Transforming Agriculture for a Sustainable Future: Our Innovative Approach to Carbon Measurement and Sequestration

Introduction

Bloci provides consultancy and implementation for Blockchain Solutions. It has set up the BlociCarbon marketplace to match UK farmers that need to sell carbon credits, with companies that need to buy carbon credits.

Carbon Credits

Whatever a company does leaves a Carbon Footprint. This can be Offset by purchasing Carbon Credits to become carbon neutral. Bloci sells carbon offsetting credits from reputable and traceable UK organisations which can be independently verified via the Blockchain.

Buying from Bloci encourages UK farmers to become Carbon Positive and selling their carbon credits enables others to be carbon neutral.

Carbon credit self-assessment process

A carbon credit self-assessment process is currently in place for UK farmers to report to UK Government. The Government then administers carbon credits, in return for proven additional farming activity that results in increased carbon sequestration. Additional carbon sequestration activities must be above and beyond the usual operating activity of a given farm. In order to achieve this, a farmer would usually have to invest time and money in a piece of land and may also lose growing or grazing land.

There are three main self-assessment products on the market, that are currently used by approximately sixteen thousand farms across the UK. These are the Farm Carbon Toolkit, Agrecalc and The Cool Farm Tool. All of these kits provide a complete business toolkit for assessing carbon production of the entire farm business and are recognised by the National Farmers Union. The information on a self-assessment is submitted by farmers using the Basic Farm Payment System.

Larger farms have existing bilateral relationships with large carbon credit purchasers, but many smaller farms or landowners don’t have this offtake opportunity.

The Challenge of Climate Change

Climate change is a global challenge that requires a collective effort from all countries to mitigate its impact. The UK government has set a target to achieve net-zero carbon emissions by 2050. Achieving this target requires collective action from various sectors, including agriculture. Agriculture is a significant contributor to greenhouse gas emissions, accounting for approximately 10% of the UK’s total emissions. However, agriculture can also be part of the solution to mitigating climate change by sequestering carbon in soils. Soil organic carbon (SOC) is an essential component of soil health and plays a crucial role in carbon sequestration. Accurate and reliable data on SOC and its spatial distribution can help farmers make informed decisions on soil management practices that can increase carbon sequestration and reduce carbon emissions.

This case study explores how combining in-situ SOC data and multispectral satellite imagery powered by modern machine learning techniques can provide farmers with important information on carbon topsoil storage and CO2 sequestration, which can help the UK meet its climate change target.

Background

Soil organic carbon (SOC) is the carbon stored in soil through the decomposition of organic matter. SOC is a critical component of soil health and plays a crucial role in carbon sequestration. Carbon sequestration is the process of capturing and storing carbon from the atmosphere in various carbon sinks, including soil, forests, and oceans. Carbon sequestration is essential in mitigating the impact of climate change by reducing the concentration of carbon dioxide (CO_2) in the atmosphere.

Agriculture accounts for approximately 10% of the UK's total greenhouse gas emissions. However, agriculture can also be part of the solution to mitigating climate change by sequestering carbon in soils. Soil management practices that increase carbon sequestration can also improve soil health, water retention, and nutrient cycling.

Accurate and reliable data on SOC and its spatial distribution is essential in making informed decisions on soil management practices that can increase carbon sequestration and reduce carbon emissions. Traditional methods of measuring SOC are time-consuming, expensive, and labour-intensive.

Work completed by the Farm Carbon Toolkit has demonstrated that every hectare of land that raises its soil organic matter levels by just 0.1% (e.g. 4.2% to 4.3%) can sequester approximately 8.9 tonnes of CO_2 per year (at 1.4 g/cm^3 bulk density). This is an extraordinary figure; in practice that is not only possible but being exceeded by farmers and growers building healthy soils.

Current manual process for data collection

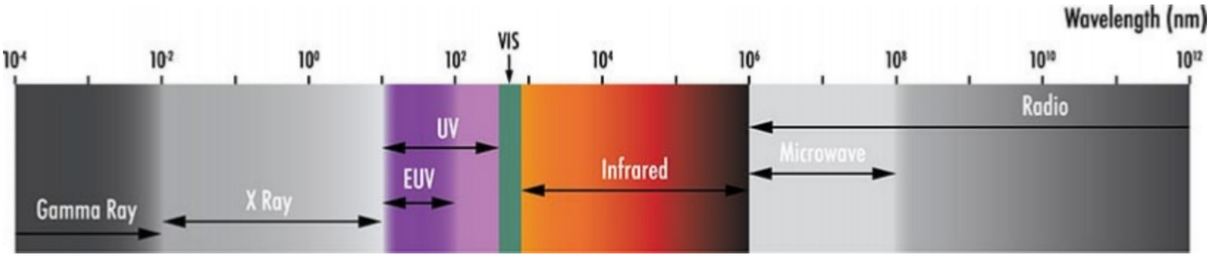
The complete business toolkits include manual soil sampling requirements (see figure 1), whereby a farmer must collect ~2-3 soil samples on land that it has designated for additional carbon sequestration activities. Guidance is provided about where to take the sample but this is not validated and specific geolocations are not provided. These samples are sent away and analysed in a laboratory. Every 12 months, a farmer is required to work through the toolkit again to see if it has gained or lost carbon.

Bloci would like to be able to improve the current data collection method for carbon content in soils, such that data collection can be undertaken more frequently than once a year and potentially over wider sample areas. BlociCarbon aims to acquire more accurate soil carbon content figures, cheaply so that data can be gathered more widely. This would have the benefits of providing higher fidelity data on the carbon sequestration process and improve the BlociCarbon platform. In turn, this would:

- *Enable farmers to optimise the self-assessment process*
- *Encouraging smaller farmers to more easily undertake carbon sequestration assessments and find offtake opportunities*
- *Provide immutable records and validation of carbon credit origins for buyers of carbon credits*

Bloci was presented with a number of options which could be split in two groups: ‘in the ground measurement’ and ‘in the sky measurement’. It was felt that due to the inherent scalability, satellite-based analysis was the preferred option incorporating a machine learning element.

In recent years, remote sensing techniques, including multispectral satellite imagery, have shown potential in mapping SOC at a large scale. Combining in-situ SOC data with multispectral satellite imagery can provide farmers with accurate and reliable information on SOC and its spatial distribution, enabling them to make informed decisions on soil management practices.



Objectives

The primary objective of this case study is to explore how combining in-situ SOC data and multispectral satellite imagery powered by modern machine learning techniques can

provide farmers with important information on carbon topsoil storage and CO_2 sequestration, which can help the UK meet its climate change target. The case study aims to:

1. *Investigate the accuracy of using multispectral satellite imagery in mapping SOC at a large scale.*
2. *Explore the potential of modern machine learning techniques in combining in-situ SOC data with multispectral satellite imagery to provide accurate and reliable information on SOC and its spatial distribution.*
3. *Evaluate the usefulness of the information provided by the combined approach in informing soil management practices that increase carbon sequestration and reduce carbon emissions.*

Methodology

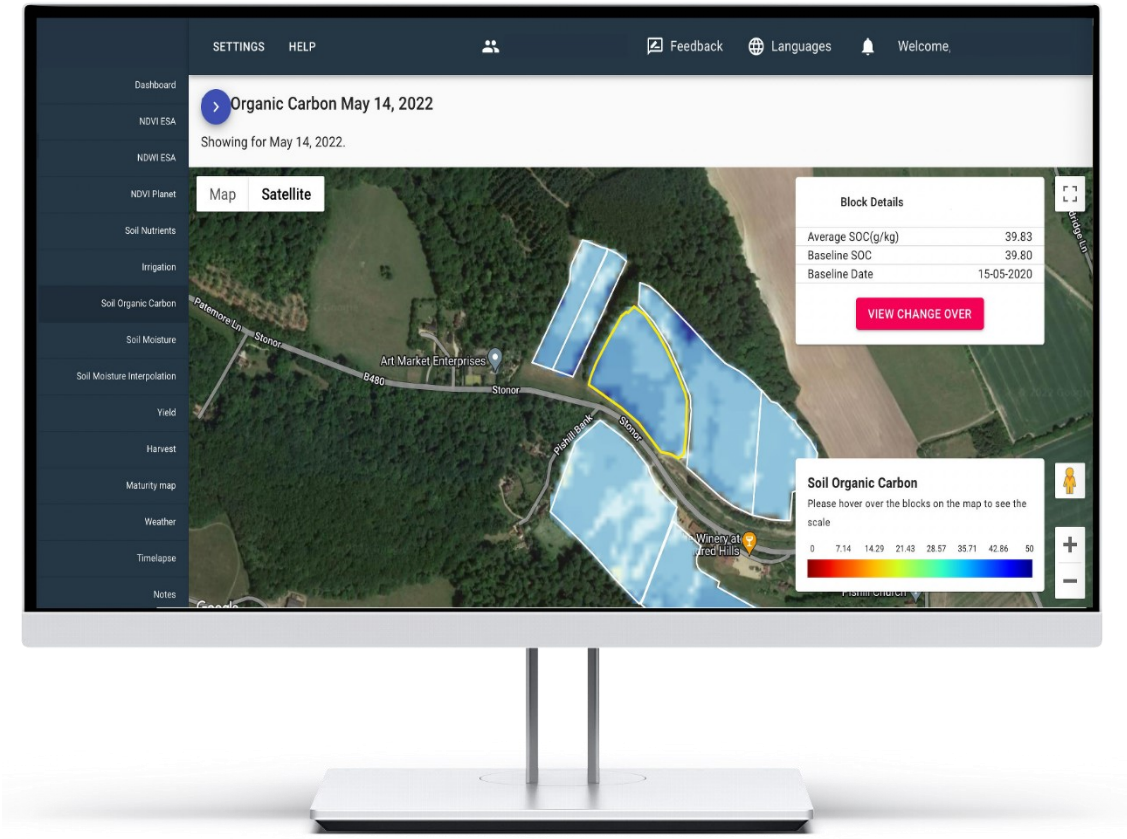
The case study used a combination of in-situ SOC data and multispectral satellite imagery to map SOC in a pilot study area in the UK. The study area covered approximately 10 hectares of mostly grazing land in North Wales. In-situ SOC data was collected using a combination of traditional laboratory analysis and field-based measurements. The laboratory analysis involved the use of the Walkley-Black method to determine the amount of SOC in soil samples.

Multispectral satellite imagery data was obtained from the European Space Agency's Sentinel-2 satellite. The satellite data consisted of 13 spectral bands, covering a wavelength range of 443 to 2190 nm. The satellite data was processed using a modern machine learning techniques.

The European Space Agency (ESA) operates a fleet of Earth observation satellites, including the Sentinel series of satellites, which are designed to provide high-resolution and multispectral images of the Earth's surface. Sentinel-2 is one of the satellites in the series that is particularly useful for monitoring soil variation.

Sentinel-2 carries a multispectral instrument that provides 13 spectral bands, covering a wavelength range of 443 to 2190 nm. The instrument has a spatial resolution of 10 to 60 meters, depending on the spectral band, which enables it to capture detailed images of the Earth's surface.

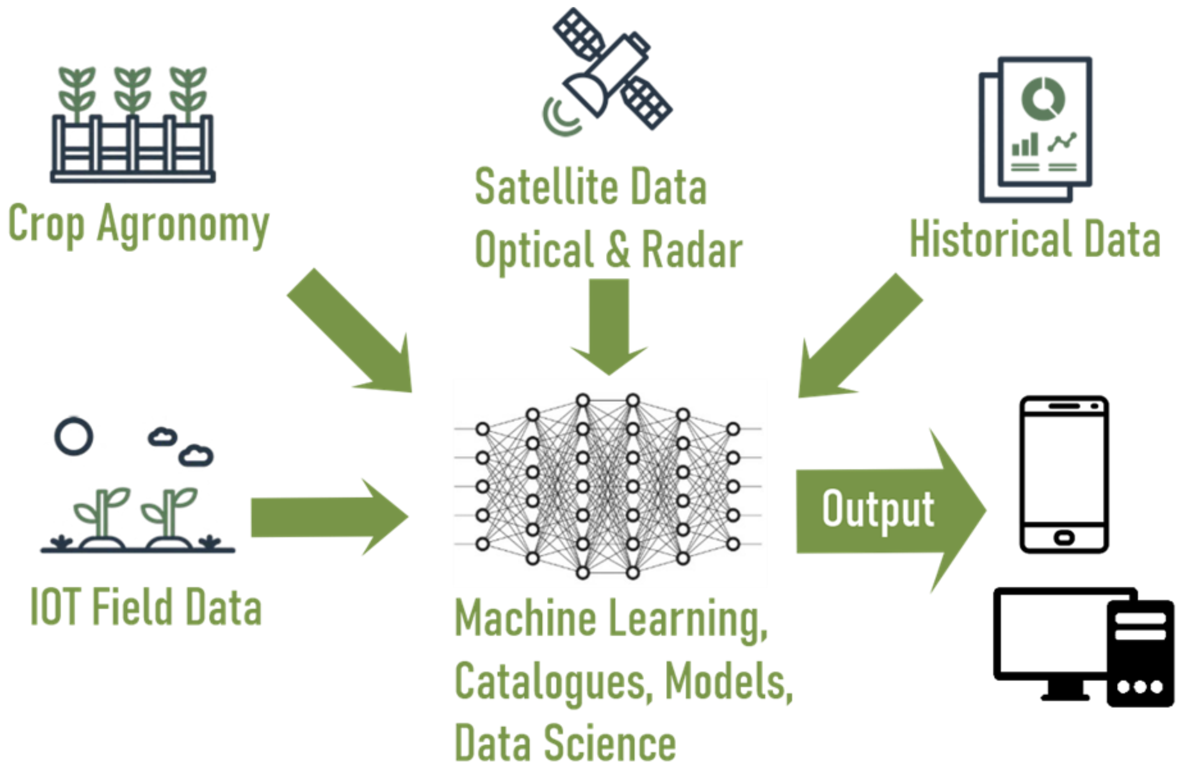
The multispectral images captured by Sentinel-2 can be processed to extract information on soil variation. For example, the Normalized Difference Vegetation Index (NDVI) can be calculated from the images, which provides an indication of vegetation cover and biomass. Areas with higher vegetation cover and biomass are generally associated with higher levels of organic matter and soil carbon, while areas with lower vegetation cover and biomass are associated with lower levels of organic matter and soil carbon.



In addition, the multispectral images can be used to identify areas with different soil types, moisture levels, and other soil properties. For example, the images can be used to detect areas with high levels of clay or sand content.

The in-situ SOC data and satellite imagery data were combined using a spatial statistical modelling approach known as kriging. Kriging is a geostatistical technique that can be used to interpolate data between sample points. The kriging approach was used to estimate SOC values at unsampled locations based on the relationship between the in-situ SOC data and satellite imagery data.

The accuracy of the combined approach was evaluated using a cross-validation technique. The cross-validation involved dividing the data into training and testing datasets, where the training dataset was used to train the random forest regression model, and the testing dataset was used to evaluate the accuracy of the model's predictions.

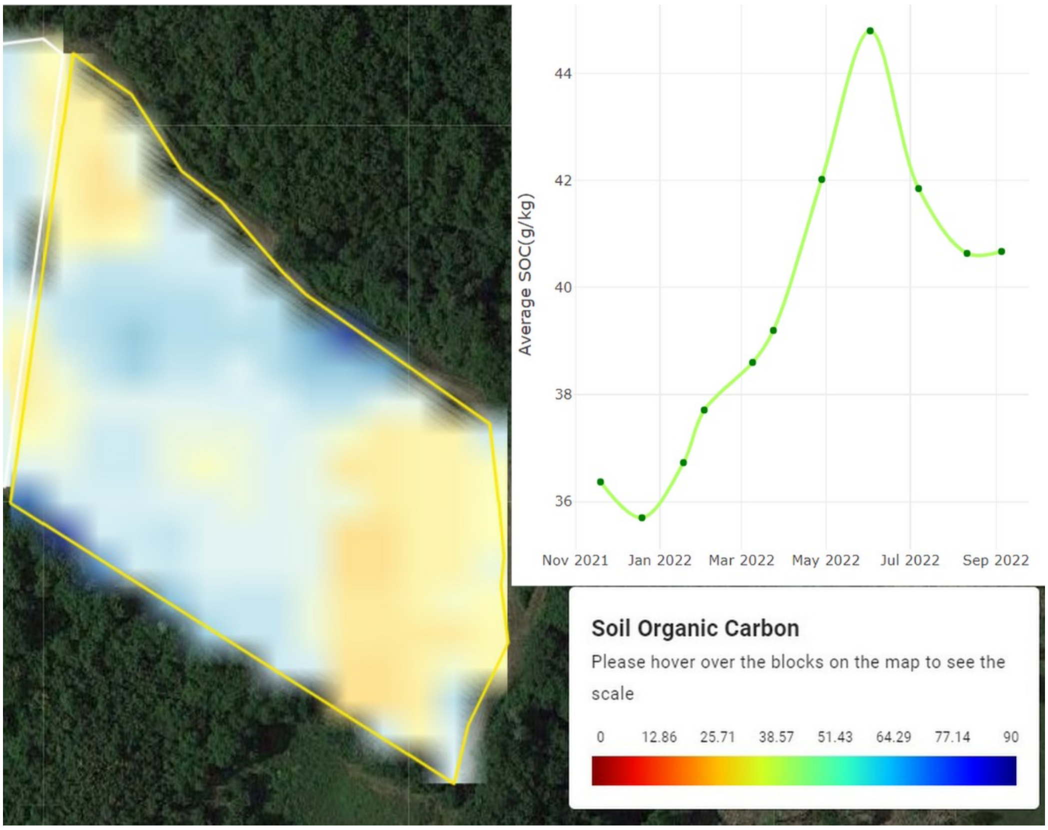


Provisional Results

The early results of the pilot study showed that combining in-situ SOC data and multispectral satellite imagery using modern machine learning techniques can provide accurate and reliable information on SOC and its spatial distribution.

The spatial distribution of SOC in the study area was mapped using the kriging approach. The map showed that SOC was spatially variable, with higher concentrations of SOC in areas with higher vegetation cover and lower concentrations of SOC in areas with lower vegetation cover. The map also identified areas with high potential for carbon sequestration, which could inform soil management practices aimed at increasing carbon sequestration and reducing carbon emissions.

The information provided by the combined approach was useful in informing soil management practices that increase carbon sequestration and reduce carbon emissions. The information could be used to identify areas of the farm that require soil improvement practices, such as the application of organic matter, cover crops, and reduced tillage. These practices can increase carbon sequestration by increasing the amount of organic matter in the soil, reducing soil erosion, and improving soil structure and water retention.



Conclusion

Combining in-situ SOC data and multispectral satellite imagery powered by modern machine learning techniques is likely to provide farmers with accurate and reliable information on SOC and its spatial distribution. The information can help farmers make informed decisions on soil management practices that can increase carbon sequestration and reduce carbon emissions, ultimately contributing to the UK's efforts to meet its climate change target.

The pilot study will demonstrate the potential of using remote sensing techniques and modern machine learning techniques in mapping SOC at a large scale. The approach could be scaled up to cover larger areas and integrated with other data sources, such as weather data and crop yield data, to provide a more comprehensive understanding of soil health and carbon sequestration potential.

Further research is needed to evaluate the cost-effectiveness of the combined approach and its scalability to cover larger areas. The approach could also benefit from the integration of ground-based sensors and other data sources to improve the accuracy of the predictions and reduce the reliance on in-situ data.

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