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Modelling and mapping the topsoil organic carbon content for Tanzania

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Soil organic carbon (SOC), held in soil organic matter, is a key indicator of soil health and plays an important role in the global carbon cycle. The soil can act as a net source or sink of carbon depending on land use and management. Deforestation and forest degradation lead to the release of vast amounts of carbon from the soil in the form of greenhouse gasses, especially in tropical countries. Tanzania has a high deforestation rate: it is estimated that the country loses 1.1% of its total forested area annually. During 2010-2013 Tanzania has been a pilot country under the UN-REDD programme. This programme has supported Tanzania in its initial efforts towards reducing greenhouse gas emission from forest degradation and deforestation and towards preserving soil carbon stocks. Formulation and implementation of the national REDD strategy requires detailed information on the five carbon pools among these the SOC pool. The spatial distribution of SOC contents and stocks was not available for Tanzania. The initial aim of this research, was therefore to develop high-resolution maps of the SOC content for the country.

The mapping exercise was carried out in a collaborative effort with four Tanzanian institutes and data from the Africa Soil Information Service initiative (AfSIS). The mapping exercise was provided with over 3200 field observations on SOC from four sources; this is the most comprehensive soil dataset collected in Tanzania so far. The main source of soil samples was the National Forest Monitoring and Assessment (NAFORMA). The carbon maps were generated by means of digital soil mapping using regression-kriging. Maps at 250 m spatial resolution were developed for four depth layers: 0-10 cm, 10-20 cm, 20-30 cm, and 0-30 cm. A total of 37 environmental GIS data layers were prepared for use as covariates in the regression model. These included vegetation indices, terrain parameters, surface temperature, spectral reflectances, a land cover map and a small-scale Soil and Terrain (SOTER) map. Prediction uncertainty was quantified by the 90% prediction interval and the predictions were validated by cross-validation.

The SOTER map proved to be the best predictor of SOC content, followed by the terrain parameters, mid-infrared reflectance, surface temperature, several vegetation indices, and the land cover map. The maps show that the SOC content decreases with depth, which is typically observed in soils. For the 0-10 cm layer the average predicted SOC content is 1.31%, for the 10-20 cm layer this is 0.93%, for the 20-30cm layer 0.72%, and for the 0-30cm layer 1.00%. The mean absolute error of the 0-10cm layer was 0.54%, that of the 10-20cm layer 0.38%, that of the 20-30cm layer 0.31%, and that of the 0-30cm layer 0.34%. The R2-value of the 0-10 cm layer was 0.47, that of the 10-20cm layer 0.49, that of the 20-30cm layer 0.44, and that of the 0-30cm layer 0.59. The next step will be the development of maps of SOC stock and key properties that are of interest for soil fertility management such as pH and the textural fractions.