Quality of Soil from Agricultural Terrace in Comparison with Other Types of Land Use, a Case Study in Nan Province, Thailand

Chawanrut Tamikanon* and Alice Sharp

Abstract— *Cultivating in mountain areas, slash-and-burn agriculture is typically practiced because it doesn't require any technology, and it has low cost. However, using this method, the land is abundant with a nutrient for a couple of years before all of the nutrients are used up. Then farmers will abandon the deteriorated land and move to another new plot. As an including result soil loses more nutrients through runoff and erosion. The agricultural terrace is suggested as a solution to the wasted land situation. Terraced fields can solve soil erosion and surface runoff problems, and this method proper with crops which require irrigation, such as rice. In addition, agricultural terrace allows sediments to accumulate between each terrace step, and it enriches soil properties. This paper presents the study of soil properties comparison of different kinds of agricultural from Nan province in northern Thailand and the aim of the study to propagate fact, knowledge and impact of properly land use for farmer.*

Keywords— **Rice terrace, soil quality, land use.**

1. INTRODUCTION

Northern Thailand is commonly mountainous areas, thus, some of agricultural activities proceed on a mountain slope. The results from that there are three direct causes of unsustainable land use: (i)The rapid expansion of upland plantation on steep slopes due to economic pressure on livelihoods, including the indirect promotion activities of the private sector based on credit provision, the use of hybrid seed varieties suitable for rain-fed crops in the highlands, and also convenient market offers. In addition, the plus highland farmers have limited market information and access to other alternative crops which can be grown under the rain-fed and steep slopes conditions. (ii) The low rate of adoption of conservation practices in the highlands. This low rate of adoption is due to land rights insecurity and also outdated forest regulation practices, which are inconsistent with highland livelihood patterns. Forest legislation that separates people from their forest livelihood sources has created a negative attitude towards the economic benefits to be derived from the forests. In addition, the cultures of the ethnic groups living in the highlands have also contributed to the low adoption of conservation practices. (iii) The limited natural resources to be found in the highlands; for example, a lack of water sources and the presence of steep slopes lead to natural low soil fertility levels and high rates of soil erosion, limiting land use options.[1]

Fire dependent agriculture is one of slash-and-burn agriculture type, that is typically practiced because it doesn't require any technology, and it has low cost. Generally, land is cleared by cutting down trees and all surplus vegetation is burned. The following result is layer of ash provides the newly-cleared land with a nutrient-rich layer which helps fertilize crops. However, using this method, the land is abundant with nutrient for a couple of years before all of the nutrients are used up. Then farmers will abandon the deteriorated land and move to another new plot. For example, maize plantation is one type of slash-and-burn farming. As a result, soil loses more nutrients through runoff and erosion.

Agricultural terrace is suggested as a solution to wasted land situation. Terraced fields decrease both erosion and surface runoff and can be used to grow crops that require irrigation, such as rice. In addition, agricultural terrace allows sediments to accumulate between each terrace step, and it enriches soil properties. However, terracing is labor intensive in construction and maintenance. Catastrophes can occur when terraced lands are not properly managed. Terraces without proper management can lead to mudslides, and increased soil erosion problem, especially with sandy soil on extremely steep terrains.[2]

This study aims of various land use type include paddy fields, maize field, economics crops old age rice terrace, new rice terrace, abandoned field and hilly paddy field to investigate and compare soil quality, soil parameter studied include of physical (soil texture, water holding capacity, and soil temperature.) and chemical soil properties(soil pH, organic matter in soil, soil cation exchange capacity and plant nutrients phosphorus and Potassium) settled minerals and suitability of soil for agriculture.

2. STUDY SITE

Nan province is located in northern Thailand. Approximately 85% of the province is at high altitude. The selected study site is in Chaloem Phra Kiat district. (Figure.1) The area of this district is approximately 518.7 km^2. Nan's land use is classified according to land cover categories. Ten categories were identified: natural forests, perennial crops, areas of slash and burn agriculture, forest stands, fields with unirrigated crops, pastures, irrigated paddy fields, orchards, urban lands,

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and water bodies. Land use for agriculture accounted for 19.72% according to Thailand Department of Mineral Resources. Paddy rice is mostly grown in lowlands as a subsistence crop, and its production period lasts from June through to November. Slash-and-burn agriculture is also practiced. Planting in upland area is allocated to various types of crops with the majority (53%) represented mainly crops as maize, banana, cashew, coffee, and millet, followed by rice (20%), permanent crops (19%), and vegetables and flowers (0.27%).[3]

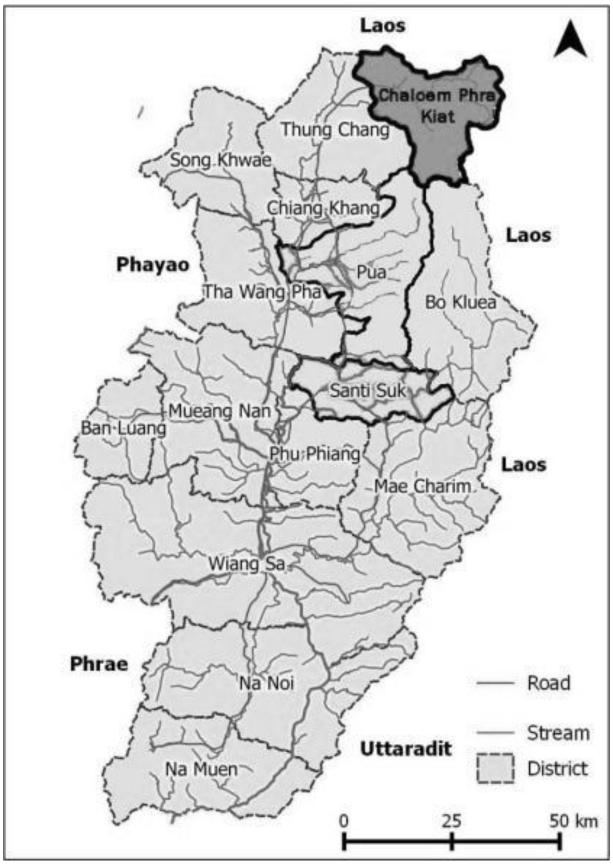

Fig. 1. Map of Nan province showing location of Chaloem Phra Kiat district boundaries.[1]

3. RESEARCH METHODOLOGY

Soil samples were collected from several sites which have different types of land use consisting of; 1) soil from low land paddy fields 2) soil from maize field 3) soil from economics crops 4) soil from old age rice terrace. 5.) Soil from new rice terrace 6.) Soil from abandoned field 7.) soil from hilly paddy field.

Collecting soil samples by random sampling method depends on land use terrain (top, middle and low area). Five samples were collected from each area. Excavation of soil samples can be done by digging from the surface deep down to about 6 to 8 inches. The shovel is inserted straight into the ground then soil is lifted out from the ground forming a V-shaped hole. (Figure 2) A 1-inch slice of soil is taken out along with a vertical side of the hole. Both sides of soil are removed and leaving about 1 inch in the center with hand. The 1 inch thick of and 6 inches long will be placed in the clean plastic bag and moved on to the next sample location. All soil samples from the same area are mixed together in one plastic bag. After collecting soil, samples are air-dried, and sun light needs to be avoided.[4, 5]

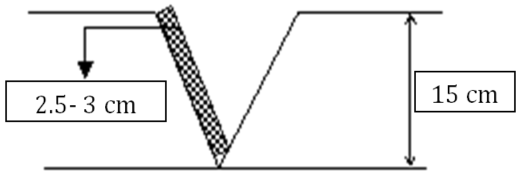

Fig.2 The V shape of soil holds.[6]

The study focuses on two major properties of soil: physical and chemical properties. Physical properties of soil are determined by the following parameters[7, 8]:

Soil texture used for determining the relative masses of sand, silt and clay in the soil sample. Classification soil texture involves with removing each particle size group (sand, silt, and clay) from pre-treated soil and water mixture that settled in a cylinder. The soil total weight of sand, silt, and clay must compile with 100% of soil. Calculations required in this method include using of scaling factor for pipette analysis and calculation for sieve analysis. For getting the complete result, the triangle (Figure.3) containing twelve textural classes is used for classification of soil texture, each of which is combined of various components of sand, silt, and clay.[9]

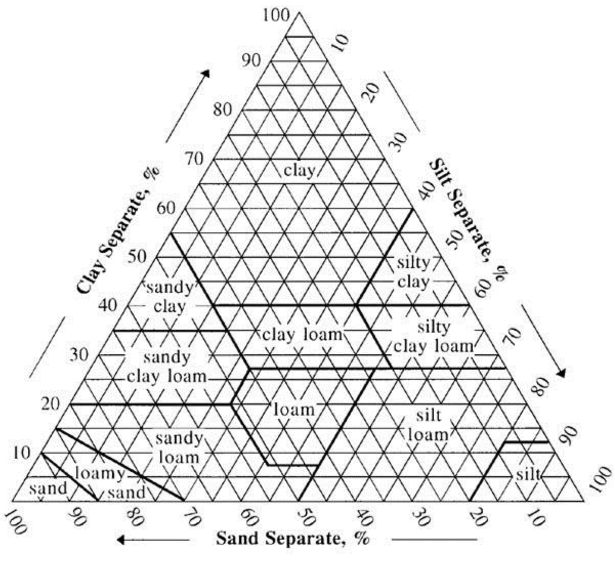

Fig.3 The textural soil classified triangle.[10]

Calculation percentages of each of the separates can be used with textural triangle;

$$\%\,clay = \frac{20 \times \text{mass of clay in a liquid}}{\text{total mass of soil}} 100\%$$

$$\%\,silt = \frac{20 \times (\text{mass of silt} + \text{clay} - \text{mass of clay})}{\text{total mass of soil}} 100\%$$

$$\%\,sand = 100\% - (\%\text{silt} + \%\text{clay})$$

Water holding capacity is related by the soil texture and the soil organic matter. Soil texture is a indicating of the soil particle size distribution. In regular, the high water holding capacity depend on the high percentage of silt and clay size particles, Small particles have much larger surface area that allows the soil can hold the greater quantity of water. The organic material in soil also influences with water holding capacity. As higher percentage of organic matter in soil, the water holding capacity also higher. The following methods can be used to determine water holding capacity; calculation of volume of water held in soil sample dry weight and the equation below.

$Water\ holding\ capacity\ (\%)$:

$$= \frac{Sample\ weight\ after\ centrifugation\ -\ dry\ sample\ weight}{dry\ sample\ weight} \times 100$$

Soil temperature is one of the factors that drive germination, flower blooming, decomposing, and a variety of other processes. Soil temperature is the measurement of the warmth in the soil. It is measured at 2 depths which are 5 cm and 10 cm deep into the ground. The screwdriver is used for making a pilot hole so that a thermometer can be easily pushed into hard soil. The process is repeated for 5 times in each area.

For chemical parameters[11], the following parameters are determined:

Soil pH is measurement of acidity or alkalinity (basicity) that is present in soil solution, which can directly affect the solubility and also the ability of plant roots can uptake of nutrients. For the test, distilled or de-ionized water is used when measuring pH. Fresh Distilled water that is close to pH $_{7.0}$ can remove ions that are processed through resin filtration and the water can be extremely reactive.[12-15] Soil pH is determined from active acidity that is calculated by the negative log (base 10) as

$$pH = -\log_{10}[H^+]$$

$[H^+]$ is the concentration of H^+ in solution (mol/L)

The pH value can be shown an amount of acidity or alkalinity. (Table.1)

Organic soil carbon, the remains composting process of plant material, roots, and soil organisms in any various stages of synthesis and decomposition, The organic content in soil has a mainly influence on soil aggregation, moisture retention, nutrient reserve, and some biological activity. (Table.2) This method uses chromic acid solution for measure the oxidizable organic carbon content in a soil. Ignition method makes weight losing that is based measuring from a dry soil sample when exposed in high temperatures. The occurrence of weight loss in this temperature is related to oxidizable organic carbon.[16-18] (Additional information in Soil organic carbon by Walkley-Black method, 1947).

Soil cation exchange capacity used for represents the total quantity of exchangeable cations that the soil can adsorb.

Table 1. Soil Classification Based on pH Value[11]

Degree of acidity and alkalinity	pH Ranges
Ultra acid	<3.5
Extremely acid	3.5 -4.4
Very strongly acid	4.5-5.0
Strongly acid	5.0-5.5
Moderately acid	5.6-6.0
Slightly acid	6.1-6.5
Neutral	6.6-7.3
Slightly alkaline	7.4-7.8
Moderately alkaline	7.9-8.4
Strongly alkaline	8.5-9.0
Very strongly alkaline	>9.0

Table 2. Rating of OM Value in soil [11]

Rating	Range (%)
Very low	<0.5
Low	0.5-1.0
Slightly low	1.0-1.5
Moderate	1.5-2.5
Slightly high	2.5-3.5
High	3.5-4.5
Very high	>4.5

The major Cations are positively charged ions such as calcium (Ca^{2+}), magnesium (Mg^{2+}), and potassium (K^+). All these cations are held by the negatively charged in clay soil and organic matter particles. The method for measurement of the soil's ability to hold cations.[19] The calculation for CEC can calculate from equation below.

$Ca^{++}\ or\ Mg^{++},\ cmol_c kg^{-1}$:

$$= \frac{Readable\ value(mgL^{-1}) \times 2 \times dilution\ factor}{equivalent\ weight\ of\ Ca^{++}\ or\ Mg^{++}}$$

Plant nutrients, The Phosphorous are regularly weak acid extractants that dissolve calcium, aluminum phosphates and iron in the soil. The bicarbonate ion can be removed from The calcium phosphates and leaving phosphorus, which are measured as an "index" by Bray II [18].

The Bray equation as:

$$Available\ Phosphorus\ (mg/kg) = \frac{B\ \times\ \mathrm{X\ (mg/kg)}}{\mathrm{A \times DF(standard)}}$$

B = Phosphorus concentration from chart/equation (µg/2.5 mL)

A = Oven-dry sample weight (g)

X= Dilution factor

and **Potassium** is used for enhance disease resistance in plants and crops by strengthening of stems stalks, stems, and also contributes to a thicker cuticle and plant protection that against disease and water loss, The ammonium-acetate extractant and potassium standard solution are widely used method for estimate K value in soil sample.[11] The equation of estimation Potassium value is

$$Available\ Phosphorus\ (mg/kg^{-1}) = 10K \times df$$

K = constant of method (mg/kg^{-1})
df = dilution factor

Secondary data is collected. Information related to land use in Nan province and other noted documents to the study will be collected from secondary source.[2, 7, 11, 20, 21]. The analysis of soil quality is carried out followed by comparing the results of all agricultural patterns that is the most suitable with mountain landscape in the northern part of Thailand which will also maintain soil surface quality.

4. RESULT AND DISCUSSION

The soil samples from 7 areas are maize field economics crops, hilly paddy field, abandoned field Low land paddy fields, old age rice terrace, and newly rice terrace. Each area is executed with different purpose. The area's detail (Table.3) can be used for explaining the correlation of inspection result. This study proceeded in September to October in the rainy season. Since the Samples were high moisture. Before laboratory inspection, Air drying was necessary. The result show varied physical and chemical properties of soil sample all areas. (Table.4)

The soil texture result classifies most soil samples are clay soil that can be majoring 3 sub-kinds of soil as the clay soil consists 40% of clay can be found at economic crops, hilly paddy field and abandoned field. The clay loam soil consists 27-40% of clay can be found at maize field and low land paddy field. The sandy clay loam consists of 20-27 % of clay and more than 45% of sand is only found at age rice terrace.

Soil texture results vary in line with soil water holding capacity. Thus soils which from economic crops, hilly paddy field and abandoned field the best absorption ability are following by maize field and low land paddy field. And the old age rice terrace is the lowest absorption ability.

The soil temperature is the indicator of soil moisture and also due to ambient temperature. The measurement of soil temperature presents invariable result. The average soil temperature is 25-30 ^{o}C. Although some area is high temperature, the collecting sample was proceeded on during the day but high soil temperature that might not be affected on plant growth.

Chemical analysis shows pH value was approximately 5-6. The old age rice terrace and new rice terrace show the soil pH are slightly acidic. Maize field, economics crops, hilly paddy field and low land paddy field were estimated pH value as strongly acid. And soil from abandoned area is very strongly acidic. The approximately percent of organic matter value is 2-3. The areas which are high OM value as maize field and new rice terrace. The reason of high OM percentage possibly from the crop straw incorporation during soil preparation and the new rice terrace can be caused by fresh area plantation.

Table.3 Detail of sample area.

Area	Area size (m^2) x10^4	Duration used (year)	Kinds of crop were planted.
Maize field	3.2	20	Maize
Economics crops	4.8	20	Coffee bean, cashew nut, banana and millet
Hilly paddy field	2.7 – 2.9	50-60	Rice
Abandoned field	1.6 – 2.4	10	Some economic plants
Low land paddy field	2.1	30-40	Rice
Rice terrace (old-aged)	12.6	15	Rice
Rice terrace (New-aged)	4.8	3	Rice, banana and coffee

The nutrients in the soil are Nitrogen, Phosphorus, and Potassium. Due to soil samples were collected from provincial area Nitrogen that loses during transporting samples. Numerically phosphorus was detected in both of old age rice terraces and new rice terrace but less than in other areas. The high phosphorus value in rice terrace may cause by rice terrace areas are wet land and the condition is not encouraged for soluble phosphorus thus Phosphorus can be detected with high amount in soil surface. In the other hand, Potassium was found with small amounts in old age rice terraces and new rice terrace that might be caused by those areas are also wet land and potassium is good solute so the value of potassium in soil might be low.

The exchange cation capacity presents good uptake ability for soil nutrients. Observations of abandoned field and economics crops are low cation exchangeable capacity, the consequence of lacking suitable maintaining soil.

Most land use in Nan province is planting rice, maize, some economics crop such as; coffee bean is recent product which was earned much profit. Cashew nut is regularly implanted. Processed banana products are popular in Nan so affected to banana demand is high. And Millet was grown in only some season.

Slash-and-burn farming in Nan province still proceeded in some area as follows hilly paddy rice and maize field, that has many negative impacts on the environment including deforestation which is consequence directly from cutting down forests for crop lands creation, an increase in human-induced forest fires and loss of habitat and species. Slash-and-burn agriculture still is significant soil problem which needs the right management in Nan. Including of soil erosion and accompanying landslides, water contamination, and/or dust clouds, blown away by winds during droughts.

The government has the solution by giving agreement with local farmers that can burn their crop residue in only specific duration. In the past rice terrace not unpopular execute because of the villager's faith. They respect in ancestor’s spirit and believe ancestor spirits could help to grow the plant and giving them high productivity. Villagers need to elucidate correctly understanding about cultivation.

Table.4 The result of Physical and Chemical soil properties from Chaloem Phra Kiat district, Nan

Sample No.	Note	Water holding capacity (%)	Sand (%)	Silt (%)	Clay (%)	Soil texture	Soil temperature (^{o}C)			pH	OM (%)	P (mg/kg)	K (mg/kg)	Cation exchange Capacity ($cmol_c kg^{-1}$)
							Ambient temperature	Average under 5 cm depth	Average under 10 cm depth					
1	Maize field	47.17	44.2	28.2	27.6	Clay loam	29.0	26.7	25.7	5.3	2.95	4	101	9.75
2	Economics crops	48.56	36.2	23.2	40.6	Clay	28.0	25.8	26.2	5.1	2.40	4	94	7.65
3	Hilly paddy field	44.14	30.2	29.3	40.6	Clay	25.0	26.1	25.3	5.1	2.30	3	117	11.06
4	Abandoned field	45.41	32.2	27.2	40.6	Clay	28.5	27.4	26.4	4.9	2.23	3	134	8.37
5	Low land paddy field	44.32	30.2	41.2	28.6	Clay loam	28.0	29.2	27.9	5.1	1.94	5	141	10.42
6	Rice terrace (old age)	39.99	46.2	26.2	27.6	Sandy clay loam	26.5	25.9	25.3	6.3	2.14	21	48	11.85
7	Rice terrace (New)	42.39	32.2	36.2	31.6	Clay loam	27.5	27.4	26.6	6.4	2.79	43	58	11.47

5. CONCLUSION

The study is a comparison of soil qualities. It shows that both soil properties are being in good condition for crop cultivation. In the present time, the deterioration of soil in Nan is in lower level. The results from the investigation summarize that mountainous agriculture has negative impact on soil surface. The results of soil qualities might be altered by adding fertilizer during planting season.

Although soil qualities show the unexpected results, exhaustive observation represents soil quality between old age rice terrace and new rice terrace are not much different. Thus, rice terrace production could be a good preservation of soil quality. In the other hand, the cause of soil deterioration can occur if other mountainous agriculture is performed for a long time without good management.

Nowadays, the villagers accept to perform rice terrace method in many areas in Nan under supervising of state aid and proper economic management. The irrigation system has been preceded for solving the lack of water during drought season.

Although rice terrace production requires the amount of budget, the government has to support and provide technical knowledge about suitable cultivation to farmers and also apportion fund for them. Those things can solve deforestation problem and also encourage better economic system. Rice terrace method does not only solve soil deterioration but also rice terrace is an attractive place for traveling which can encourage tourism business in local community.

Therefore, this study aims to provide scientific information for the assessment of physical and chemical properties of soil from various types of land use and represent the advantages and disadvantages of each kind of mountainous agriculture.

6. RECOMMENDATION

In this study, it contains only the analysis of physical and chemical properties of soil. For further research, biological properties, such as a number of plants growing nearby should be included in the study. The study got the incomprehensive result, so the exploration should add more detail as production profit under the supervision of government or compare soil properties between original agriculture and after improving agriculture.

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