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Monitoring of land use intensification and linkage to soil erosion in Nigeria and Benin

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Abstract
The growing population and the increasing food demand in sub-Saharan Africa require comprehensive land use intensification. Land scarcity and soil degradation are some consequences that necessitate enhanced land use management by using remote sensing data. This study presents the analyses of aerial photographs and satellite images for inventory land use and its changes within time as well as for monitoring soil erosion. The example from a pilot village located in southern Benin shows the increase of the cropping area and the growth of erosion gullies within the last decades. As the data provide the basis for installing soil conservation techniques, they are a useful tool to restore soil productivity and to cope with the food demand in the country.

1. Background and aim of study

Since the 1960s, a dramatic acceleration in population growth has taken place in sub-Saharan Africa (SSA). The annual urban growth rate (2.3 % 2000 - 2004) was more rapid than in any other part of the world. For instance, Nigeria is the most populous country in Africa with a population of 128.7 million people and an average population density of about 130 persons per km^2 (World Bank, 2006). The increasing demand to feed the growing population leads to land use intensification. Non-adaptable land use practices inevitably lead to soil degradation (Hudson, 1995). In SSA, soil degradation has already become the most critical environmental problem (Mbagwu et al., 1984, Eswaran et al., 2001). Soil erosion is one manifestation of soil degrading processes that results in reduced soil quality and productivity (Morgan, 1995, Lal, 2001). There is an urgent need to combat the accelerating trend of soil degradation, to maintain soil productivity and to contribute to the food security of current and future generations (UNEP, 1997).
Precise information about changes in land use, agricultural intensification and soil erosion is required to tackle this problem. Traditional methods like terrestrial mapping are time consuming and expensive making them less suitable for gathering precise data for environmental studies especially on larger scales (Bach, 1997). As land use information are not available for many areas which are currently undergoing rapid and wide-ranging changes, the study of conversions necessitates the use of remote sensing. The approach provides data at synoptic scales and facilitates the discerning of large-scale ecosystems patterns and its changes (Stroemquist, 1997).

The application of remote sensing data has already been tested in Africa (Pilesjoe, 1992, de Jong, 1994, Stroemquist, 1997, IMPETUS 2003, Duadze, 2004). This study presents the use of remote sensing approach for monitoring changes in land use and soil erosion in a tropical savanna environment of SSA.

2. Methodology

The approaches used in this study include the analyses of land use intensification and the evolution of soil erosion for seven pilot villages across a transect from the Derived to Northern Guinea Savanna of Benin and Nigeria. In this report, only results from the pilot village Eglimé (N 7°15', E 1°86'), Benin, are presented. Luvisols, Cambisols and Gleysols dominante in the area Cassava, maize, oil-palm and cotton are the main crops of the farming system. Livestock is of minor importance. Tillage is performed manually by using hoes.

For monitoring these changes within the last decades, an aerial photograph from 16.1.1982 (scale 1:50.000) and panchromatic and multispectral IKONOS images (1 m and 4 m spatial resolution) from 1.12.2000 were interpreted. The images were digitized, labeled and manually classified. An unsupervised classification of IKONOS images by using Kmeans algorithm in Envi 4.1 also was done. In September 2006, the interpretations were ground checked by field visits together with local farmers. The images also were analysed in regard to monitor soil erosion by digitizing linear erosion features. The distribution of the latter was checked in the field by mapping the length of the current erosion gullies using the Global Positioning System (GPS).
Additionally, interviews with elder farmers (30 persons per village) were made in February 2006 to get more information about the population dynamics as well as about farming systems, crops, use of fertilizer, soil properties and degradation.

3. Results and Discussion

The interpretation of the historical aerial photo and the recent IKONOS images shows a large expansion of the cultivated area around the settlement of Eglimé within the last decades. From 1982 to 2000, the area of arable land increased by about 164 ha, the oil-palm cropped area by about 76 ha (Tab. 1, Fig. 1). The local farmers confirmed this development and explained it by the increased production of cash crops such as cotton. However, the cultivation of the food crop yam has reduced due to decreasing soil fertility.

Tab. 1: Areas of different land use types in Eglimé in 1982 and 2000 (in ha)

Classes of land use	**1982**	**2000**
Oil-palm, high density	18.6	90.3
Oil-palm, low density	13.5	17.4
Arable land	46.6	210.3
Settlement	3.9	14.9
Total	**82.5**	**332.9**

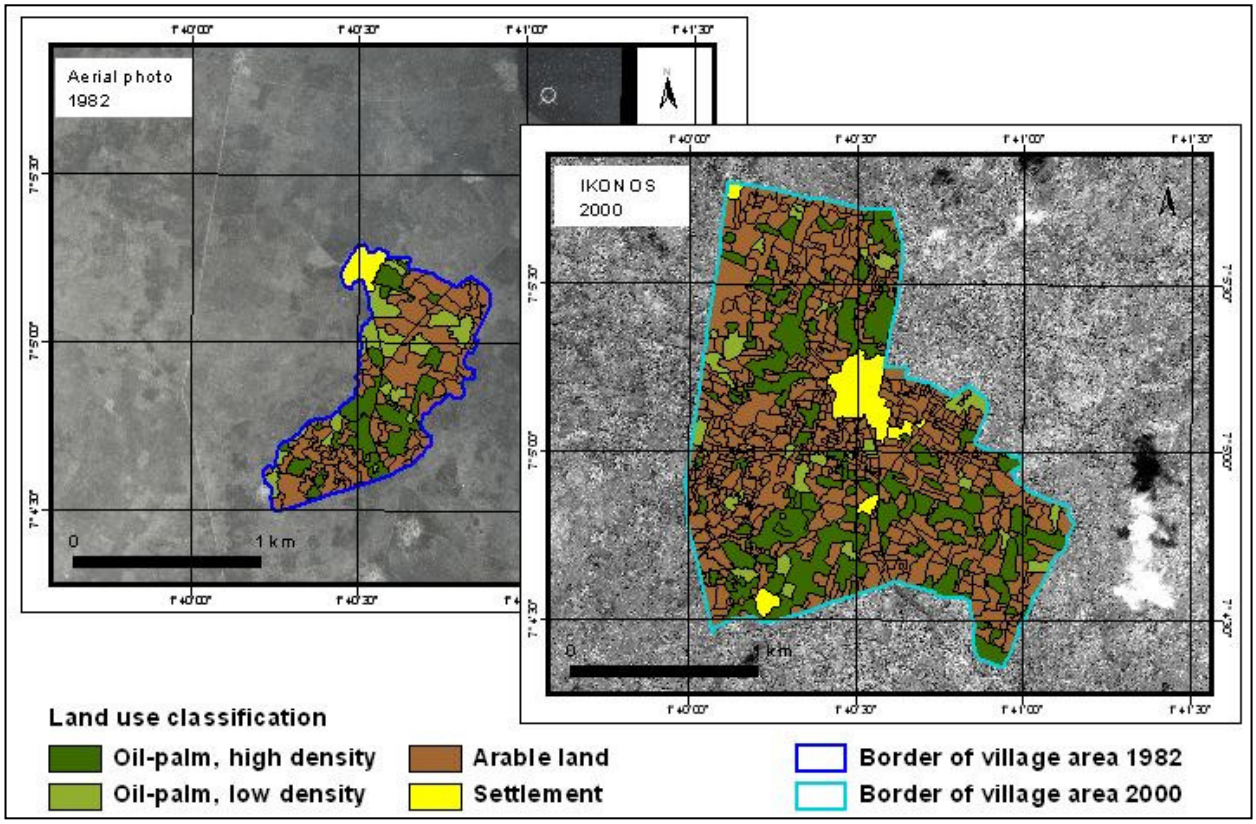

Fig. 1: Land use in the area of the settlement of Eglimé in 1982 and 2000

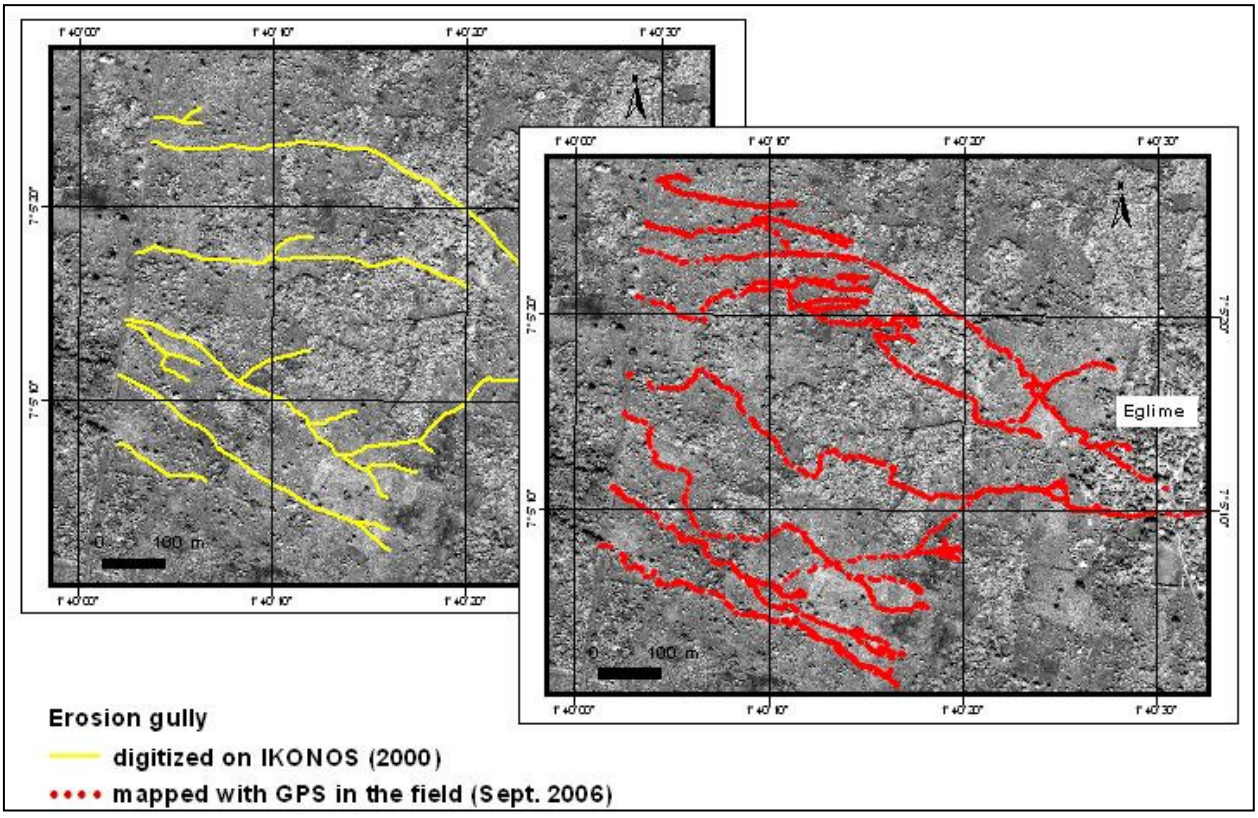

Fig. 2: Distribution of erosion gullies in Eglimé in 2000 and 2006

Soil erosion could not be detected on the aerial photograph from 1982. One reason might be the low spatial resolution of the picture. Another possibility is the non-existence or the small size of linear erosion features at that time which are impossible to capture. Gullies easily could be determined on the high resolution IKONOS image from 2000. The comparison with gullies mapped by using GPS in September 2006 shows an increase of their lengths within the last six years (Fig. 2).

4. Summary and Conclusion

The analysis of remote sensing data from the pilot village Eglimé reveals land use intensification and increase of soil erosion within the last decades. This approach is useful to monitor changes in land use and soil degradation within time and therefore is an important tool for enhanced land use management of a rural area in Benin. As the data provide the basis for installing soil conservation techniques, they contribute to reduce the rate of soil degradation and to restore soil productivity, important strategies to cope with the increased demand for food in SSA.

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