Impact of agricultural development on natural resource

PREUMKAMOL Vichian (1) and **WIROJANAGUD Wanpen** (2)

(1) Agricultural Engineering Department, Faculty of Engineering, Khon Kaen University, Khon Kaen 40002, Thailand
(2) Environmental Engineering Department, Faculty of Engineering, Khon Kaen University, Khon Kaen 40002, Thailand

Abstract

Deterioration of natural resource would be caused by various factors. Inappropriate agriculture development is possibly one of such factors. Impact of the conventional agricultural practice on natural resources including soil, forestry and water resources in Khon Kaen Province, Northeast, Thailand was preliminary assessed by comparing the data of such natural resources in the past (1990) with the present data (1998) using GIS. Considering the suitability of soil series for the cultivated crops made soil resource assessment. Decreasing of suitable soil was 4,720 hectare/year while increasing of unsuitable soil was 5,146 hectare/year. Deterioration of forestry area is indicated by the existing conditioned forest area of 0.084 million hectare (data reported in the year 1999) being equivalent to 7.49% of the total provincial area of 1.09 million hectare. The average decreasing rate of forest area was 4,609 hectare/year evaluated from the data of the year 1976 up to 2000. Assessment of water resources was made by comparing the water availability of the main rivers and water requirement particularly for agriculture. Total water availability of the Pong and Chi rivers is 768 MCM/year (dry season) and 4,966 MCM/year (rainy season). Water requirement for agriculture is 1,188 MCM/year. Water is not sufficient for agriculture in dry season. Evidently, natural resources have been continually deteriorated. It is therefore very necessary to plan for natural resources management and agricultural development under the sustainability concept. It is proposed to employ the soil and water conservation approach being implemented under the Crown Princess project as well as the expansion of sustainable agricultural area of 4 acre/household for the target erosion area of 944,000 hectare within 20 years. It is estimated that increasing of soil fertility of 368,000 hectare, decreasing of soil erosion of 3.7 million ton/hectare/year and water storage of 32 MCM/year. With the aim of increasing forest area to 30% of the province area in next 20 years. The forest area will be increased from 292,800 hectare to 302,400 hectare and the conditioned forest area will be increased from 7.49% to 15% (144,000 hectare) and reforesting should be carried out at least 16,000 hectare/year.

Keywords: natural resources deterioration, soil, water, forest, sustainable agriculture development

Introduction

Thailand has a land area of approximately 51.4 million hectares. The major natural resources in Thailand are forest, soil and water resource. Demand for use of natural resource has been significantly increased due to a rapid growth of population, social and economic development. The current management, however, is ineffective and inappropriate. The abundant natural resources have been adversely deteriorated. The environmental quality status report in 1997 from the Office of Environmental Policy and Planning, Ministry of Science, Technology and Environment reported that the country's forest coverage occupied with 27 million hectares or 53% of the country area in 1961 was decreased to 13 million hectares or 26% of the country area in 1993. Regarding to soil resource, at least 17.6 million hectare are not property utilized according to soil capability and about 21.4 million hectares of watershed and up-land have been eroded. Meanwhile, 30.6 million hectare of land contain low level of soil fertility, which is unsuitable for agriculture. Inappropriate agriculture practice may contribute to accelerating soil degradation. It also leads to finding the new area for agriculture, which possibly encroaches the forest areas. Similar to other natural resource utilization, water demand of both surface water and ground water, has been accordingly increased, from 20,530 million cubic meters (MCM) in 1980 to 43,000 MCM in 1990. The potential to develop a large scale of water resources in limited and the ability to store fresh water is decreasing and also water quality is deteriorating. Water shortage has become a critical problem, leading to conflict of water uses for agriculture, industry, and community. Moreover, the water availability is not consistent throughout the whole year, 85% of stream water flowing in the wet season, but only 15% available in dry season. This situation creates the problem of flooding and drought in wet and dry season, respectively.

The Northeastern region covers 659.56 million hectares or one third of the total land area of the country. The forest coverage in the Northeastern region is the second runner after the northern region. However, if compare the forest coverage to a regional area, it is found that the region has the smallest forest coverage with the area, around 12.6%. In addition, the forest exploitation rate in the region is accelerating considered as the highest rate of the country. A decreasing rate of the forest coverage in 1961-1995 was 3.7% or average 5.63 million hectares a year. This outcome results from the plateau landscape of the region, leading to facilitate tree cutting, forest encroachment for upper crop farming and the expansion of second rice farming. The quality of soil itself is low fertilized and sandy which has been eroded for a long time before becoming paddy fields. Soil salinity is another critical problem covering more than 111.25 million hectares in many provinces, especial in Korat basin and Sakolnakorn basin. Furthermore, the Northeastern region is found to be the region with the potential lowest precipitation. During 1990-1996, the precipitation rate dropped of 0.6% a year (an average precipitation was 1,407 million meters a year. Water quantity in the region is about 36,700 MCM, but only 7,780 MCM or 21% of water can be stored.

Problems in degradation and decrease of the nature resources, especially soil, water and forest derive from many factors. One of causes is inappropriate agriculture practice. Consequently, the need for researches and studies on the issue is necessary. This research therefore draws the objective to study and analyze the relation and impacts of agricultural development towards soil, water and forest resources as well as propose the model and process of natural resources management in Khon Kaen Province.

Materials

Two types of data are used for the study and analysis. One is the secondary data aggregated from the relevant studies for example, Khon Kaen Basic Data Report, Planning for Community Environment and Green Area Management Project, A Study of Action Plan Making and Investment Prioritization for Environmental Problems Solving in Khon Kaen Province Project, A Report on the Quantity of Water Use for Plants in the Northeastern Region and etc.

The other is GIS in soil characteristic layer, soil series layer, forest layer, land use layer in 1990 and 1998 and agricultural promoted area layer in 1998 with a scale of 1:50,000 and 1:250,000 by Agriculture Promotion Department and Land Development, Ministry of Agriculture and Cooperatives.

Methods

Soil study

a) Overlaying soil series layer and land use layer in 1990 and 1998 produces the new layer called soil suitability for each type of important economic plant. The criteria have 3 levels based on the criteria from Land Development Department, Ministry of Agriculture and Cooperatives. The first level is suitable, the second one is not quite suitable and the third one is not suitable at all. The assumption is that each type of soil is suitable for a particular type of plant. For example, Rice is suitable to soil series1, but not to soil series 28B/31B, while sugar cane is suitable to soil series 28B/31B, but not soil series1.

b) Overlaying between soil suitability layers in 1990 and 1998 produces the trend of land use suitability.

Forest resources study

An analysis in the current status of forest coverage, forest degradation and trends is made from related secondary data. (1973-1998), for example, Khon Kaen Basic Data Report, Planning for Community Environment and Green Area Management Project and etc.

Water resources study

The water use for water supply production, industry and irrigation is brought to an analysis. An emphasis places on irrigation purpose to assess water availability for agriculture. Land use layer is consequently in use for seeking agricultural area.

A case study for soil and water resources management is Human Life Quality Development Project under the patronage of HRH Princess Maha Chakri Sirindhorn for 5 villages in Nong Song Hong district. For forest resources management, many cases of community forest in Phuwieng district are studied.

Sustainable agriculture study

An integrated agriculture implemented by the farmer at Wang Noi district was used as case study

The study in natural resources management and sustainable agriculture as mentioned in above is taken to consideration for Khon Kaen provincial planning. As a result, enhancement of soil erosion becomes the main issue by targeting three areas which are 36.875 million hectares, 18.750 million hectares and 7.5 million hectares for 20 years.

Results and Discussion

An assessment of agriculture development impact on natural resources

Soil resources

The result of GIS overlay technique between soil series layer and land use layer in the same year appears that the trend of land use suitability to soil series is low level. In 1990, 46.108% of the land area of Khon Kaen Province used suitability, while 49.42% of the area used non-suitability. In 1998, land use suitability was down to 42.63% of the area, while land use non-suitability was up to 50.22% of the area.

As shown above, possibility to assess that the trend of land use for agriculture is from low suitability to non-suitability to each type of soil series. (Table 1 and Figure 1. Non suitable land use was 201,018.75 hectares in 1988. Within 10 years time, potentially increase to 12,330,793.75 hectares. This contributes to soil degradation in terms of non - fertility, salinity, acidity, erosion, water holding capacity. Agriculture practice relating to soil characteristic should be promoted to enhance soil fertility.

Table 1 Level of land use suitability to soil series.

Level of suitability	Area (hectare)		Change/yeas		Forecasting of remaining area in 2008 (hectare)
	1990	1998	(%)	Hectare	
1. Suitable	3,136,856	18,130,313	-0.94	184,381	16,286,500.00
2. Low suitable	2,120,060	11,267,719	-1.87	247,831	8,789,406.25
3. Non suitable	1,357,994	10,095,606	+2.36	201,019	12,330,793.75

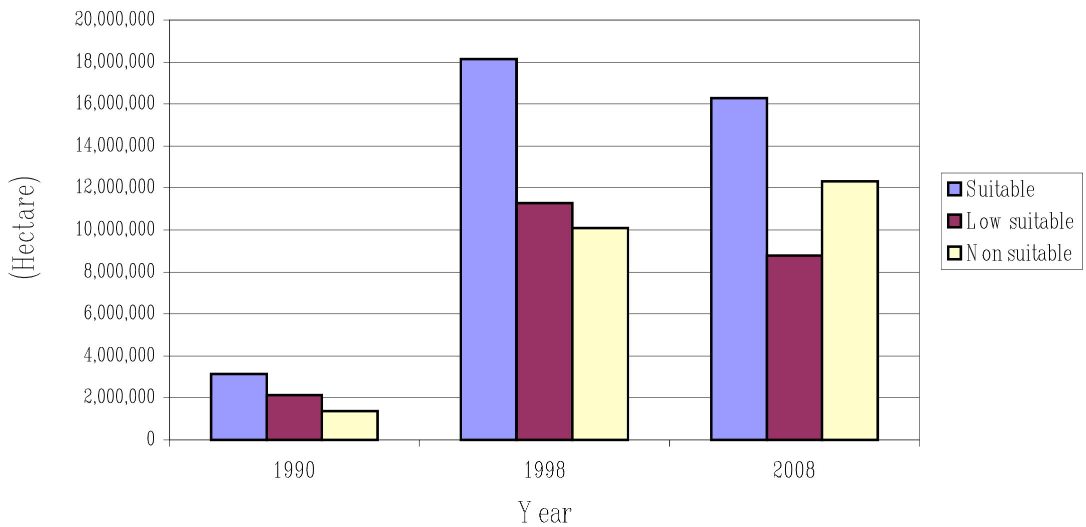

Figure 1 The Trend of land use suitability to soil series level.

Forest resources

With 10,885.99 km^2 of Khon Kaen Province in 2000, forest coverage (National reserved forest) was around 2,929 km^2 or 26.6%of the province's land area. But the existing forest coverage was only 844 km^2 or 3,295,893.75 hectares (7.72% of the province's land area).

In addition, community forests and public abundant areas such as Don Pu Ta forest, cemetery forest and temple forest scatter around villages and Tambon in the province. From Khon Kaen Provincial Forestry Office's survey in 1992, there are 1,157 community forests found approximately accounting to 765,531.25 hectares.

An assessment from forest statistic appears that during 1973-1985, the forest decease was 362,956 hectares/year and up to 738.281.25 hectares/year during 1985-1988 (Table 2). Although reforestation scheme was initiated, the rate was fluctuating (Figure 2). However, it can state that the forest decrease rate during 1988-1998 was 457,031.25 hectares/year. The average forest decrease rate from 1976 to 1998 was 180,037.50 hectares/year. If the situation still remains, natural resources will be affected not only forest decrease, but also deterioration in soil and water resources.

Table 2 The changing of forest area in Khon Kaen province (1973-1998).

Year	Forest area		%	Decreasing rate	
	km^2	Hectares		km^2	Hectares
1973	2,236	8,734,375.00	20.54	-	-
1976	1,829	7,144,531.25	16.80	407	1,589,843.75
1978	1,555	6,074,218.75	14.28	264	1,031,250.00
1982	1,184	4,625,000.00	10.88	371	1,449,218.75
1985	1,121	4,378,906.25	10.30	63	246,093.75
1988	931	3,640,625.00	8.56	189	738,281.25
1989	917	3,582,031.25	8.42	15	58,593.75
1991	844	3,296,875.00	7.75	73	285,156.25
1993	833	3,253,906.25	7.65	11	42,950.00
1998	815	3,183,593.75	7.49	18	68,825.00

Source: Forest statistic of Thailand (1990, 1992, 1993 and 1998; Royal forest department)

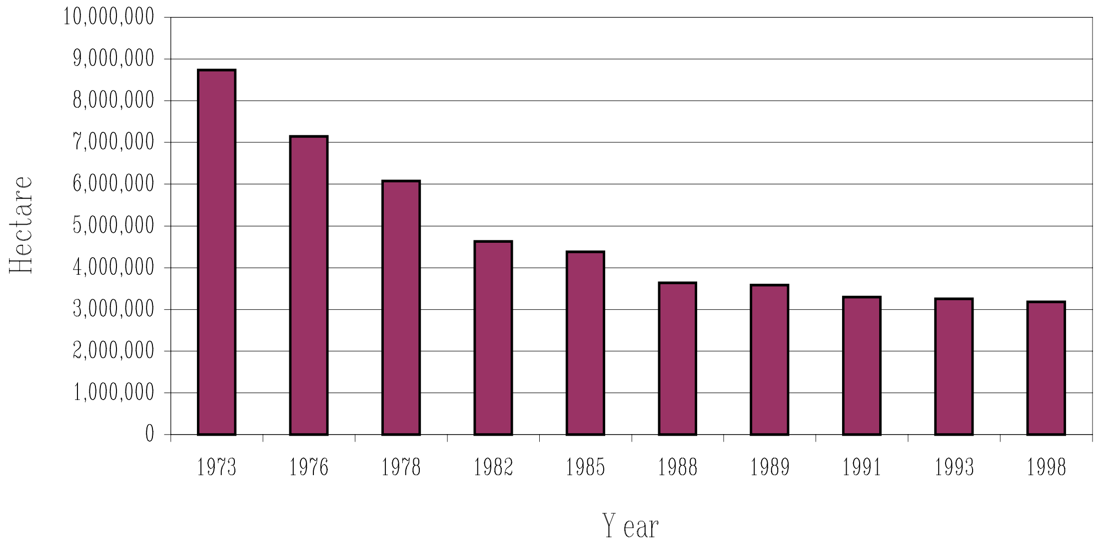

Figure 2 The changing of forest area in Khon Kaen province.

Water resources

Natural water body

Important water bodies for domestic and farming used in Khon Kaen Province are the Chi river, the Pong river and the Chern river. These rivers originate from western mountains of the province, in the watershed area of 10,921 km^2.

Water quantity

The measurement of water quantity from gauging station of Royal Irrigation Department and Department of Energy Development and Promotion along the Pong river, the Chi river and tributaries can conclude that a range of annual average water quantity of the Pong river and Chi river is 73.47 – 1,450.60 MCM/year and 694.10 – 3,515.00 MCM/year, respectively.

Water use

Water use in Khon Kaen Province was about 1,248 MCM per year divided into three types; irrigation (1,188 MCM per year), industry (37MCM per year) and water supply (29 MCM per year) The ratio of irrigation use is the highest accounting to 95.22%. The ratio of water supply is close to that of industry which is 2.365 and 2.46 respectively (Table 3).

Total water quantity of the Pong river and the Chi river is around 768 MCM/ year in a dry season and 4,766 MCM/year in a wet season. Water use rate for agriculture is 1,188 cu.m./year, while the actual water requirement for agriculture is 1,425.07 cu.m./year. This indicates insufficiency of irrigated water for agriculture use, particularly in a dry season, due to deep percolation in the loamy sand and low fertilized area.

Table 3 Water use for activities in Khon Kaen province.

Activity	Water use rate (million cu.m/year)	Ratio (%)
1. Water supply	29.01	2.32
2. Industry	36.65	2.46
3. Irrigation	1,188.46	95.22
Total	1,248.12	100.00

National resources management and sustainable agriculture

Natural resources management

Soil resources management

The land area of People Life Quality Development Project under the patronage of HRH Princess Maha Chakri Sirindhorn Project is sandy, bumpy and slopes (2-5%). When farmers do upper-crop farming, soil surface is easily eroded by rain-wash. As a result, the project initiates soil and water conservation system by making levee for 51 km^2, growing elephant grass for 11.4 km^2 covering the area of 46,525.75 hectares. The outcome is able to prevent soil erosion about 0.46 ton/hectares/year. In addition, Land development officers from Khon Kaen Land Development Station make demonstrated fields and promote organic fertilizer, green manure and composting fertilization to improve soil quality. Farmer's leaders are trained on producing and using organic fertilizer with chemical fertilizer in an appropriated way, leading to increase the fertility of farming land not less than 852 hectares a year. In the future, soil degradation in project land area will expectantly lessen.

Water resources management

Due to drought and no natural water body in the project land area, Land Development Region office 5 then allocated the budget for making 1,260 cu.m. ponds in a paddy field. In the fiscal year of 1995-1998, there are 162 ponds and 76 sediment traps drilled. Levees were designed to drain rainfall to the ponds.

Forest resources management

Regarding to community forest case study in Ban Napang – Koanoy Tambon Koanoy and community forest in Ban Napang – Koanoy, Tambon Koanoy, community forest in Ban Prabaht-Huoypung, Tambon Wathong, Phuwieng District and community forest in Ban Nonton, Tambon Nonsomboon, Banhad sub-district, Khon Kaen province. The committee is set up to regulate forest encroachment with a charge of 500 and 1,000 ThB for violators depending on cases. Reforestation and buffer zone is arranged for forest enhancement and conservation. The regulation and scheme support Khon Kaen Province Environmental Management Plan's target (2002-2006) setting to have forest 30% of Khon Kaen land area within 20 years. By the first 5 years, planning to increase from 7.49% to 15% of the province land area. Conservation forest is prevented at a minimum of 625,000 hectares a year. Bio-diversity and forest use is taken into account.

Sustainable agriculture

Mr. That Krayom is a case study for the integrated farming system. He lives in Ban Soknamkhoa, Tambon Kanleung, Wangnoy District, Khon Kaen Province. His farmland is 75 hectares dividing 50 hectares for rice, 6.25 hectares for permanent trees such as mango, lemon, jack fruit, 6.25 hectare for banana, 3.125 hectares for accommodation and 3.125 hectares for chicken and duck farms. There are 4 ponds with 1,000 cu.m. calculating to about 6.25 hectares. Estimated water use from the requirement for crop is 3,895 cu.m. showing the sufficient water quantity for the requirement.

The presentation of natural resources management model for Khon Kaen province

Due to natural resources management and sustainable agriculture development plan, 36.875 million hectares of eroded area is targeted to improve by using data from soil and water conservation project (a case study of Royal Project) and sustainable agricultural land expansion project (a case study of Mr. That.) For forest resources management, using data from five - year provincial environmental management plan (2002-2006). The model for natural resources management and sustainable agriculture development is shown on Table 4.

Conclusion

As a result of inappropriate agriculture practice, leading to environment degradation, soil erosion is up to 36.875 million hectares, forest coverage comes down to 7.75% of the province land area and irrigation is insufficient for agriculture in a dry season. However, from the environmental management study in the project under the patronage of HRH Princess Maha Chakri Sirindhorn and sustainable farming by Mr. That Krayom, there is the potential to solve the mentioned problems. If the concept and method of the approach is widely accepted throughout Khon Kaen Province, environmental degradation will enable to ease. By the first 5 years, the target should set at a low level specifying to enhance an eroded area of 7.5 million hectares in 20 years or 375,000 hectares/year. With the above target, soil erosion will be decrease to 18,461.54

tons/hectare/year. In the meantime, Soil fertility and water storage will increase 3.125 million hectares and 6.4 MCM/ year respectively. The success of this approach is under the condition that Royal project and sustainable farming area should expand to 62.5 hectares/household/year and widen the target area every year according to natural resources management and sustainable agriculture development plan proposed.

Table 4 Sustainable agricultural development and natural resource management plan.

Activity	Target/result		
	Case 1	Case 2	Case 3
Soil and Water conservation Area: 6,645 hectares	Improve eroded area 36.875 million hectares within 20 year or 1.843750 hectares/year	Improve eroded area 18.750 million hectares within 20 year or 937,500 hectares/year	Improve eroded area 7.5 million hectares within 20 year or 375,000 hectares/year
1) Decrease erosion 0.15 - 0.46 ton/hectares/year 2) Increase soil fertilization 825 hectares/year 3) Increase water quantity 723,564 cu.m./year	1) Decrease erosion 90,769.23 ton/hectares/year 2) Increase soil fertilization 14.375 million hectares 3) Increase water quantity 32 MCM/year	1) Decrease erosion 46,153.85 ton/hectares/year 2) Increase soil fertilization 7.5 million hectares 3) Increase water quantity 16 MCM/year	1) Decrease erosion 18,461.54 ton/hectares/year 2) Increase soil fertilization 3.13 million hectares 3) Increase water quantity 6.4 MCM/year
Expand sustainable agriculture area 62.5 hectares/household	62.5 hectares/household or 29,500 household/year	62.5 hectares/household or 15,000 household/year	62.5 hectares/household or 6,000 household/year
Forest management Five year Environmental management plan (2002-2006)	Target: Increase forest area from 7.49% to 15% of the provincial area within 20 years, reforests at least 625,000 hectares/year.		

References

Agriculture Promotion Department. 1998. Geographic Information System Data. Ministry of Agriculture and Cooperative.

Division of Special Project and Planning. 1984. The Irrigation Agriculture of Thailand. Agriculture Promotion Department, Ministry of Agriculture and Cooperative.

Direk Thongaram. 1986. The Irrigation Agriculture of Thailand. Department of Agriculture and Cooperative Promotion, Sukothaithamathirath University.

Environmental Management Center. 2001. Final report: a study on making process of Changwat development plan for sustainable agriculture and natural resource management, period II. Faculty of Engineering, Khon Kaen University.

Office of Environmental Policy and Planning. 1999. The Environmental Quality Status Report in 1997. Ministry of Science, Technology and Environment.

Khon Kaen Irrigation Project. 1998. The guideline for efficiency implement of irrigation. Royal Irrigation Department, Ministry of Agriculture and Cooperative.

Khon Kaen Province. 1995. Final report: a study of action plan making and investment prioritization for environmental problems solving in Khon Kaen Province. Project by Khon Kaen University.

Khon Kaen Province. 1995. Final report: planning for community environment and green area management. Project, by Khon Kaen University.

Khon Kaen University. 1997. Crop water requirement in Northeastern Region of Thailand. Environmental and Water Resource Institute, Faculty of Engineering, Khon Kaen University.

Land Development Department. 1990. Geographic Information System Data. Ministry of Agriculture and Cooperative. (1998), Ministry of Agriculture and Cooperative.

Maidment, David R. 1994. Engineering Hydrology. *In* K. Subramanya (ed.). Handbook of Hydrology. Tata Ma Graw Hill.

Sunee Sornsomboon 1983. The Irrigation Agriculture Apply. Royal Irrigation Department, Ministry of Agriculture and Cooperative.

Viessman, Warren Jr. 1977. Introduction to Hydrology. London: Harper & Roc.

Wiboon Bulcharokul. 1983. The Principle of Irrigation. Department of Irrigation Engineering, Faculty of Engineering, Khon Kaen University.

Wiroj Masnete 1987. Soil and Water Conservation. Department of Agricultural Engineering, Faculty of Engineering, Khon Kaen University.