IMPACT EVALUATION OF AGROTECHNOLOGIES IN WATERSHEDS*

M. A. GOMARASCA
National Research Council of Italy, IRRS Telerilevamento, Via Ampère 56, 20131 Milano, Italy, E. Mail: mario@tel-irrs.mi.cnr.it

Abstract. The special project RAISA (Advanced Researches for Innovation in Agricultural Systems) of the National Research Council of Italy concerns the development of new methodologies for the study and evaluation of the impact of agrotechnologies on the environment. In the project, several trans-disciplinary Units have worked together since 1990. The aim of the project is to define systems, using tools such as remote sensing and Geographical Information Systems, for decision making support in land planning and land use management, with particular attention to groundwater table pollution. The fundamental steps for evaluation of the impact of agrotechnologies on the Po river watershed, 75,000 km² in northern Italy, and Tevere (Tiber) river watershed, 17.169 km² in Central Italy are described here. The study concerns particular areas located in the western part of the Po River plain, where flooded rice is the main crop, and in the central plain of the Tevere basin where the risk of water pollution is considerable, due to small and medium sized swine breeding farms. The aspects considered were water pollution due to mineral nitrogen used to fertilize the rice crop and the nitrogen contained in the waste water from pig farms. For the Po river basin the methodology developed was based on the integration of satellite remote sensing images, and the available cartography, such as topographic and thematic maps, together with the hydrological and the toxicological data of the chemical fertilizers employed, summarized in maps of the groundwater table pollution hazard. A simpler evaluation was obtained in the Tevere river basin: the thematic layers were crossed in bi-directional matrices and the result merged with the map of the territorial distribution of the swine. In both cases the selected information was integrated and processed in Integrated Geographical Information Systems to produce weighted final maps of the vulnerability and risk on basin and sub-basin scale. The GISs led to the development of a user-friendly system for formalizing our knowledge of the degree of pollution hazard in simple and readable maps.

Keywords: Remote sensing, GIS, Nitrogen pollution, Rice crop, Swine farms, hazard maps.

1. Introduction

The integration between GIS, georeferred remote sensing data, computer cartography, computer aided design (AutoCad) and data base management can be successfully developed to study and solve environmental problems (Cowen, 1987, Fisher and Linderberg, 1989, and Fabbri, 1992). The contributions of various experts in specific domains of specialization help to bring into focus the terms of the problems. The impact of agrotechnologies is a key aspect in the equilibrium between economic activities and the environment (Polelli, 1993, Abbozzo and Mennella, 1993). Obviously, even conventional agricultural techniques produce an impact on the environment. The production processes of modern agriculture interfere with the natural cycles of ecosystems. In the effort to improve yields, the agroecosystem is so constantly subjected to actions of disturbance that ecosystem self-regulation may become impossible. As we grow more aware of the risks this exploitation involves, increasing efforts are being made to achieve an integration of
agroecosystems and natural ecosystems for a development compatible with the necessary respect of the environment. This is particularly true in rice growing where the large quantities of fertilizers and herbicides used, together with the great volume of water and other agricultural practices can cause a strong impact on the environment with high risk of pollution, both in soil and water. The possibility of land damage from anthropical actions can be called Environmental Vulnerability. We are concerned here with pollution risk in a rural environment where the potential source of pollution is well defined. An interdisciplinary approach has been developed, using as much information as possible in order to better understand the dynamics of the phenomenon. This approach includes an advanced development of an Integrated Geographic Information System (IGIS) dedicated to agricultural analysis and agrotechnology impact evaluation. It uses satellite remote sensing images with different pixel resolutions for different territorial approaches (Gomarasca et al., 1993b). With the integration of the NOAA Advanced Very High Resolution Radiometer (AVHRR) images, global-scale cartography, and a comprehensive data base, synoptic overviews of the Po and the Tevere watersheds and preliminary observations are possible. Studying the problem progressively in different scales provides more detailed information at the sub-district and sub-basin levels. The basic knowledge of the IGIS developed for this study allows the management of informational layers by means of rules defined by the interdisciplinary experts.

2. Objectives

The main difficulty within the RAISA project concerning the impact evaluation of agrotechnologies, was to develop a user-friendly system that can formalize knowledge of the degree of pollution hazard in simple and easy to read maps. Two similar, but different approaches to the organization of information in Geographical Information Systems were described, compared and analyzed. The GIS is conceived as an interdisciplinary integration of remote sensing and digital analysis of the images recorded with topographic and thematic cartography management and organized in overlaying spatially referenced single layers. A multiscale approach to ecosystem analysis, gauged to the required level of detail, must also be defined. From this study, maps were produced of the groundwater table pollution hazard caused by the nitrogen used to fertilize the rice grown in a sub-basin located on the western side of the Po River basin, as well as a map of the nitrogen pollution hazard due to the waste from swine raising in the Tevere River basin. These maps represent the basic tools of territorial knowledge in decision making in terms of land management to control the environmental impact of agrotechnologies in rice growing and swine breeding. With these systems we hope to help replace the customary approach to territorial studies in Italy based on the administrative rather than natural boundaries.