Precision Agriculture techniques to delineate site heterogeneity on the farm level in Organic Agriculture

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Abstract

In the past few years uniform management of fields in agriculture has been gradually replaced by environmentally based management, which involves exploiting the multi functionalities of landscapes (Córdoba et al 2016). Dividing a single agricultural field into a group of crop zones with homogenous features is one such way of redesigning agricultural landscapes (Córdoba et al 2016). This results in reduced crop field sizes, which have been found to have higher within-field biodiversity (Fahrig, et al., 2015). This work uses a combination of remotely sensed data and ground truth data to segregate the soil in the study area into different classes, and combines this information with landscape elements to delineate the heterogeneity in a particular field site, considering also farm specific characteristics like machinery width and management practices. Delineating the heterogeneity is the first step to having management zones that promote reduced and site specific use of agricultural inputs.

Introduction and Objectives

Precision Agriculture aims to optimize crop management by taking into account spatial variability, and thus optimize use of farm inputs (*Georgi et al 2017*). Management zones are usually delineated based on yield maps (*Derby et al 2007*), soil and topographic properties (*Derby et al 2007*), remote sensing data (*Georgi et al 2017*) or a combination of the above (*Derby et al 2007*). Yield data tend to have a lot of erroneous points from sources such as sensor errors, georeferencing and even operator and data processing errors (*Georgi et al 2017*). The cost and time efforts to pre-process these georeferenced data, which indirectly or directly implicate physical or chemical properties of the soil, is high because of the complexity of programs and the expertise required. As stated above, to delineate management zones, several variables (crop as well as soil) have been used as inputs for clustering (*Khosla et al 2010*). The objective of this analysis is to combine soil properties as variables along with landscape factors, without having the need to collect extensive yield data, and divide the field into management zones. The farm characteristics like machinery width are also taken into account to analyse traffic

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lanes to ensure that farmers have enough space to turn with standard machinery sizes, even with reduced field sizes.

Methods

Primary data collection and Calculation of Crop Growth Metrics

For the calculation of the metrics that affect crop growth, satellite data in two scales were collected in the organic mixed farming field site Gladbacherhof: Sentinel 2 images in 10 m resolution and PLANET Scope Images in 3 m resolution for the period of 2021-2023 in the vegetation periods. The vegetation indices for the crop (currently oat, followed by beans) are calculated with the help of GIS tools and python based on this data. Soil heterogeneity is calculated based on soil data collected in May 2022 (Geophilus System) and the ground truth values collected in 2021 and partly in 2023 with the help of a Multi Linear Regression model. The generated soil heterogeneity data is compared with the crop growth metrics, and a correlation matrix is calculated. With the help of this matrix, indicators for crop growth in organic farming are identified.

Analysis of site heterogeneity: Erosion and slope

After identifying the indicators of crop growth, the landscape factors are calculated with the Invest SDR Model (based on the ongoing project EROSPOT), for the areas in the field where erosion models have not yet been calculated. These models can then be used as a reference to make recommendations for management decisions.

Conclusions

Delineation of Management Zones and Automation

Management zones will then be identified: based on the site heterogeneity and the Crop Growth Metrics calculated with the help of both crop and soil data. The resulting zones will belong two categories: Productivity zones and Ecosystem Service Zones. The productivity zones will be classified into highly productive zones and low productive zones, and the Ecosystem service zones will be zones which require ecosystem services because of factors like erosion. The correlation between both the categories of zones will also be examined, if there is any.

Literature

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