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Land Degradation from Socio-Environmental Perspective: A Causal Chain Analysis from Thailand

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Abstract: The study adopts a socio-environmental perspective to determine root causes of the widespread land degradation problem in many parts of the Southeast Asia. Based on a method combining visual assessment, focussed group discussion, information gathering from published literature and secondary data repositories and causal chain analysis for a showcase watershed in Thailand it is found that declining soil fertility and reduced water availability (restricting farmers' crop choice) are the immediate causes of land degradation. The causal factors responsible for soil fertility reduction are inappropriate agro-chemical use and soil erosion. The later is also responsible for silting up of the streams and reservoirs restricting the scarce source of irrigation. The identified root causes of these causal factors are many reflecting the complexity of issues affecting degradation. It is expected that understanding of the root causes of degradation will help develop priorities for action and set policy options to combat land degradation.

Key words: Land degradation, land use change, agricultural watershed, Thailand

INTRODUCTION

Southeast Asia is one of the most densely populated regions in the world. Largely agrarian, the region is experiencing enormous land use changes in the form of deforestation/afforestation, cropland abandonment and clearance for agriculture during the last century. Its ecosystems are subjected to high stress from increasingly intensive agriculture. Thailand is a case in point. During the middle of the last century, land pioneering (called *ha na da* in Thai) in the country was instrumental in meeting the food and fiber requirements of the rapidly expanding population at the expense disappearing forest area that were converted to paddy fields, residential areas and cash crop areas. The country's forest cover shrunk to 28% from 42% during 1973-88 prompting the Royal Thai government to close all forest areas in 1988. Nevertheless, forest encroachment continued unabated. FAO (1999) estimated that from 1990 to 2000 forest cover decreased at an annual rate of 0.7%. Unfortunately, agriculture in cleared forestland has often been established under adverse soil and climatic conditions, which in combination with unsuitable market-driven agricultural land use has severely degraded many upland watersheds of Thailand. Today, upland agriculture risks losing land productivity, which will affect millions of smallholders in Thailand.

Literature pertaining to research on upland land degradation have overwhelmingly related contemporary degradation to the large-scale replacement of native vegetation from sloping lands for cultivation (Nagle, 2001; Riethmuller, 1988). This popular view, however, fails to emphasize that farmers' land use decisions are influenced by economic, cultural, political, historical and institutional factors at multiple scales. For example, in-field situations in Lesotho, Brazil, India and Nepal indicate that faulty assumptions or misapprehensions-about farmers' perceptions, about cause-effect relationships between erosion and yield and about the dynamics of land use change-might have led to inappropriate emphasis in the formulation of programs to tackle land degradation problem (Shaxson, 2001). Therefore, there remains ample scope to explore the causes of land degradation from a socio-environmental perspective. Along this vein, this study is taken up to understand the dynamic linkages between different human and environmental conditions that effect the land degradation at watershed scale.

MATERIALS AND METHODS

The study area: A typical Thai agricultural watershed, Lam Phra Phloeng, where large parts of the local forests were cleared for agriculture after 1970, is selected for the study. The watershed is situated (between latitude 14°18'18"-14°45'29" east and longitude 101°29'06"-101°54'29" south) in the Khorat Plateau and is bound in the north by the Pha Khao Phu Luang reserved forest and in the south-southwest by Khao Yai Reserved Forest (Fig. 1).

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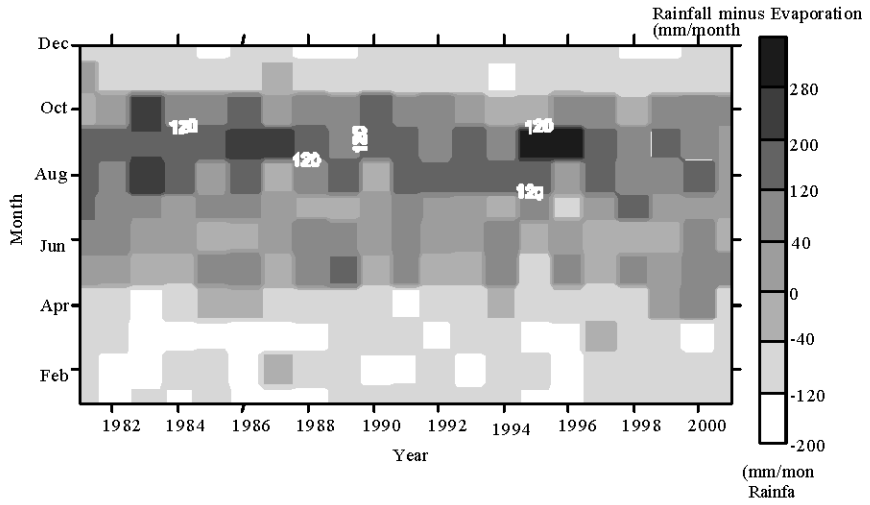

Fig. 1: The study area

The general topography is undulating with many small hills. The elevation varies between 260-1,150 m above the mean sea level and covers an area of 815 km^2. Administration-wise six sub-districts (Tambon) of Nakhon Ratchasima (or Khorat) Province occupy major parts of the watershed. These are: Wang Mee, Ra Roeng, Wang Nam Khieo, Wang Ka Ta, Pong Ta Long and Ta Trob. The six sub-districts consist of 66 villages with 8,357 households. The total population is 29,152. The male population outnumbers the female population and constitutes 57% of the total population. The average population density (36 persons per km^2) is lower than the Thai national average of 118 persons per km^2 (NSO, 2003). Seventy four percent of the total population is educated up to at least sixth grade.

Climate: The watershed has a tropical Savannah type climate-typical of northeast Thailand-where the dry season and the rainy season are sharply distinct from each other. The dry season includes summer and winter and typically runs from November to April, while the rainy season is from May to October. About 85% of the rainfall occurs during the rainy season. Analysis of rainfall and evaporation data (average of the years 1981-2001) from 18 meteorological stations in and around the watershed shows that the mean annual evaporation is 600 mm higher than the mean annual rainfall, which clearly indicates that the area is, normally, dry (Fig. 2).

Being in a tropical climatic zone the study watershed has 3 temperature regimes: The cool dry (mid-October to mid-February), the hot dry (mid-February to mid-May) and the rainy season (mid-May to mid-October).

Geology and soils: Geologically the watershed is on the edge of the larger Mun River basin, which covers much of the northeast Thailand. Three kinds of geological formations are prominent, viz., Quaternary Deposits, Maha Sarakham and Khok Kruat formation. Soil parent materials are mainly weathered mantle bedrock and finer matrix of gravel bed. The spatial distribution of the parent material and soil type are congruous. These materials are transported relatively shorter distance by wash, creep, wind action etc. (Nakhapakorn, 1997). Soil textures vary from loamy to clayey sand (LDD, 2002).

Land use: Digital maps of land use were prepared by analyzing Landsat MSS satellite image of 1973 and Landsat TM satellite image of 2002. Ground Control Points (GCPs) were taken from topographic map of Thailand. The classified land use types were verified through ground truthing. Image classification shows that two major lands dominate the landscape-agricultural land and forest. Agricultural land consists of field crop cultivation and orchard and covers 82% of the watershed area in 2002. The forest consists of dry evergreen, dry dipterocarp forests and reforested area and constitutes 17% of the watershed in 2002 compared to 50% in 1973.

Land degradation: Land degradation is overarching problem of agriculture in the watershed (Douglas, 2006). Signs of degradation are manifested through loss of

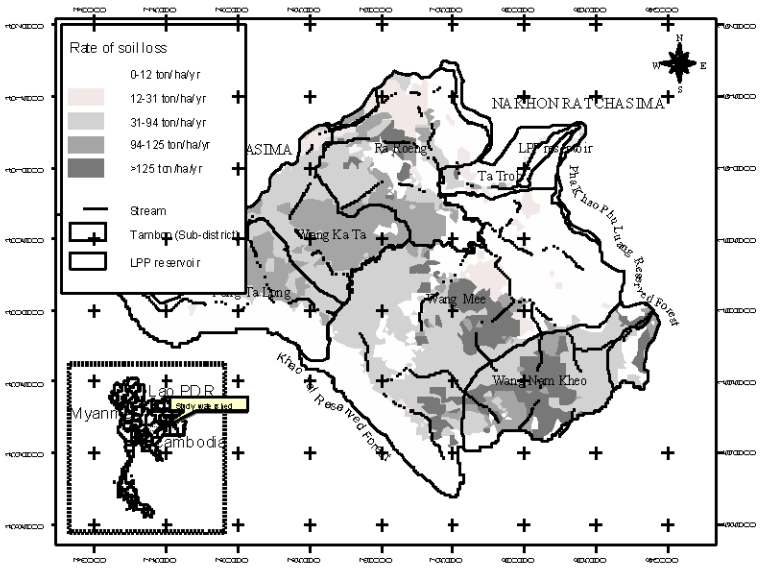

Fig. 2: Rainfall minus evaporation (1981-2001)

topsoil and formation of rills and sedimentation and siltation of rivers and reservoirs. Information on the extent of erosion was obtained from Land Development Department of Thailand (Fig. 1). It was found that about 30% watershed area suffer moderate to severe erosion (>30 ton/ha/yr).

Water resources: The major sources of water are rainfall and surface water from rivers and reservoirs. Unfortunately surface water availability is declining. The two reservoirs in the watershed are termed as two of the most sedimented reservoirs in the upper Mun river basin of Thailand (Charuppat and Mongkolsawat, 2003; Heijnis *et al*., 2003). Based on information obtained from the Royal Irrigation Department of Thailand, the LPP reservoir has lost $40*10^6$ m^3 of storage capacity during a period of 24 years (1967-1991). Also as can be expected from the seasonal pattern of rainfall (Fig. 2) the rivers retains very low flow (<0.5 m^3 s^{-1}) during the dry season. Domestic water requirement is dependent on rainwater harvesting.

The key theme of the study is concerned with socio-environmental construction of land degradation at watershed scale. While it is acknowledged that rigorous monitoring and GIS data can provide representation of watershed, but depending on the frequency of monitoring, the data might not reflect chronic conditions but rather provide a snapshot of conditions unique to the time of sampling, especially when dealing with parameters that are highly variable and sensitive to localized impacts (e.g., fertilizer use). Therefore a causal chain analysis that treats land use system as complex and subject to multiple interpretations and traces the cause-effect pathways from the socio-economic and environmental impacts back to its root causes is adopted. When applied from the systems perspective, causal relationships are able to: Prevent biases or lapses of logic that are otherwise not immediately apparent and increase confidence that conservation efforts are targeted at factors that can truly improve overall condition.

To make the most of causal evaluation, it is important to analyze the data/information with an understanding of the real world. Therefore, a method combining visual assessments, focused group discussion and data gathering to support visual assessment was used (Fig. 3).

Visual assessment is one of the most rewarding and least costly assessment methods. By walking and driving through the watershed, water and land conditions were observed. Uses and changes over time that might otherwise be unidentifiable became evident during visual assessment, e.g., erosion delivering sediments into the stream and illegal forest encroachment. In addition to visual inspection, anecdotal information from local stakeholders was collected to analyze and interpret historical information that was not identified through visual assessment. Major groups of people directly or indirectly involved in the utilization and planning of watershed resources were distinguished. This included various stakeholders-farmers, landless labourers, Village Headmen, Tambon (Sub-district) officials, Amphoe (District) officials and Changwat (Provincial) level staff. Non-structured informal interview and group meetings of these stakeholders were made in 2004. Pictorial conceptual model (as if-then links) were used to guide local stakeholders identify root causes of the degradation problem. The procedure proved useful to familiarize local

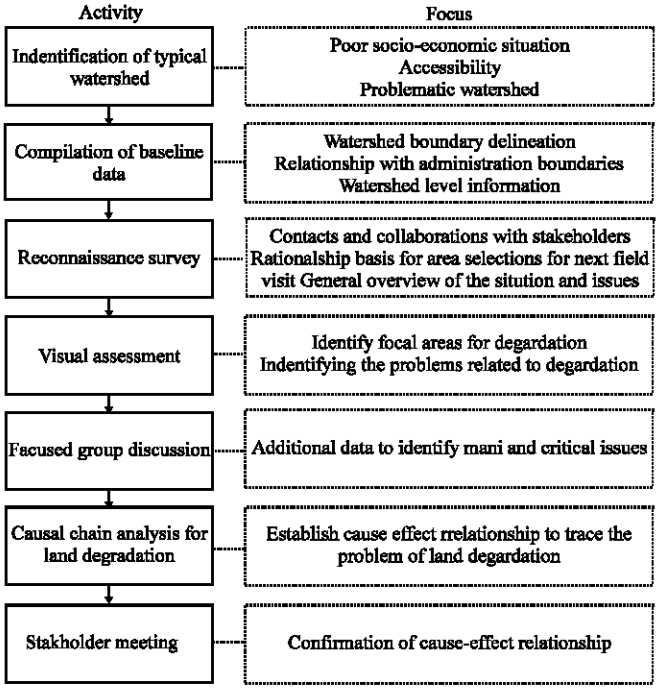

Fig. 3: Method

stakeholders, decision makers, citizens and line agency personnel with activities occurring in their watershed.

Based on the identification of potential causes of degradation through visual assessment and group discussions, necessary supporting data on socio-economic setting and issues were obtained from National Economic and Social Development Board, Thailand database (gorchor-chor-2-kor), Tambon Administrative Office (TAO, 2000) Department of Agriculture, Agricultural Extension Office, Soil Research Institute. Village was selected as the smallest spatial unit for data gathering since, often, some socio-economic aspects related to degradation can be better evaluated at the village level. For example, issues like social capital or social cohesion are not very evident from the household data (Mertens *et al*., 2000).

RESULTS AND DISCUSSION

Based on land and water resources endorsement and socio-economic setting and issues, the problem of land degradation has been traced following a cause-effect relationship and is presented as causal chain (Fig. 4). The causal chain is discussed with the local and regional stakeholders for greater elucidation. It is found that immediate causes of land degradation are declining soil fertility and reduced water availability owing to accelerated soil erosion, inappropriate land and agro-chemical use. In the following sub-sections the underlying causal factors of land degradation are explained.

Inappropriate use of agro-chemicals: Over the past decade, smallholders in the watershed, as elsewhere in Thailand, are operating their farms in different socio-environmental context than before, producing a variety of cash crops. The switch to market oriented crops has intensified cropping systems which is largely fuelled by the in appropriate use of inorganic fertilizers, pesticides-especially herbicides and flowering hormones (Cho and Zoebisch, 2003). The rates of application of fertilizer have more than doubled since it began to be used widely during 1987-88, from around 210 kg ha^{-1} to about 470 kg ha^{-1} in 2002 to maintain desired crop yield. Cho (2003) reported a lower response to added fertilizers due to nutrient imbalance and/or micro nutrient deficiencies. Comparative yield assessment of maize in 2 major cropping systems showed that average maize yield increased from 4,456 kg ha^{-1} to 6,337 kg ha^{-1} in between maize-maize and fallow-maize cropping systems. During focused group discussions farmers identified 2 causes behind inappropriate used of agro-chemicals. First, agricultural extension service is poor and farmers are unaware of the optimum dosage of agro-chemical application. Secondly, since *in-situ* nutrient availability in soil was low, farmers were overusing agro-chemicals,

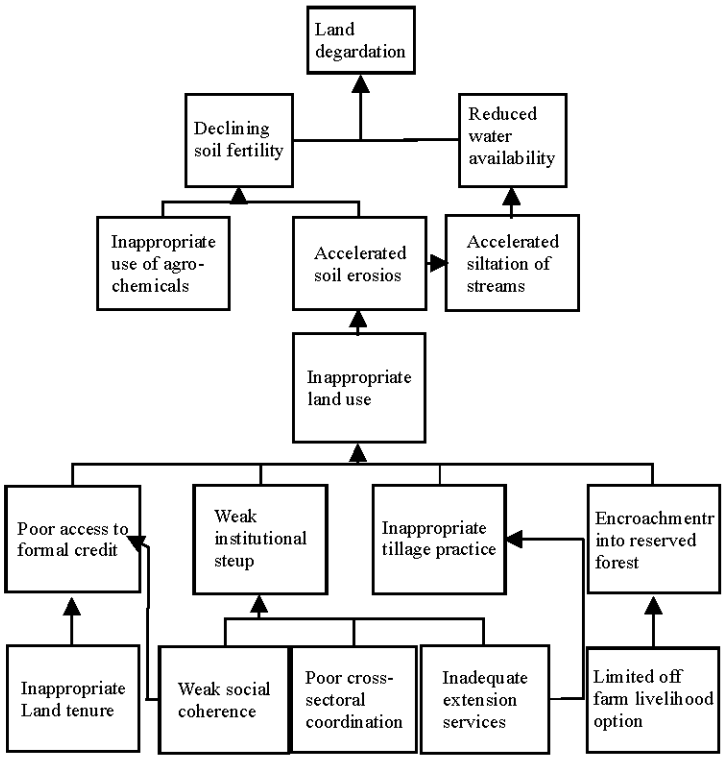

Fig. 4: Causal chain analysis for land degradation

especially fertilizer, to maintain production level. It was also observed that organic fertilizers were seldom used and crop residues were either burnt or thrown outside the field mainly to ease tillage operation by tractor for the following crop.

Inappropriate land use: Land use in the watershed is highly distorted given its biophysical endowment (topography, water resources, climate, geology and soil). A complex interlinking set of socio-economic elements-whereby the smallholders have poor access to formal credit, institutional setup remains weak, tillage practices are inappropriate, deforestation and encroachment into the forest goes unabated-has created a system of inappropriate use of land without adoption of conservation measures. Land predominantly suitable for forestry, agro-forestry and pasture-and to a lesser degree upland agriculture-is increasingly being utilized for cash crop cultivation.

Land use history show that after initial settlement in 1970, natural forests were cleared through slash-and-burn practice and converted into cropping lands heralding the beginning of the cropping history. Since then a wide-scale diversification of land use, from upland rice to maize and from subsistence to market-oriented farming is reported (Cho and Zoebisch, 2003). The cropping system was subsistence oriented mainly based on indigenous knowledge that continued only a couple of years. After that farmers embraced modern technological interventions in terms of crop varieties, tillage implements and the required external inputs. Yield, market demand and price of produce, input or production costs, labour availability and costs, availability of water, severity of pest and diseases, developments of infrastructure etc dictated the land use decision. Maize is the main component of the dominant cropping system (77% of agricultural household grow maize) while 6.6% household is involved in cassava or sugarcane cultivation though cassava is getting gradually lesser importance in the farming communities due to poor return on investment. All these systems are market oriented and mostly based on high yielding varieties and hybrid crops that need increased levels of inputs to maintain the expected yields.

Inappropriate land tenure and poor access to formal credit: Problems of land degradation in the watershed are closely related to type of prevalent land ownership. Combined with low income (average annual household income is US$ 1,265 compared to the national average of US$ 3,842), insecure ownership means that farmers can not use their land as collateral to obtain agricultural loans from formal credit providers. In the study area, 2 types

of land document are dominant-PBT 5 (land tax receipts) and SPK 4-01 (Sor Por Kor, Agriculture Land Reform Policy). 45.2% households in the study area possess SPK 4-01 land certificates while 36.8% possess PBT 5 certificates. In the case of PBT 5 certificates, farmers use tax certificates as evidence of land tax payment. Since tax is collected from any occupied land in Thailand, irrespective of its legality, many farmers are apparently willing to pay the rather low land tax with the hope that it will help them to establish full legal rights at a later time (Feder *et al*., 1988). Though PBT 5 types of land titling system is a temporary kind of leasing arrangement it allows unlimited size of the land holding. This has prompted rich absentee landlords to hold most of PBT 5 land titles. However, legally, farmers are not allowed to sale the land to other people. The Government also retains the capacity to vacate the farmers from their land. Therefore, without permanent land titles, farmers of these kind of land can not use their land as collateral to obtain credit from the main formal credit source-the BAAC (Bank of Agriculture and Agriculture Cooperatives). This has a bearing on the poor PBT 5 land holders who has to rely heavily on non-institutional credit sources where interest rates are exorbitantly high (5% per month). Often, because of the cumulative loans from the middlemen, some poor farmers have to sacrifice their land to the moneylender (middlemen)-who are also often absentee landlords-because of high indebtedness.

SPK 4-01 is also temporary land right title and developed to redistribute agricultural land to smallholders and landless (ESCAP, 1998). In this condition, the land area to be occupied by each household is limited by the government-maximum 2.4 ha (or 15 rai). This land title can be used as collateral to obtain credit from the bank. It can be inherited by successive generations but can not be sold to other people. Also, if the land is not cultivated or used for a certain period of time, they must be returned back to the government. Often, farmers are reluctant to obtain this kind of land title since maximum amount of land is limited to only 2.4 ha. Though farmers with small land holding and without any other source of income are willing to get SPK 4-01 certificate to obtain credit from the BAAC, the bank's credit rule remains skewed. It values the land within US$ 1,650 per ha irrespective of prevailing market price and the maximum amount of credit offered by the BAAC is 50% of the value of land put forward as collateral. Hence, in most of the instances, farmers with SPK 4-01 land certificates are not able to get required amount of credit, which forces them to search for alternate sources of credit.

Weak institutional setup: There are seven major government institutions directly involved with development of the watershed-Royal Forest Department, Department of Livestock Development, Department of Agriculture, Agricultural Land Reform Office, Land Development Department, Department of Mineral Resources and Department of Agriculture Extension. Coordination among these departments is poor. Agricultural extension services are nearly absent. For example, farmers expressed their willingness to develop orchards, but indicated lack of technical know-how for the same. Poor extension services are attributed to: Insufficient number of extension workers, lack of service facilities like service centre at the field and lack of monitoring and evaluation system/follow-up program.

Provision for local people's participation in the development related planning and budgeting, from sub-district to provincial level, is minimal. Tambon Administrative Office (TAO) follows a top-down approach during its planning and budgeting process and has very little influence in the decision making process in Provincial or Central level for budg location. Development budget-often inadequate to promote land conservation activities-is allocated by the Provincial Office (PO) directly to the TAO on a lump sum basis. On the other hand poor endowment of natural and other resources means that locally collected tax is very meagre to develop the infrastructure and other public service necessary to change land use practices that do not contribute to land degradation.

Social coherence of the watershed settlers is weak. Due to cultural diversity of the initial land pioneers, coming from different ethnic backgrounds around Thailand, the local people are not socially united as evidenced by the near-absence of marketing groups, credit and saving groups, women groups and youth groups in the watershed. In terms of social capital this means smallholder can not influence development planning and budgeting activities or obtain formal credit or improve market access-all of which impact farmers land use practices.

Inappropriate tillage practice: Farmers' agricultural practices in the field are not conservation oriented. Almost all the sloping lands in the watershed are ploughed along the slope using four-wheel tractors. This happens because farmers are unaware of the negative consequences of ploughing along the slope-inversion of the soil and burying of crop residues making the soil surface unprotected and exposed to greater erosive action of water (Kammueng, 1985). Few farmers, though aware of the result of ploughing upslope and downslope, also are reluctant to stop the practice since they have to hire the tractor from the moneylenders to till the land and tractor drivers do not plough along the contour line because of fear of tipping over their tractors.

Limited off-farm livelihood options and encroachment into reserved forest: Positive association between degradation and lack of off-farm livelihood options has been reported by a number of studies (Walsh *et al*., 1999). The study watershed is also a case in point. It is found that only 8.6% households are engaged in small scale handicrafts enterprises like baskets and broom making from the bamboo and prevalent poor marketing facilities are gradually failing to attract farmers economically to pursue these activities. Non-timber forest products (e.g., mushroom, bamboo shoots and other minor forest products) are collected in a small scale for household consumption only. Limited off-farm employment option and poor implementation of government policy to restrain cultivation on steep slopes (>35%) mean that some landless farmers often encroach conservation forest areas for agriculture. Often ill definition of the boundary between steep slope land (reserved forest) and the farm land means that cultivation on steep lands goes unabated making these lands highly vulnerable to land degradation. This is not surprising given the sheer magnitude of the problem faced by the Royal Forest Department as a central agency responsible for managing the reserved forests in Thailand.

Lack of off-farm employment opportunities, in combination with low wage (US$ 2.6/day), is also encouraging agricultural labours to migrate out of the study area in search of better employment opportunities. This often creates labour shortage in the short peak agriculture season and promotes degrading agricultural practice.

Reduced water availability: Perennial source of water is limited. High soil erosion in the watershed means that streams are increasingly silted up depriving the farmers scare source of irrigation. Current agricultural practice of the farmers is mostly rain fed. Unfortunately, rainfall is concentrated during 6 months in a year (Fig. 2). Inter-annual rainfall variability is also high. Under such water-constraint situation, smallholder also lack technical knowledge to harvest the rain and runoff water thereby limiting their choices of crop. High cost of constructing conservation ponds also adds to the problem.

CONCLUSION

This study is a contribution to informed watershed management and intended to put into perspective the underlying causes of land degradation in a showcase watershed in Thailand. It is found that changes in land use are contributing to land degradation in the study area. Deforestation is generating rapid runoff of rainwater, which in turn results in soil erosion in the upland areas and a consequent soil fertility reduction. Accelerated soil erosion is leading to siltation of the drainage channels and reservoirs.

Changes in land use reflect continuous interplay between typical agrarian human use-system (tenure, institutional setup, social capital and credit facility) and the physical base (climate, soil, vegetation and geology). Starting from 1970, largely forested upland areas have been clear-cut by settlers to initially produce subsistence crops and later cash crops. A system of mono-cropping practiced over many years, without proper soil conservation measures, means that agriculture has become vulnerable to land degradation. Unsecured land tenure deters adoption of soil conservation measures. Smallholder families are unsure of their permanence and are thus reluctant to practice soil conservation because farmers are unwilling to trade costs now for benefits to which they may have no right in the future.

Farmers' choices of crop are affected by labour and water availability. Prevailing low wage and limited off-farm employment options mean that labour shortage is acute during peak agricultural labour demand periods. Therefore, the need to keep labour demand to a minimum is affecting farmers' crop choices. Maize and cassava has become the most important cash crop, as they can grow on marginal lands where other crops fail and requires low labour, water and fertilizer inputs. Since the money earned from cash crop harvesting is used as capital for the first planting in the following season, fluctuations in market price play a major role in adopting soil conservation measures. Given lack of social coherence to influence market fluctuation and weak institutional setup to allow farmers' participation in planning and budgeting at sub-district level, farmers' freedom for creativity is becoming increasingly limited because of the economic risk. For example, promotion of new intensive farming systems or soil and water conservation frequently ends up with poor results due to a lack of farmer participation. Credit plays an important role in the lives of the smallholders. Economically, government programs and policies, including those related to the land tenure arrangement, are inadequate for either providing a cheap source of credit for production and consumption purposes or solving the marketing constraints. Therefore, given the ecological fragility (cropping in marginal land, soil fertility decline, soil erosion and sedimentation of streams) and farmers' excessive reliance on agriculture for living, land degradation problem will intensify unless conservation measures are adopted considering socio-environmental construction of land degradation problem.

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