Management models for a sustainable use of manure in intensive livestock areas

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Foreword

In Lombardy Region, the recent redefinition of vulnerable zones under Directive 91/676/EEC, together with the actual consistency of farms and agricultural land use, raises serious doubts about the viability of the livestock industry in Lombardy. Indeed, in vulnerable zones, even assuming a homogeneous distribution of effluent on the surface available, the new rules require to reduce nitrogen application to the field of at least one third.

The purpose of this study, funded by the Lombardy Region, is to define the possible intervention strategies in order to reduce nitrogen applied to the fields, safeguarding the competitiveness of arable and livestock farms.

This paper presents and analyzes the first step of the multi-criteria decision support system, carried out in the Province of Lodi.

Material and Methods

A Geographic Information System based on the existing database and cartographic support of the Province of Lodi has been set up.

The effectiveness of the system was increased by implementing a more detailed scale (field level) and a multi-criteria evaluation system based on criteria and objectives devised by the planning team. Using the developed methodology and tools, a detailed knowledge of the studied area and the effects of the possible changes in manure utilisation were obtained. The database at the field level was obtained from the Regional Agricultural Information System, where all the information about each field is recorded and updated yearly under the CAP procedure.

The assessment of the situation and possible solution was carried out at three levels: municipality, farm, and field level.

The analysis at the municipal level aimed to highlight areas where the amount of nitrogen in livestock manure was higher considering all the land available. For this assessment, the maximum amount of nitrogen that could be spread yearly was considered to be 170 $kg.ha^{-1}$ in vulnerable areas and 340 $kg.ha^{-1}$ in other areas, according to actual regulations. All the agricultural area was considered available for manure spreading.

The assessment at the farm level considered the available farm area for manure spreading; thus, it was possible to highlight the amount of nitrogen surplus for each farm.

To have a realistic approach to the feasible alternatives for farmers, however, a more detailed evaluation had to be carried out. The scheme of analysis adopted was based on a methodology that weighs and indexes a set of criteria to calculate an index as a combination of factors.

The method used was derived from the method of Weighted Linear Combination, as reported by Malczewski (2006), and it is one of the most frequently used methods when the multi-criteria analysis is based on GIS, especially if the analysis is used to classify a territory through the use of multiple attributes (Multi attribute decision analysis). This

decision support method is based on some assumptions, the principal of which is that the criteria used in determining the rating of the various alternatives have an additive effect and that they are, therefore, independent (Triantaphylou, 2000). For this reason, the methodology developed provides a verification of independence obtained through the analysis of linear correlation (Geneletti, 2007).

Moreover, to overcome the limits of linear combination when criteria have different sizes, they were standardised. In accordance with the directions of Malczewski (2000), the normalization was done according to a function obtained by allocating scores at different values of the criterion, standardized to a scale from 0 to 1. A hierarchical structure of multi-criteria evaluation was used, allowing values to be obtained for a certain goal that could subsequently be used as a criterion for further evaluation. The importance of each criterion was quantified by a weight establishing the relative importance of various attributes used in the evaluation. The value of the weights was the result of a subjective assessment made by the decision group in relation to the goal. The methodology developed assigned a weight as a number from 0 to 1. Clearly, a weight equal to 1 is assigned to the factor (or factors) judged by the highest importance for the analysis. Conversely, a weight of a lower value represents a factor considered of secondary importance. The approach used to assign weights was based on the “swing weights technique” (Malczewski, 2000), in which the maximum value was assigned to the criteria considered most important while the other values were scaled to the first in relation to their maximum variation.

The multi-criteria analysis was adopted to characterise each field for its capability of being used for manure spreading, minimising the risk of pollution and considering the suitability of use also in relation to the distance from a livestock farm.

The assessment report considered three different hypotheses about land availability. The more restrictive type (hyp. 1) defined a field usable for manure spreading when it was not owned by a livestock farm. Its suitability to receive manure, as stated by the soil survey organisation, was moderate or good, and the distance from an urban center had to be greater than 100 m.

The second type (hyp. 2) considered the land owned by a livestock farmer to be usable provided that the amount of nitrogen distributed was under the maximum allowed and That the other conditions remain the same. The third option (hyp. 3) was the most optimistic and considered all the fields usable, provided that the soil suitability was at least sufficient and that the maximum amount of nitrogen was below the legally allowed.

Results

The evaluation at the municipal level is reported in figure 1. It can be noted that few areas show a surplus and that only four municipalities have a high surplus of nitrogen from livestock manure. The farm level situation, however, shows a different picture (Figure 2). Many farms have a relevant surplus of nitrogen if located in areas where, on average, there is not a general surplus. The additional step takes into account the assessment at the field scale where the multi-criteria method has been applied. Figure 3 reports the field level classification of an area where the municipal evaluation did not show a nitrogen surplus, showing the available fields at different distances from the group of farms used as a reference and for hyp. 1 and hyp. 3. The differences between the two maps highlight the importance of the multi-criteria analysis in evaluating different scenarios. While the result of hyp. 1 seemed to be unquestionably applicable and useful as a sustainable solution, hyp. 3 involved some challenging conditions, like the use of more environmentally risky soils and fields located close to urban areas. Moreover, the use of the land of other livestock farmers could be proposed under a general agreement and, possibly, in the framework of an association of farmers for the management and eventually the treatment of the manure produced.

around the livestock, or 2) reduce the amount of nitrogen produced by adopting a treatment system or exporting a part of the manure.

Conclusions

Spatial analysis of the structural characteristics and livestock enterprise management related to the production of manure and its use has not only highlighted a critical situation but also made it possible to quantify the amount of nitrogen applied to different areas to comply with the requirements of legislation.

Figure 1 – Map of the municipalities of the Lodi province classified according to the livestock nitrogen surplus. The surplus is considered moderate when below 20% of the total nitrogen produced.

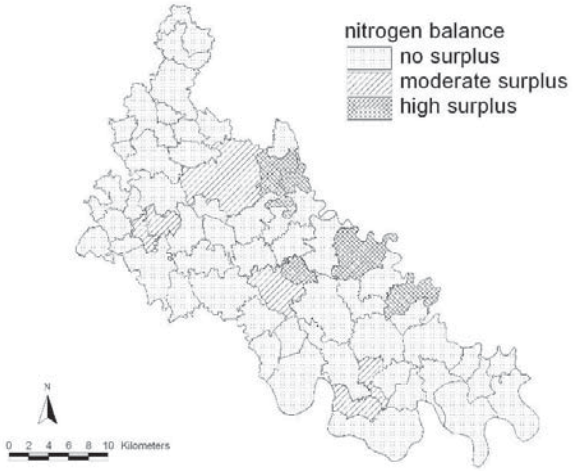
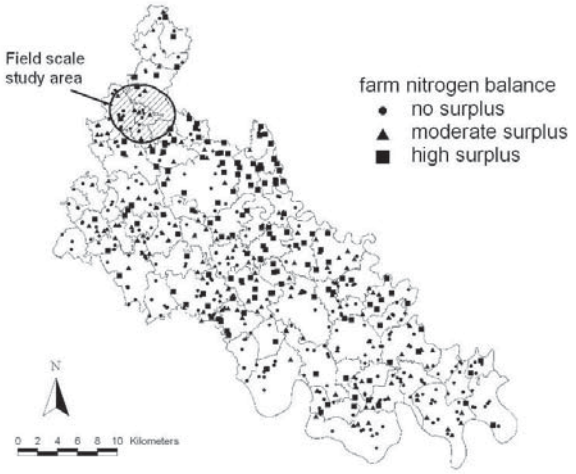


Figure 2 - Farms of the Lodi province classified according to the livestock nitrogen surplus. The surplus was considered moderate when below 40% of the total nitrogen produced.



The results of the spatial analysis of the different hypotheses considered are summarized in figure 4, where the amount of nitrogen that could be spread was plotted against the distance from the group of livestock farms considered. Considering that the overall nitrogen

surplus was approx. 50 tonnes, the available land needed to be a reasonable distance away in hyp. 2 and 3, while in hyp. 1 the fields at a distance of around 2 km from the farms were unlikely to actually be available due to the proximity to other farms. Therefore, the assessment for this group of farms results in two possible approaches: 1) define an agreement among farmers to guarantee a uniform distribution on the neighbouring land, remaining inside an area of 1 km.

These tools may allow the identification of appropriate solutions and common strategies for the application of laws that avoid creating unnecessarily high pressure on agriculture, leading to unsuitable investment and unexpected detrimental results.

This ongoing research project will continue to evaluate the technical and economic viability of different treatment solutions to give farmers sustainable solutions for manure management while minimizing negative impact on the environment.

References

Geneletti D., (2007) An approach based on spatial multicriteria analysis to map the nature conservation value of agricultural land, Journal of Environmental Management, 83, 228-235.

Malczewski J., (2000) On the use of Weighted Linear Combination Method in GIS: Common and Best Practice Approaches, Transaction in GIS, 4(1): 5-22.

Malczewski J., (2006) GIS-based multicriteria decision analysis: a survey of literature, International Journal of Geographical Information Science, 7 (20): 703-726.

Triantaphylou E., (2000) Multi-criteria decision making methods: a comparative study, Kluwer Academic Publishers, Dordrecht, The Netherlands.

Figure 3 – Maps of the field scale study area. The fields are classified according to the distance from a group of farms (grey shaded). Only fields available for spreading are considered for hyp. 1 (left) and hyp. 3 (right).

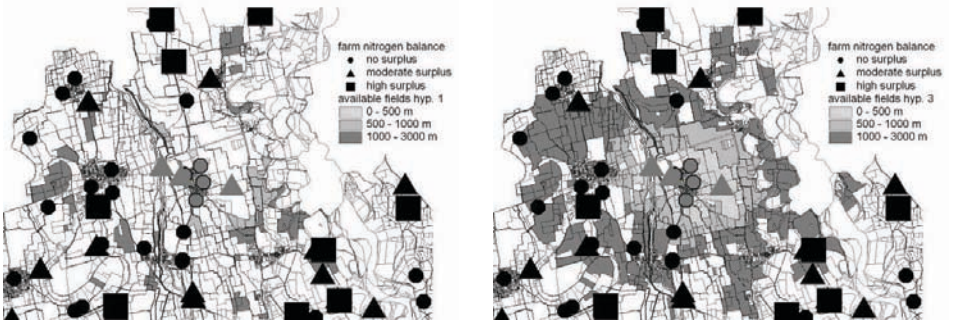


Figure 4 – Distance from the livestock required to find available land, in relation to the nitrogen surplus and the criteria used, for the selected group of farms.