Integrating Watershed Management for Land Degradation and Improving Agricultural Productivity in Northeast Thailand

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Abstract

Thailand's northeastern region accounts for one third of the country's population and land area, but generates only 15 percent of the gross domestic product. Most of the region's inhabitants have small holding, are 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. Due to these problems the current agricultural productivity and income is very low. The deforestation and other agricultural practices have led to the changes in the hydrologic environment and caused widespread land degradation problems. To tackle these problems several watershed management programs have been implemented by various government departments and organizations. This paper reviews the various watershed development management works in northeast Thailand and discusses their approaches and impact on agricultural productivity and natural resources.

The impact of small-scale water resources (SSWR) development program implemented by the Thai Royal Irrigation Department and Ministry of Agriculture and Cooperatives, on the socio-economic conditions of the farmers in NE Thailand was studied. It was found that the farmers in SSWR area earned more income from agriculture, than farmers outside SSWR area. Farm profitability and source of farm cash income of SSWR farmers were closely related to dry season cash crops rather than wet season rice. Area under double cropping was found to be higher in SSWR area than those outside SSWR area. In terms of productivity, profitability and equity the weir type SSWR system was found to be the most appropriate for northeast Thailand. Overall the study indicated that the small scale water resources can play very significant role in increasing the productivity and income of small rainfed farmers in northeast Thailand. The Department of Land Development approach of watershed development and management gives greater emphasis to small farm ponds and control of soil erosion. This program is being implemented on large scale in Thailand. The Kingdom Watershed Management Program for small, medium and large scale watersheds is also discussed.

The results from integrated participatory watershed management project implemented jointly by the Department of Agriculture, Land Development Department and Khon Kaen

University in close collaboration with International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) are discussed in detail. This project is being carried out at two benchmark sites, viz., Tad Fa in Phuphaman district and Wang Chai in Phuwiang district in northeast region of Thailand. Results shows that with proper land use planning and use of integrated soil, water and nutrient management (SWMM) and crop management options the land degradation can be controlled (soil loss of 5 t/ha/yr in improved system vs soil loss of 37 t/ha/yr in the traditional system). The project interventions significantly increased the water availability and crop yields. Promising watershed management technologies developed at the project sites provide a good framework for increasing productivity and income of farmers on sustained basis, while improving the soil and water resources.

Introduction

Northeast Thailand is situated between 19° and 14° N latitude, and 101° and 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 per capita 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.

Northeast Thailand has a monsoon climate similar to other parts of southeast Asia, but the region's geophysical characteristics create special conditions. Annual rainfall normally averages between 1300 and 1400 mm for the entire region, but with considerable variation. More than 90 percent of the annual rainfall occurs between May and October (i.e. rainy season). The western half of the region is substantially drier (1100 mm/year) as a consequence of the rain shadow effect. In contrast, annual rainfall in the extreme northeast corner of the region is about 1800 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.

Soils in the 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 caused widespread salinity problems. Also, the soil erosion and soil fertility deteriorations are some of the serious problems coming up in many areas. 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 suffering from water shortage. Due to these problems, a vicious cycle of soil degradation, low yields, poverty and low investment has gripped the rainfed agriculture.

To address these problems several watershed management programs have been implemented in Thailand during the past two decades by various government departments and institutions. Most of the initial watershed programs by Thai Royal Irrigation Department, Ministry of Agriculture and Cooperatives, and Kingdom Watershed Management Program were primarily focused on increasing the availability of water for agriculture. Several other watershed programs by Agriculture Development and Research Center (ADRC) and Land Development Department (LDD) were focussed on reducing land degradation and improving soil quality. More recently, the Integrated Watershed Management Project implemented by consortium of the Department of Agriculture (DOA), the Department of Land Development, Khon Kaen University (KKU) and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is focussing more on increasing the productivity and improving livelihoods of farmers through better management of natural resources. This paper reviews the various watershed management programs in Thailand with particular emphasis to rainfed areas in northeast region and discusses their approach, problem, and impact on agricultural productivity and natural resources.

General Background of Northeast Thailand

Landscape of Northeast Thailand

Northeastern region of Thailand is a plateau, which is gently sloping from the western toward the eastern part bordering PDR Laos or the Mekong river. There are numerous streams and rivers, some of them drain directly into the Mekong river but the majority of them drain into two main rivers, the Chi and Moon. These two rivers also drain into the Mekong river. In terms of agricultural development, there are two main agro-ecological basins, Sakon Nakon basin on the northeastern corner and the inner and larger Korat basin.

Soil Features and Management

Soil features: Land is gently undulating (nearly 80% of NE landform), covered by Mesozoic and Paleogene Tertiary sedimentary rock formation (ADRC, 1989). The soils are characterized by sandy textured topsoils. A skeletal soil owing to shallow laterite layer is widespread in Sakon Nakon Basin and comprises 13 percent of NE. Saline and sodic soils commonly occur in plateau and cover about 17 percent of the region. The alluvial plain, a fertile soil, are distributed along the Mekong, Chi and Moon rivers and their tributaries but comprising rather small area of only 6 percent of total NE area. Thus sandy top-soils, salt-affected soils and skeletal soils are three major problem soil in the northeast. Low soil fertility caused by these soils on the plateau as well as erratic rainfall are closely responsible for the low agricultural productivity of the northeast as a whole.

Soil erosion and nutrient loss: Increasing population in Thailand is putting strain on the natural resources such as land and water. The increase in population causes encroachment of forest area for agricultural land. The run-off that is loaded with the sediments impoverishes the soil and also causes reduction in the storage capacity of the water bodies.

Soil erosion is the main problem in degradation of natural resources. The sediment load and the extent of soil erosion in NE Thailand are shown in Table 1.

Sedimentation is secondary process after soil erosion, consequently, transported to streams or reservoirs. Soil erosion causes huge soil nutrient loss through transportation of sediments to other regions (Table 2).

Table 1. Sediment load in the run-off water in northeastern Thailand watersheds

Watershed	Mean annual suspended sediment (MCM)	Depth of erosion (mm)
Mae Khong	9.36	0.16
Chi	1.04	0.02
Moon	1.00	0.01

Source: Montien Somabhi and Peaingpen Sarawat.

Table 2. Nutrient loss (tonnes/year) through soil erosion in different regions of Thailand

Region	Nitrogen	Phosphorus	Potasssium
North	38.29	4.47	75.59
Northeast	18.90	1.21	91.64
Eastern	17.89	1.07	30.86
Southern	17.31	0.45	13.45

Source: RID, Thailand.

Crop Production and Socio-economic Conditions

According to archeological excavation at Ban Chiang and Udon Thani, the region's agriculture has been developed more than 3000 year ago. The lowland areas were first utilized for the cultivation of rice, the staple food of the early inhabitants. The upland area has only been significantly utilized since the last 40-50 years for additional family incomes. The first major upland crop was kenaf, followed by cassava in low fertility areas, and maize along the fertile land tracts. Other major upland crops introduced into the area were sugarcane, cotton, peanut, soybean, castor, mungbean and sesame. Kenaf has experienced a continuous decline due to competition with cheaper synthetic products and marketing problems. Cotton has also rapidly decreased in planting area due to pest-control problems. At present the cassava area has slowly decreased because of market problems and the replacement by sugarcane. The sugarcane areas have rapidly expanded in recent years due to the relocation of many sugar mills from other parts of country. At the same time most local mills also improved their equipment and increased the crushing capacity. The fruit trees were slowly introduced into the cropping systems of the northeast. Since only in the last two decades, the commercial fruit-tree production has been initiated and in recent years many large plantations were established because of the availability of cheap land and labours.

The majority of the northeast farmers are still dependent on the cultivation of crops. Crop incomes account for more than 60 percent of the total family's farm income and livestock and agricultural employment account for about 32 percent. However, the off-farm income of the average northeast farm family was slightly larger than the agricultural incomes. This fact implicate that the low agricultural income is not sufficient to support the family and seeking employment outside the farms is necessary for the majority of NE farm families.

The economic and social conditions of the country have changed dramatically and rapidly during the past two decades. The NE agricultural production has also been affected by these changes. The farm labours were drawn into the industrial and service sectors in other parts of the country. The NE agriculture production needs proper adjustment in order to improve family incomes, adapt to reduced-farm labour regime, and lead to a sustainable production system.

Soil management: Several research inputs to improve problem soils (sandy, saline, erosion and skeletal) aiming to increase crop production had been developed. Various kinds of maps such as agro-ecological zone map, land suitability map, saline soil map, erosion status map, underground water and land suitability for small scale water resource development map have been produced. Innovation of new hypothesis of soil salinization that saline groundwater originates from rock salt and moves up through the fractured zone and contaminates shallow aquifer and further moves to surface during dry season. Vetiver grass (*Vetiveria zizanioides*) and Ruzi grass (*Brachiaria ruzizensis*) planted contour-strips were useful to prevent soil loss and water run-off. *Sesbania rostrata* showed high potential as a promising green manure crop for supplying both nitrogen and phosphorus in infertile soil of NE rainfed lowland rice. Similarly, Hamata (*Stylosanthes-hamata*) and sunhemp (*Crotolaria juncea.)* are well suited for upland green manuring crop rotation. Application of biofertilzers such as mycorrhiza, blue green algae and azolla enhanced the efficiency of chemical fertilizers. Use of 1.5 m wide ridges associated with 14-day irrigation interval gave highest irrigation efficiency for soybean cultivation. Eucalyptus trees planted in upper part can suppress severe salinity in lowland paddy. These research findings are extensively used for reclamation of problematic soils in NE Thailand.

Land development technology transfers: The Land Development Department plays major role in both soil improvement and soil conservation through the conventional concept of extension and technology transfer that clearly covers all three areas of technology development process-researcher, extension staff and the farmers. The soil conservation has been receiving less attention in the past. The mobile units helped farmers build terraces on sloping land. This approach did not prove effective as farmers considered the terraces as the government properties and did not maintain them (Samran, 1995). This was an example of common failure of public resources land management. The information flew in one direction from researcher to extension staff and to farmers with little or no interaction and, seldom had good understanding of the farmers' environment and constraints. The concept of 'People-Centered' and 'Farmers' Participatory' concepts are now generally accepted that soil conservation program must work in close collaboration with land users right at the initial stage. The 'Soil Doctor' nowadays well known as 'Soil Doctor Volunteer (SDV)' is established in each Land Development Village (LDV) programs, which are being practised countrywide. SDVs are considered as good agents for land development which help in cost-sharing of various on-farm conservation measures, farm inputs, job contraction such as the award of contract to produce seedling or work on project activities, infrastructure for better village farm road, education such as field trips and vocational trainings and ensuring people's participation in project activities. However, some concerns are again emerging about this LDV programs in which government pays almost the total cost of establishing soil and water conservation measures, whether it could be as effective without such subsidies.

Water Resources Development for the Northeast

Strategy of water resources development: The water resources development strategy for the northeast follows two-pronged water policy. Firstly, it emphasizes proper distribution system for the existing sources of reservoir and rivers. In zone I (2.1 million rai, 8-9 % of farm families), farms are irrigated by large reservoirs, while in zone II (1.9 million rai, 10% of farm families), farms are irrigated by pumping water from reliable rivers. The second challenge is to meet basic requirement in every village which can be classified as zone III which have no access to reservoir and reliable rivers and support 80 percent of farm families. In these areas small scale water resources (SSWR) development may be possible to meet basic domestic water needs and minimal supplementary irrigation requirements.

The potential effectiveness use and alternatives of SSWR development projects to meet the basic requirement of villages can be visualized as summarized in Table 3.

Table 3. The potential use of alternatives (types) for small-scale water resources projects

Village use & requirement	Alternatives for small scale water resources projects						
	Weirs	Rehabi-litation	Village tanks	Dug ponds	Deep wells	Shallow wells	Roof run-off
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 typically found in NE watersheds in common lands. Dug ponds or 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 and require pumping. The shallow (open) wells are usually dug manually by villagers down to the water table. And the last alternative is collection of run-off rainwater from household roofs for drinking purpose.

Agencies for water resources development: Electricity Generating Authority of Thailand (EGAT) is concerned with construction of the major/mega dams for electricity production only. For agricultural purposes, several departments of the Ministry of Agriculture and Cooperatives (MOAC) are responsible in various contexts. The

Royal Irrigation Department (RID) plays important roles in agricultural water resources development associated with irrigation system facilities. It has divided the whole Kingdom into 25 main river basins and NE Thailand shares only 3 main river basins, namely, Mekong, Chi and Moon river basins (Table 4). The Royal Irrigation Department is responsible for construction and maintenance (large and medium schemes) of reservoirs associated with main irrigation systems. These supply main water resources for 15 percent of the irrigated area of the country. It also constructs small scale schemes such as village tanks, rehabilitation (dredging) of natural streams and swamps, levee for flood protection, and mobile pumping for emergency cases (drought relief program, in particular).

Table 4. Main river basins, drainage area, run-off, and RID water resources development in northeast Thailand

Main river basins	Drainage area (*1000 km^2)	Mean annual run-off (*billion m^3)	RID water resources development schemes			
			No. of large & medium	No. of Small & others	Stock (m.m^3)	Irrigable area (m. rai)
Kingdom (25)	511.48	213.42	694	694	9362	37.45
Northeast (3)	165.85	44.03	178	5184	6.02	2.90
Mekong	46.67	13.29	na	na	1.16	na
Chi	49.48	11.24	75	2025	1.79	1.24
Moon	69.70	19.50	109	3159	3.07	1.66
NE (%) share	32.4	20.6	25.7	55.4	15.9	7.5

Source: Consolidated from RID.

In sub-river basin defined as Zone III with sloping undulated upland, mini-watersheds are formed. Major responsibility of Land Development Department (LDD) is soil conservation. Water resources projects are included as part of soil conservation needs. In terms of SSWR development, the LDD is focusing on on-farm level in the watershed, for instance, on-farm ponds, shallow wells, dredged waterways, and earthen bunds. Up-to-date, LDD has completed construction of 1,807 number of SSWR (LDD, 2004). Similarly, the Office of Land Reform (OLR) has responsibility of land reform and consolidation, but is also empowered to construct water resources projects as a part of agricultural land development. The Office of Permanent Secretary (OPS) is launching integrated farming program, under King's New Theory Farming Initiation, which also stress farm pond as a key component of all pilot farms. The Department of Agricultural Extension (DOAE) has also initiated deep well pumping project as part of extension promotion program.

The Community Development Department has major responsibility in community development and generally takes over the RID-SSWR projects for further development but, the department also develops its own water resources as part of the program. The drillings program of Department of Mineral Resources is for mineral exploration, however, the wells where good groundwater is encountered are developed for use. The rural water supply development program of the department in Ministry of Public Health is aimed to provide good drinking water for rural community. National Energy Authority (NEA) develops groundwater irrigation of medium and large scale. The results were very promising, but unfortunately NEA is not authority in line agency for executing the pumping schemes.

The three main types of SSWR of RID such as weirs, tanks and natural stream rehabilitation which are typically located in lowland, indicated that water availability in dry season has boosted upland crop and vegetables production. The impact on socio-economic conditions of the farmers in NE Thailand was found that the farmers in SSWR area earned more income from agriculture than farmers outside SSWR area. Farm profitability and source of farm cash income of SSWR farmers were closely related to dry season cash crops rather than wet season rice. The area under double cropping was found to be higher in SSWR area than those outside SSWR area. In terms of productivity, profitability and equity, the weir type SSWR system was found to be most appropriate for the NE Thailand. Overall the study indicated that the small scale water resources can play very significant role in increasing the productivity and income of small rainfed farmers in NE Thailand.

This can be implied that the productivity of rainy season paddy in zones I and II watershed (20% irrigable farm families) may not need much of supplemental irrigation water, however, water is required during dry season in contrast to Zone III watershed (80% rainfed farm families) where SSWR played important role for both rainy season paddy security and obtaining extra farm income from dry season crop cultivation.

Integrated Watershed Development Experiences

An earlier overview showed that independent activities on soil improvement, land development, water resources development, crops and livestock production are executed by individual departments without any coordination. It has now been realized that more of the integration of multi-disciplinary partnerships is required for holistic management. Generally, the term 'Watershed' refers to a sub-drainage area of a major river basin (Dixon and Easter *et al.*, 1991), whereas the Integrated Watershed Management Approach is the process of formulating and implementing the course of action involving natural and human resources in the watershed to achieve specific social objectives. This means developing proper linkages between the upland and lowland in both biophysical and socio-economic context.

Integrated Watershed Management for Enhancing the Livelihoods of the People

The concept of integrated watershed management with holistic approach for increasing the agricultural productivity and enhancing people's livelihoods is relatively new in NE Thailand. In 1999, an integrated watershed management program was initiated at Tad Fa village in Phupaman district of Khon Kaen province. A new farmer participatory consortium model for efficient management of natural resources and reducing poverty has been adopted. A consortium of institutions, as opposed to a single institution, was formed for project implementation and technical backstopping. The Department of Agriculture (DOA), the Land Development Department (LDD), Khon Kaen University (KKU), along with International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) formed the consortium for implementation and technical backstopping at two benchmark sites, viz., Tad Fa wateshed in Phupaman district and Wang Chai watershed in Phuwiang district.

Tad Fa Watershed, Phupaman, Khon Kaen

Tad Fa watershed is part of a large basin of Chi river, which is located at latitude 15° 30′ N and longitude 101° 30′ to 140° 30′ E and is about 150 km northwest of Khon Kaen. It is a junction of three big watersheds, namely, Chi in east, Mae Khong in the northeast, and Pasak in the southwest. Tad Fa watershed falls in two provinces: the eastern part of the river Tad Fa comes under Khon Kaen province, which has nearly 700 ha, while the western side comes under Petchabun province. This watershed project was carried out in the eastern part of Tad Fa watershed of Khon Kaen province.

Mean annual rainfall at Tad Fa watershed is about 1300 mm with 1900-2000 mm evaporation and in terms of temperature regime the area is tropical (26-30°C). Topographically it has high to medium slopes and soils are mostly Ustults. The land use mostly comprised field crops, horticulture, and vegetables. The cropping systems under rainfed condition include maize as a cash crop on high and medium slopes and upland rice on the lower slopes. The fruit trees and vegetables are usually grown close to supplementary water resources on the lower slopes. Sometimes, legumes and cereals are rotated with maize. Some of the major research and development activities carried at Tad Fa watershed are discussed.

Watershed development: In consultation with the farmers, the Land Development Depatment has constructed about 17 farm ponds each of 1260 m^3 capacity. This provides much needed supplemental irrigation to crops/fruit trees/vegetables, particularly in the post-rainy season. In large areas the field bunds have been constructed along with vetiver grass. This is necessary for controlling soil erosion, which is one of the major problem in Tad Fa watershed. The annual soil loss of 40-60 tonnes/ha is quite common in this watershed.

Soil and water management: 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 percent area was planted on contour on mild slopes. The cultivation increased the maize yield by 30-40 percent compared to conventional up and down cultivation. It also significantly reduced the soil loss.

Integrated nutrient management: Most of the farmers in northeast Thailand apply chemical fertilizers for their cash crops in order to harvest decent yields. Chemical fertilizers are one of the costliest inputs and there is a need to search other alternatives or supplement sources to overcome nutrient constraints. There is not much scope to use farmyard manure (FYM) as farm animals have been replaced by tractors for draft purposes. The use of legumes in the cropping system would certainly help to reduce the amount of chemical N fertilizer. Several legumenous crops viz. rice bean (*Vigna umbellata*), black gram (*Vigna mungo*), sword bean (*Canavalia gladiata* (Jacq) DC) and sunnhemp (*Crotolaria juncea*) were evaluated. Based on the N-difference method, N_2 fixation varied from 20 to 104 kg N/ha and net N benefit expected to the succeeding crop was expected in the range of 2 to 51 kg N/ha. Following legume crops, a maize crop was grown with 40 kg N/ha along with the organic matter from the legume residues. Grain yield of succeeding maize crop was significantly higher by 27 to 34 percent in case of treatments following black gram, rice bean and sumhemp over the yield of control maize crop (Table 5). Although N_2 fixation was highest in case of sword bean (104 kg N/ha), the benefits were not translated in terms of increased maize yields. These results demonstrated that it is not only the quantity of N_2 fixed that determines the benefit to the succeeding crop but the quality of organic matter and N release pattern from the legume residue. However, in long-term for sustaining land productivity the sword bean crop could play an important role.

Table 5. Dry matter of maize grown after five different crops at Ban Koke Mon in the rainy season of 2000

Treatment	Dry matter (kg/ha)			
	Stover	Cob	Seed	Total
Rice bean	7.069	816	4,541a	12,425
Sunnhemp	6,634	786	4,720a	12,141
Sword bean	6,689	659	3,642b	10,991
Black gram	6,786	875	4,488a	12,149
Maize (fallow)	5,560	697	3,525b	9,781
F-test	NS	NS	*	NS
CV (%)	14.57	14.41	13.36	13.13

* The maize crop received N from crop residue as mentioned plus 40 kg N/ha in the form of chemical fertilizer.

It was found that for quick benefits for succeeding maize crop, farmers would be benefitted by growing legumes such as rice bean, sunnhemp and black gram. In another experiment, the effect of groundnut stover management on growth and yield of upland rice was studied. The stover of groundnut grown in many areas is left unattended after the final pod harvest. Generally no attempts are made to use it for the succeeding crop production. The study included two parts i.e. preceding crops and succeeding crops. Preceding crops were local groundnut and non-nodulating groundnut. Succeeding crop was glutinous rice (*Pla Ziew Maew*, a local variety).

Data in Table 6 shows dry matter production of upland rice grown after different treatments at final harvest. It clearly shows that stover removal results in lower growth and yield of rice. The treatments where the stover is returned either as incorporated or mulched increased growth and yield of rice. Treatments where groundnut stover was returned could supply sufficient N for rice as N application at panicle initiation period did not significantly increase rice growth and seed yield.

Table 6. Grain and dry matter yields (t/ha) at final harvest of upland rice grown after groundnuts with different treatments (Ban Koke Mon site, 2003)

Treatment	Grain dry weight	Total dry matter weight
-S**+N_0+P_0+K_0 (Control)	2.56bc	5.98bc
+S(incorp.)+P+K	3.63ab	8.62ab
+S(mulch.)+P+K	3.94a	9.25a
+S(incorp.)+P+K+NPI*	3.75ab	9.84a
+S(mulch.)+P+K+NPI	4.21a	9.99a
-S(non-nod)+P+K	2.02c	5.60c
-S+(½N)+P+K	3.56ab	7.89abc
-S+N+P+K	3.02abc	7.20abc
-S+(2N)+P+K	3.48ab	8.57ab
F-test	**	*
C.V.(%)	22.64	22.31

* Nitrogen at panicle initiation stage, ** Groundnut stover, N : Nitrogen, P : Phosphorus, K : Potassium

Diversifying land use system: Cultivation of fruit trees is being popularized in the Tad Fa watershed. This assists in controlling soil erosion and provides better and more sustainable income to the farmers. During last 2-3 years the area under fruit trees cultivation has increased in and around Tad Fa watershed. Several new fruits and varieties have been introduced to increase the productivity and the survival of fruit trees. Several new systems, viz., intercrop banana with other fruit trees, mulching, inter-row water harvesting and growing annual crops along with fruit trees have been introduced.

Improved crops and cropping system: Several new crops and their varieties have been introduced in the watershed. New relay and sequential cropping systems have been identified and tested. A large numbers of farmers have adopted these new crops and varieties.

Empowerment of community: Empowerment of communities, individuals and the strengthening of village institutions were done through concerted efforts. It was observed that when people are empowered to take decisions and execute the activities, they own the program very well. They run the watershed activities according to local, social and cultural systems.

Hydrological measurements: An automatic weather station has been installed in the watershed to monitor rainfall, temperature, sunshine, humidity, wind velocity, and soil temperature at fixed intervals. Two digital run-off recorders along with automatic pumping type sediment samplers are installed at two sub-watersheds to monitor the run-off 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 run-off and soil loss from the two sub-watersheds during 2003 are shown in Table 7.

Table 7. Rainfall, run-off and soil loss from two watersheds (Tad Fa, 2003)

Land use systems	Rainfall(mm)	Run-off(mm)	Soil loss (t ha^{-1})
Annual crops	1650	256	32.5
Fruit trees	1650	142	6.3

Wang Chai Watershed, Phuwiang, Khon Kaen

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 percent 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. 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. Major crops grown in the watershed are rice, sugarcane, cowpea and groundnut. Small areas are also under fruit trees and vegetables. The average productivity of most of the crops is quite low

The biophysical and socio-economic base line data from the Wang Chai watershed have been collected and analyzed. The major constraints for increasing the agricultural productivity were identified. The topographic, land use and soil maps have been prepared. Most of the areas in the watershed have moderate to low slopes.

Major research and development activities: In consultation with the farmers, 39 farm ponds each of about 1250 m^3 storage capacity were constructed. In large areas the field bunding has been done and total 9 km village 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 run-off water. The rainfall, run-off and soil loss have been monitored.

During the last two years various research and development activities on integrated nutrient management, water management, crops and cropping systems were taken up. 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 pure rice seed production farms were established. Training was given to farmers for value addition to field crops products. The farmers are quite happy with the various watershed activities. The construction of farm ponds has significantly increased the cropping area in the post-rainy season. Some of the activities have already resulted in increased agricultural productivity and income.

Lessons Learnt

Integrated watershed management project is only 5 years old. Some of the initial lessons which could be drawn from this integrated watershed management project are:

- Consortium approach consisting of various research and development organizations, University and farmers helped to effectively plan, implement and monitor the watershed. This model of bringing the key organizations (DOA, LDD and KKU) together needs to be replicated in other watersheds for their success.
- The integrated watershed program resulted in tangible economic benefits to individual farmers through improved soil, water, nutrient and crop management options on their lands.
- Participatory planning with the farmers for deciding the location of the water ponds was found highly beneficial.
- Adoption of improved technologies (new crops and fruits, new varieties, tillage systems, land and water management, water harvesting, etc) substantially raised productivity and augmented farm income. Some of the watershed activities such as cultivation of fruit trees were found highly successful in attaining the livelihood and environmental objectives of the watershed.
- It was found that most of the farmers come together for immediate and private gains rather than the long-term social gains. As long as the collective action yielded sufficiently higher private gains, farmers participated actively in watershed programs.
- The formation of self-help groups was found to be highly beneficial. Particularly the self-help group formed in the watershed for fruit trees cultivation was highly successful. Farmers were able to share the various information about the new technologies, new varieties, insects and pests problems and possible solutions.
- A strong network of information is found necessary for increasing the effectiveness and sustainability of watershed program. In the changing economic regime, the technologies are changing rapidly and affecting competitiveness, markets, consumer preferences and prices.
- The integrated watershed management is relatively new in NE Thailand. There is need to address the second-generation watershed problems. The policy, institutional arrangement and problem of scaling up need to be taken up in future.

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