SWE-03

CLUSTERING SOIL PROPERTIES FOR APPROPRIATE SOIL IMPROVEMENT IN HUAY SAI ROYAL DEVELOPMENT STUDY CENTER, THAILAND

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ABSTRACT

During the 1980s, land in the Huay Sai area located in Petchaburi Province, Thailand, was frequently over-cultivated without accompanying soil conservation practices. This led to depletion of soil fertility and soils eventually became sandy. However, following establishment of the Huay Sai Royal Development Study Center, soil quality at Huay Sai has gradually been restored. Nevertheless, acidic and sandy soils and soil loss remain problematic. This study aims to categorize soil properties in the Huay Sai area in order to apply as the database for appropriate soil improvement. Forty-three soil samples were collected for analysis of pH, texture, organic matter, phosphorus and potassium. The analytical results were subjected to hierarchical cluster analysis with average linkage and squares Euclidean distance in order to cluster soil properties and highlight critical parameters for each cluster. The clustering results showed four soil property typologies i.e. moderately fertile soil, extremely acidic low nutrient soil, sandy low nutrient soil, and low fertility soil. The analysis indicates that some soils at Huay Sai area are infertile and need suitable amendment by appropriate methods prior to renewed use in agriculture. Moreover, soil properties should be regularly monitored for applying as land development database of Huay Sai Royal Development Study Center.

INTRODUCTION

Soil degradation is defined as a long-term decline in soil productivity and its environment-moderating capacity (Obalum et. al., 2012). Soil degradation may occur as a result of several processes: (a) soil erosion by water and wind; (b) development of extreme soil reaction (acidification, salinization, alkalization); (c) contamination from natural or anthropogenic sources (Bone, 2010); (d) nutrient depletion due to a decline inorganic matter content, leaching, extraction by plant roots without adequate replacement; (e) contamination; or (f) soil sealing, e.g. by urbanization or road construction (Bindraban, 2012). Soil degradation may also result from inappropriate land use or from a process or combination of processes, including processes arising from human activities and habitation patterns (UNCCD, 1994).

Many studies indicate that land use and soil management practices greatly impact the direction and degree of soil quality changes (Wang, 1998; Jin, 2011; Liu, 2010; Vera, 2007). Improper land use and management lead to soil erosion, acidification, nutrient depletion, pollution and other natural resource problems that threaten human development. Conversely, it has been shown that appropriate land use and management methods can improve soil quality and the local ecology (Rozanov, 1990; Cheng, 1993).

Deforestation for continuous cultivation especially in drought-prone environments is one of most important causes of accelerated soil degradation (Jaiyeoba, 2003), but is widely practiced due to intensifying competition for land and food. For this reason there is an urgent need to improve soil quality by developing sustainable agricultural land use and management practices.

Soil properties of degraded sites must be investigated in detail in order to identify the critical parameters which influence soil quality of the site and which drive degradation processes.

The aim of this study is to investigate and categorize soil properties in the selected study area using cluster analysis.

DESCRIPTION OF STUDY AREA

The study was conducted at the Huay Sai Royal Development Study Centre area, in Cha-am District, Petchaburi Province in southern Thailand. Until 1983 the site, covering approximately 1,841.46 hectares, was completely forested, but thereafter was subjected to deforestation and expansion of agricultural land; droughts subsequently increased in both frequency and severity. Moreover, over-cultivation without soil conservation caused depletion of soil fertility and soils eventually became sandy. The resulting land degradation triggered desertification processes in the area and its vicinity. After King Bhumibol visited the site in 1983, His Majesty made a comment for the recovery of this area under the Huay Sai Royal Development Study Centre Project. Subsequent restoration of this area was based on three approaches: natural resource restoration, water resource development and quality of life for local residents. The latter included improving knowledge and awareness of the need to protect natural resources, and their importance for ensuring a sustainable balance between humans and nature (Wijitkosum, 2011). Nevertheless, acidic and sandy soils and soil loss remain problematic.

The past 30-year record of climatic data from the nearest weather station at Hua Hin, shows a mean temperature in the study area of 28.1□C with mean maximum and mean minimum temperatures of 35.1□C and 19.5□C, respectively. Mean rainfall was 954.8 mm, with evaporation of 1,711.0 mm. Most of Huay Sai Royal Development Study Centre area is covered by forest and agricultural area; agriculture is dominated by monocropping and livestock farming.

MATERIALS AND METHODS

Soil Properties Investigation

Forty-three soil samples were collected on a 1x1 km grid plotted over the study area. A stainless steel spoon was used for surface soil sampling at a depth of 15 cm below ground surface. Soil properties analyzed included pH, soil texture, organic matter (OM), phosphorus (P) and potassium (K).

CLUSTER ANALYSIS OF SOIL PROPERTIES

Results of soil properties analysis were subjected to hierarchical cluster analysis with average linkage and squares Euclidean distance in order to cluster soil properties and highlight critical parameters for each cluster. The conceptual framework is shown in Figure 1.

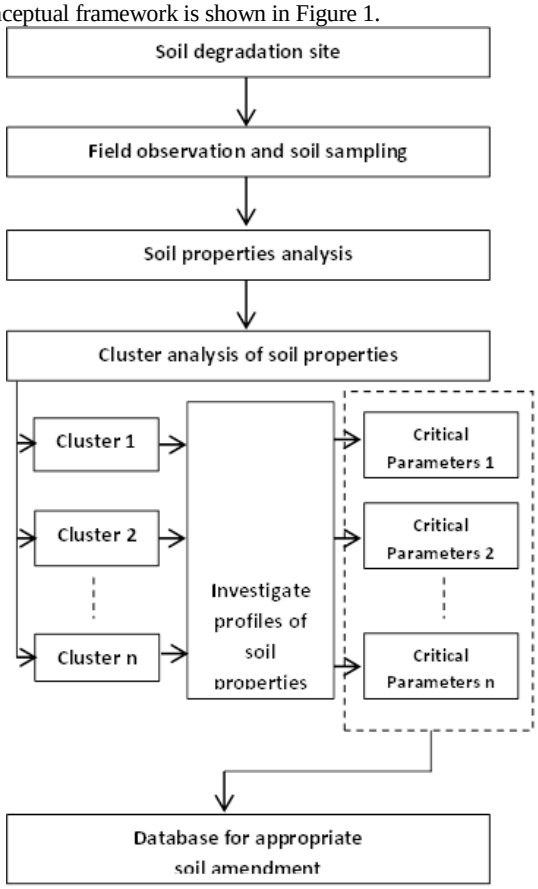

Figure 1 Conceptual framework for the research

RESULTS

Soil Properties

The analysis results of soil properties are summarized in Table 1.

Table 1 Overview of analysis of soil properties

Parameter	Unit	Range	Mode
pH	-	3.3-6.8	5.0
%Sand	%	71-97	81
Organic matter (OM)	%	0.20-2.48	0.91
Phosphorus (P)	mg/kg	2-92	3
Potassium (K)	mg/kg	5-160	20

The analytical results showed that most soil of study area is very strong acid with low OM and nutrient

Soil Properties Clustering

Figure 2 illustrates the resulting dendrogram obtained by clustering soil properties data, which gives four property typologies.

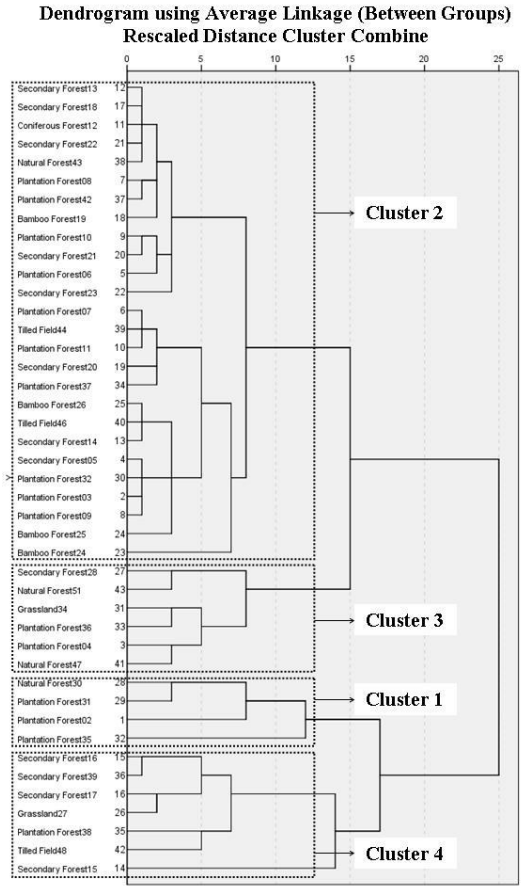

Figure 2 Cluster analysis of soil properties

Histograms of soil properties of the five parameters and four soil groups obtained from cluster analysis were plotted in order to investigate the profiles of soil properties of each soil groups (Figure 3). As can be seen in Figure 3, soil Clusters 2, 3 and 4 have similar nutrient levels. Soil in Cluster 2 is extremely acid meanwhile soil in Cluster 3 is characterized by sandy soils. Cluster 1 differs in that it has more fertile soil than the other clusters

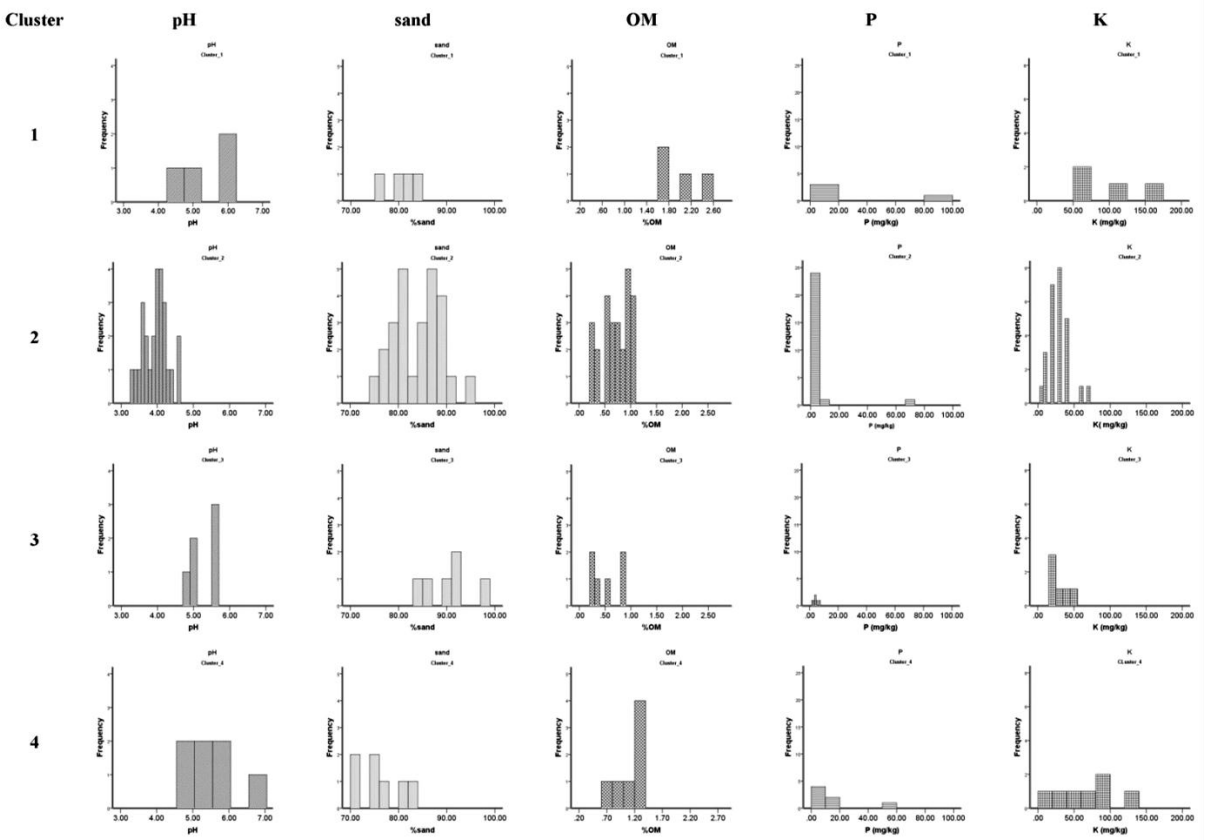

Figure 3 Profiles of soil properties of each soil groups

DISCUSSION

Huay Sai Royal Development Study Centre area has faced soil degradation for over 40 years due to deforestation, expansion of agricultural land, improper use of land, and over-cultivation without any consideration of soil conservation. Cluster analysis of soil properties highlighted that soil clusters 1 and 4 have low to moderately fertile soil which can be improved by adding organic fertilizers. Meanwhile, low soil pH and sandy soils were identified as critical problems requiring urgent amendment in Clusters 2 and 3. Soil acidity inhibits root growth and mineral absorption, which can drastically weaken plants. Some plants have difficulty absorbing any nutrients at all in highly acidic soils (Lacoma, 2012). Meanwhile, sandy soils have low soil moisture-holding capacity (Buchanan, 2010); this limits growth of vegetation (Piedallu, 2011); the sparse or absent soil cover leaves the soil open to erosion by water or wind (Wijitkosum, 2012). Moreover, sandy soils generally have low fertility and CEC which both limit plant growth.

In addition, one of the most severe soil problems in the study area is soil compaction due to drought and over-cultivation on sandy soils. Soil compaction is the physical consolidation of the soil by an applied force that destroys structure, reduces porosity, limits water and air infiltration, increases resistance to root penetration, and often results in reduced crop yields (Wolkowski, 2008).

Nevertheless, due to the efforts of the Royal Development Project, during the period from 2000 to 2010 the forest canopy in the area surrounding the Huay Sai Royal Development Study Centre increased significantly (Wijitkosum, 2012). The change has brought increased rainfall and more even distribution over the year, reduced temperature fluctuations and reduced evaporation (Wijitkosum, 2011). Therefore, the increase in forest cover may play an important role in supporting soil improvement in the Huay Sai area.

CONCLUSIONS

The investigation of soil properties revealed that soil degradation remains a severe problem in the area around Huay Sai Royal Development Study Centre. Clustering soil properties can indicate the critical soil problems affecting each zone; obtaining these data is an important prerequisite for selecting appropriate soil amendment methods. Soil properties should be regularly monitored for inclusion in the land development database of Huay Sai Royal Development Study Centre.

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