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Research Application Summary

Mapping rangeland degradation by using rainfall and remote sensing data, North-Eastern Region, Sudan

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Abstract

Climate factors in conjunction with Satellite imagery and aerial photographs provide an opportunity to undertake routine natural resources monitoring for mapping land degradation over large areas such as pasture lands. These facilities provide efficient decision making instruments for resources management and implementation of applicable control measures. To explore climate change in terms of rainfall and its impact on the rangeland conditions in north-eastern part of Sudan, annual time series (1940 to 2004) for two weather stations across the area were analyzed. Aerial photographs for three selected sites in the study area were used to produce maps using grey tone, drainage pattern, vegetation cover and land use. These maps were overlaid with the Landsat images for 2000 to map out land degradation. The analysis of the rainfall data showed a significant decrease in annual rainfall during period 1940 to 2004. From remote sensing data, the map showed that during the 1960s there was active rain-fed agriculture and dense trees and bare soil in the area. When these maps were overlaid with Landsat 2000, it was noticed that the eroded and bare soil area had increased considerably but there were some areas covered with grass which was an indication of bush encroachment. The results suggest that the different ecosystems in the area were subjected to various forms of site degradation. These have led to sand encroachment and increased water erosion in the northern part of the area. Degradation is however reversible in many parts of the study area provided organized control measures are introduced.

Key words: Rainfall, rangeland degradation, remote sensing, Sudan

Résumé

Les facteurs climatiques, en combinaison avec l'imagerie par satellite et des photographies aériennes fournissent une occasion de procéder à un suivi des ressources naturelles de routine pour la cartographie de la dégradation des terres sur de grandes surfaces telles que les terres de pâturage. Ces installations fournissent des instruments efficaces de prise de décision pour la gestion et la mise en œuvre des mesures applicables de contrôle des ressources. Pour explorer le changement climatique en termes de précipitations et de son impact sur les conditions de pâturage dans le nord-est du Soudan, des séries chronologiques

annuelles (1940 à 2004) pour deux stations météorologiques dans la région ont été analysées. Les photographies aériennes pour trois sites sélectionnés dans la zone d'étude ont été utilisées pour produire des cartes à l'aide du toner gris, model de drainage, la couverture végétale, et l'utilisation des terres. Ces cartes ont été superposées aux images Landsat de 2000 pour cartographier la dégradation des terres. L'analyse des données sur les précipitations ont montré une diminution significative des précipitations annuelles durant la période de 1940 à 2004. A partir de données de télédétection, la carte a montré que dans les années 1960 il y avait l'agriculture pluviale active, des arbres denses, et un sol nu dans la région. Lorsque ces cartes ont été superposées avec Landsat de 2000, il a été remarqué que la zone de sol érodé et nue avait considérablement augmenté, mais il y avait des zones couvertes d'herbe qui étaient une indication d'embroussaillement. Les résultats suggèrent que les différents écosystèmes de la région ont été soumis aux diverses formes de dégradation du site. Celles-ci ont conduit à l'ensablement et l'augmentation de l'érosion de l'eau dans la partie nord de la zone. La dégradation est toutefois réversible dans de nombreuses parties de la zone d'étude pourvu que des mesures de contrôle organisées soient introduites.

Mots clés: pluie, la dégradation des parcours, la télédétection, le Soudan

Introduction

The land degradation of arid and semi-arid lands, often termed desertification in its irreversible form, due to human impact and/or climatic change has been much debated since the mid 1970s. It is believed to be one of the most serious global environmental problems of our time (Reynolds and Stafford Smith, 2002). Deterioration of natural vegetation is the prime indicator of land degradation. Vegetative indicators are characterized by a visible degradation of the natural plant cover up to the point of complete destruction. Vast areas entirely cleared of natural vegetation show an irreversible loss of the natural regeneration of the trees, shrubs or herbage cover. A change in the composition of the species can be a further indicator of the degradation.

Monitoring of land degradation over large areas is difficult (Grainger and Bradley, 1998), resulting in a lack of reliable data that has even raised questions about the existence of land degradation (Thomas and Middleton, 1994). By combining image analysis with Geographical Information Systems (GIS) models that take into account both environmental and human impacts, the ability to monitor land degradation will be extended (Burrough, 1986). More specifically, GIS and/or remote sensing have been used in assessment of different kinds of soil degradation and conservation; to map temporal and spatial changes in land cover, land use and to identify areas of degradation. Aerial photographs from different time periods allow the study of erosion dynamics, mainly the growth of rills and gullies (Alam and Harris, 1987). In this study aerial photographs and Landsat images were combined together with the GIS techniques to evaluate and map the extent of the land degradation in parts of Sudan.

Materials and methods

The monthly and annual rainfall data for period 1940 to 2004, for two weather stations across the study area were used. The boundary of the study area was adjusted according to

the availability of the aerial photographs for the three sites for period 1965 and 1966, and Landsat image. The image processing tool used in this study was ERDAS IMAGINE 8.5, and Arc Map 9.1 software. Therefore the methods used in obtaining multi-spectral classifications were taken from ERDAS.

Results and discussion

Rainfall data analysis. The time series analysis was conducted using long-term monthly and annual rainfall data for the two stations in the study area. The results showed that there had been a gradual decrease in the monthly and annual rainfall during the period of 1940 to 2004 (Fig. 1). The non-parametric analysis for annual rainfall data for the stations indicated that there had been a significant decrease in the annual rainfall during the period of 1940 to 2004 for Shambat and WadMedani stations (P = 0.025 and P= 0.002, respectively).

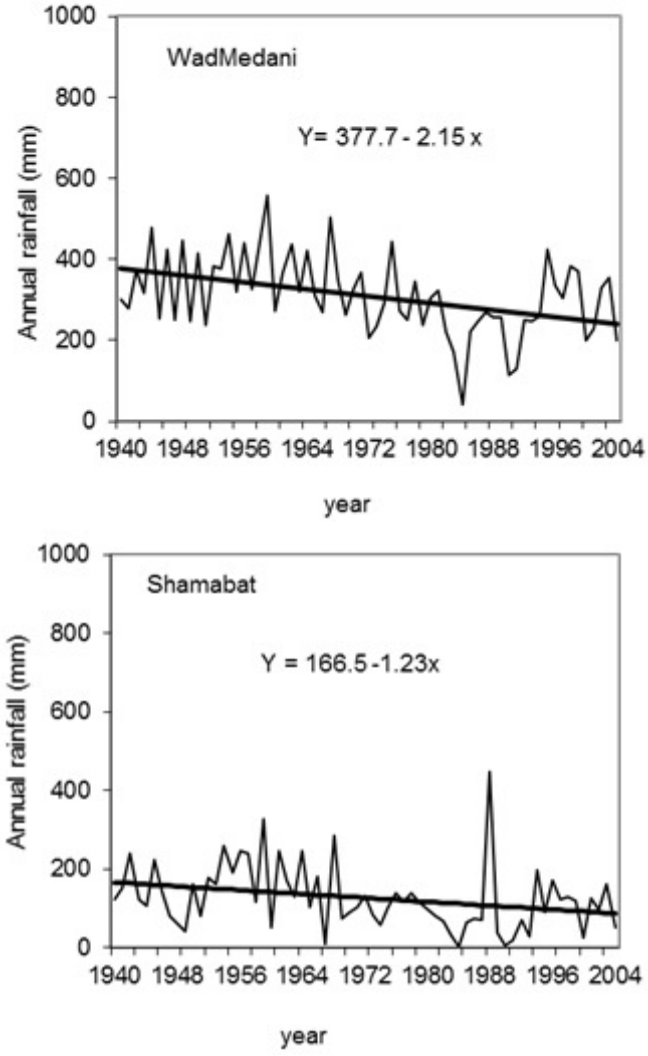

Figure 1. Trend of annual rainfall for Shamabat and Wad Medani weather stations

Aerial photographs. Maps for Kamlin (1965), El Maseid (1964), and Shareif Baraket (1966) areas were produced using grey tone, drainage pattern, vegetation cover and land use. These maps were overlaid with the Landsat image for 2000. Figure 2 shows that during the 1960s there was active rain- fed agriculture and dense trees in the Kamlin area. When these maps were overlaid with Landsat 2000, the results indicated that the eroded and bare soil area had increased considerably. However, there were some areas covered with grass which was an indication of bush encroachment. For example at the Kamlin site the dense vegetation area (V1) during the year 1965 (block 33° 15' to 33° 19' E and 15° 11' to 15° 15' N) became eroded soil by the year 2000. The active rain fed agriculture during 1965 (block 33° 13' to 33° 17' E and 15° 0' to 15° 3' N) by the year 2000 became an eroded soil with sparely scattered grasslands.

For El Maseid site when comparing the maps of 1960 with Landsat 2000 (Fig. 3) it can be noticed that there was active rain- fed agriculture areas (R1) (block 32° 55' to 32° 58' E and 15° 19' to 15° 21' N), while in the year 2000 Landsat image showed this area to be

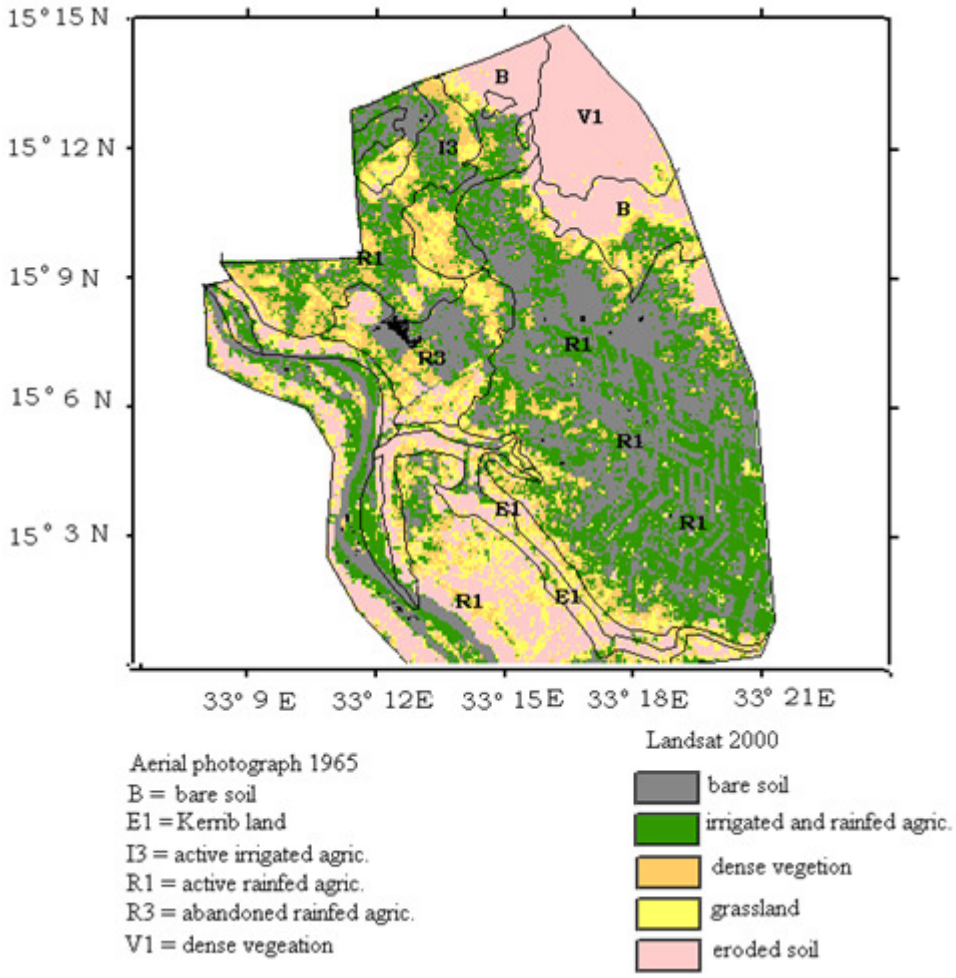

Figure 2. Map from overlay of the 1965 aerial photos and Landsat image (2000) for Kamlin site

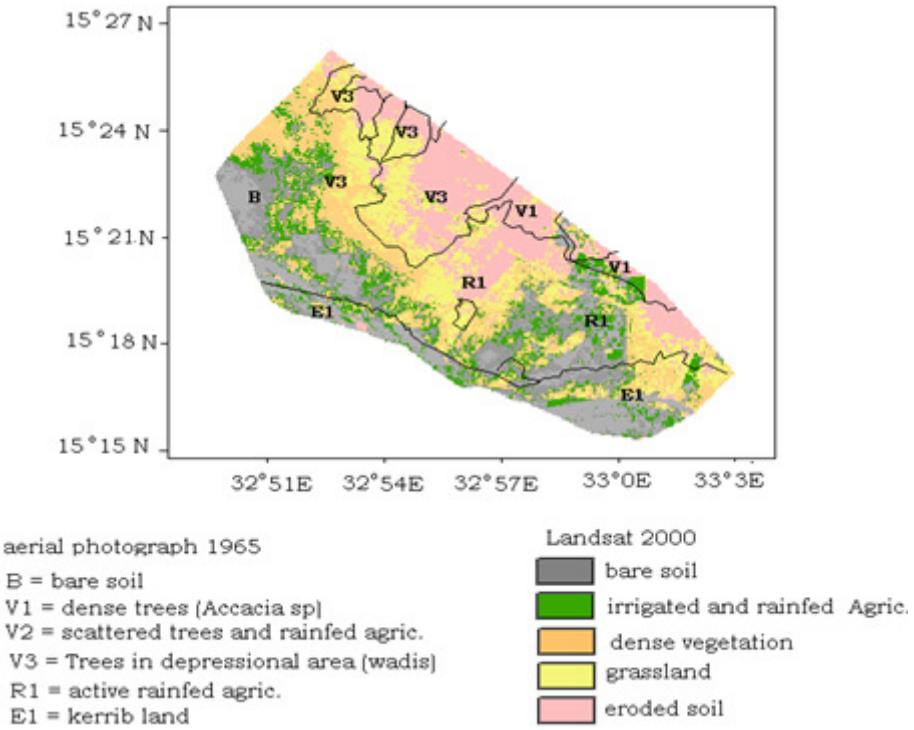

Figure 3. Map from the overlay of the 1965 aerial photos and Landsat image (2000) for El Maseid site

predominantly eroded soil with some grassland on the edges. This area had changed from active production to an eroded area in 35 years. Further, the rain- fed agriculture (R1) and dense vegetation (V1) area in block 32° 58' to 33° 3' E and 15° 17' to 15° 20' N during 1960 were completely eroded by the year 2000 with only small patches of irrigated areas in the west interspersed with bare soil and some grassland. This showed decreased productivity from this area and increased degradation with time.

Shareif Baraket site (Fig. 4) showed considerable change in the landscape pattern. For example, the rain fed agriculture area (R1) during 1960 changed to dense vegetation in some parts and to eroded soil in other parts in the year 2000. At the sametime, the area that was covered by dense trees (V1) and grass (V5) in 1965, became an eroded soil land by the year 2000. This was attributed to the decline in vegetative cover except for small areas adjacent to the Nile river bank/the Wadis. The rest of the land remained with scattered grassland which was not recognised in 1965 maps.

Conclusion

The extensive spatial, regular temporal coverage and reasonable cost of satellite imagery provide an opportunity to undertake routine natural resources monitoring. This can contribute to efficient decision making in natural resources management, especially to monitor and

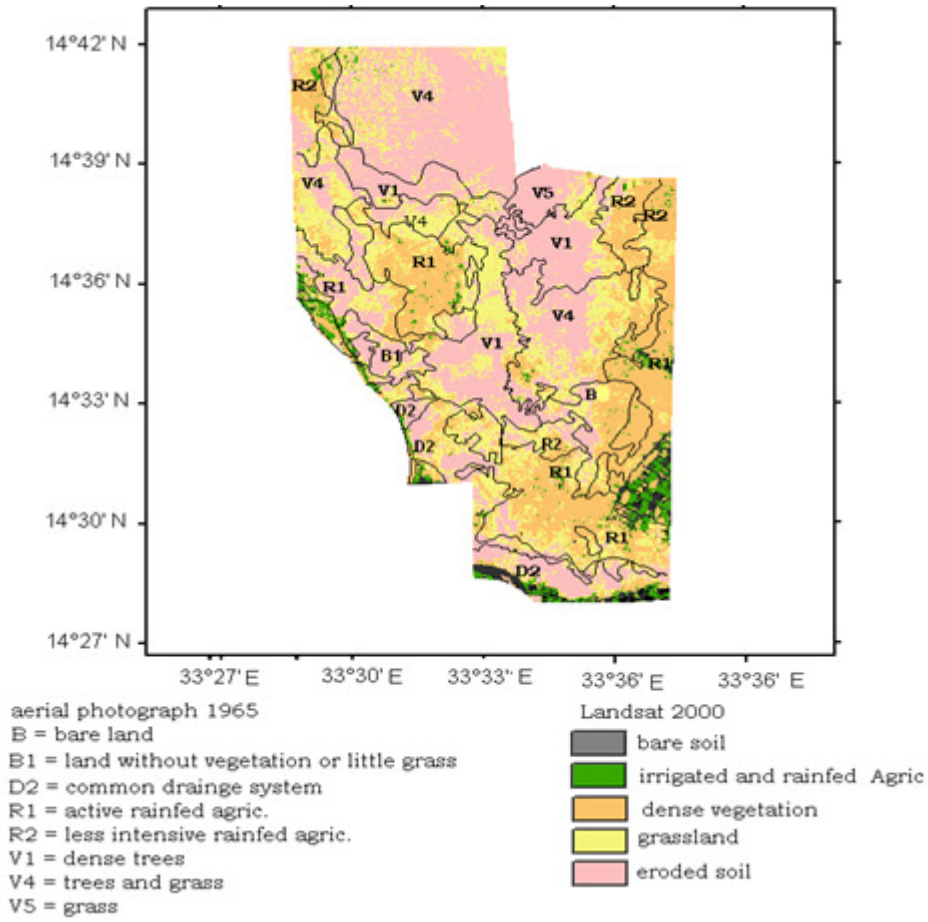

Figure 4. Map from overlay of 1965 aerial photographs and Landsat image (2000) for Shareif Baraket site

map the land degradation over a large area and over a long time period. From the results it can be noticed that the different ecosystems were subjected to various forms of site degradation. These have led to sand encroachment and accelerated development of dunes and also increased the water erosion in the northern part of the area. Pastures have deteriorated in quality and quantity. But in many parts the degradation is still reversible if organized land use and water points are introduced.

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