A GIS-Based approach for the sustainable management of livestock effluents at Cam Lam district, Khanh Hoa province

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Abstract

Sustainable livestock effluent management is becoming an increasingly important issue in Cam Lam district of Khanh Hoa province, with particular regard to the agro-environmental performance of forage production and the social acceptability of organic fertilizer application in mixed urban-rural contexts. The present paper proposes a GIS-based methodological approach to the management and planning of digestate spreading on hay meadows, based on the integration of spatio-functional database about cultivated agricultural land. The proposed methodology was tested in Cam Lam district, with pig 78 farms. Environmental parameters of TSS, BOD_5, COD, nitrogen production by pig was quantified and compared to sustainable requirements provided by national and local regulations were spatially implemented. Findings are transferrable to other regions based on cattle farming management.

Keywords: livestock effluents, organic fertilization, pollution, Cam Lam district, Khanh Hoa province.

1.   Introduction

The economy of Cam Lam district is based on agriculture, light industry, tourism and livestock farming, which ensures the attractiveness of urban-rural territories by providing high quality traditional dairy products and maintaining typical, bio-diverse cultivated landscapes. One of the main critical issues in study area related to the co-existence of animal husbandry and other human activities, especially tourism, is the odor impact of livestock breeding and effluent spreading. National and local legislation provide spreading restrictions in order to minimize the odor emissions of organic fertilization, but issues persist.

Considering the small size of livestock farms in Cam Lam district, anaerobic digestion plants have to be planned, constructed and run by several farms together, grouped in cooperatives or enterprise networks. This is necessary not only to take advantage of economies of scale, but also to tackle odor issues at a larger level. In addition, creating multiple-farm cooperation in livestock

effluent management represents a chance to address the sustainable use of organic fertilizers in the area (Peratoner et al., 2010).

The overall objective of the present study is to provide livestock farms operating in alpine environments with innovative tools for a sustainable use of livestock effluents. The methodological approach proposed, based on GIS tools, was developed on Microsoft Access database for Cam Lam district but it is transferrable to any other similar context with urban-rural economies built on livestock farming.

2. Materials and methods

2.1. Data collection through farm surveys

As required by national and local legislation, data collected through direct on-farm survey, regarding in particular farm size and composition, were used to calculate TSS, BOD_5, COD and nitrogen production. Initial data about herd size, herd composition, housing system and current effluent management were collected through farm surveys, in order to quantify housing related environmental parameters produced by each farm on a yearly basis. Standard field values provided by national legislation were applied.
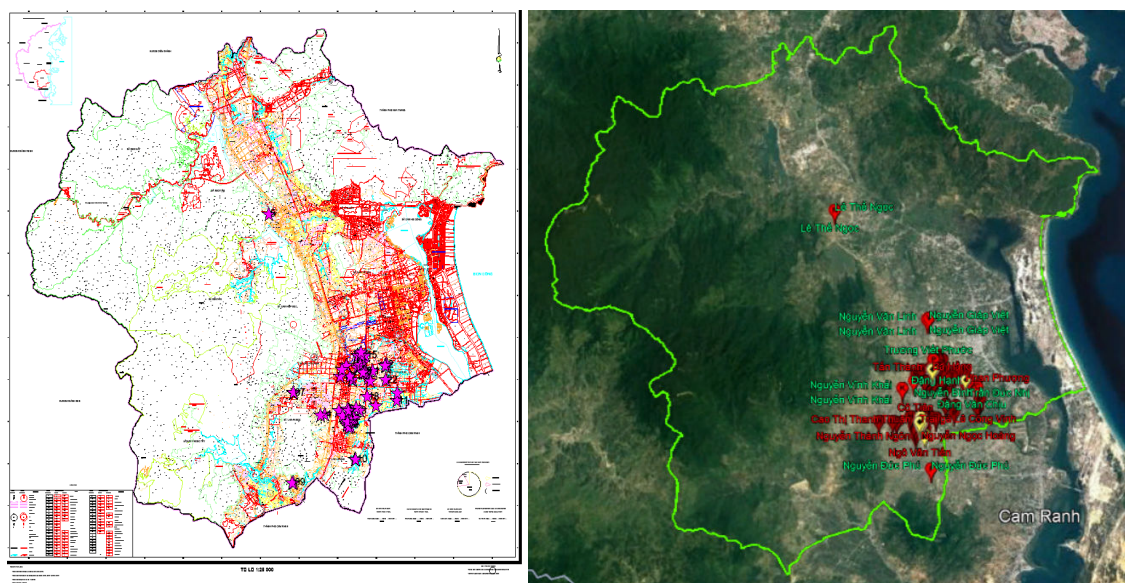

Figure 1. Location of 87 pig farms in study area

2.2. GIS-Based data management framework

Dealing with spatial patterns of environmental database and potential pollution spreading requires a common data framework with spatial reference, in which existing information layers, i.e., topographic maps, infrastructure maps, cadastral maps, can be integrated with newly processed or collected data, i.e., farm plots, areas with spreading restrictions. Such framework was created for the area of interest using a GIS application of MapInfo and a database on Microsoft Access.
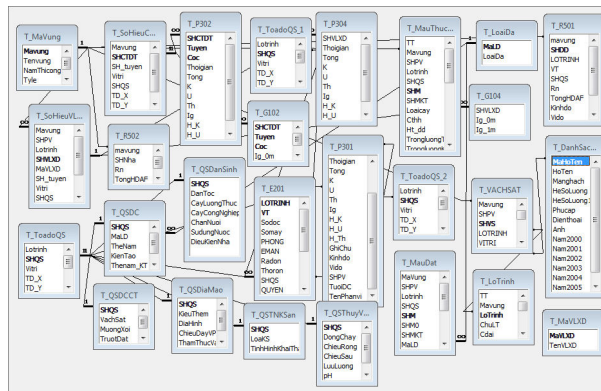
Figure 2. Relational database for environmental parameters on pig farms

One of the preliminary steps was to convert existing data into spatial layers, which contains the polygons plots cultivated by each farm, net of non-productive areas such as trees, roads and buildings, with information about the user and cultivated surface. These layers represents the base for further data collection and processing. National and local legislation define spreading restrictions for livestock effluents were also included, in order to compare and minimize the impact of organic pollution on other human activities (i.e., tourist, housing, public infrastructures) and on the environment (i.e., contamination of surface and groundwater through leaching and surface run-off).

3. Results and discussion

The 78 farms surveyed farms with slurry-based effluent management were collected in the database and the declared total number of pig was about 84.700 units. The total size of the biogas tanks is 113.805 cubic meters and settling tanks is 123.736 cubic meters. Total effluent stock capacity was equal to 237.541 cubic meters. Main environmental parameters of TSS, BOD_5, COD and nitrogen excretions are mapped for intensive pig farms in Cam Lam district and may be over-estimated when applied to more extensive farming systems in other areas in Vietnam or other countries. For instance, the data in the North Vietnam or in Italian Alps (Regione Autonoma Valle d'Aosta, 2017) have introduced lower nitrogen excretion values for local breeds.
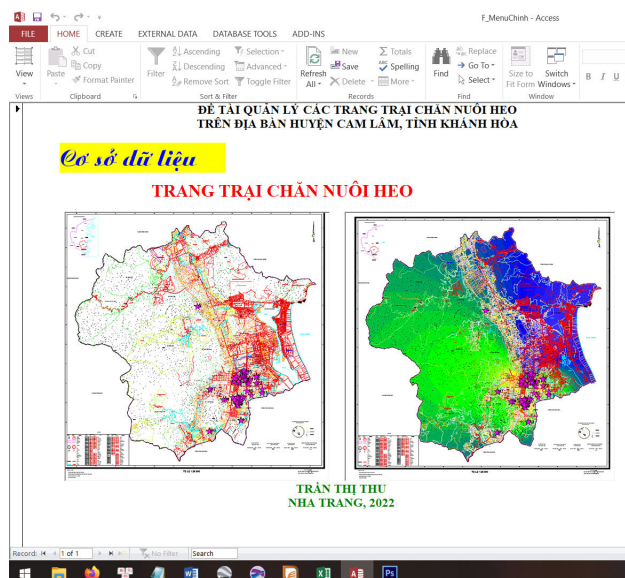
Figure 3. Management tool developed on MS Access

The effluent spreadings were cartographically implemented to identify and evaluate the portions of plots subject to limitations in organic fertilization. Figures below show cartographic detail of these implementation in study area. Pig farms are heavily concentrated in the South of Cam Lam district, therefore interpolated values on other regions are not neccesseraly corrected for mapping pollution spreading. This confirms the need to take the specificity of concentrated areas into consideration when planning normative tools for the agro-environmental management of livestock effluents.
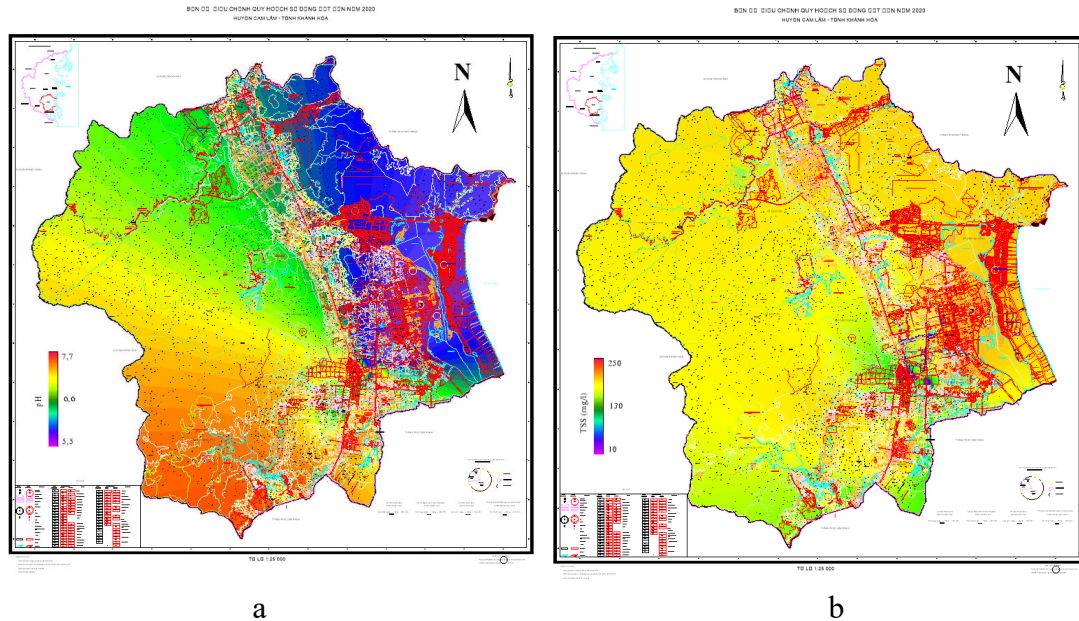

a   b

Figure 4. Maps of pH (a) and TSS (b) derived from the management database
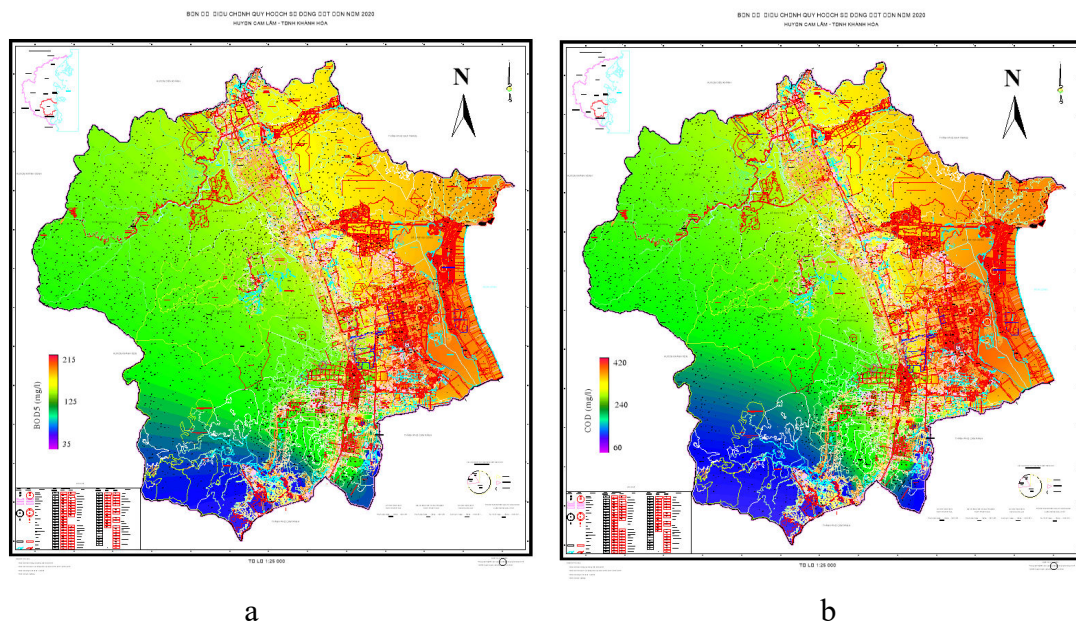

a   b

Figure 5. Maps of BOD_5 (a) and COD (b) derived from the management database
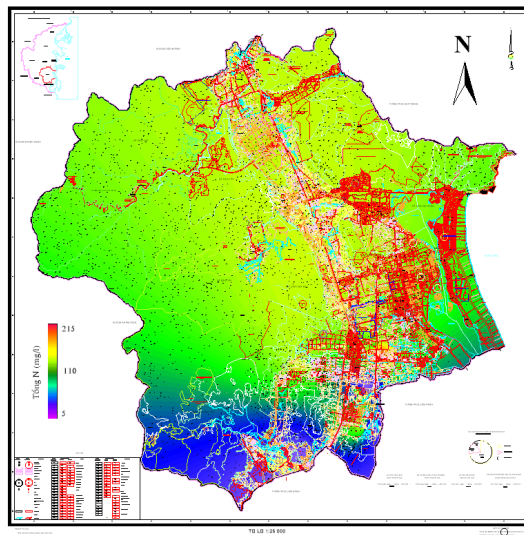
Figure 6. Maps of nitrogen production derived from the management database

Effluent spreading restrictions maps were showed in detail for the Southern part of study area in order to see the environmental impact of effluent spreading. The information layers created for this purpose might be potentially integrated in an open-access webGIS application, which helps not only the farmers but the local management agency to identify areas to pay more attention. Information about environmental parameters such as pH, TSS, BOD_5, COD or nitrogen production of each farm were used to map the dispersion of pollution in the study area. The spatial distribution patterns as well as site-specific pollution potentials could be taken into account when compared with the allowed legislation.
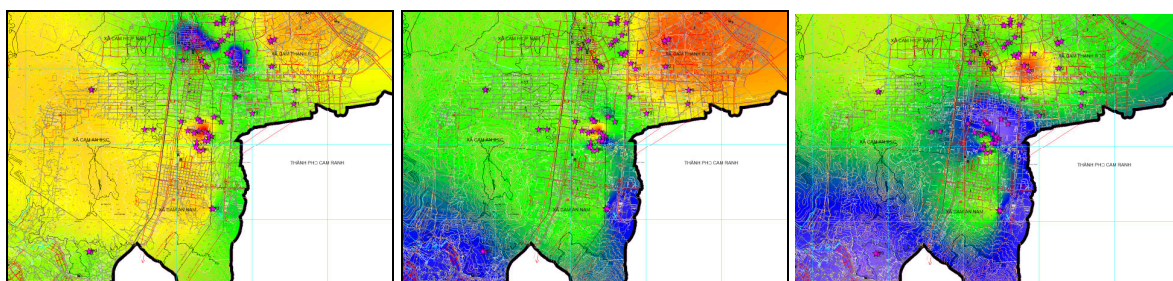

Figure 7. Close look at the Southern part of Cam Lam district for TSS (a), BOD_5 (b) and nitrogen (c)

For other regions, transferability may be limited by the lack of comprehensive, site-specific information. However, simplification of farm types integrated with literature data about pollution potentials still allows method implementation, even if with a larger degree of approximation. The developed dataset can also helps to quantify the sustainable digestate volume per operation and runoff risk potential.

4. Conclusion

The methodological approach proposed in the present study allows to tackle the issue of animal effluent spreading in Cam Lam district of Khanh Hoa province, with a specific focus on the environmental aspect of pig farms. Data collected on-site were spatialized and integrated with

existing geographic information layers, in order to develop new management and planning tools which are transferable to livestock farmers and help them adjust effluent spreadings and pollution patterns as well as to the potential risk of surface runoff. The case study of Cam Lam district allowed to test a new methodological approach, delivering usable results for the agronomic utilization of digestate in seven 78 farms in an urban-rural context. The methodological procedure as well as findings about the potential pollutions and effluent related surface runoff are transferrable to other regions based on livestock farming, and are also applicable for other type of farms for management in general.

To date, the present study represents the first implementation of GIS tools for the management of livestock effluents in Cam Lam area. Besides methodological aspects, one of the most important elements is the spatial scale, which enables to deliver agro-botanical and management information about pig farming at the local level of managemant. Further developments regard the implementation at a larger geographic scale and the integration of computed geo-referenced data in existing regional cartographic portals and web-GIS applications. Validation as well as monitoring of results will occur in the next 3 years during practical implementation, in order to verify the quality and effectiveness of the proposed framework.

5.   Reference

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Letter of Acceptance

Dear Authors,

Based on the recommendations from the peer review board, I am delighted to inform you that your following manuscript has been accepted for publication.

Paper ID:	HIW1-6T02
Tittle:	A GIS-Based approach for the sustainable management of livestock effluents at Cam Lam distritc, Khanh Hoa province
Authors:	Nguyen Quoc Phi
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	Phi Truong Thanh
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Accepted papers will be published in the Proceeding Book of *"Innovative Water Solutions for Vietnam and Region"*.

Thank you very much for your contribution to the VACI 2022!

Best regards,

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