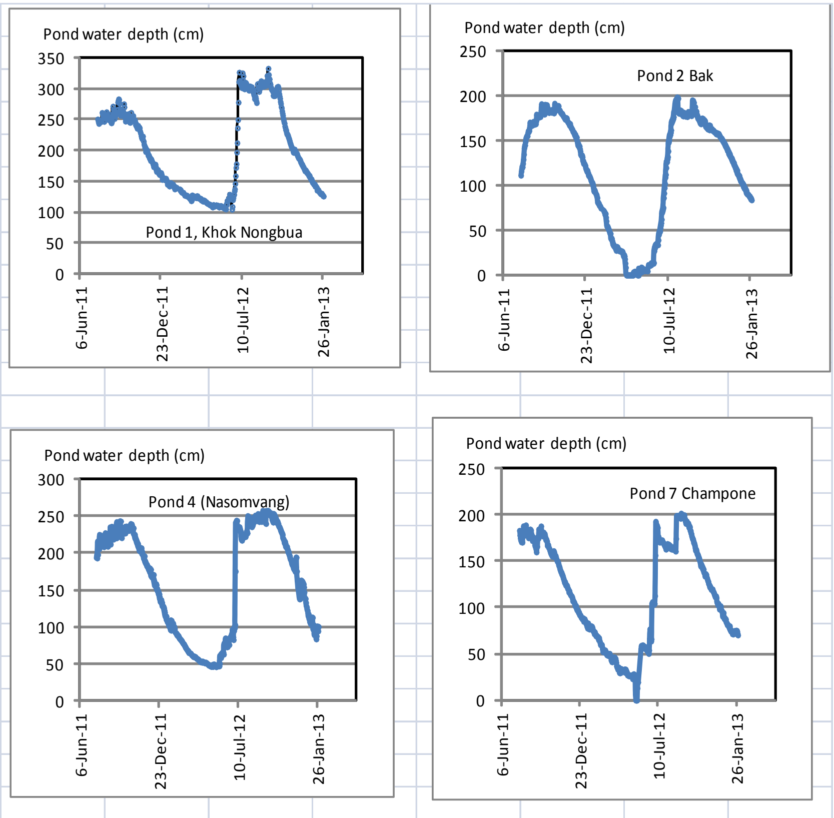

Figure 3. Pond water level dynamics in selected ponds from may 2011 to January 2013.

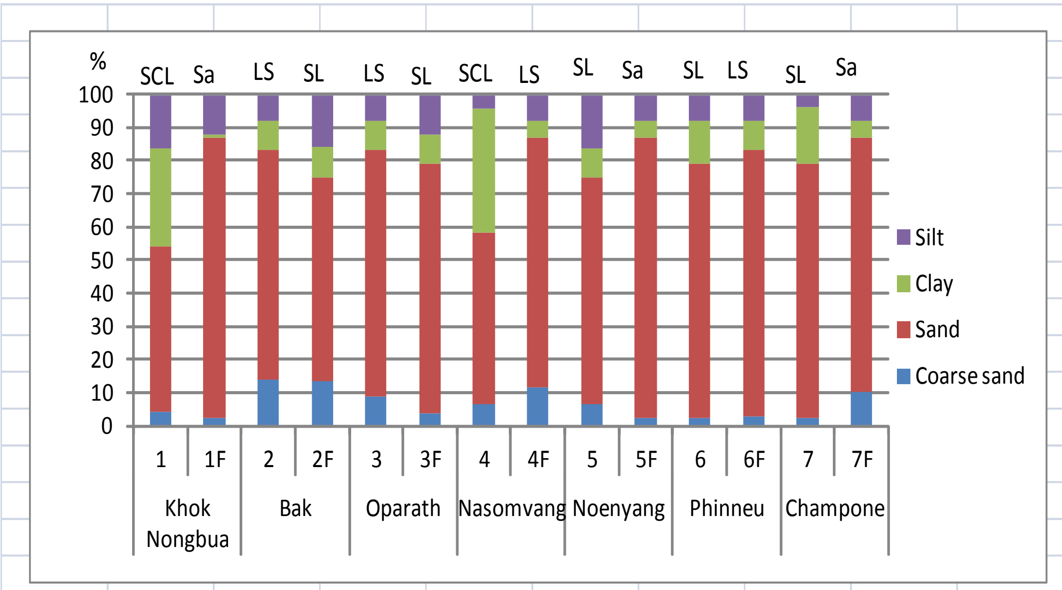

Figure 4. Percent sand, silt and clay distributions and textural classifications of the sampled soils from the beds of the 7 selected ponds, and from the adjacent farmer's fields.

Discussions and conclusions

Farmers owning farm ponds had higher average farm size (3.4 ha) compared to farmers without ponds. In all selected villages and in most part of Southern Laos, rice production is the most important agricultural activity especially during the wet season. The average reported rice yield of 1.7-2.5 t ha^{-1} during the wet season in the study site is relatively lower than the national average (3.4 t ha^{-1}) for rainfed lowland system in Lao PDR (Linquist et al, 2006). This was maybe because the reported yields were based from 2011 wet season harvest where about 10% of the total area planted in that season was affected by severe flooding (Eliste and Santos 2012).

Farm ponds in the study sites play significant role in increasing farmer's total income. Farm ponds provide a water source for crop irrigation in the dry season, fish and livestock production. Other farmers use the water for seedbed preparation and supplemental rice irrigation during the wet season. Producing some surplus in dry season such as high value crops (vegetable, maize or even pond fish) and selling to local market generated extra income for rural poor household. The results from our research showed significant differences in household income from famers with a pond (15-23 million LAK) and that without a pond (13 million LAK). This was in agreement with the concept that integrated farms have more opportunities for agricultural production due to their larger water availability (Ruaysoonnern and Penning de Vries, 2005). Income from farms without ponds was generally less diversified and approximately half that from farms with ponds. This implies that farms without ponds are more vulnerable to drought and do not have an extra source of income (e.g. vegetable in dry season). These farmers relied more on off-farm activities. Farm ponds in the study sites varied in sizes (1,324-2,442 m^2). Multiplying this with pond depths of 2-3 m, water storage capacity of ponds are in the medium class size (1,000-10,000 m^3) based on the system defined by Shahbaz Muzhtaq et al. (2006). The land-water ratio (which is defined as the ration of the pond surface area over the farm area) is very low (5-9%) indicating that water in the pond is not sufficient to support substantial scale of agricultural activities particularly during the dry season. Penning de Vries et al. (2005) suggested an optimal value of 30% water-land ratio to allow year-round irrigation.

In general, water availability tended to increase with depth of the pond. Unexpectedly, there was no clear relationship between depth and water availability in all cases. Many ponds with shallow water depths (1-1.5 m of depth) retained water throughout the year. This may indicate that there are other factors that influence water availability of pond such as capacity of water storage (dimension of pond), leakage rate of the pond, cropping patterns and utilization of pond water. In Southern Laos, rainfall in rainy season was sufficient to fill the ponds into their full capacities. Maximum water depths can be attained in September to October. However, if farmers intend to use the stored water for crop production, they have to start using it at end of October to optimize its productive use. Due to relatively higher leakage (about 4-6 mm d^{-1}) and evaporation losses of water in the ponds, only about 30-60% left in the pond at the start of January (Table 7) due to these losses.

Table 7. Maximum volumes and change in storage at the seven ponds in the study sites.

Location	Volume (ML)			
	Ave Max (2 yrs)	Volume Jan1, 2012	Volume Apr 30, 2012	Change in storage
1.Khok Nongbua	1.6	0.8	0.6	0.2
2. Bak	11.9	6.7	0.0	6.7
3. Oparath	11.2	7.2	1.5	5.7
4. Nasomvang	2.3	1.2	0.4	0.7
5. Noneyang	14.3	9.9	5.2	4.7
6. Phin Nuang,	11.7	7.2	5.3	1.8
7. Champone	1.2	0.5	0.2	0.4

To conclude, the construction of farm ponds undoubtedly alleviates the persistent lack of water for agricultural production during the dry season in Champassak and Savanakhet provinces. Small farm ponds can be used to harvest rainwater and runoff during the rainy months for more productive usage in the dry season. Farm ponds provide opportunities for farmers to increase their income by allowing farmers to plant vegetables and other crops in the dry season. However, at the moment farm ponds are relatively small in sizes and its land-water ratio is low (5-9%) to support a substantial part of the farm for irrigation in the dry season. These coarse-textured soils in the study sites also promote higher losses of water through leakage, and thus need to be addressed. Research on modeling of water use efficiency from pond irrigation concept is needed in order to bear some hints for policy implications.

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