Mapping Soil Organic Carbon for Regenerative Agriculture and Reducing Atmospheric Carbon Using Multispectral Satellite Imagery and Machine Learning

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Conventional agricultural practices have caused the world's soils to release 133 billion tonnes of carbon to the atmosphere and are one of the major contributors to global greenhouse gas emissions. Regenerative agriculture practices have great potential in sequestering large amounts of CO2 back into the soil as soil organic carbon (SOC) and can help combat climate change. Critical to its success is the ability to accurately quantify SOC, but current methods involve manual soil sampling and are expensive and time-consuming. The purpose of this research was to apply machine learning to create an efficient and low-cost solution to quantify SOC using multispectral remote sensing and to predict the impact of agricultural practices on SOC. The Harmonized World Soil Database was linked to NASA/USGS Landsat 8 satellite images (surface and top-of-atmosphere reflectance). Panchromatic image sharpening and topographic correction were applied to each image, 151 spectral indices were extracted, and machine learning models were trained. For predicting future SOC, AgEvidence datasets were used. As part of this research, two novel spectral indices were developed to quantify topsoil and subsoil SOC. A mobile app was also developed to provide an interface to the trained models to help farmers follow regenerative agriculture practices. For SOC quantification, the LightGBM model had the best root-mean-square error (RMSE) of 0.97. For predicting the impact of agricultural practices on SOC, the RMSE was less than 5 for each category. The models created are generalizable and can accurately quantify and monitor SOC and help reduce atmospheric carbon.

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