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Correlation between soil organic carbon and land use, slope class and soil texture in chaing rai province of Thailand

Sasirin Srisomkiew[1], Pitayakon Limtong[1], Supawat Chaikasem[2]*

[1][Land Development Department, sasirin_ldd@hotmail.com and pitaya49@msn.com]

[2][Kasetsart University, Sriracha Campus, supawat.ch@ku.th, Faculty of International Maritime Studies]

Abstract

The main aim of this research is to understand soil carbon stock dynamic in soil for various factors affecting it and analyses degradation of land. We present the degradation of land based on soil carbon stock with various factors affecting its content while emphasizing on the guideline to analyses land degradation and proper management of the area with low carbon stock using various degradation maps.

Keywords: Land degradation, Soil erosion, Soil organic carbon, land use, slope class, soil texture

Introduction

Soil organic carbon (SOC) content is an important component of soil nutrient and the most important elements in the soil system whose loss lead to soil degradation in which soil erosion is found to be the major cause of SOC loss [1]. Land use change (LUC) is a main factor influencing content and quality of SOC. Moreover, conversion of arable land into grassland leads to increasing of SOC as higher input of plant and root residues in grassland soils is stabilizing SOC stock in the top soil [2]. Conversion of grassland to cropland was a dominant driving factor responsible for carbon sources, and the recovery of grass cover from cultivated lands enhanced SOC sinks, but the magnitude of sequestration may depend on specific management measures [3]. The conversion of desert steppe to arable land led to increases in SOC content and storage with SOC stock in arable land increased after abandonment. Moreover, the trend for loss of carbon storage change resembled that for the SOC storage after land use conversions. There were significant differences in SOC content at the 0–10 cm depth in the conversion from arable land to artificial grassland and at the 20–40 cm depth in the conversion from desert steppe to artificial woodland, the SOC content did not change significantly following LUC [4]. Crop cultivation led to decrease in SOC content with effect on land use on soil carbon content limited to the upper 20 cm depth while the texture effect is found all along the soil profile influencing the soil organic carbon stock. In addition, cultivation influences the texture by deepening the particulate component as near-surface level becomes more particulate and advisable for organic matter mineralization [5]. However, SOC content decreased with depth at all topographic positions with clay fraction increased with the depth [6].

Globally, LUC can cause a change in soil carbon stock with an overall average across all land use change examined, land use conversions had significantly reduced soil carbon stock. The LUC decreased soil carbon, however, the reverse process usually increased soil carbon stocks and vice versa [7]. Soil Organic Matter (SOM) has a positive correlation with soil texture. The amount of SOC in soil depends on vegetative growth or soil cover which includes agricultural activity whereas there were no correlation between SOM with the soil depths [8]. SOC stocks differ significantly between soil types in the topsoil as texture has a strong impact on SOC stocks suggesting soil type to be used as a principal predictor of SOC stocks [9]. Soil erosion is one another major factor of loss of SOC as soil erosion transported plenty of sediment and associated organic carbon. Significant linear relationships were observed between SOC loss and sediment loss which indicated that the loss amount of predicted by transported sediment. Soil type

has a great impact on SOC loss through influencing sediment erosion pattern and the SOC content in original soils [10]. The effect of SOC concentration is more vital than that of the amount of eroded sediment on the total SOC loss for soils if the SOC content is large enough. Significant correlations between sediment and SOC losses were observed, and such correlations became relatively close if the organic matter content of the soil was low. SOC loss depended more on flow dynamics if the clay content was low, and it could be well predicted by flow velocity and slope. For soil with a high clay content, total SOC loss could be simply predicted by slope, and geomorphology was identified as the only direct cause [11]. In addition to the land use effect on the SOC, [12] examined effects of climate and land use changes on SOC storage on the Loess Plateau of China in the context of multiple global changes by using an integrated ecosystem model.

In this research, we choose the location which is in the north of Thailand in the province name Chaing Rai. This area is mostly mountainous with high slopes. However, farmers still use the area for cultivation which risks soil erosion, soil surface loss and water runoff. It has become the region with the severest cases of soil erosion of top soil in the upper part of watershed areas, which affects extensively this area and lower area. This causes degradation in physical, chemical and biological aspects of soil properties, including the wider degradation of the environment in both on site and off site areas.

Problem Statement

Chaing Rai has a complex slope with slops at more than 35% and different soil types. Erosion is the main problem including risk for landslide and floods. It is well known that the soil in this area is not suitable for agriculture, but there is still demand to use the area for agriculture as the plain areas are limited which leads to deforestation and changes to forest land to plant field crop/ monoculture. In addition, soils in lowland areas have low fertility. Therefore, it is necessary to leads efforts on effective intervention related to the measurement of soil conservation, soil management and selecting plants to grow properly.

Main Objectives

The main objective of this research work is to understand the soil carbon stock dynamic in the complex geographical. In this work, we present the change in soil carbon stock based on its land use variation i.e. whether it is agricultural field, forest, grassland and find the relationship between it. In addition, we assess the slope of the region and find its effect on the soil carbon stock. Finally, we study the soil type and find its relationship with soil carbon stock. Following is the specific objective of this research.

a. To investigate the development of Geographic Information System (GIS) for analyze and visualize
   soil organic carbon (SOC), soil stock class and map
b. To evaluate the correlation between soil carbon stock, land use variation, land slope and soil texture/soil series

The scope of this research work is to find the factor that is more prevalent in loss in soil carbon stock dynamic and propose recommendation to manage the soil so that these losses could be minimize.

The Study Area and Methodology

The study area is the Chaing Rai province which is located at the north of Thailand. Chaing Rai has the total area of 1,157,759 hectares (ha). Topographically, the Chiang Rai province has a mixed geographic relief with small plateaus as well as plains along the river. The land use is categorized into cropland 589,840 ha (50.95%), forest 451,450 ha (38.99%), settlement 60,916 ha (5.26%), wetland 33,136 ha (2.86%), grassland 19,740 ha (1.71%) and others land use 2,677 ha (0.23%). In terms of soil

series category, 51 different soil series type is available in this province for which the soil organic carbon value ranged from 9 to 28. The study area is in characteristically tropical savanna climate zone with high average relative humidity.

Statistical analyses were carried out using the computing environment R version 3.3.2 (R Programe). The correlation analysis between soil organic carbon with the land use, slope as well as the soil texture/soil series. Significance of the correlation test and variance were used to evaluate relationship between the soil organic carbon and the factors affecting it.

Results and Discussion

The research is conducted following the considering the UNCCD protocol and using its factor to evaluate correlation with soil carbon stock. The consideration is taken for the land use and land cover. As shown in Fig. 1(a)-1(c), soil carbon stock in agricultural area is lower than that of forest or grassland which can cause land degradation in those agricultural areas. The change from agricultural area to the forest, the soil carbon stock will increase. In addition, if the land has higher slope without any conservation system, there is high risk of loss of soil and consequently the loss of soil carbon stock causing the land degradation in the slope area. Finally, considering soil texture, if the soil is sandy then carbon stock has relatively lower value with higher land degradation as compared to clay soil which has relative high carbon stock.

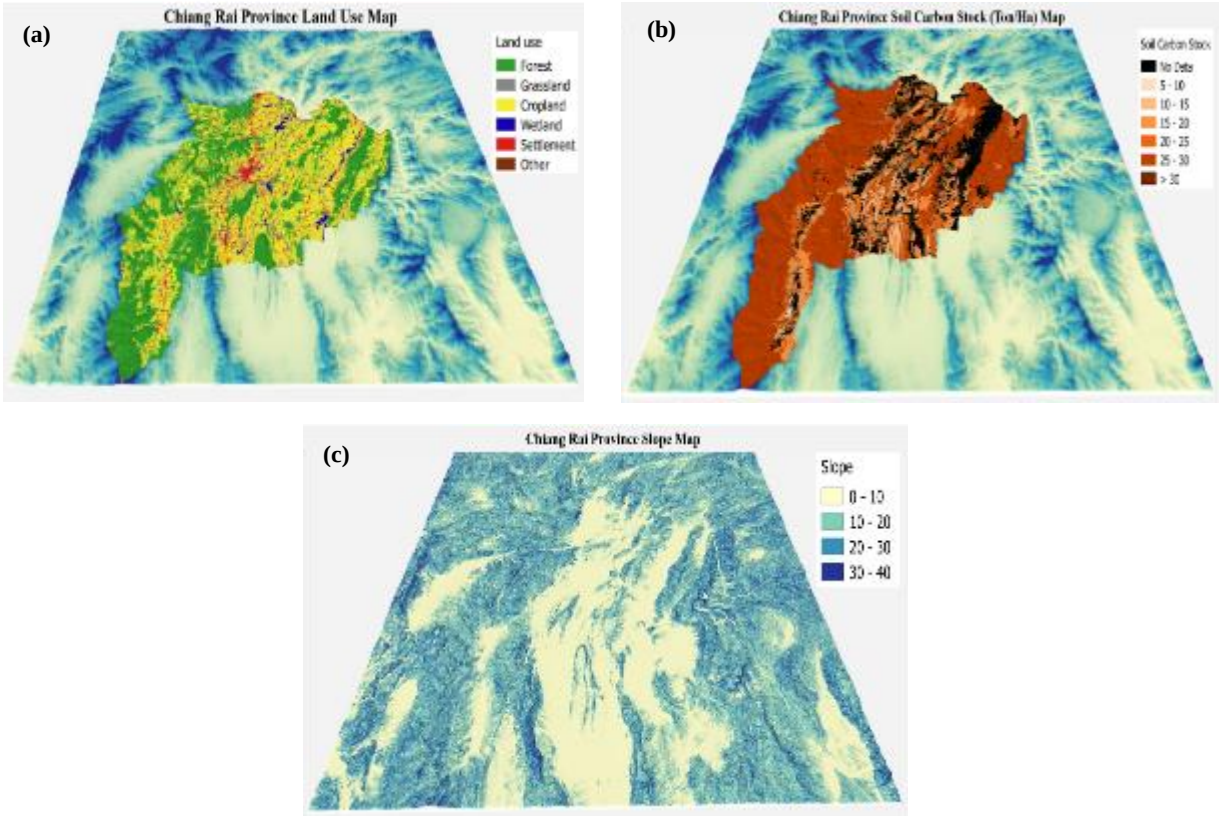

Fig. 1: Chaing Rai Province (a) Land use (b) Soil carbon stock (c) Slope map

Conclusions

Land degradation and soil erosion is the major cause of SOC loss. GIS was used to establish land use, soil carbon stock and slope potential map of Chiang Rai province, Thailand, with the aim of the study is to evaluate the soil carbon stock dynamic in soil with various factors affecting it and analyses land degradation. This study developed GIS as a tool for building the map and integrating them to establish the SOC loss map and proposed proper management to the study area with low carbon stock using various land degradation maps.

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