The environmental effects of meat from livestock to slaughter in Italy: integration between data and GIS

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ABSTRACT

The food production chains are subject to increasing attention to food quality and safety aspects and to the environmental impacts that they produce. The livestock sector has significant impacts on different environmental matrices including soil, air and water.

Related to the atmosphere, the Carbon Footprint is one of the major indicators; it describes the emissions of greenhouse gases generated by a set of agricultural and industrial processes. Irrespective of the rules of calculation and from the selected indicators, it is clear how the meat is the principal food with the highest environmental impact per unit mass (the kg, for example). In particular livestock cause significant methane production resulting from the digestive processes (enteric emissions). In this paper will be presented some evaluations of these environmental impacts through the use of several indicators in order to evaluate the polluting effect of cattle and buffaloes, sheep, goats and pigs emissions at the local level. This will be estimated integrating administrative.

The environmental effects of meat from livestock to slaughter in Italy: integration between data and GIS data and data from statistical surveys. Livestock farms surveyed from the Ministry of Health Registry, data derived from Istat survey on the slaughter of red meat will be taken into account. Through the use of geographic coordinates related to livestock farms, it will be possible geo-referencing the proposed indicators and representing cartographic products.

Keywords: GIS, Environmental, Livestock

PAPER

1. Introduction

The evaluation of the environmental impacts of a product can be performed using different methods that, based on the specific characteristics of the object, focus particularly on some characteristic indicators. The livestock sector has significant impacts on environmental aspects including air, water and soil (Williams et al., 2006). The most common indicators in the calculation of the environmental impacts are related to the use of water resources (water footprint) and to the greenhouse gas emissions (carbon footprint). Regarding water plays a very important role is played by nitrate pollution, caused by the release of nitrogenous substances in the surface aquifer. In the atmosphere, the major impacts are on the emissions of ammonia (NH_3), methane (CH_4) and nitrous oxide (N_2O) (Campbell et al., 2008). Ammonia emissions from the agricultural sector are primarily produced by intensive farming and animals.

An emission inventory is an accounting of the amount of pollutants discharged into the atmosphere. It usually contains the total emissions for one or more specific greenhouse gases or air pollutants, originating from all source categories in a certain geographical area and within a specified time span, usually a specific year.

An emission inventory is generally characterized by the following aspects: types of activities that cause emissions, chemical or physical identity of the pollutants included, geographic area covered, time period over which emissions are estimated, methodology to use. Emission inventories are compiled for both scientific applications and for use in policy processes.

In this work it was decided to investigate the environmental impact in terms of carbon footprint being the most widely used indicator, and interpretation easier. The project is expected to consider livestock farms surveyed from the Registry from the Ministry of Health, data derived from Population Census for Emilia Romagna region and at the provincial level. The data refers to 8,822 farms on a total of 10,000 in Emilia Romagna who hold cattle, buffalo and pigs in the year 2015.

Livestock farms within the territory of Emilia Romagna are of a primary importance as the value of dairy cows in the production of "Parmigiano Reggiano" and of pigs for "Prosciutto".

In this area data related to various features have been gathered: data on livestock, on the type of animal bred and geo-referencing data (geographic coordinates that identify the farms). In the next table it is presented the distribution within the province of the animal types considered: dairy cows, bovine, buffaloes, pigs.

2. Emission factors

In order to calculate the emissions of livestock pollutions it has been considerate three elements:

- Ammonia (NH3): ammonia emissions in the agricultural sector contribute to the increase of the greenhouse gases for the production of gases. These emissions also contribute to the formation of fine particles. The formation of ammonia from animal manure depends upon the enzyme urease, whose activity is affected by the pH and temperature.
- Methane (CH4): methane livestock formation depends on the digestive processes (enteric emissions).

- Nitrous oxide (N2O): in the livestock farming, the nitrous oxide emission depends on the storage and the spreading of manure on the land.

So, these three factors have been taken into account (ARPA, 2013), as well as the number of heads for animal typology (just for dairy cows, bovine, buffalo and pork) in three phases of livestock process:

- Livestock housing;
- Storage of manure;
- Spreading manure.

In the following table we show values of the emission factors (kilo for head) for the three pollutants and for the three process steps involved. The factors of emissions are calculated considering several studies (IPCC, 2006), using specific weights depending on different animal species.

Table 1 - Emissions factors, kilo for head and animal typology

	NH3			CH4		N2O
Animal typology	**Livestock housing**	**Storage of manure**	**Spreading manure**	**Livestock housing**	**Storage of manure**	**Livestock housing and Storage of manure**
Dairy cows	15.46	20.36	12.65	113.24	15.04	2.1497
Bovine	6.66	8.96	5.46	44.72	7.65	0.6683
Buffalo	12.61	16.61	11.95	69.74	11.96	1.89
Pork	2.39	2.00	1.39	1.5	7.94	0.0202

Final results of emissions per provinces are shown in the following table:

Table 2 - Total emissions per province, year 2015

Provinces	**NH3 (Kg)**	**CH4 (Kg)**	**N2O (Kg)**
Rimini	117,007.80	417,347.22	51,421.26
Piacenza	4,975,971.03	7,178,382.13	88,349.12
Parma	7,424,407.50	10,774,264.21	142,990.23
Reggio nell'Emilia	7,171,421.04	10,309,793.92	134,397.42
Modena	6,458,882.35	9,621,531.77	128,905.33
Bologna	5,501,862.58	7,985,779.79	110,200.00
Ferrara	1,102,631.27	1,663,968.47	21,765.89
Ravenna	1,364,916.02	1,997,112.97	26,730.18
Forlì-Cesena	3,771,979.30	5,475,044.37	71,996.43
Total	**37,889,078.89**	**55,423,224.85**	**776,755.86**

The assessment of health effects from environmental hazards involves people who lives close to the livestock. To compute the risk it was built an indicator that put in relationship the emissions and population under potential health risk.

We have created multiple buffers at specified distances around the urban areas and we have selected farms inside them.

The distances considered are: 100 mt, 200 mt, 300 mt and 500 mt.

In other words let Ai be the area of the i-th urban area, i=1,2...m for each province and *Ai the buffer area corresponding to i-th urban area for a distance D. Then the risk is defined as:

$$r_i = \frac{P_i}{e_i}$$

where P_i is the population in $^*A_i$ and e_i is the total emission from the n_i farms in $^*A_i$

$$e_i = \sum_{j=1}^{n_i} e_{i,j},\ n_i \geq 1$$

for $i \in I$ where I is the subset of urban areas $^*A_i$ that contains at least one farm.

The locations building for the Population Census are been considered: urban areas, inhabited areas and production areas (Istat, 1992).

If the indicator is high it means that the proportion of the population exposed at health risk is higher.

The results are reported in table 3 for provinces. The column "total" expresses the values for provinces total population. Considering the total values, every indicator is high for Rimini, Parma, Piacenza and Reggio nell'Emilia provinces. It's important to underline the different results based on the distances by the livestock houses. Obviously the population size nearest to the farms is small but the pollution risk is higher. So it's important to highlight also the high results of the indices for Modena and Bologna for the indices relative to N2O and Ferrara provinces for all the indices (N2O, NH3 e CH4). Note that it was possible to achieve this because the data refer to a geographic scale more accurate than the provincial one.

Table 3 - Potential population espoused at health risks for distance

Provinces	Meters (N2O)				Total	Meters (NH3)				Total	Meters (CH4)				Total
	100	200	300	500		100	200	300	500		100	200	300	500	
Rimini	3,9	7,2	13,6	19,2	335,5	39,0	63,7	112,4	144,9	1.748,9	33,9	60,2	108,2	148,2	2.492,1
Parma	139,9	195,7	231,4	321,6	498,0	619,3	863,9	1.031,6	1.441,1	2.262,0	966,3	1.337,4	1.590,1	2.214,7	3.482,7
Reggio nell'Emilia	171,9	187,5	219,0	283,8	384,9	801,3	877,7	1.043,1	1.341,2	1.888,4	1.246,3	1.356,0	1.619,6	2.082,3	2.873,4
Piacenza	174,2	192,8	200,0	265,9	458,8	830,5	920,3	965,8	1.280,2	2.402,2	1.200,3	1.318,8	1.379,2	1.853,2	3.590,4
Forlì'-Cesena	4,5	6,0	9,8	12,8	85,2	42,0	58,1	100,2	128,4	501,7	43,6	59,6	114,5	145,6	633,1
Ravenna	3,9	5,4	6,1	7,2	47,2	50,1	55,7	63,3	91,2	401,5	61,2	68,2	74,7	117,2	444,8
Bologna	12,8	14,8	16,2	21,7	10,9	70,9	80,8	93,5	124,0	100,4	95,4	108,6	122,9	162,6	137,6
Modena	58,3	65,8	87,1	127,8	18,0	269,2	321,7	426,4	652,5	197,9	411,4	480,1	645,2	974,0	213,0
Ferrara	34,5	33,3	37,3	46,6	18,2	272,1	263,3	308,7	354,0	138,7	255,7	247,4	280,8	342,0	147,3
Region	63,2	75,8	90,3	122,9	168,5	306,2	367,3	447,0	608,1	880,6	452,8	540,8	656,7	896,5	1.278,1

3. Maps data analysis

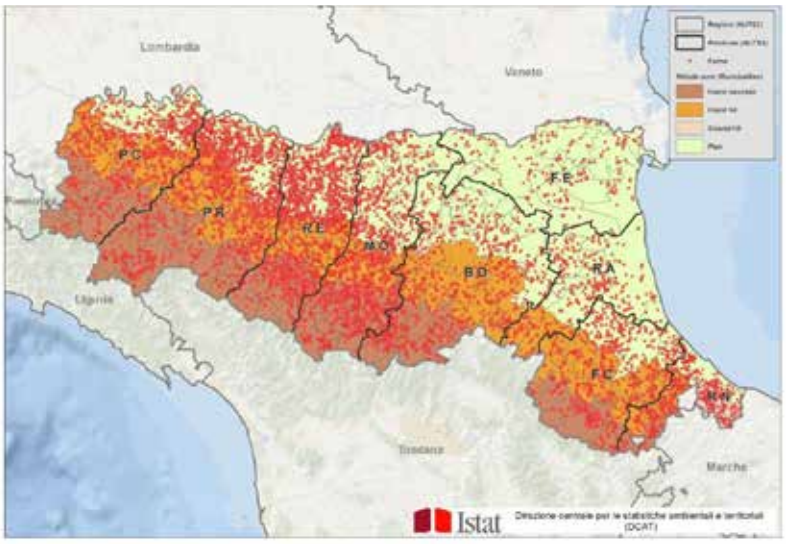
In Emilia-Romagna 8,822 farms have been georeferenced of a total of about 10,000[1]. The difference depends on the inexistence of a validated coordinates for few livestock houses. The farms without geo-referred data are little in terms of heads and uniform distributed on the territory. The emissions calculated and the relative indicators are represented on the following maps.

The farms with livestock are concentrated in the provinces Forlì-Cesena, Modena, Reggio nell'Emila, Parma (figure 1), Parmiggiano Reggiano e Prosciutto production areas. On the coast the number is lower, probably because this is an area with a great sea tourism vocation (Bologna, Ferrara, Ravenna and Rimini provinces).

In the figure the farms are represented by altimetric area (each farm is a geo-referenced point). It's clear the independence between this matter and the presence of animals. Very interesting could be the evaluation of environmental and health risks for people who lives close to the livestock.

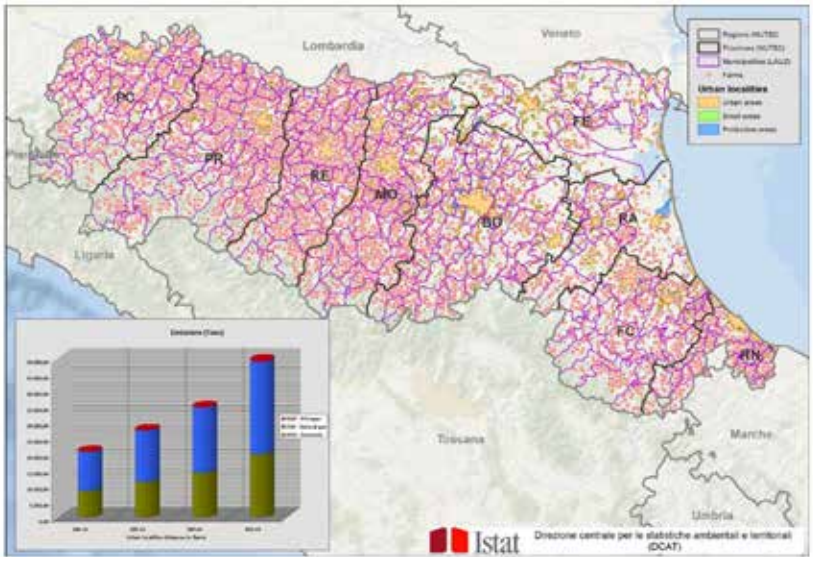
[1] Source Registry from the Ministry of Health

Figure 1 - Farms by municipality and altimetric area.



In the urban localities, delimited by a geographic information system (GIS) and available on the Istat site web[2], are detected and localized people and local units of the general censuses of population, enterprises and agriculture. The integration between the thematic maps of territorial bases (Lipizzi, 2013) and geo-referred farms, estimates the potential health risks on humans.

Figure 2 - Farms and emissions for distances from built-up, inhabited and production.



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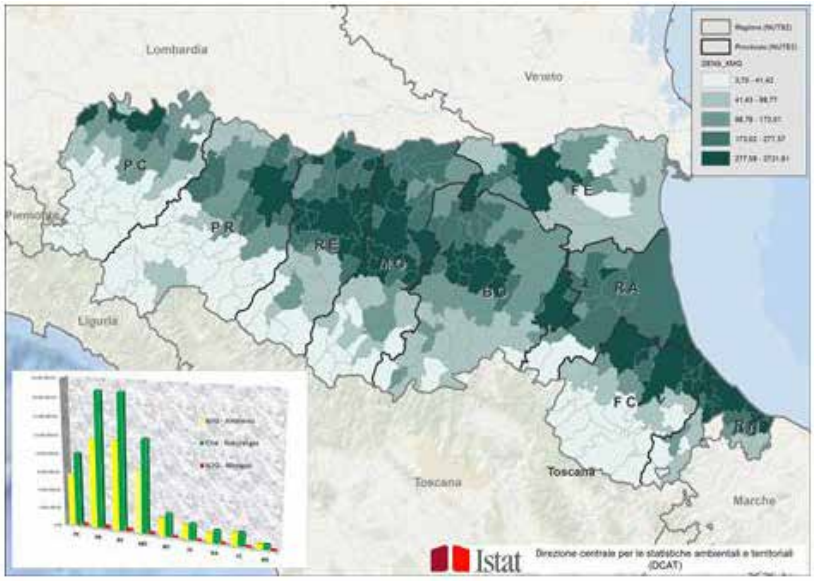
In the figure 2 are geo-referred the livestock houses and the urban localities, urban area (high density population) in yellow color, small area (inhabited areas) in green, production areas in blue. Each municipality is categorized according to quintiles of regional distribution. In figure it is also shown a graph, which indicate the sum of pollutant emissions by distance to the livestock houses. Methane and ammonia are the elements more consistent in the region Emilia-Romagna.

The figure 3 show the density population. The soft green indicate a low density and the deep green an high density. The population is concentrated in the north of motorway, into the Po valley.

The graph shows the total pollution per province. Methane and ammonia production caused by livestock are concentrated in Piacenza, Parma, Reggio Emilia and Modena provinces, how reported in table 2.

[2] http://www.istat.it/it/archivio/104317

Figure 3 - Density municipal population and total pollutants per province.



The last three figures are the overlapping of figure 1 and 2: they show for municipality the three components of carbon footprint (ammonia, azote and methane) normalized based on the population density. The theming is done by classifying quantile. In other words, they represent the table 2 calculate at municipal level.

Considering the single factors the situation is quite different respect to the total pollutant. It's clear the high concentration of polluting factors in interior area of the Region (particularly in Piacenza, Parma and Reggio nell'Emilia provinces), where is more incisive the presence of nitrous oxide (figure 5).

The areas near the cost are deeper because of the presence of Valli di Comacchio, a vast uninhabited wetland located in Emilia-Romagna, in the provinces of Ravenna and Ferrara. So even if the density population is lower, people lives nearest the farms and the health risk is higher.

Figure 4 - Ratio between ammonia produced in the municipality and density population

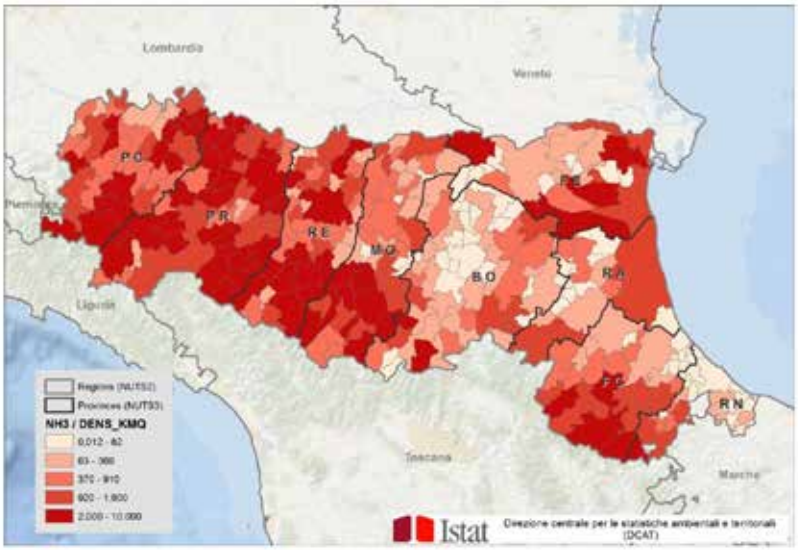


Figure 5 - Ratio between nitrous oxide produced in the municipality and density population

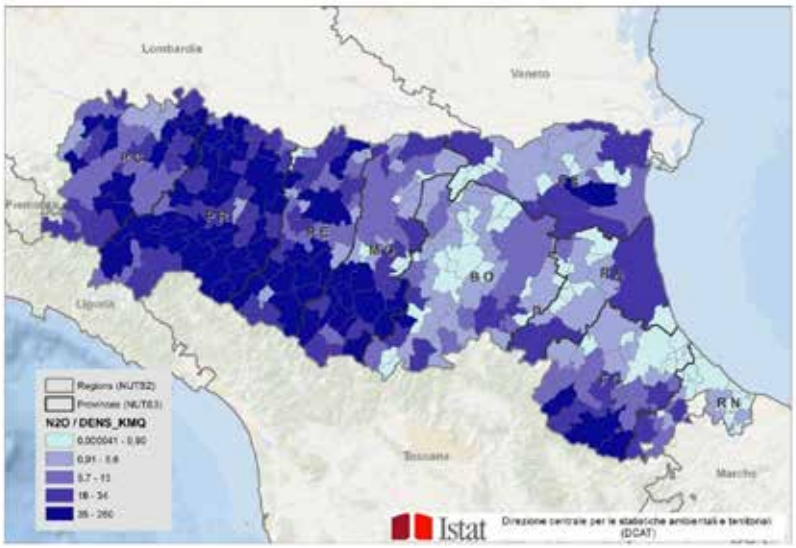
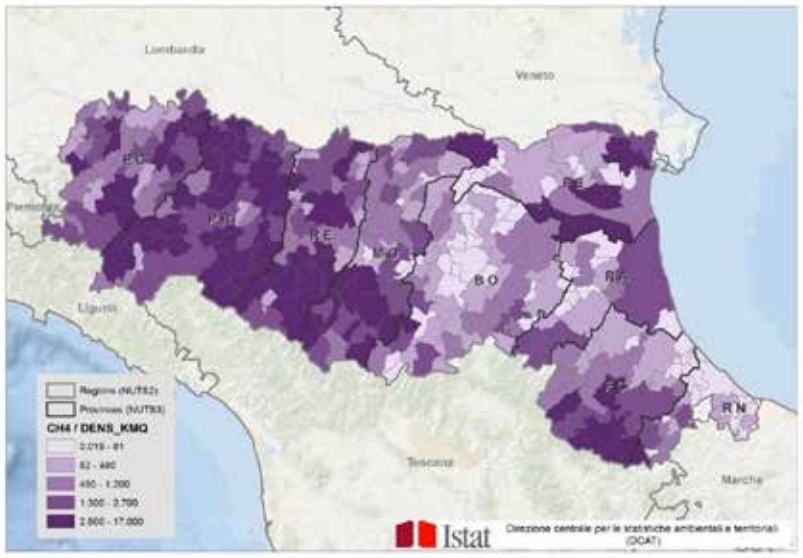


Figure 6 - Ratio between methane produced in the municipality and density population



Conclusion

The exercise carried out shows the increasingly important need to overlap geo-referenced data coming from multiple sources in order to obtain a broader and more detailed information linked with the territory . Data previously heterogeneous now take the chance to a new interpretation . It should be stressed that the potential of georeferenced information depends on the easy availability of them.

This study highlighted the strong connection between data related to bovine and data relate to the atmosphere. The results of this paper allow a more accurate definition of emissions from livestock activities and the evaluations obtained may also be useful to develop abatement strategies of pollutants in order to reduce emissions from the livestock sector.

Furthermore the analysis on a sub-municipal level, is a discriminating factor in assessing more accurately the health risk to the population. It would be interesting to extend the analysis to all regions and in other critical areas.

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