
A Regional GIS Model for Water Quality Assessment in Irrigated Areas in France

INTRODUCTION

Following decades of highly intensive agriculture, nonpoint source pollution from agricultural areas is becoming an increasing concern in western Europe as chemical loads are increasing in both surface water and groundwater. This pollution is added to the untreated components of waste water from urban areas. Altogether it contributes to increasingly jeopardize the natural eco-system and the domestic water supply. European authorities have recently been driven to enforce strict standards for domestic water quality and promote better watershed monitoring and management. In the low lands along the Mediterranean coast in the southeast of France, the situation of lagoons is worrisome in that regard. An average increase of nitrate content of 2 mg/l per year has been measured during the eighties in the groundwater connected to the Mauguio lagoon, east of Montpellier. Some wells for water domestic supply are now temporarily or permanently abandoned as they do not match the quality standard for nitrates. In 1991, a survey made by Cemagref showed that:

- 448 tonnes/year of nitrates are contaminating the lagoon and its aquifer, out of which 50 percent is estimated coming from urban areas, and 36 percent from agricultural areas

- 68 tonnes/year of phosphorus are pouring into the lagoon, out of which 80 percent is from urban areas
- 80 percent of the nitrogen and phosphorus pollution from urban areas is located downstream of sewage treatment plants which were not originally designed to treat those components

These alarming figures motivate regional authorities to:

- develop a regional model to monitor the agricultural practices and the resulting pollution within the watershed
- invest in tertiary treatments to reduce nitrogen and phosphorus from sewage water

The regional model for agriculture was developed in 1993–94, on a pilot area (2,300 ha) of the Manguio lagoon watershed totaling 357 km². It has been used essentially to assess the spatial variation of the vulnerability and the risk to nitrate and phosphorus pollution. A second unexpected application of the regional model has been the identification of possible sites for reuse of waste water in agriculture as an alternative to tertiary treatment.

REGIONAL MODEL FOR VULNERABILITY AND RISK TO NITRATE AND PHOSPHORUS POLLUTION

The regional model has been developed as a combination of a GIS (ARC-INFO) and a semi-deterministic distributed model: CREAMS (Knisel 1981) and also with the upgraded version GLEAMS. The CREAMS model is composed of several sub-models: Hydrology - plant growing - nitrogen leaching - erosion - phosphorus production. It calculates the daily runoff, erosion, deep percolation, and chemical fluxes from time-dependent parameters at a daily time step (rain, crop growing information, data of chemicals applications, and irrigation inputs). It requires some macroscopic calibration (lumped level). CREAMS was interfaced with ARC-INFO using a special linking program.

APPLICATION TO NONPOINT SOURCE POLLUTION ASSESSMENT

The definition of “sensitive area” to pollution, includes both vulnerability and risk notions. Vulnerability is defined as the propensity of an area to be impacted by a specific threat. This is a general concept depending

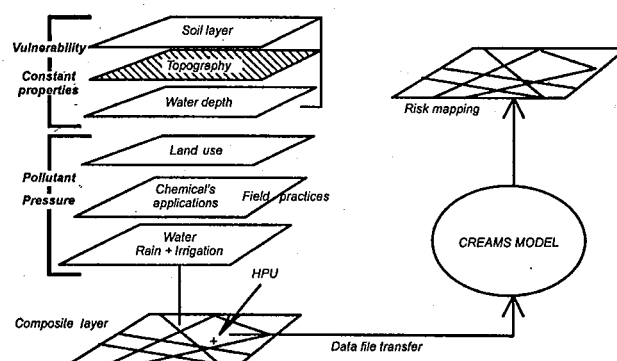
only on the permanent land characteristics (soil, topography, etc.) and the physical and chemical behavior of a specific pollutant. For example, nitrates are mostly leached towards groundwater while phosphorus is carried along by runoff. Vulnerability does not change over time.

The notion of Risk is derived by combining the vulnerability of a given area, with a “pollutant pressure” representing in that case, specific land uses, and agricultural and irrigation practices (quantity and frequency of inputs). The notion of Risk varies in time as practices can change.

In the first stage, an overlay weighted process was used to identify a homogeneous unit for vulnerability from soil, topography, and water depth layers of information. The resulting vulnerability map allows to identify particularly areas for which soft practices should be highly promoted. In a second stage, the homogeneous production unit (HPU) combining vulnerability and pressure layers of information (land use, field practices, and water budget), is identified as shown in figure 2. Each HPU has specific land use, soil type, general slope, tillage, fertilization, and an irrigation scenario. Except in a highly contrasted situation, practical consideration has led to retain existing fields as the frame for the HPU.

For each HPU, CREAMS Model computes the daily amount of nitrate leached below the root zone and of phosphorus that has drifted away from the field. The output is a risk map displaying the load of pollution per time. It allows to simulate the current

Figure 2.
Mapping vulnerability and Risk.



situation and evaluate the performance of any alternative scenario of agricultural practices in reducing the pollutant load.

APPLICATION FOR DESIGN SUPPORT SYSTEM FOR REUSE OF WASTE WATER IN IRRIGATED AREAS

The regional model and particularly the GIS abilities, appear to be also very useful for site identification and the design of management rules for reuse of waste water in agricultural areas. This study was motivated by the fact that for small and medium communities, the cost of classical tertiary treatment is somehow prohibitive and reuse of water on agricultural lands after primary and secondary treatments appears to be an interesting potential alternative.

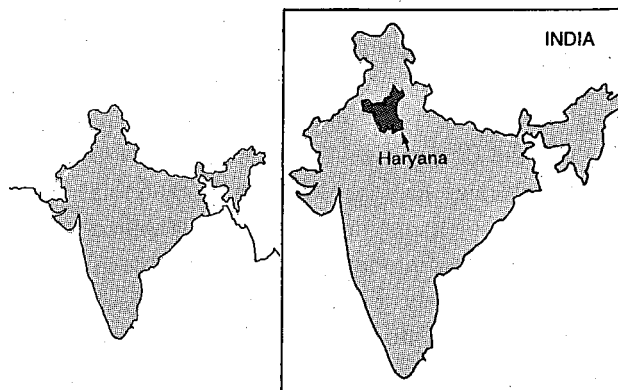
The methodology was developed in several steps (i) exclusion of areas with regulation constraints: identification of sensitive entities (household, water withdrawal points,...), building of protected areas around them (buffer), and identification of the remaining fields; (ii) identification of the more suitable irrigated fields, combining distance to the treatment plant, vulnerability to erosion and percolation; (iii) identification of the system layout, by testing manually or automatically different layouts; (iv) identification of fields for a low duty system (water supply limited to evapotranspiration); (v) identification of fields for high duty system (duty greater than evapotranspiration) for nonirrigation season; and (v) management scenario and performance of the elimination.

The results showed that the scattered urban area development around the greater treatment plant (10,000 inhabitant equivalents), leaves no place for waste water reuse in agriculture. For the two others, 700 and 3,000 inhabitant-equivalents, several scenarios were proposed to the partners of the project. The flexibility of the GIS regional model was found to be a paramount property, as it can be adjusted to any change in the negotiation process between local authorities and farmers. And in sensitive issues such as reuse of waste water, this was felt to be of great importance.

Daniel Renault, ITIS Unit
International Irrigation Management Institute
P.O. Box 2075, Colombo, Sri Lanka.

Tel: (94-1) 867404, Fax: (94-1) 866854, E-mail: d.renault@cgnet.com
ENGREF/Cemagref, Montpellier, at the period of the study

INDIA



Regional Water and Salt Balances Obtained from GIS and Hydrological Models

INTRODUCTION

The rapid expansion of irrigated lands in Haryana, India, during the last two decades has led to a destabilization of the regional water and salt balance. Although irrigation water is scarce, Haryana is afflicted by large-scale waterlogging. Improved on-farm water and salinity management is conceived as the cornerstone for the development of a better and sustainable agricultural irrigation system. On-farm water losses at micro scale affect the meso scale buildup of water and salts. Micro scale field experiments conducted in the framework of the Indo-Dutch project at Hisar focused on studying the response of the soil-crop-atmosphere continuum to various irrigation regimes at a set of given boundary conditions. The experiment indicated possibilities to halt the imbalance between inflow and outflow of water at field scale by means of water management interventions such as reduced water supply at shallow water tables, installation of subsurface drainage systems, and lower application depths to prevent groundwater recharge. These results from small-scale experimental pilot areas should, however, be envisaged as being site-specific.

The canal command area of the main canal Bhakra system serves more than 1.2 million ha comprising a variety of climatic conditions of the overlaying