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Evaluating use of satellite imagery in planning and poverty alleviation in the Mahikeng – Ramotshere Moiloa Local Municipalities based on vegetation cover

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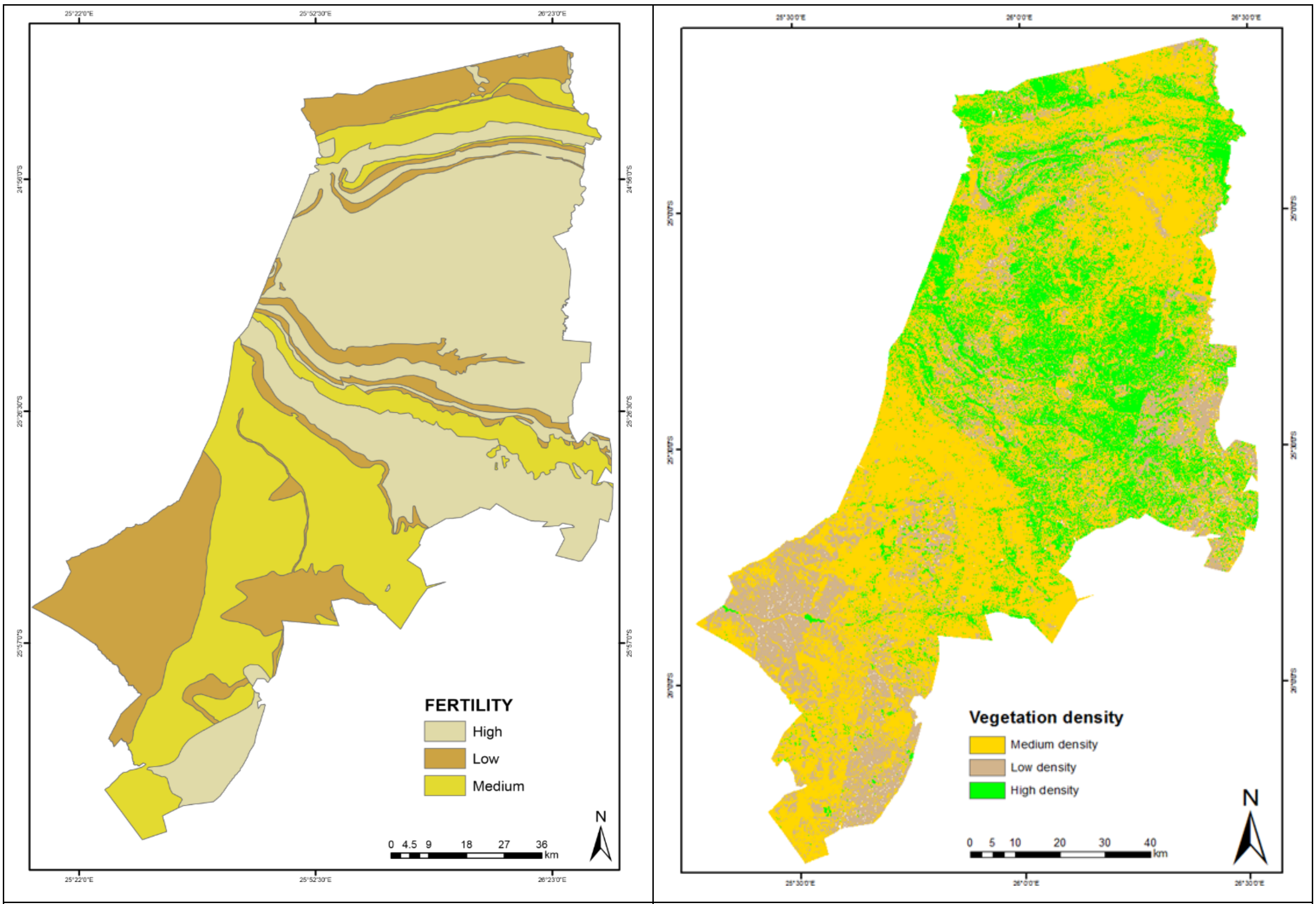
Abstract:

Evaluating the success of poverty alleviation interventions in rural areas has been challenging with limited geo-spatial data (Guo et al., 2022), which hinders the effective assessment of projects' impact in the communities (Morikawa, 2014). The advances in spatial analysis tools have made it possible to access a wide variety of remote sensing data that can function as evaluation indicators. Integrating remote sensing and geo-spatial data now has the potential to answer questions about rural poverty alleviation projects at effective resolution, both spatially and temporally, than may have been possible in the past. Municipalities are charged with the responsibility to deliver services. However, the predominantly rural communal areas of South Africa have inherited historical apartheid factors (Masiya et al., 2019) and this has left a need for delivery of services and poverty alleviation through informed planning (Xiao and Zhan, 2009), policy development and/or review. According to Sishodia et al. (2020), agriculture is an engine of economic growth for many nations, which provides the most basic needs of humankind. Marudu (2017) and Guo et al. (2022) depicted lack of geo-spatial data in South Africa at a lower scale than local municipalities to inform planning as one of the hindrances in advancing delivery of services. Mahikeng Local Municipality (MLM) and Ramotshere Moiloa Local Municipalities (RMLM) of Ngaka Modiri Molema District Municipality (NMMDM) in the North West Province of South Africa are predominantly rural and in need of development planning through the implementation of related legislative framework, which informs Spatial Development Frameworks and Integrated Development Plans. The aim of this work was to assess the potential use of remote sensing in informing planning and alleviating poverty in the predominately rural communities of Mahikeng and Ramotshere Moiloa Local Municipalities based on vegetation cover.

High spatial resolution (10m) SPOT 5 HRG and lower spatial resolution (250m) MODIS imagery were used as test case. March-April 2012, thirteen adjacent SPOT HRG imagery scenes of the rainy season covering the MLM and RMLM were obtained from the South African National Space Agency (SANSA), which presented problems in obtaining same date images due to cloud cover problems. A same rainy season MODIS 16-day (21 March – 06 April 2012) Normalized Difference Vegetation Index (NDVI) image was acquired to cover the study area. It was important to use imagery from the rainy season because vegetation was at its maximum productivity. A geological fertility map of the area was extracted from the 1:1 million digital geology map of South Africa. Vegetation cover on the SPOT 5 HRG images was enhanced using the NDVI. Field work at 41 sites in protected areas in the study area was done during the same rainy season, which yielded ground truth training data on vegetation attributes of canopy cover, tree density, tree height ranges, grass cover, and dominant vegetation types. The protected areas in which the data were collected were Madikwe Game Reserve, Molemane Game Reserve, Mafikeng Game Reserve, Botsalano Game Reserve and Marico Bushveld Nature Reserve. Protected areas were used because the vegetation there was undisturbed. The field data indicated a weak but statistically significant correlation between geological fertility and canopy closure ($r = 0.378$, $P < 0.02$), which permitted the use of mapping vegetation density, using on the NDVI, as an indicator of geological fertility. Using low, medium and high vegetation density as the classes, supervised maximum likelihood classification was performed on both the SPOT 5 HRG and MODIS NDVI images. Using the geological map as reference data, the results showed that the higher resolution SPOT HRG images produced a more accurate classification (overall accuracy 68.3%, $\widehat{K} = 0.63$) than the MODIS image (overall accuracy 48.3%, $\widehat{K} = 0.39$). Therefore, classification of a SPOT 5 HRG image mosaic extract covering MLM and RMLM into high, medium and low vegetation density classes was performed to obtain the final output. The results in Figure 1 show that geological fertility can be inferred based on tree density in the area, and using this characteristic, that remotely sensed imagery can contribute to agricultural development planning for poverty alleviation. The high vegetation density zone seemed to be the most suitable for rural agriculture since it correlates with high geological and soil fertilility. It is recommended that more municipalities in the country should use remote sensing and geospatial information as development planning tools and for the advancement of the delivery of basic services.



(a) (b)

Figure 1. Relationship between geological fertility and vegetation density in Mahikeng and Ramotshere Moiloa Local Municipalities, from a classification of a SPOT 5 HRG imagery mosaic extract of the area: (a) geological fertility of the area, (b) vegetation density correlation with geological fertility.

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