Application of Remote Sensing for Environmental Impact Assessment in the Central Rand Goldfield

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Abstract
Environmental impact assessment is now an integral part of the mining operation in South Africa. However, this was not practiced during early mining due to lack of environmental legal requirements relating to environmental impact assessment. The lack of environmental management programme has led to legacy of environmental impacts associated with the post-closure of the mines of the Central Rand Goldfield. These include water pollution, air (dust) pollution and general environmental degradation which limit the land use potential of the area. The large-scale spatial, high-resolution spectral remote sensing data, including aerial photographs and historical data provide a tool for environmental impact assessment and monitoring of this widespread mining activity. Remote sensing data enables the identification, delineating and monitoring of pollution sources, distribution of affected areas including derelict land and surface land use. This paper examines the use of remote sensing data, geographic information system and other historical data for monitoring and developing effective environmental management, reclamation and rehabilitation strategies on a long-term basis for integrated environmental management of large defunct mining area.

Introduction

Multispectral-remotely sensed satellite data and aerial photographic data have been used for environmental impact assessment and monitoring of mining activities of the historical Central Rand mining district. These studies have shown that remote sensing is an ideal modern tool for this purpose (Limpitlaw et al. (1998), Jhanwar (1996) and Rathore et al. (1993)).

Remote sensing data are of importance as a modern tool in providing information on variation over time essential for environmental monitoring and change detection in mining areas. Remote sensing data are also ideal for environmental impact assessment due to their spectral range, affordable cost and rapid coverage of large areas.

Study area

The historical Central Rand sector of the Witwatersrand goldfield extends for a distance of 45 km west and east of Johannesburg. Geographically the Central Rand goldfield lies to the south of Roodepoort, Florida, Johannesburg, and to the north of Alberton, while Germiston is located on the old mines of the eastern end of the goldfield. The Central Rand goldfield is of importance in the mining history of South Africa, because it is where gold was first discovered in the Witwatersrand goldfield in 1886 and where mining and population settlement first occurred. Residential and industrial townships are in close proximity to the old mining areas and the impacts are of the very evident and troublesome.

Methodology

Aerial photographs, orthophotos, topographical maps, satellite images, geographic information systems and field survey were used for data collection, analysis (processing) and as a base for future planning and rehabilitation of the area.

The satellite data used are Modis Airborne Simulator and ASTER. These data sets were processed using the image-processing package TNT Mips. The field survey (ground truthing) was undertaken to verify and confirm information from remote sensing data and other additional information such as topographical maps.

The assessment included a study of the environmentally critical areas of land degradation, water pollution and air pollution as well as land use cover/ changes in the Central Rand. It will assist with the development of rehabilitation

strategies and development of land for other land use options.

Data products

MODIS Airborne Simulator (MAS)

MAS is an airborne scanning spectrometer that acquires high spatial resolution imagery of cloud and surface features from its platform, the NASA ER-2 high altitude research aircraft (Smith, 2000). MAS has a spatial resolution of 50m and a spectral resolution of 50-bands that range from 0.4427-14.428 μm and data were acquired as part of the SAFARI 2000 project hosted by the University of the Witwatersrand.

ASTER

ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) is an imaging instrument that is also carried on Terra. ASTER can be used to obtain detailed maps of land surface temperature, emissivity reflectance and elevation. Its properties are as follows: spatial resolution range from 15 to 90m and spectral resolution of 14 bands ranging from between VNIR, SWIR and TIR.

Results

The false colour composites of MAS and Aster managed to pick up the conditions of the mine tailings (figure 1). These were also verified with aerial photographs. This enables the classification of mine tailings into four different categories:

- Abandoned mine tailings (generally covered by vegetation)
- Formerly rehabilitated, but now deteriorating tailings
- Gold-bearing mine tailings currently being exposed and treated for their gold content
- Active mine tailings deposition from retreatment operations

MAS and Aster also enables the detection of acid mine drainage especially on top of the active tailings dams and nearby water dam and streams. For example bands 3, 12 and 21 of MAS (figure 1). Detection and monitoring of water and moisture content on the top of tailings dams can also be effectively undertaken and use as an early warning system for possible tailings dam collapse aided by liquefaction. These satellite images compliment each other to maximize their capability of detecting and monitoring different types of land surfaces and environmental issues.

Conclusion

The use of MAS, Aster and aerial photographs hold a considerable promise for monitoring and developing effective environmental management, reclamation and rehabilitation strategies on a long-term basis for integrated environmental management. This is an effective tool for mapping large mining districts and monitoring pollution and land use cover and changes.

References

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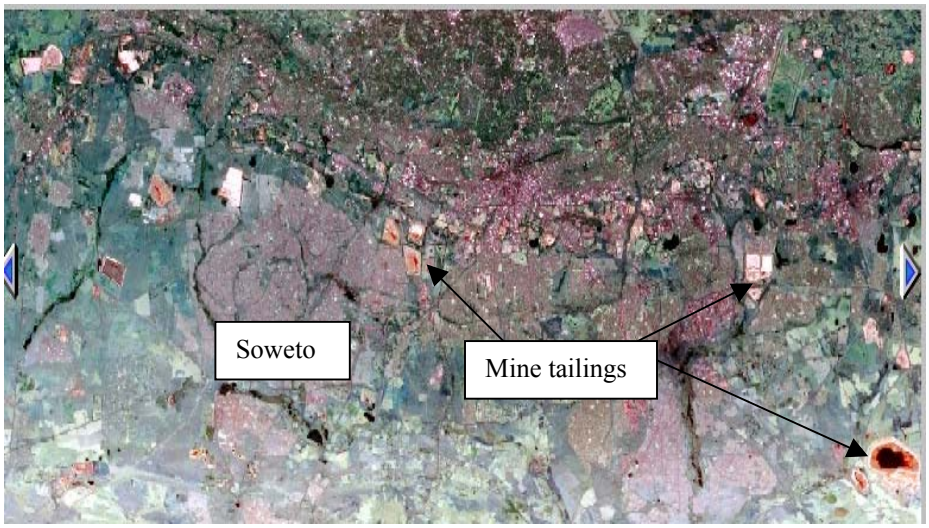

Figure 1: BANDS 3, 12, and 21 of Modis Airborne Simulator (MAS) showing Witwatersrand mine tailings and Soweto -22 August 2000