(Draft)

Sustainable agricultural productivity through farm pond option in the integrated watershed management of Northeast Thailand

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Abstract

Northeast Thailand is handicapped by unpredictable and uncontrollable availability of surface water: this usually suffers either from a shortage or an excess of water, both remain detrimental to sustainable of agricultural productivity. The south–west and the middle mountainous ranges boundary of region divide the whole northeastern watershed into two main river drainage systems namely “Sri-Songkhram” systems in the North and “Chi-Mun” systems in the South which both drain east-downward to the great Mekong river systems. Each topography are characterized by mini watersheds in associated with various landforms called highland in hilly, upland and lowland formed rolling patterns in subsequently. These restrict to larger scale of water resources development. Remaining about 80% farm families are favorable and can make use to small scales water resources. Nevertheless, uncontrolled runoff water causes severely soil erosion and land degradation problems in highland whereas drought and flooding problem are common in undulated area. These factors play virtual role on overall agricultural productivity as well as farm families’ livelihood of this region.

The integration of technologies with natural resources such a soil, water and vegetative in a basin to optimum use in sustainable manner for betterment of people, two three-year phases on “Participatory Watershed Management for Reducing Poverty and land Degradation in SAT Asia” project, have been jointly implemented by a multi-sectoral consortium team with often trans-boundary approached by the ICRISAT and Thai research organizations under financial support of the ADB. This project have carried out in two benchmark watersheds of (i) a hilly landform “Tad-Fa” watershed in Phu Phamann District and (ii) a rolling landform “Wang-Chai” watershed in Phu Waing District, Khon Kaen Province, Northeast Thailand, since 1999 and 2003 in respectively. The project interventions, especially the role of farm ponds in the watershed are discussed in details. Moreover, overall results have significantly increased the water availability and crop yields, and with the proper land use planning and with use of integrated soil and water management and crop management option, the land degradation, the results show that it can be controlled in which the soil loss of 5-6 t/ha/y indicated in improved systems vs. the soil loss of 25-33 t/ha/y in the traditional systems.

A thirty nine of farm ponds, a key option of this integrated watershed management, have been governmentally implemented in the project area by the Land Development Department, constructed as small structure in farm land to capture surface runoff but some excavated enough to utilize ground water, each are about 1,260 m^3 of storage capacities for the impoundment of water supplementary. Farm-ponds’ function

indicates not only increasing crops yield in both rainy and dry season but sediment load drown-stream exhibited reduction. Farm pond water utilization indicated that hilly farm pond water was used for rainy vegetables, orchard, and home garden crops whereas rolling landform farm pond water was occasionally used for rainy paddy rice securing and supplementary used for various dry season vegetables and field crops cultivation such as cabbage, Chinese cabbage, fresh corn, groundnut, mung-bean, soy bean, etc., These direct farm ponds benefits enable farm families earn additional income in which about 85%, 10% and 5% were derived from vegetables, fruit trees and local herbs in hilly Tad-Fa watershed, meanwhile in the rolling Wang-Chai watershed, about 78%, 10%, 8% and 4%, were derived from paddy, fish, vegetables and fruit tree respectively. The factors effluent water ponding capability, lasting of water level maintained in a year round, indicated that soil types in associated with its complexities play various virtual roles to water ponding in hilly whereas the water ponding level show highly closed relationship to ground water level of rolling watershed.

These can be anticipated that if proper water-soil-crop management where small scales water resources are paid much attention and achieved to integrate in watershed management, the other than farm ponds such as village tanks, weirs, marsh rehabilitation, dug ponds, and deep wells in particularly, also can play significant role for enhancement of farm productivity and better livelihood of small rainfed-farm families in Northeast watershed regional wide. Furthermore, the promising watershed management technologies developed at the project sites provides a good framework for increasing productivity and income on sustained basis, while improved soil and water resources national wide.

Introduction

Northeast Thailand is situated between 19° to 14° N latitude and 101° to 106° E longitudes. It encompasses 17.02 million hectares, roughly one third of the entire country and is the poorest region of Thailand in terms of resources, economy and personal income. Most of the region's inhabitants are small holding, low income farmers who face diverse agricultural and resource problems related to extreme environmental variability, an adverse climate, poor soils, and limited, often unreliable water resources**.** **Topography** of northeast Thailand is generally characterized by high saucer-shaped plateau with the ranges of Phetchabun and Dong Paya Yen are on the west, and Panom Dongruk bordering Thailand with Combodia, is on the south and southeast, and Mekong river bordering with the Lao People's Democratic Republic on the north. On the middle, the range of Phu Phan divides the Northeast watershed area into two basins: Sakhon Nakhon basin in the upper part and Mun basin in the lower part. Mountainous areas occupy 13% of its total area which locate in those three main mountain ranges. Watershed is drained toward to Mekong river in the east boundary. It has a monsoon climate similar to other parts of Southeast Asia, but the northeast geophysical characteristics create special conditions. **Annual rainfall** normally averages between 1,300 and 1,400 mm for the entire region, but considerable variation is found. More than 90% of the annual rainfall occurs between May and October (i.e. rainy season). The western half of the region is substantially drier (1,100 mm/year) as a consequence of the rain shadow effect. In contrast, annual rainfall in the extreme northeast corner of the region is often 1,800 mm. The actual amount and pattern of rainfall are often extremely erratic and unpredictable. This creates considerable risk for agricultural production, 80 percent of which involves rainfed cultivation. In rainfed areas, the water is becoming one of the major constraints for increasing and sustaining productivity. Many regions of Thailand have suffered from longer than usual drought periods, higher temperatures and unusual rainfall anomalies which have devastated rural economies in rainfed areas. In Thailand 46 out of its 76 provinces are currently sufferings from water shortages. **Soils** in Northeast region are generally loamy sand or sandy loam, both having low fertility and a poor moisture retention capacity. Through deforestation, the cultivable area has expanded rapidly during the 1960's. The deforestation and other practices have led to the changes in the hydrologic environment and have caused widespread salinity problems. Also, the soil erosion and soil fertility deteriorations are some of the serious problems coming up in many areas. Due to these problems, a vicious cycle of soil degradation, low yields, poverty and low investment has gripped rainfed agriculture.

Soil erosion and nutrients loss is the main problem in degradation of natural resources. It is about 6.7 billion ha (40%) annually encountered in soil erosion.

Table 1 Sediment load in the runoff water in Northeast of Thailand watersheds

Watersheds	Mean annual suspended sediment (million t)	Depth of erosion (mm)
Mekong	9.36	0.16
Chi	1.04	0.02
Mun	1.00	0.01

Source: LDD, 2000

Mean annual suspended sediment are, transported by Mekong, Chi and Mun rivers which shown in Table 1, about 9.39, 1.04, and 1.00 million t/yr and 0.16, 0.02, and 0.01 mm/yr depth of soil loss respectively. Sedimentation is secondary process after soil erosion, consequently, transported to streams or reservoirs. Soil erosion causes on soil nutrient loss through reaching out process, are comparative high of K loss in the Northeast whereas N, P and K result highly in the North.

Soil improvement: Land Development Department (LDD) plays major role in both soil improvement and soil conservation through the conventional concept of extension and technology transfer that clearly separates in three actors in technology development process-researcher, extensionist and implementers (farmers). The soil conservation has been playing less attention by farmers' perception. The mobile unit, made up of a technical officer, driver and tractor, was used to help farmers build terraces on sloping land by expected farmers share little perhaps petrol and sometime meal. This approach did not prove effective as farmer tend to consider the terraces as the government properties and did not maintain them. (Samran 1995). This is an example of common failure of public resources properties management. The concept of "People-Centered" and "Farmers' Participatory" concepts are now generally accepted that soil conservation programme must work close collaboration with land users from beginning stage. The "Soil Doctor" initiated in 1992 and nowadays well known as "Soil Doctor Volunteers (SDV)" has been established in each Land Development Villages (LDV) and being up-scaling country-wide. SDVs are seemingly good actor for LDD representatives as key local informants in which being empowered by various forms of LDD incentives' providing in such as cost-sharing of various on-farm conservation measures, farm inputs, job contraction such as the award of contract to produce seedling or part time working for LDD on site activities, infrastructure for better village farm road, field trips and vocational trainings, giving consults for villagers whom involved in project activity. However, some worries, are again emerging about this LDV programmes in which government pays almost the total cost of establishing soil and water conservation measures whether it could be effective if those are absent.

Water available and land degradation are addressing in National Plan

Moreover, the constitution of Kingdom of Thailand 1997 said require the state to organize appropriate land holding and land use systems; provide sufficient water resources for farmers; protects of farmers in the production and marketing of agricultural products to achieve maximum benefits; promote the role of farmers in the preparation of agricultural plans and protect their mutual interests; provides right and liberties for people to participate in natural resources management. It also provides for the right of person to participate in the preservation and exploitation of natural resources and biological diversity, and to protect, promote, and preserve the quality of environment. A cabinet resolution on land policy, 1 September 1987, said the government should accept full operational responsibility in area with serious land degradation problems that beyond the capability of farmers to solve for themselves. These are principal law and government policy for LDD, and other relevant agencies, engages for land and water management.

Water demand of Thailand: Table 2 indicates that water resources availability will be inevitably constrained by sharply increasing demand of all sectors. To solve the problem of water shortage would have been involved by both of demand and supply sides, in particularly, from the demand side should be improve water delivery systems, minimize water use and optimize irrigation water allocation whereas supply side have to develop additional water resources, surface of underground water, to meet those such demands.

Table 2 Water quantity required by major sectors, 1990, 2000 and 2010

Year	Total amount of water resources	Total amount of water withdraw	Sectored withdrawal		
			Domestic	Industry	Agriculture
1990	199,000	43,000	2,000	1,000	40,000
2000	199,000	85,000	6,000	3,000	76,000
2010	199,000	167,000	15,000	8,000	144,000

Source: Sethapura *et al.*, 1990 *Unit: Million Cubic Metres*

Water resources development and agencies involvement: In multi-purposes, the Electricity Generating Authority of Thailand concerns with construction of the major mega dams for electricity production only. Various downstream facilities are linked for domestic water supply, irrigation or flooding control by agencies accordingly. The Royal Irrigation Department (RID) plays important roles in agricultural water resources development and constructs irrigation system facilities. The RID define the whole Kingdom's watershed into 25 main river basins which NE shares only 3 main river basins namely Mekhong, Chi and Mun river basins, about one-third in which 20% runoff drainage of the whole country are tabulated in Table 3.

Table 3 Main river basins, drainage area, runoff, and RID water resources Development in Northeast Thailand

Main river basins	Drainage area (*1000 km^2)	Mean annual runoff (*billion m^3)	Water Resources Development Schemes By RID			
			Large & Medium (No)	Small & Others (No)	Stock (mill.m^3)	Irrigable (mill. rai)
Whole Kingdom	511.48	213.42	694	9362	37.75	38.17
Northeast	165.85	44.03	178	5184	6.02	2.90
Mekhong	46.67	13.29	na	na	1.16	na
Chi	49.48	11.24	75	2025	1.79	1.24
Mun	69.70	19.50	109	3159	3.07	1.66
Shared by NE (%)	32.4	20.6	25.7	55.4	15.9	7.5

Source: Consolidated from RID Website, http://www.rid.go.th

A number of large, medium and small schemes with its main irrigation systems have been constructed. However, Those NE schemes are able to stock water only 15% off country-wide whereas 55% of small scale schemes such as, weirs, village tanks, rehabilitation (dredging) natural streams and swamps and others of levee for flood protection and mobile pumping (drought relief program in particularly) were implemented in NE region.

Water resources development in the Northeast

Strategy of water resources development: Severe droughts, remains a key important role of NE agricultural productivity. The water resources development strategy for the Northeast follows in two-pronged water policy needs. Firstly, to emphasize on distribution system from existing sources of reservoir and rivers. Under this prone, can be classified as two zones which zone I are, 2.1 million rai, 8-9 % of farm families living in, which irrigable by large scale reservoir, while zone II are, 1.9 million rai, 10% of farm families which irrigable by pumping from reliable rivers. And second is to meet basic requirement in every villages which can be classified as zone III which is inaccessible from reservoir and reliable rivers in which contain 80% of farm families living whereas small scale water resources (SSWR) development is, possibly, capable way to meet basic domestic water needs and minimal supplementary irrigation requirements. The potential effectiveness use and alternatives of SSWR development projects to meet of basic requirement of villages can be visualized as summarized in Table 4. The marks indicate the potential use of any alternatives.

Table 4 Potential and alternatives (types) use of small scale water resources

Village use & requirement	Alternatives for small scale water resources projects						
	Weirs	Rehabi--litation	Village tanks	Dug ponds	Deep Wells	Shallow Wells	Roof Runoff
Drinking					x,?	x, ?	x
Domestic use	x	x	x	x	x	x	?
Animal	x	x	x	x	x	x	
Wet season crop	x	x	x	x	x, ?	?	
Dry season crop	x	x	x	x	x, ?	?	
Fisheries	x	x	x	x			

Note: x = Indicates potential use, ? = Questionable or limited use

The first three types, weirs, rehabilitation of natural streams (*Huay*) and swamps (*Nhong*), and small reservoirs or village tanks are in responsible to RID. These typically locate in NE watersheds where available of common land for inundation can be found. Dug pond, recently "farm ponds" are built by excavating the earth below the water table or higher ground with some sorts of seepage prevention which are relatively smaller than village tanks and usually dry out through seepage in the dry season. The deep (tube) wells are dug down to a confined aquifer which almost are required pumping installment due to the piezometric head is below ground level whereas some area water quality is unacceptable due to the NaCl salt. The shallow (open) wells are usually dug manually by villagers down to the water table. And the last alternative is collection of runoff-rainwater by household roofs, this are promising of good quality water and suitable only for drinking purpose.

Integrated watershed management for enhancing the people's livelihoods

Integrated watershed management: An integrated model for watershed management is a consortium team work of four institutions such as Department of

Agriculture (DOA), Land Development Department (LDD), Khon Kaen University (KKU) and the International Crops Research Center for Semi-Arid Tropical (ICRISAT) work together with farmers as "centered actor" through farmer participation. The concept of integrated watershed management with holistic approach for increasing the agricultural productivity and enhancing people's livelihoods is relatively new in Northeast of Thailand. A new farmer participatory consortium model for efficient management of natural resources and for reducing the poverty has been adopted. The ADB-ICRISAT integrated watershed management project is carried at two benchmark sites in northeast region of Thailand viz Tad Fa in Phuphaman district in 1999 and Wang Chai in Phuwiang district, in 2003 under the financial support of ADB. A consortium of Thai institutions, DOA, LDD, and KKU along with the ICRISAT as opposed to a single institution was formed for project implementation and technical backstopping at the Tad Fa benchmark site to address the above problems and increase agricultural productivity through a sustainable manner by adopting integrated soil, water, and nutrient management (SWNM) and integrated crop management options Some of the major research and development activities are summarized as following.

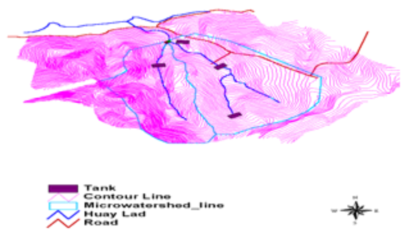


Figure 1 Tad Fa Watershed Topographic

Tad Fa Watershed:

Physical and location: The western watershed is distinct by hilly to mountainous topography, except the area closed to northeastern part which is undulating to rolling topography. Tad Fa watershed is located within the junction of three main watershed namely, Mekong watershed in the northeast, Chi watershed in the east and Pasak watershed in the southwest. Land degradations in intra-mountainous highland, severe soil erosion which scenario by widespread of stone exposures, poor water holding capacity, plant nutrients loss as indicated by farmers have adding increased dose of chemicals up year to year, are remaining and living villagers in these areas indicate poor and lack of technical backstops of watershed management supports to sustain agricultural productivity. ***Improved crops and cropping systems:*** High yielding cultivars were introduced such as ricebean (L28-0395) as sequential to maize gave 222%, 225% and 113% of grain yield and black testa cowpea (K305) as relaying to maize are superior cultivar which gave 179%, 142% and 134% of grain yield over the local cultivars respectively. ***Soil and water management*****:** Tad Fa watershed, in order to reduce tillage on very steep slopes which result in high soil loss, minimum tillage is being tried. On mild slopes contour cultivation or cultivation across the slopes is being popularized in the watershed. During 2003-2004 about 68% area was planted on contour on mild slopes. On mild slopes the cultivation has increased the maize yield by 30-40% compared to conventional up and down cultivation. It also significantly reduced the soil loss. In large areas the field bunds have been constructed along with vetiver grass (*Vefiveria nemoralis*). This is necessary for controlling soil erosion which is one of the major problems in Tad Fa watershed. In Tad Fa watershed the annual soil loss of 40-60 t ha^{-1} is quite common. In large areas the field bunding has been done and total 9 km village farm-roads have been constructed. To protect the bunds and roads from erosion, the vegetative barriers were planted. Drains were constructed for safe disposal of excess runoff water. The rainfall, runoff and soil loss have been monitored. ***Hydrological measurements:*** Two digital runoff recorders along with automatic pumping type sediment samplers are installed at two sub-watersheds to monitor the runoff and soil loss from the two land use management systems. Sub-watershed-I has land under the horticultural tree-based cultivation with some areas under annual crops. Sub-watershed-II has most of the areas under annual crops and cropping systems. The runoff and soil loss from the two sub-watersheds during 2003 are shown in Table 5.

Table 5 Rainfall, runoff and soil loss, Tad Fa, in 2003 and 2004.

Land-use Systems	Rainfall (mm)		Runoff (mm)		Soil loss (t ha^{-1})	
	2003	2004	2003	2004	2003	2004
Annual Crops	1,650	1,312	256	214	32.5	24.6
Fruit Trees			142	135	6.3	4.8

Within the proper land use planning and with use of integrated soil and water management and crop management option, the land degradation, the results show that it can be controlled in which the soil loss of 6t/ha/y indicated in improved systems vs. the soil loss of 33 t/ha/y in the traditional systems.

Wang Chai Watershed:

Physical and location: Wang Chai Watershed is part of a Nam-Phong basin and is about 75 km northwest of Khon Kaen city. Wang Chai village falls under the Phuwiang district in Khon Kaen province. Mean annual rainfall is about 1000 mm. About 90% of the annual rainfall occurs between May and October. Often the actual amount and pattern of rainfall are extremely erratic and unpredictable. This creates considerable risk for agricultural production since most of the watershed area is under rainfed cultivation.

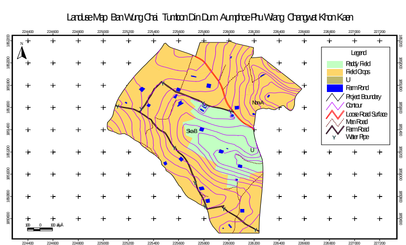


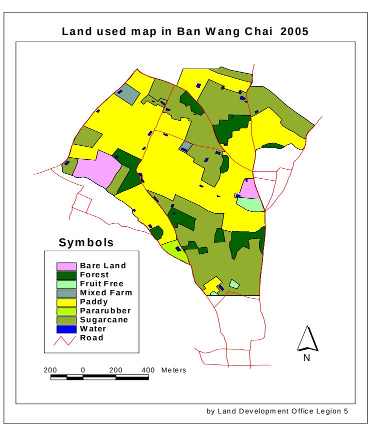
Fig. 2. Topographic, soil and land use maps of Wang Chai watershed

The soil in the watershed is mostly sandy or sandy loam with very low water holding capacity. The organic matter content is also very low. During the last two years, various research and development activities on ***Integrated nutrient management*** by using leguminous green manure on succeeding sugarcane, ***Water and soil management***: farm road with planting vetiver grass planting along sides were constructed across slope of valley form half circle structure to conserve water and flooding control, ***Crops and cropping systems*** were taken up: High yield groundnut cultivars, KK6 and KK5 introduced growing after rice in dry season in dry season 2004/05, gave 148.8% fresh pod (132.1% dry pod) yield and 131.5% fresh pod (125.3% dry pod) yield superior to local cultivars respectively which enable farmers obtain more about 2,056 and 1,326 bahts ha^{-1} over the local cultivars. Several self-help groups were formed. ***Farm and community based activities*** were initiated to enhance the agricultural productivity and income. New crops and varieties were introduced in the watershed. ***Village based purifying rice seed*** was established. ***Training*** was given to farmers for value addition of field crops products. The farmers are quite happy with the various watershed activities. ***Land use and crop intensification***: Total land use of Wang Chai watershed are 942 rai, in 2005 can be classified into 8 classes. Paddy field are major about 47%, sugarcane in upland are about 36 %. Some new lands are opened for rice and sugarcane. Pararubber is the new comer crop are, 1%, replaced to cassava in upland. Due to the drought some idle land are insisted in the survey year. Some of LDD farm pond farms can be classified to be mixed farm**.**

Farm pond roles virtual option in watersheds

River basin context whereas earlier defined as Zone III watershed prone, gently sloping undulated upland in which mini-watersheds are formed which large and medium schemes are limited. In terms of SSWR development, such as weir, village tank and various rehabilitation schemes which belong to public were usually constructed by the RID. Topo-sequence from the uppermost part to lower portion of valley which mostly are occupied by paddy field (lower paddy), a few years past, the Ministry of Agriculture and Cooperatives (MOAC) have launched an integrated farming project, under King's New Theory Farming Concept, which farm pond is a key optional component in all 7,600 pilot farms (MOAC 2001). The new Theory farm ponds normally have no limit in term of size and water storage capacity, but in upper portions which closed to the uppermost where upper paddy and field crops have engaged in which soil erosion problem and water limitation are dominant. The Land Development Department (LDD) is a major responsibility in soil conservation, again where it deems fit, water resources project will be included as part of soil conservation needs. The LDD activities are focusing at on-farm level in the watershed, for instance, on-farm ponds, shallow wells, dredged water-ways, and earthen bunds. The sediment weirs or retard ponds now farmers' sound is very few. Up to date, LDD has completed construction of 1,807 number of SSWR. LDD farm ponds (LDD-FP) have been priority specified as a key optional component to implement in selected farmland in every LDD-Village. These LDD farm ponds, excavated 3-3.5m in dept with variable range of 10-15m x 20-30m width specification to meet its standard of 1,260 m^3 water storage capacity, 17 in Fad Fa and 39 in Wang Chai watersheds have been implemented.

The function of farm ponds (FP): Recently, Thai government now on launching a five year project (2004-2008) of "One farm family one farm pond" in order to up-scaling 450,000 ponds are given into targeting (LDD 2004). With a small volume of water storage capacity, wondering of average 5 mm/d dairy evaporation rate of the region, how these farm ponds enable to storage water through year round.



At Wang Chai watershed, the study was conducted in 2004 to 2005. Water ponding dept scales were installed in each of 13 farm ponds in 2004 and ground water measurement tubes set were installed aside each 3 of those in later year aiming to investigate their capability of water storage and the water utilization. After paddy harvesting of each crop year, all 13 FP owners (inside project) and other type of 21 FP owners (outside project) were interviewed by structural questionnaires for socio-economic benefits and impacts.

Additionally, 3 FP owners of Tad Fa watershed were interviewed in 2005 crop season to extend more understanding. The results were summarized as follow.

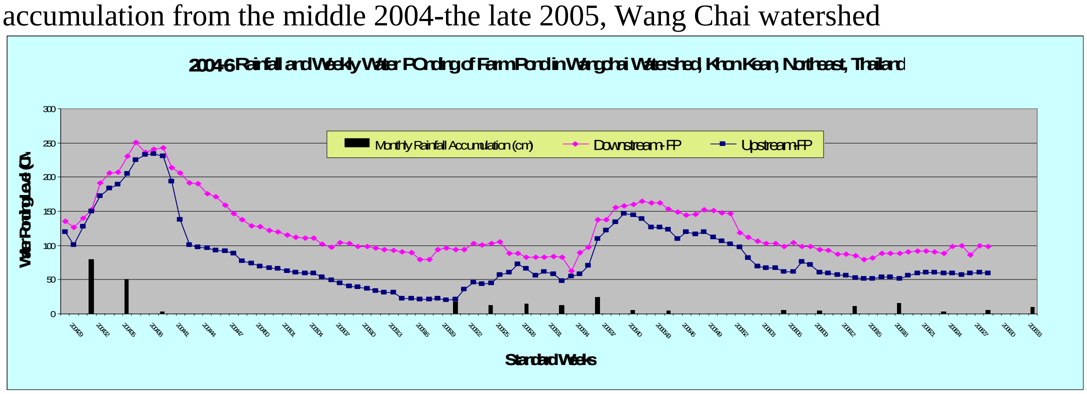
Farm pond location in focusing: Vetiver-farm road divided the watershed into upstream and downstream area. Initial location of farm ponds said by LDD work-plan, 9 and 4 farm ponds locate in paddy field and upland which 5 and 8 of these farm ponds are defined in downstream and upstream area in respectively. However, after having consultation with a SDV and farm owners, LDD people let farmers' experiences share where is suitable to locate the farm pond at his/her farmland during implemented stage. The 82% of farm ponds initial in paddy field were shift to higher terrain parts which sit closely to either vetiver-farm road for downstream farm ponds (100%) or to adjunction of local forestry for upstream farm ponds (82%) whereas the other upland field-FPs were implemented as indicated in LDD work plan shown in Table 6. These evidences can be implied that farm owners experiences favored locating farm pond in upper terrace rather than lower area.

Table 6 Number and percentages of farm ponds re-location after farmers' experiences

Location	Down-stream		Up-stream		Total	
	No FP	Re-locate	No FP	Re-locate	No FP	Re-locate
Paddy Area	3	3 (100)	6	5 (82)	9	8 (82)
Field Crop Area	2	0 (0)	2	0 (0)	4	0 (0)
Total	5	3 (60)	8	5 (62)	13	8 (61)

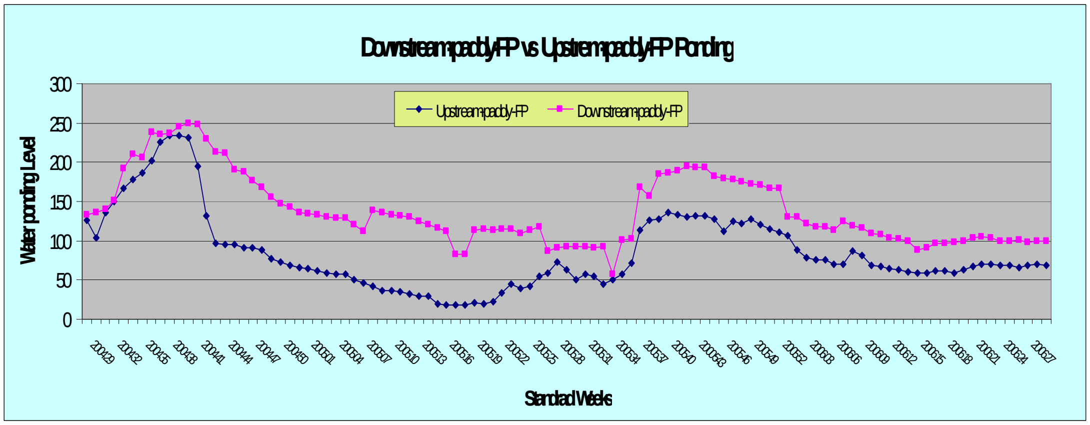
Water ponding capability: Weekly basis, water ponding level of 13 LDD-FPs inside project site were continuously recorded by each farm owners. The overall ponding levels of downstream-FPs exhibited small gap of higher in early but did bigger than upstream-FPs from mid-rainy season which closely related to rainfall accumulation. However, water ponding levels of both have sharply dropped in 2 times during in the middle (30th week) in July and in the late (41st week) of rainy season in September till the end of rainy season (43rd week) in October. During this period, rice were in heading stage which maximized use of water to achieve their seed development. Consequently, induced rapid shallow of water ponding and become to dry out soon after. In this situation, farmers have to do paddy security by pumping up once wider flooding paddy plots as much as possible. In 2005, overall FP ponding resulted shallower as monthly rain fall accumulation in indicates smaller amount compare to 2004. The pattern of ponding level of downstream-FP and upstream-FPs of both years exhibited similarly but overall water ponding level of downstream-FPs exhibited higher shown in Figure 3

Figure.3 Water ponding of downstream-FP and upstream-FP in associated with rainfall accumulation from the middle 2004-the late 2005, Wang Chai watershed



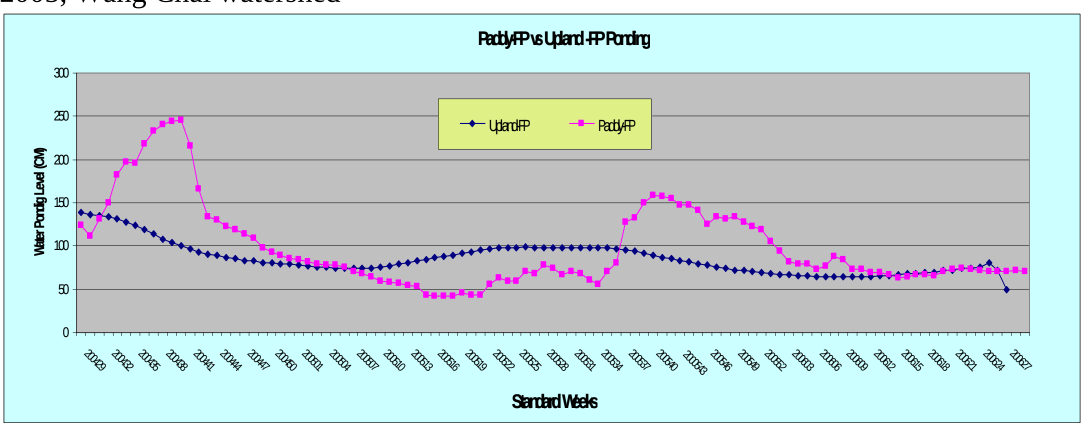
This evidence was similar to downstream-paddy-FP and upstream-paddy-FPs which can be implied that the paddy-FPs played important role in the overall ponding levels as shown in Figure 4**.** It is more clearly evidences that the ponding water level of upstream-paddy-FPs, generally was upper paddy, performed sharply decreasing rate than downstream-paddy-FPs which was lower paddy.

Figure 4 Water ponding of downstream-paddy-FP and upstream-paddy-FP from the middle 2004-the late 2005, Wang Chai watershed



The water storage capability and the lasting of water ponding of upland-FPs and upstream-paddy-FPs performed shallower than downstream paddy-FPs in lower topo-sequences but the use of farm ponds water in upper paddy (upstream) were greater amount of used (pumping up)

Figure 5 Water ponding of paddy-FP and upland-FPs from the middle 2004-the late 2005, Wang Chai watershed

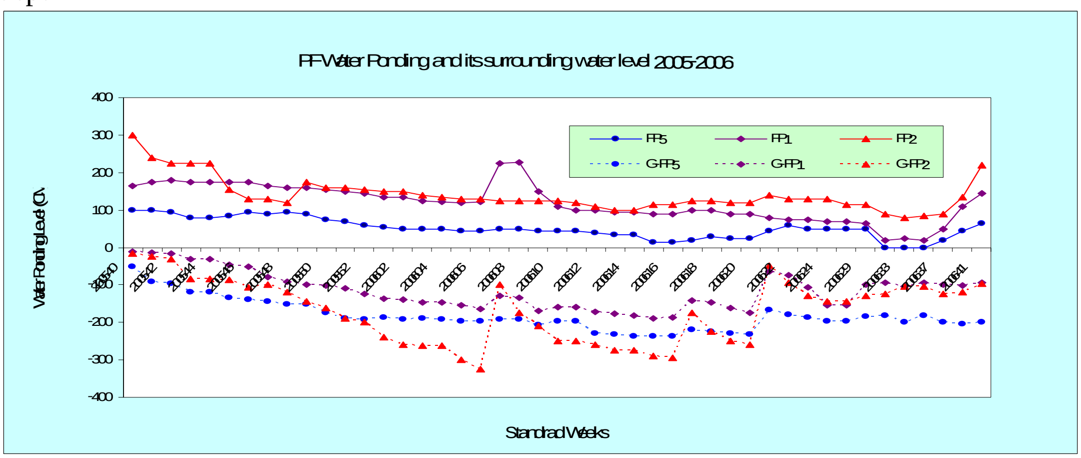


This more clearly explained that the utilization of water of upland-FP relative small amount compare to paddy-FPs which vary fluctuation of water ponding level by occational use of water during rainy paddy and dry crop growing season as shown in Figure. 5

Ground water influents: A rapid increasing of water level in early season and sharply dropped of water level in late season of farm ponds in upstream-paddy-FPs were performed. This can be explained that these farm ponds are being a counter actor as runoff water receptor in upper terrain and gradual seepage called "Recharger" zone whereas the downstream paddy-FPs are being act as water seepage receptor called “Discharger” Zone. However, only one farm ponds water (in upper paddy area) found dry out at the end of rainy season due to over pumping up. This wonders us about to the rest that why they enable to maintain water level through year round.

Therefore, recharging of underground water was investigated in 2005. A 3 selected farm ponds, one (FP1) locates in downstream-paddy-FP and the other two (FP2, FP5) are in the each shoulder (upstream-paddy-FP) of the valley sit closely to local forest. Each were installed with a set of 3 piezometers cylinder placed 3.5 m dept in line at 10-20 m interval beside body of farm pond. Ground water levels were measured in weekly basis from the end of rainy season to the beginning of next rainy season. Ground water level data in associated with their water ponding levels were analyzed and shown in Figure 6.

Figure 6 Three farm pond water ponding in associate with its surrounding groundwater depth



The evidence indicated that FP water level is considering closed relationship to underground water level. A sharply decreasing water ponding of upstream-paddy-FP2 during the last week of October, it may result of the use of water for paddy in grain filling stage. It was not clear evidence of the sharply jerking of surrounding underground water level of FP2 but not of FP5 to the rainfall events. Nevertheless, water ponding level of downstream-paddy-FP1 which located in foot of valley (discharge area) performed more stable (higher) water ponding level than the other two FPs which are gradually decreasing along with its ground water level. An incidence of heavy rain reflected positively both ponding and underground water level of downstream-paddy-FP1. In this case, rainfall events were playing an important role on underground water level and LDD-FP water storage capability.

Socio-economic impact of LDD-farm ponds

General information of LDD-FP farms and the other FP farms: Results showed in Table 10 that both groups are similar in average of 2.7 h /HH and 2.4 h/HH of paddy land holding and also number of the procession of farm-pond as 1.2 and 1.3 respectively. Most of them have used FP water mainly for paddy rice as their target crop by pumping method. Other benefits such as cash, both have directly withdrawal from the FP utilization are the same by vegetable (700 Baht/y), fruit tree as 435 Baht/y and 591 Baht/y respectively. Big gap of benefit was found fish raising of other-FPs generated cash in three fold (1,878 Baht/y) greater than LDD-FD (600 Baht/y). Moreover, LDD-FP farmers have not allowed animals get in pond whereas the other FP group let them get in for water drinking. LDD-FP farmers have plaid much attention on FP water save use as well as doing pond deeper as for their more effective use of water than the other FP groups have not much concern above.

Table 7 General information of LDD-FP farms and other FP farms in Wang Chai watershed, Phu Waing, Khon Kaen, 2004

Utilization & Benefits	LDD-FP Farms	Other FP Farms
Paddy holding (ha/HH)	2.7	2.4
Average No Pond/HH	1.2	1.3
Rice is their target crop	100%	90%
Pumping use	100%	100%
Direct withdrawals from farm ponds		
Fish (Baht/y)	600	1,878
Vegetables (Baht/y)	706	700
Fruit trees (Baht/y)	435	591
Animal drinking (freq)	0	187
HH use (freq)	37	67
Farmers try and effective utilization		
Save use	100%	62%
Dig deeper	38%	24%
Enlargement	8%	10%

Paddy production of LDD-FP and other FP farms: Accordingly. LDD-FPs functions have played important role in rice farming production security, especially in Wang Chai watershed. Paddy production in 2003 and 2004 crop season of LDD-FP and other FP farms were investigated. The planting area and method were greater changes in LDD-FP farms from the previous season (2003) than the other FP farms. The transplanting area with paddy yield of LDD-FP farms have increased from 2.1 h/farm (1.38 t/h yield) in 2003 to 2.4 h/farm (1.54 t/h yield) in 2004 whereas other FP farms have minor changed (1.9 h/farm) in which 1.39 to 1.45 t/h. Meanwhile directed seeding rice area cultivation of LDD-FP farms decreased from 1.4 h/farm to 0.8 h/farm but yield increasing from 0.57 to 1.19 t/h whereas the other FP farms increased in area from 2.7 h/farm (0.37 t/h yield) in 2003 to 2.9 h/farm (0.55 t/h yield) in 2004, respectively, shown in Table 8.

Table 8 2003 and 2004 rainy season paddy production of LDD-FP farms vs other FP farms

Farms	Crop season			
	2003		2004	
	LDD-FP Farms	Other FP Farms	LDD-FP Farms	Other FP Farms
Area (Yield) t (t/h)				
Transplanting	2.1 (1.38)	1.9 (1.39)	2.4 (1.54)	1.9 (1.45)
Direct Seeding	1.4 (o.57)	2.7 (0.37)	0.8 (1.19)	2.9 (0.55)

Irrigated and non-irrigated paddy yield of LDD-FP farms: Supplementary water from LDD-FP can irrigate occasionally for a quarter of his/her paddy field during critical growing period such a heading stage. Paddy yield of irrigated plots gave five times (1.58 t/h) greater than non irrigated plots (0.35t/h).

Farm pond water utilization and benefit withdrawal: In 2004 and 2005 crop season surveys, Table 9 shows that using of FP water to the crop growing was vary year to year. In 2005, domestic use was more frequently use and 15 % LDD-FP farms shared dry season crop in his/her crop calendar, more diversity of use may make he/she decision to limit water in use for the other crops use. Moreover, direct farm ponds benefits enable farm families earn additional income, averagely 77%, 10%, 8% and 4%, were derived from paddy, fish, vegetables and fruit tree respectively.

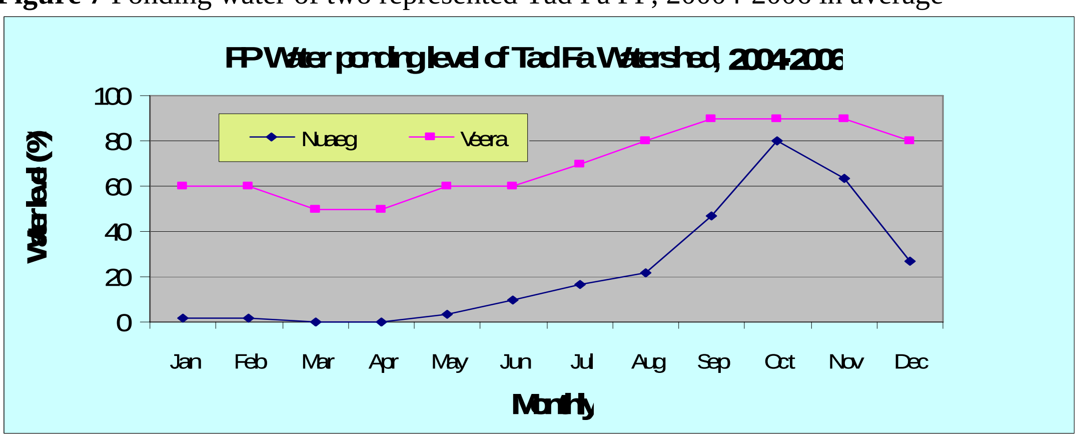
Table 9 The use of farm pond water of LDD-FP farms in 2004 and 2005

Items of use	LDD-Farm Pond Farms		
	2004	2005	Average (%)
Crop growing use (%)			
Paddy Rice	100	85	93
Fruit tree	77	54	66
Vegetables	31	23	27
Dry season crop	0	15	7
Methods of use			
Pumping (%)	100	92	96
Manual pick up (%)	-	67	34
Benefit withdrawals			
Paddy (Bath/y)	5200	6175	77
Fish (Baht/y)	600	812	10
Vegetables (Baht/y)	706	475	8
Fruit trees (Baht/y)	435	200	4
Animal drinking(freq)	0	0	0
Domestic use (freq)	37	73	1
Idea to make more water in use			
Saving use	100%	46%	73
Digging deeper	38%	31%	35
Enlargement	8%	-	4

Farm pond in Tad Fa Watershed:

An additional of 2 representative LDD-FP farms were selected to interview, over 5 year of history of various FP characteristics which averagely were expressed by farmers can be summarized as follow: ***Locations:*** FP locations were limited by hilly topographies and speedy of down hill run off, only mild sloping valleys were available. Typically, one was in the middle (shoulder) and the other one in foot of the valleys.

Figure 7 Ponding water of two represented Tad Fa FP, 20004-2006 in average



Water ponding capability: Farmers have given us two domain phenomenon of LDD-FPs in water storage in Tad Fa watershed**,** two-third of FPs was able to maintain a year round water ponding but storage water available of the rest were only during the second half of rainy season shown in Figure 11. With on site observation, the later FPs usually sat in fertile (black) sediment soil at basin of upper valley nearby stone exposures. A clayey (white) soil with gravel complex in shoulder of valleys resulted positive factor for FP water storage capability. ***Farm Beneficial***: FP generated a benefit of additional farm income which about 85%, 10% and 5% were derived from rainy vegetables, fruit trees and local herbs. Typically, rainy vegetables cultivation has shared 45-50% of annual farm income.

Conclusion

Farm ponds are seemingly good sound for farmer**s** and good fit at farm level of technology interventions. LDD-FPs in particularly, have currently implemented to replace the soundless of farmers on a technically “bed-load pond” or “retard pond” activities on soil conservation which failure to up-scaling when in solely approached. Another similar failure of contour bunding was constructed across sloping of watershed, but in diversified mode of “vetiver farm road” found farmers happy to participate and to up-scaling in the mini watershed successfully. Moreover, farmer participation approach through “Soil doctor volunteer” of community in SWM programme extended with cropping systems would be a good model such of this integrated watershed management project. However, the lesson from this project that each FP performed its own specific characteristic, the other word, various farm ponds with variables of dimensions, sizes, locations, bio- physical contexts, etc., will act various specific functional to each of various combinations be existing in particular watershed. In this case, only his/her farm ponds which have been done shared his/her experiences exhibited potentially to more effective in use and good maintenance, a single magic point of view done by outsider learnt never found success but diversified integration approach will be.

These can be anticipated that if proper water-soil-crop management where small scales water resources are paid much attention and achieved to integrate in watershed management, the other than farm ponds such as village tanks, weirs, marsh rehabilitation, dug ponds, and deep wells in particularly, also can play significant role for enhancement of farm productivity and better livelihood of small rainfed-farm families in Northeast watershed regional wide. Furthermore, the promising watershed management technologies developed at the project sites provides a good framework for increasing productivity and income on sustained basis, while improved soil and water resources national wide.

Acknowledgement: need more to finalize.

References:

LDD. 2000. Yield Gap Analysis of 3 Main Watersheds in the Northeast Thailand. Project No 2: The Eco-regional Database, December 2000, Land Development Department, Ministry of Agriculture and Co-operatives, Bangkok, Thailand.

LDD. 2004. Farm Pond in Non Irrigated Zone Project (2004-2008). Land Development Department, Ministry of Agriculture and Co-operatives, Bangkok, Thailand. (in Thai)

RID. Large, Medium and Small Schemes Development Database, Royal Irrigation Department, Ministry of Agriculture and Co-operatives, Bangkok, Thailand. (http://www.rid.go.th) (in Thai).

MOAC. 2001. New Theory Farming Project Report. Office of Permanent Secretary, Ministry of Agriculture and Co-operatives, Bangkok, Thailand. (in Thai)

Samran Sombatpanit. 2000. Soil Conservation Extension: from Concepts to Adoption. In *Soil Conservation and Watershed Management in Asia and the Pacific*, Asian Productivity Organization, Tokyo.

Prathed Sutrabhutara. 1994. Annual Report of the Current Situation of Environment Qualification. Office of Planning and Policy, Ministry of Science and Technology, Bangkok, Thailand. (in Thai)