UNIVERSITY OF KWAZULU-NATAL ™

INYUVESI YAKWAZULU-NATALI

Assessment of soil organic matter in KwaZulu-Natal, SA using Remote Sensing

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Introduction

- The study is conducted in KwaMaye, a rural community in the province of KwaZulu-Natal (KZN), South Africa, to manage the plenty of risks confronting them and how they prepare for climate change.
  - Assessing household vulnerability in the light of climatic and non-climatic riskscapes: https://doi.org/10.3354/cr01737
  - The future looks empty: embodied experiences of distress triggered by environmental and climatic changes in rural KZN, SA. https://doi.org/10.1007/s10708-021-10426-1
    - Findings indicate that environmental and climatic changes, which have manifested in the form of increased drought conditions, soil infertility, and soil erosion have undermined farmers' ability to produce food and engage in livestock production effectively. These circumstances evoked frustrations, increased anxiety, sadness, reduced self-value and self-worth as well as internal migration.
  - The assessment of soil organic matter in KwaMaye and its relationship to spectroscopy (Analytical Spectral Device (ASD) FieldSpec3 data. https://doi.org/10.1080/10106049.2024.2361702

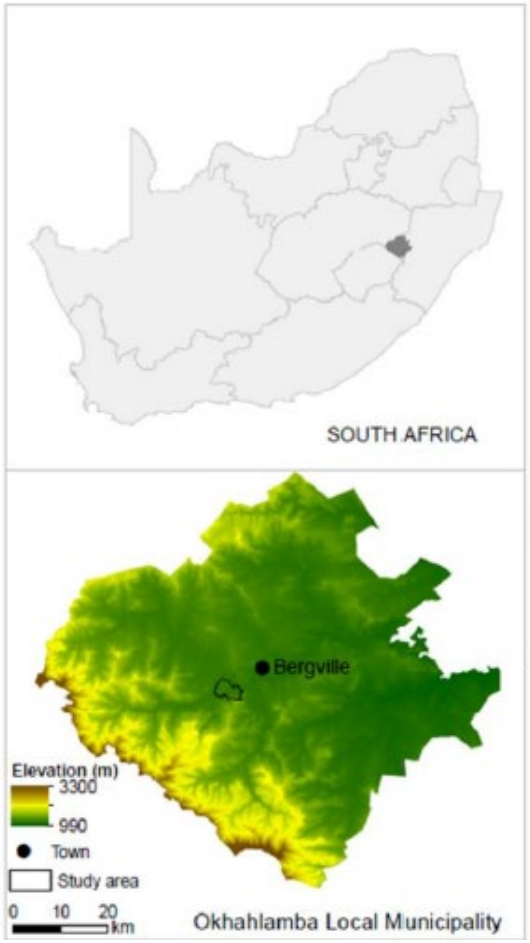
Soil Organic Matter (SOM)

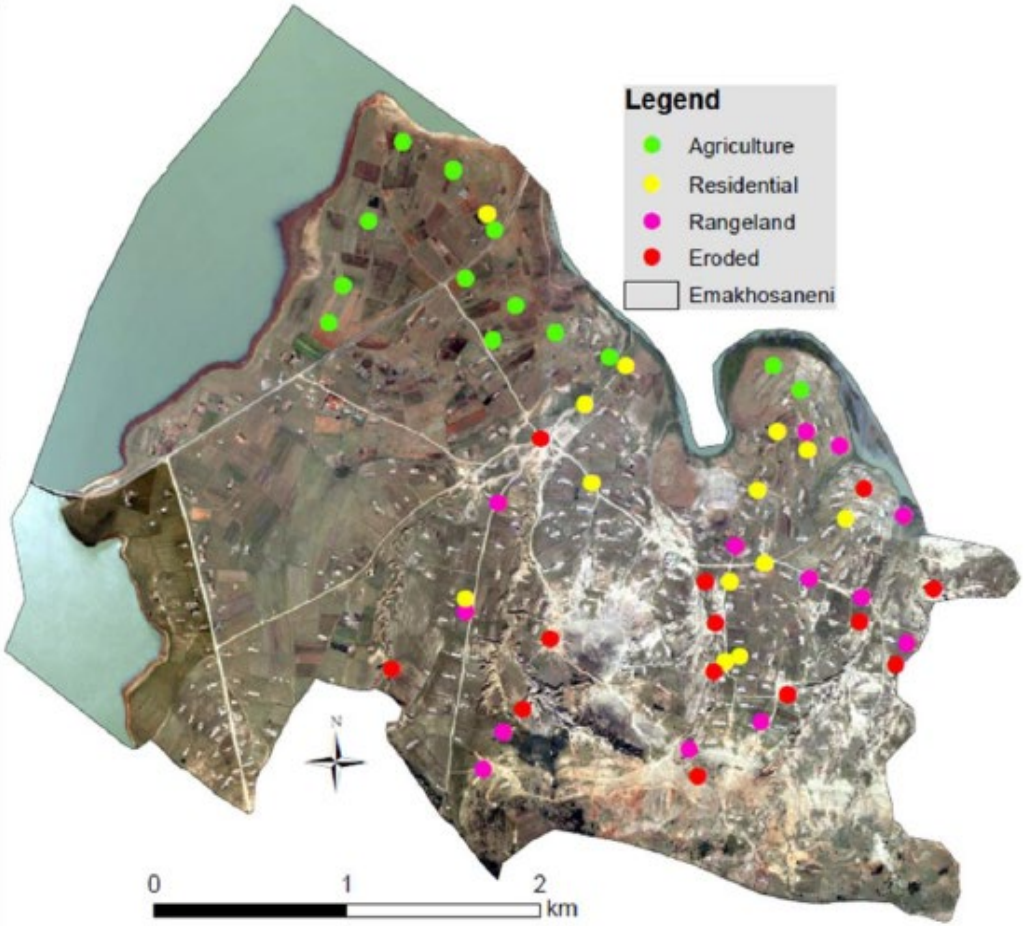
- SOM is a key mechanism for vitality and soil health. It is highly related to soil productivity, plant growth and the soil's ability to cycle nutrients, which is why its decline is considered one of the greatest threats to soil degradation.

- Understanding SOM dynamics is crucial for land management and for applying soil health measures.

- This demands cost-effective and spatially comprehensive strategies to measure and monitor SOM with a satisfactory degree of accuracy.

Description of the study area KwaMaye





Description of the study area…

- The area is located at an elevation of 1,150m within a municipality that borders the Free State province and the Kingdom of Lesotho at the foothill of Drakensberg Mountain.

- The area is surrounded by various water sources, the Woodstock Dam to the north and the Tugela River and Driel Dam to the east of the area.

Soil Sample

- Four main land-use classes common in the area, namely *agricultural land*, *residential land*, *rangeland, and eroded land*.
- Collected a total of 52 soil samples, 13 from each category
- We collected samples from the soil surface to a depth of 15cm using a standard auger with a dimension of 8cm.
- We then placed the samples in a labelled, airtight plastic bag to prevent the sample from spilling or drying out, after which the GPS coordinates were recorded.

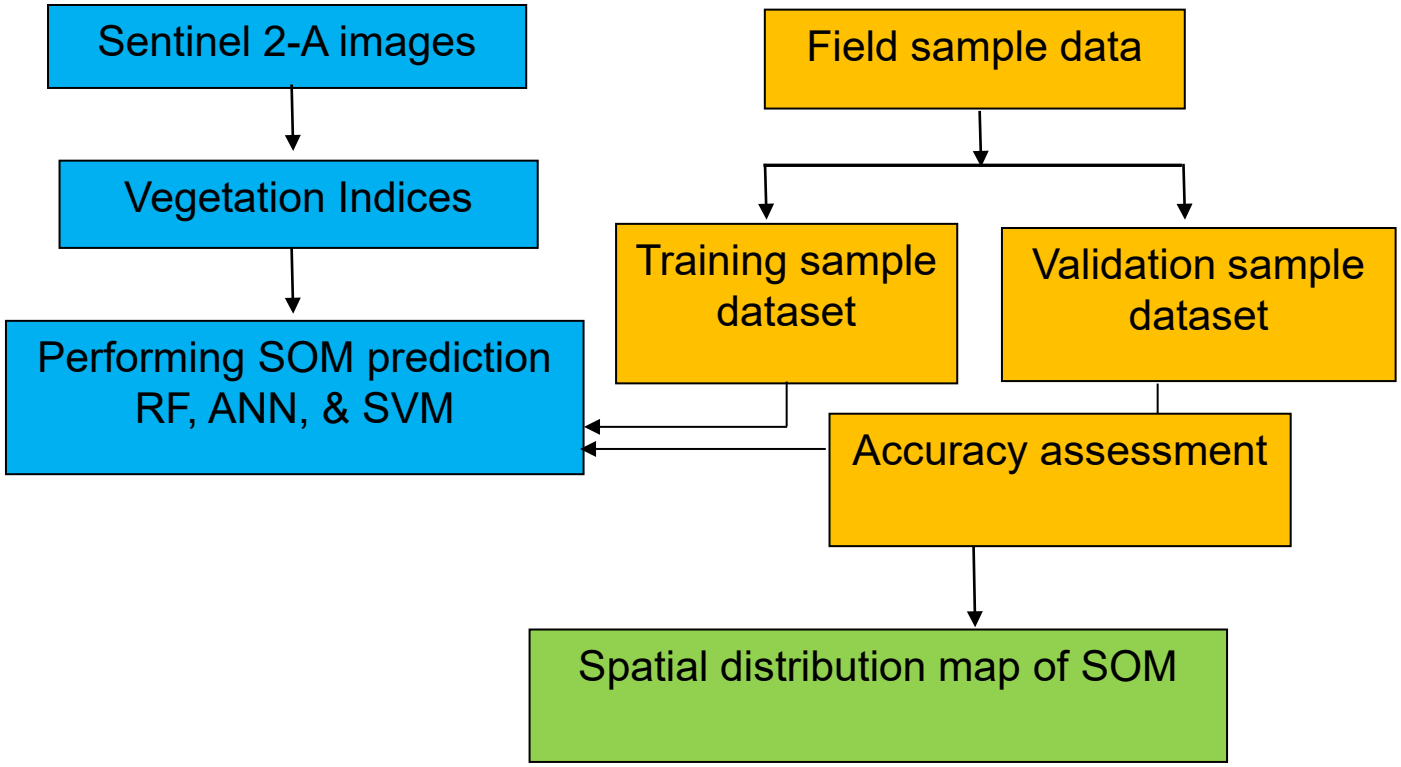
Soil Sample Preparation

- We dried about 500g of each soil sample in the oven overnight at a temperature of 105 °C.
- crushing the samples into fine soil particles using a porcelain mortar and pestle.
- We passed the crushed pieces through a 1mm stainless steel sieve.
- The soil sample was separated into two parts for reflectance spectrum acquisition (ASD) and for SOM determination.
- We used the Walkley-Black, one of the most common methods for determining the percentage of SOM content in soil samples. This is a wet oxidation method that uses acids to determine the amount of oxidizable carbon in the soil; this amount is then converted to SOM using a conversion factor.

Soil Sample Preparation…

- The 52 sampling sites were divided into two groups. The first group, the training samples, were used for creating the models (n = 40, 80% of sampling sites), and the second group was used in the validation of the models (n = 12, 20% of sampling sites).

Workflow for mapping…



Remotely sensed imagery

- Sentinel-2 imagery, obtained from the Copernicus (https://scihub.copernicus.eu/dhus/#/home; accessed on 16th July 2019). The image was a Level 2A product that is processed by the Sen2Cor processor.
- 16 spectral indices:
  - Brightness Index (BI), the Second Brightness Index (BI2), Redness Index (RI), Colour Index (CI), Hue Index (HI), Saturation Index (SI), Normalized Differences Vegetation Index (NDVI), Transformed Vegetation Index (TVI), Enhanced Vegetation Index (EVI), Green Normalized Difference Vegetation Index (GNDVI), Vegetation (V), Renormalized Difference Vegetation Index (RDVI), Difference Vegetation Index (DVI), Soil Adjusted Vegetation Index (SAVI), Modified Soil Adjusted Vegetation Index (MSAVI), and the Second Modified Soil Adjusted Vegetation Index (MSAVI2).

Spectral Indices

Index	Formula	Reference	Equation
BI	$\frac{\sqrt{(Red \times Red) + (Green \times Green)}}{2}$	Escadafal (1989)	(1)
BI2	$\frac{\sqrt{(Red \times Red) + (Green \times Green) + (NIR \times NIR)}}{3}$	Escadafal (1989)	(2)
RI	$\frac{Red \times Red}{Green \times Greened \times Green}$	Pouget et al. (1990)	(3)
CI	$\frac{Red \times Green}{Red \times Green}$	Pouget et al. (1990)	(4)
HI	$\frac{2 \times Red - Green - Blue}{Green - Blue}$	Mandal (2016)	(5)
SI	$\frac{Red - Blue}{Red + Blue}$	Mandal (2016)	(6)
NDVI	$\frac{NIR - Red}{NIR + Red}$	Rouse et al. (1974)	(7)
TVI	$(\frac{NIR - Red}{NIR + Red})^{0.5} \times 100$	Nellis and Briggs (1992)	(8)
EVI			

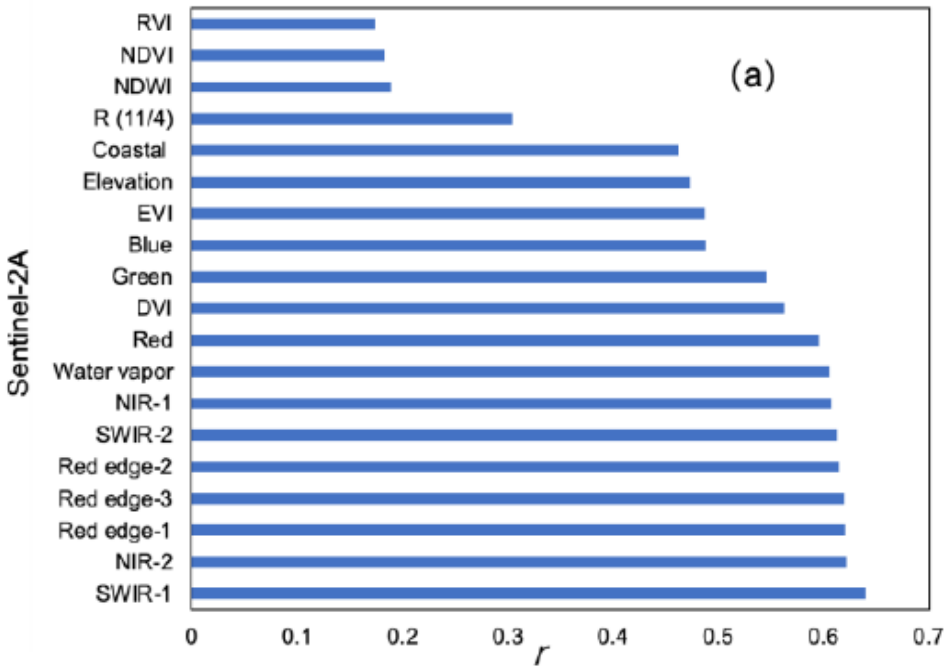
Results and Analysis

- Descriptive statistics of the SOM content

Soil Dataset		SOM		
	N	Minimum %	Maximum %	Mean %
Training dataset	40	0,14	2,2	0,87
Validation dataset	12	0,13	2,2	0,86

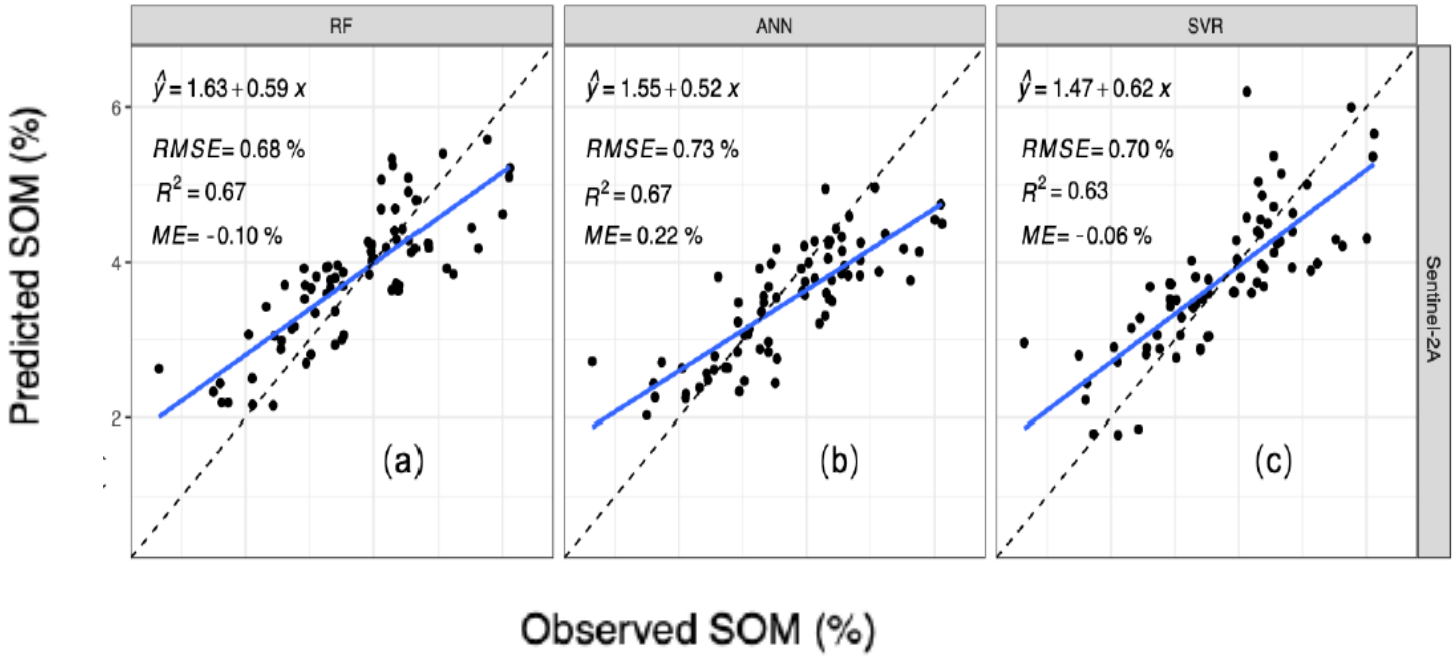
Model performance

- The Pearson correlation coefficients (r) between the independent variable and the SOM content were calculated and then used to rank all the independent variables.

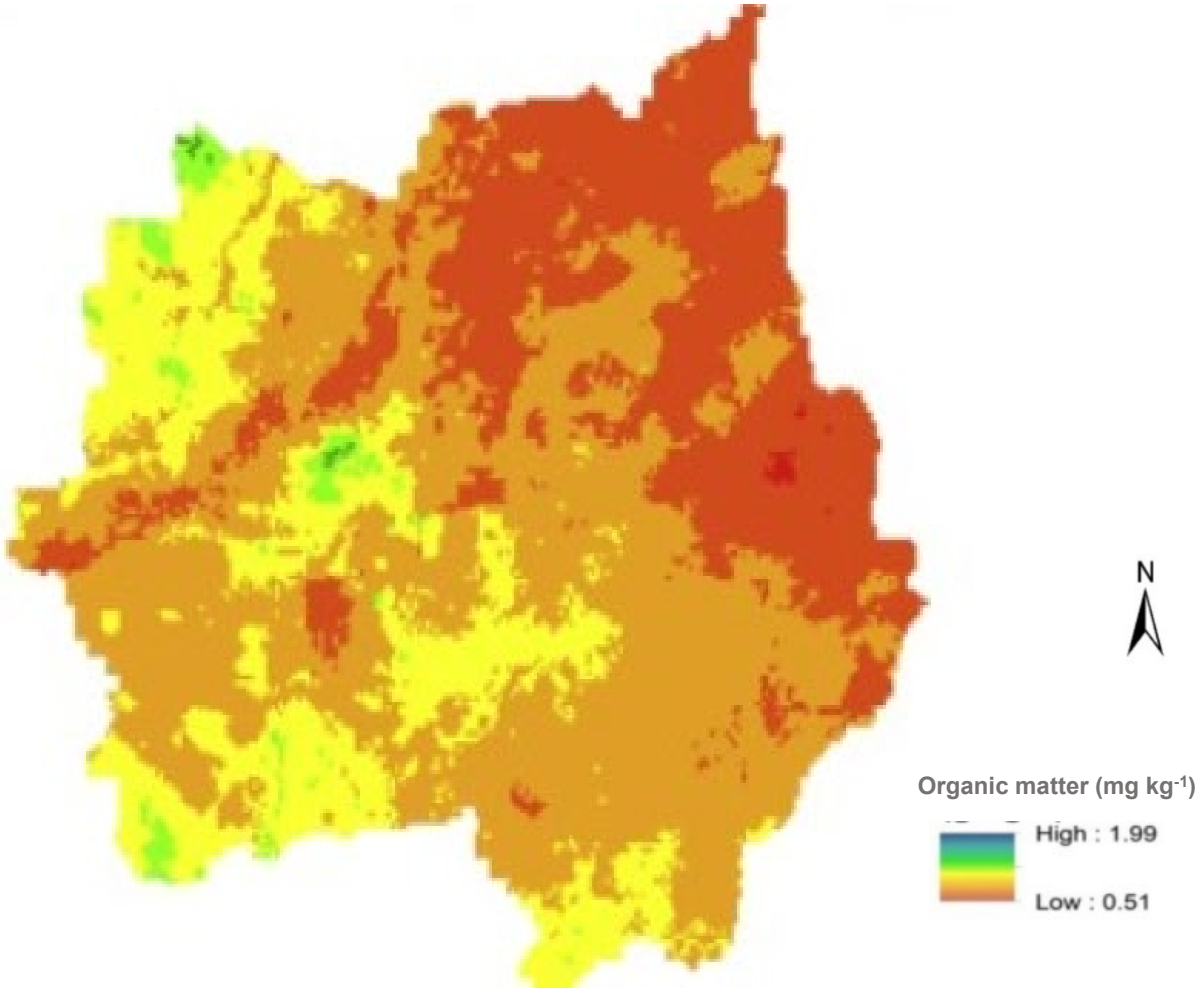


- We found that the independent variables as the model inputs had a good correlation coefficient with the SOM content on all of the predicted scenarios.

Performances of RF, ANN and SVR



Spatial distribution map of SOM



Conclusions

- Satisfactory result is reported using the spectral indices of sentinel 2A images for SOM prediction and may provide an opportunity to generate high-resolution, high-precision maps of the spatial distribution of SOM.

- The results showed that the RF algorithm achieved slightly better performance than the ANN and SVR algorithms. Consistent with the existing literature,

- Further studies are recommended for broader scales, more samples for different land use practices, and very high spectral resolution imagery for SOM prediction.
- Cloud computing and easy access to the community and land rehabilitation manager at the municipal level.

Thank you!