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Evaluation of soil quality identified by local farmers in Mai-Negus catchment, northern Ethiopia

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ABSTRACT

Though soil quality (SQ) degradation is a serious challenge to national food security, little information is available that evaluate farmer SQ knowledge vis-à-vis scientific knowledge at catchment scale in Ethiopia. Scientific soil analysis is not an effective approach for SQ assessment in developing regions. An alternative option to evaluate using farmer knowledge is thus necessary but this can be sound after verified scientifically in the context of each region. The present study aims to evaluate SQ status (categories) identified by local farmers using scientific soil measurements, and assess their potential as indicators of soil degradation for decision making in the Mai-Negus catchment, northern Ethiopia. In this study, the scientifically measured soil attributes significantly differed ($P \leq 0.05$) among the SQ categories identified by the local farmers. Using variables retained in the four identified component factors, discriminant analysis identified soil porosity to be the most powerful variable that can help discriminate the SQ status. The study shows that farmer derived SQ status (low, medium, high) could be crucial in providing basis for management and policy decision making as validated by analytical components. Therefore, attention should be given toward integrating farmer knowledge in SQ management to increase chance of technology adoption by farmers.

1. Introduction

A significant decline in soil quality (SQ) has occurred worldwide through adverse changes in physical, chemical and biological soil properties and contamination by inorganic and organic chemicals (Barrios and Trejo, 2003; Karlen et al., 2001). In the past half century, over 25% of the 8.7 billion ha of agricultural land, permanent pastures, and forests and woodlands have been degraded, with the largest part being in developing countries (Krowntree and Fox, 2008; Steer, 1998). As a result, growth of global grain production dropped from 3% in the 1970s to 1.3% in the 1983–1993 periods (Steer, 1998).

In many areas of Sub-Saharan Africa (SSA), positive feedback dynamics between growing populations, land cover and climate change have led to a rapid loss in the capacity of soils to deliver essential ecosystem services (Davidson et al., 2003). These changes are not easily reversible and represent major development costs. This challenges the prospects for a better future for Africans, and has potential for increased conflicts over land (Moseley, 2001). Moreover, SSA's population is likely to double over the next 25–30 years, rising to an expected ~1.75 billion people (Hendrix and Glaser, 2007), which will pose serious pressure on resources and their services. Thus, maintaining the levels of production or aspiring to increase output in order to meet the needs of the ever increasing number of people requires improvement of soil quality. This has sparked interest in the concept of SQ assessment (Barrios and Trejo, 2003; Karlen et al., 2001; Larson and Pierce, 1994; Mairura et al., 2008).

In natural conditions, SQ tends to maintain an equilibrium between pedogenetic properties (Masto et al., 2007; Parr and Papendick, 1997). However, this equilibrium is easily upset by human activity (e.g., agricultural activities) and natural factors (Masto et al., 2007). Such effects are aggravated in arid and semi-arid developing countries such as Ethiopia with its poor technical and financial resources.

Knowledge of SQ is important for developing appropriate anti-degradation measures and design management plans. However, acquiring SQ data based on field measurements and laboratory analysis is difficult, especially in developing regions. An alternative option for evaluating soil conditions to prioritize areas of intervention is thus necessary. Evidence indicates that assessing SQ degradation based on the knowledge of local farmers is rapid, less costly and has high reproducibility (Paytona et al., 2003; Pretty, 1995). Local knowledge generally offers important long-term insights about human responses to environmental change, such as SQ degradation processes (e.g., Neef, 2005). However, such a claim

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should be first assessed in the context of each region before employing the approach for effective soil resource management planning purposes. Measured data from representative locations can be used to evaluate farmers' knowledge so that results can be extrapolated to similar areas with reasonable accuracy. There is thus a need to evaluate the SQ issue under Ethiopian conditions by concurrently integrating the knowledge of farmers and measured soil parameters at catchment scale.

Assessment of SQ change from the perspective of farmers' knowledge in combination with the technical knowledge is the primary concern of sustainable agriculture (Karlen et al., 1997). Integrating and harnessing knowledge from within and between scientific and local knowledge bases enhance communities to fully realize their capacity and become involved in monitoring and responding to the challenges of soil degradation (Karlen et al., 1997, 2001). This enables development and introduction of appropriate management systems and also the enhancement of technology adoption. The present study aims to evaluate the SQ status identified by local farmers using scientific soil measurements, and to assess their potential as indicators of soil degradation for decision making processes in the Mai-Negus catchment, northern Ethiopia. The study will contribute to enhancing the synergies and discrepancies in scientific and local knowledge of soil quality in the developing countries like Ethiopia.

2. Materials and methods

2.1. Study area

The study was conducted in the Mai-Negus catchment in Tigray, northern Ethiopia (Fig. 1), which covers an area of 1240 ha. The landscape of the catchment is generally rugged terrain with altitudes ranging from 2060 to 2650 m.a.s.l. Land use is dominantly arable with a teff (*Eragrostis tef*) cropping system (>80%) but with different percentages of pasture and scattered tree/bush/shrub covers. The major rock types are lava pyroclastic and meta-volcanic. Soils are dominantly leptosols on the very steep positions, cambisols on the middle to steep slopes and vertisols at locations around the flat areas. Soils are highly eroded in most parts of the landscape. Besides, terrain erosivity potential is high, as slope gradients reach more than 85%. Surface cover is poor, and human disturbance is high, which facilitates SQ deterioration.

2.2. Research approach and soil sampling procedure

The study employed two approaches. The first one deals with identification and categorization of SQ using knowledge of local farmers. In the second approach, SQ status is determined based on laboratory analysis of soil samples located in the different SQ status as identified by farmers.

In the first approach, participatory field transect walks with groups of randomly selected 15 farmers, having different economic status were conducted to identify SQ indicators that used by farmers for categorizing soils into low, medium and high SQ status. The collected information was supplemented by group meeting discussions with other 52 household farmers in the catchment not involved in the walk. Local farmers agreed on the SQ indicators such as crop yield and performance, soil depth, color, erosion, fertility to categorize soils into different status. The detail of the first survey approach is given in Tesfahunegn et al. (2011).

In the second approach, soil samples were collected at 0–20 cm soil depth (plow layer) after teff (*E. tef*) crop harvest based on the SQ categories identified as the geographical location of the sampling points is shown in Fig. 1C. Considering the analytical costs and soil variability, a total of 51 composite soil samples were collected to represent the SQ categories of low, medium and high, for each SQ category having 17 soil sampling points. For each sampling point in each SQ category, six (n = 6) composite soil samples were collected in

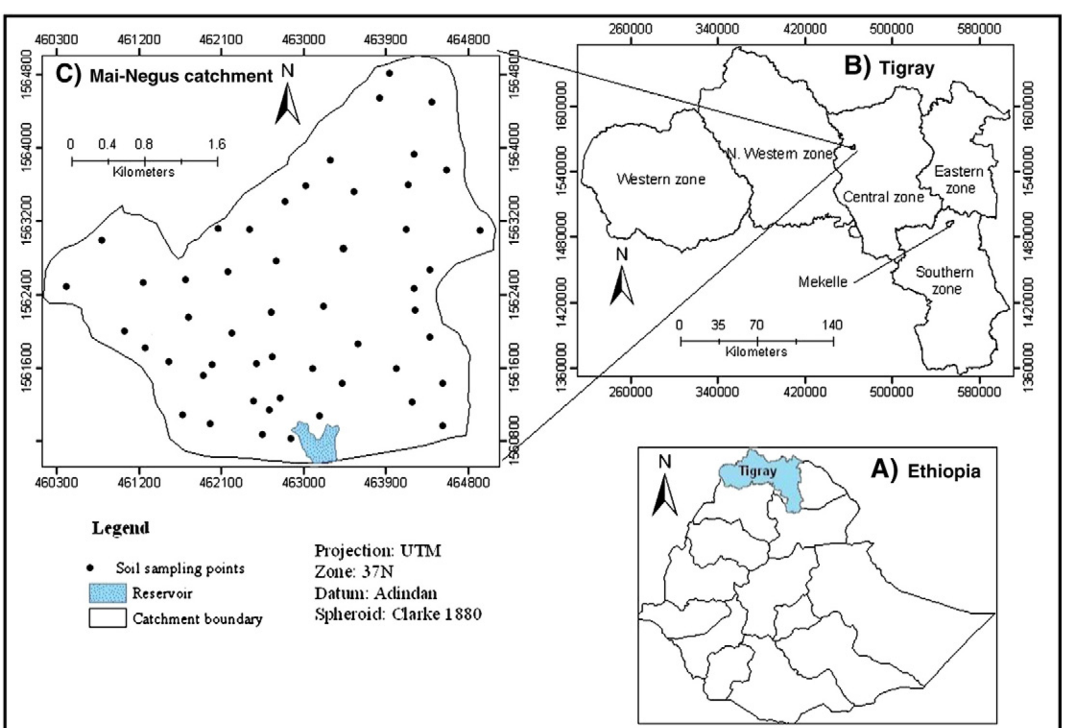

Fig. 1. Map of Ethiopia (A), Tigray (B) and Mai-Negus catchment (study site) with spatial location soil sampling points (C).