STUDY OF CANOPY VARIABILITY AND IRRIGABLE POTENTIAL OF REHABILITATED AND VIRGIN MINE LANDS BY MEANS OF REMOTE SENSING AND SPATIAL ANALYSIS

By

GIOVANNI NARCISO

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DEPARTMENT: Plant Production and Soil Science

In the

FACULTY OF NATURAL AND AGRICULTURAL SCIENCES
UNIVERSITY OF PRETORIA
PRETORIA
Supervisor Prof. J. G. Annandale
Co-Supervisor Dr. N. Z. Jovanovic

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ABSTRACT

The Department of Plant Production and Soil Science of the University of Pretoria has undertaken to study the use of mine waste water for the irrigation of crops grown on rehabilitated mine lands and previously un-mined landscapes. The main objective of the research project is to recommend sustainable cropping and irrigation management practices for these conditions.

Within this framework, Mr. Giovanni Narciso and the Institute for Soil, Climate and Water of the Agricultural Research Council (ARC-ISCW) were appointed to carry out a study on the cause/effect relationships of soil spatial variability on crop canopies irrigated with mine water on virgin and rehabilitated landscapes. The study concentrated on two pivots within the boundaries of the Kleinkopjé Colliery and it was conducted making use of remote sensing technology and geographic information systems (GIS).

The two centre pivots, named 'Major' and 'Tweefontein' are both irrigated with gypsiferous mine water. Tweefontein is a rehabilitated opencast mine section, while Major has been undermined but has a 'virgin' soil profile.

For Pivot Tweefontein, the variability in the crop canopy can be broadly attributed to the non-uniform preparation of the soil sub-stratum when the land was reclaimed and the resulting drainage problems that ensued. For the Major pivot, on the other hand, the variability in the development of the crop canopy may be explained by the presence of an impermeable layer of varying depth in certain portions of the field. The capacity to identify and map these occurrences as well as to relate them to the final productive outcome of the cultivated crops was the main scope of this project that was structured in the following phases:

- Acquisition of aerial imagery and other available information.
- Field surveys and measurements.
- Data processing and the creation of a database for static and dynamic

variables. These data gave origin to maps that were integrated in a GIS

- Data analysis and interpretation

Four aerial images were acquired for each of the two pivots, over two growing seasons (1998 and 1999). These images were acquired using the STS-DMSV (SpecTerra Systems-Digital Multi-Spectral Video) sensor carried in flight by a Jabiru micro-light aeroplane. Additional data sets were acquired from other research projects being conducted simultaneously on the same sites.

A soil survey was carried out during the 1999 season, when both pivots were cropped to wheat and the crop was in an early stage of development. When harvest time came, in spring 1999, a harvester specifically equipped with a GPS and a data-logging device recorded the yield and its spatial distribution over the pivot areas. This and all the other information considered relevant to the study went through specific processing in order to be transformed into maps that were analysed in a GIS environment. This operation can also be described as the assembling of a 'spatial database'.

The first task of the analysis was to identify a gauging tool and a spatial measure for performance and variability. Indicators derived from the spectral values[1] of the STS-DMSV sensor's bands provided these measures. Among the many possible indicators the analysis was restricted to the TVI (Transformed Vegetation Index) and the First Principal Component (PC1). Both performance and spatial homogeneity of the cultivated crops is expected to differ between 'virgin' Major and rehabilitated Tweefontein, due to the differing natures of the substratum, and, specifically for Tweefontein, the different depths of spoil material and the differing levels of compaction resulting from the rehabilitation works. On this basis, the analysis addressed the detection of possible differences in crop canopy

[1] **Spectral values**: For any given material, the amount of solar radiation that reflects, absorbs, or transmits varies with wavelength. This property of matter makes it possible to identify different substances or classes and separate them by their spectral signatures (spectral curves).

growth of the two pivots within the same season and over different seasons. Once these differences were detected, the analysis aimed at explaining the possible causes of both the spatial and performance variability between the two pivots. The following analysis procedures were implemented:

- A statistical correlation analysis between indicators derived from remotely sensed images and the various maps derived from data collected on the ground, referring to both permanent (static, e.g. soil properties) and variable (dynamic, e.g. crop growth) features.
- A focal, correlation analysis carried out in an attempt to represent the statistical correspondence between remotely sensed indicators and ground data, in the form of a map.
- An analysis of variability between the two pivots and within the same pivot, across two seasons and different crops. This was done by extracting both statistics from the images and by plotting diagrams of the distribution of the vegetation indices.

The analyses yielded the following results:

- The performance and productive outcome of the crops cultivated on Major and Tweefontein pivots showed distinct differences from one another over the period of the experiment (1998-1999). Furthermore, within each pivot a marked variability was evident.

- These outcomes showed better performance and less variability for winter crops than for summer crops, especially over the rehabilitated pivot, with the possible conclusion that rehabilitated pivots can be irrigated successfully in winter while they can take only supplemental irrigation in summer (otherwise water logging may result and drainage systems may be required for excess rain).

The biggest achievement of this work, however, was the design and implementation of a system for the analysis of spatial variability of cultivated fields. Such a system has the potential of evolving into an innovative crop management tool.