Chapter 3
GIS Use for Mapping Land Degradation: A Review of Research Carried Out in Tunisia

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ABSTRACT

In this chapter, the author presents a review of the GIS use during the research carried out during the past three decades dealing with land degradation. The objective is to assess the viability of applying GIS with different modes of remotely sensed data acquisition for quantifying land degradation in Tunisia. Various GIS based modelling approaches for soil erosion hazard assessment such as empirical and physical distributed are discussed. Five case studies are selected from several projects. They apply different methods for land degradation investigation at different scales using GIS and remotely sensed data. The research dealt mainly with: 1) The prediction of soil erosion at the regional level related to conservation techniques; 2) The quantification of soil erosion at the gully level based on GIS, digital photogrammetry and fieldwork; 3) The monitoring of gully erosion using GIS combined to images acquired by a non-metric digital camera on board a kite.

INTRODUCTION

During the past three decades, several research studies has been carried out aiming at establishing and implementing a comprehensive methodology for the assessment and mapping of land degradation in arid and semi-arid areas in Tunisia. The results were expected to provide both a better understanding of the land degradation phenomena and indications for appropriate conservation responses at different scales.

During this period, the investigation moved:

1. From qualitative to quantitative researches;
2. From macroscopic to microscopic scales depending on the extent of the investigation unit: from the watershed scale, to the lithological unit, to the ravine; and
3. From the use of satellite images, to aerial photography, to kite photography.

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In this review, the objective is to address the land degradation issue using geographical information systems (GIS) and remote sensing. For this purpose, five case studies are selected from several projects which have been conducted with many partners including the Tunisian Ministry of Agriculture, the Research Centre of Geomatics at Laval University in Quebec City (Boussema, Chevallier & Pouliot, 1996) and the French Institute of Research for Development (IRD) (Baccari, Nasri, Boussema & Lamachère, 2007; Feurer, El Maaoui, Boussema & Planchon, 2014).

The first research was conducted in the 1990s, at the regional scale and focused on the use of GIS and satellite remote sensing. It addressed practical problems of multi-source data integration while developing an information and spatial decision support system (SAGATELE: Système d'Aide à la Gestion et Aménagement du TErritoire pour la Lutte contre l'Erosion) in order to estimate soil erosion in a variety of conservation practices, to propose tangible solutions for erosion management and to serve the information needs of conservation planning in a particular watershed. Organizational details are presented in (Boussema et al, 1996; Pouliot, Thomson, Chevallier & Boussema, 1994).

The same methods continued to be applied in many researches. They were extended to assess conservation practices and to propose a new methodology for rehabilitation of existing dysfunctional facilities (Baccari, Boussema & Snane, 2005; Baccari et al., 2007).

Then in the 2000s, the second phase of the research, aiming at quantifying erosion, was based on investigations into the sediment yield provided by first order gullies on gentle and steep slope catchments underlined by the Souar and Fortuna lithological formations. New methodologies were developed based on GIS techniques, fieldwork and digital photogrammetry. The methodology and results can be found in the following references (Bouchnak, Sfar Felfoul, Boussema & Snane, 2009; El Maaoui, Sfar Felfoul, Boussema & Snane, 2012).

In parallel, research based on physically based distributed erosion models has been conducted to predict surface runoff generation patterns and soil erosion hazard in view of identifying and prioritizing the most degraded sub-catchments based on estimated runoff and sediment yield. The models used are: the Soil and Water Assessment Tool (SWAT) model (Mosbahi, Benabdallah & Boussema, 2011; Mosbahi, Benabdallah & Boussema, 2014) and the Areal Non-point Source Watershed Environment Response Simulation (ANSWERS) model (Boughattas, Snane, Sfar Felfoul & Boussema, 2010). The latter research will not be presented hereafter.

Then, the desire to access data at decimetric or centimetric resolution led, in the third and still ongoing research, in a collaboration with IRD, to investigate the feasibility of gully erosion monitoring using GIS combined with images acquired by a non-metric digital camera on board of a kite (Feurer et al., 2014).

Globally, the researchers have faced many challenges. Besides the need for a GIS that allows selection of critical areas, help in designing anti-erosion protection works, and studying the behavior of watersheds, they had to modernize data acquisition and management tools, and to integrate in their achievements the engineers and decision makers' activities.

The chapter is therefore organized as follows. After a background presenting the land degradation phenomenon and the related topics, Section II highlights the Geospatial information for soil erosion and conservation policy issues, including the remote sensing response to the erosion issue. Section III presents the researches already carried out modelling erosion using GIS and involving satellite images and digitized aerial photography. Section IV provides an overview of the ongoing research dealing with the kite stereo-aerial photography for gully erosion assessing.