

ENVIRONMENTAL RISK EVALUATION TO ASSURE THE QUALITY OF AGRICULTURAL PRODUCTS

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Abstract

The quality of agricultural products may be influenced by the environmental pollution. The prevention of pollution risk, or at least its knowledge, can be supported by the monitoring of the pollutions sources of potential environmental risk (e.g., incinerators, thermal power plants, highways, industrial plants, etc.) near the agricultural area of production. An instrument to assess this potential risk, related to the presence of pollution sources, may be a "Precaution Index". This index was developed starting from the inventory and geo-referencing of all pollution sources in the study area, using a GIS software. To take into account the relevance of each source, a multi-criteria decision analysis (MCDM), that is ideal to support spatial decision making process, was used. Results are represented in a digital map of "Precaution Index" for the considered regions.

Keywords: Environmental pollution; Precaution Index; GIS; Multi-criteria analysis.

Introduction

In recent times the amount of Italian territory used by urban and industrial settlements, not to talk about roads and highways, has been increasing (see "The European environment – state and outlook" 2010). A secondary effect of this trend is the increase of "peri-urban" agriculture. This means that agricultural products are grown closer to potential sources of pollutants, such as incinerators, power plants, highways, industrial factories, etc. Data about monitoring of this sources are widely available both in the scientific literature (Capuano *et al.* 2005, Nadal *et al.* 2007) and at institutional web sites (e.g. European Pollutant and Release and Transfer Register <http://prtr.ec.europa.eu>), what is lacking is literature about the effects of pollutant on agricultural products (Agraval *et al.*, 2003). Aim of this work was to take into account all the main potential sources of environmental pollution in a certain region, calculating an environmental "Precaution Index" that can be then related to the production of vegetables and food in general.

Materials and Methods

The methodological approach consists of the following main steps:

- (1) analysis of the state of the art of the relationships between contaminants and agriculture, to define the sources of pollution;
- (2) setting-up of a GIS database, by means of the software ArcGis 9.1. The database of all major pollution sources was developed for several regions of Northern Italy;
- (3) the creation of a GIS map for each source, including its radius of influence as reported in literature, which represents its presence and relevance within the area;
- (4) multi-criteria analysis with weighted linear combination and priority ranking of the sources (criteria), using the application of the Analytical Hierarchy Process (AHP) method, as decision support. The AHP method allows to assign a weight to each pollution source and pollutant, considering their relative importance, by means of a pair-wise comparison matrix;

- (5) development of the environmental precaution index P;
- (6) making of digital maps of the P index.

The assessment of a potential environmental risk is a process of overlay mapping, by which we build complex level information based on expert opinions, structuring information in simple levels (Cherubini *et al.*, 2006; Geneletti, 2004). The graphic overlay mapping operation is the product of the weights of individual sources, which result gives the overall precaution index P , and that was computed as following:

$$P = \sum_{i=1}^n d_i \cdot p_i$$

where:

$d_i = 1$ if the criteria exists; 0 if the criteria doesn't exist

$p_i =$ weight of each criteria

$i = 1 \dots n$, criteria (pollution sources).

Tab.1 - List of the considered pollution sources.

List of the pollution sources			
1	Polluted sites	10	Roads and urban areas
2	Nuclear sites	11	Natural gas power plants
3	Incineration plants	12	Ceramics industries
4	Foundries	13	Paper mills
5	Cement plants	14	Waste treatment plants
6	Refineries	15	Treatment and coating of meta
7	Landfill	16	Agro-food industries
8	Chemical industries	17	Commercial areas
9	Oil/coal power plants		

Tab.2 - List of the main sources of data.

DATA SOURCES
IGM (Istituto Geografico Militare http://www.igmi.org/)
Map archives of the Regions
Arpa of the regions
ISTAT National Institute of Statistics http://www.istat.it
European Pollutant and Release and Transfer Register http://prtr.ec.europa.eu
Istituto Superiore per la Protezione e Ricerca Ambientale (ISPRA) http://www.isprambiente.gov.it
Ministero dell'Ambiente, Tutela del Territorio e del Mare - Inventario nazionale degli stabilimenti a rischio di incidente rilevante http://www.minambiente.it

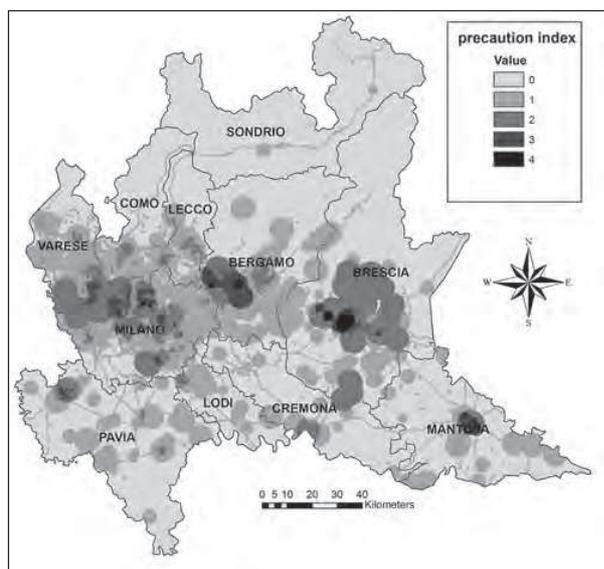


Fig. 1 Map of the Precaution index for the region Lombardia. Darker colours show a higher need of precaution against environmental risks, coming from the sources listed in Tab. 1.

Results and Discussion

Nearly 1200 specific sources of anthropogenic pollution have been identified and individually georeferenced, in addition to the main roads network and generic urban-industrial areas. These sources were divided into 17 categories (criteria). They are listed in Table 1 in order of importance, that depends on the type of object on which you want to know the effect of pollution. The sources are uploaded in a pair-wise comparison matrix to obtain the weights of each category. Table 2 summarizes the main sources of data used to produce the database. The final result of the multi-criteria evaluation is a raster map of each region studied, which represent the Index of environmental Precaution. The index value is displayed with a five colour legend, where light grey (or 0) means that there is no need of precaution, because there are no

pollution sources in the area, while the increasing colour, from grey to black (1 to 4) advice for an increasing need of environmental precaution. The map in figure 1 shows the situation for the Lombardia region.

Conclusions

For this kind of studies, GIS software are the ideal tool, because of their ability to manage, correlate, and display, in a short time, relevant spatial data and implement the various disciplines. They can also be easily used in combination with multi-criteria analysis, which allows to take in account all the factors (criteria) involved in a process.

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