Chapter 3.3
An Agricultural Decision Support System for Optimal Land Use Regarding Groundwater Vulnerability

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ABSTRACT

The availability of quality water is a basic condition of socioeconomic development. The agriculture water demand can be damaged by contamination of groundwater resources. This paper proposes a tool to preserve groundwater quality by using groundwater vulnerability assessment methods and a decision support system (DSS). The mapping of intrinsic groundwater vulnerability was based on reliable methods, the DRASTIC and the SINTACS methods. A DSS was developed to assess the groundwater vulnerability and pollution risk due to agricultural activities and land use changes. The proposed DSS software package was designed using the Matlab language and efficiently performs tasks while incorporating new maps to cover new areas. The tool was tested at two study areas located in the Mediterranean that are dominated by different prevalent hydrogeological features, that is, the typical porous features of alluvial deposits in the Greek study area and the typical fissured and karstic features of limestones and dolostones in the Italian study area.

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INTRODUCTION

In many countries, including those in the Mediterranean region and numerous coastal areas with worldwide distribution, groundwater is the main source for drinking and irrigation use. The availability of good quality water is a key factor for social and economical development. For this reason, preserving its availability and quality is a crucial issue for the future (EU Council, 1998; UNESCO, 1998). The degradation of groundwater resources can be quantitative if the discharge exceeds the natural recharge and qualitative if the chemical, physical, and biological water quality is threatened. In the former case, if the aquifer is on the coast, overexploitation is also qualitative risk due to possible seawater intrusion, causing salt degradation in the groundwater quality (Polemio et al., 2009a). The definition of a suitable policy for water is important in the context of growing scarcity and competing uses (Bazzani, 2005). For this reason, the importance of integrated water resource management was emphasized in the recent EU Water Framework Directive (2000/60/EC).

If groundwater degradation risks are considered, planning decisions should be reached based on risk assessment procedures in which the effects of anthropogenic activities on natural resources and the environment are considered. Agricultural activities are surely some of the most relevant endeavors. However, massive soil and continuous groundwater exploitation have a relevant negative impact on the environment.

In many farming areas, anthropogenic modifications are mainly caused by the following two types of activity: direct pollution from agricultural activities due to the use of agrochemicals, fertilizers, and pesticides and farming improvements, thereby provoking other negative impacts. Fires and the clearing of forests and stones with the advent of machinery have been widely used to make the land suitable for farming. Over-irrigation and salt-recycling due to overexploitation in the coastal areas also create problems (Voudouris et al., 2004). The effects on groundwater availability and quality are complex and generally negative.

The regional assessment of groundwater vulnerability is a useful tool for water resource management and protection. The results provide important information that can be used by local authorities and decision makers. A groundwater vulnerability assessment could be used to more effectively determine the choice of land use modifications, the location, the type of farming, and use of chemicals and irrigation in the farming endeavor.

The use of computer-based systems to support decision making regarding groundwater resource management has increased significantly over the last decade. In the case of land management, decision support systems (DSSs) are typically used to select an optimal or satisfactory solution from a set of feasible alternatives (Shim et al., 2002; Manos et al., 2004a). DSSs are defined as computerized systems that include models and databases used in decision-making (Uricchio et al., 2004). They are useful tools that help scientists and administrators in the decision-making process and in choosing the economically, socially, or environmentally best alternative solution (Hwang & Yoon, 1981; Manos et al., 2004b; Manos et al., 2007; Leung, 1997; Zhu et al., 1998; Vacik & Lexer, 2001).

The implementation of geographic information systems (GIS) and DSSs in hydrogeology offers effective tools for groundwater resource management. GIS has been widely used to establish a database for collected data (Süzenm & Doyuran, 2003; Gemitzi et al., 2006). In hydrogeology, both GIS and DSS have been developed to support local authorities, decision makers, and stakeholders in terms of groundwater resource management, vulnerability and pollution risk assessment, and protective zoning.

From a theoretical point of view, the paper briefly describes the main methods for groundwater vulnerability assessment while considering typical porous aquifers on the alluvial or coastal plains and the peculiarities of rocky aquifers (i.e.,