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Impact of Agro-environmental measures in the Tuscany Region. Geographic Multi-Criteria Analysis

Emanuele Gabbrielli – University of Florence - emanuele.gabbrielli@unifi.it

Abstract

Agro-environmental policies are taking increasing importance in community strategies and represent the main instrument for financing Rural Development Programs (RDP).
The difficulty of assessing real environmental effectiveness is one of the elements characterizing agro-environment measures. This difficulty is essentially related to the problem of identifying suitable parameters for evaluating farms according to their impact on territory.
The research aimed at providing an analytical model suitable to different territorial situations.
Organic and integrated farms, financed by Tuscany region with Rural Development Plans 2007-2013, were evaluated through the use of Multi-criteria Geographical Analysis.
Farms were classified according to their environmental impact, through multidimensional indicators. In particular, a simulation on economic and environmental effects of EU funding budget reductions, using geo-referenced data was conducted.
The implemented methodological approach was a helpful tool to assist Policy Makers in their own decisions, in ex-ante, interim, ex-post analysis, and also in the preparation of new measures on programming 2014-2020.

Keywords
Rural Development Programme, Agri-environmental Payments, Measure 214, GIS, Multi-criteria Analysis.

Introduction

Agri-environment measures support economically farmers in the protection, conservation and enhancement of environmental quality of their farmland. Promoting actions beyond legal and mandatory requirements, the measures integrate rules of statutory management requirements (SMRs) and Good Agricultural and Agronomic Conditions (GAEC). Agri-environmental policies, included into the Rural Development Programmes (RDPs), play a major role within EU Policies.
One element characterizing agri-environment measures, is the difficulty of assessing real environmental effectiveness. However, of agri-environmental assessment is a key point for the justification of such interventions that have granted significant financial resources.

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The aim of this work is to develop a tool, adaptable to various local situations, able to analyze the distribution and impact of EU funding, and allowing to perform a classification of farms that receive funding from Rural Development Plan. To this purpose a Spatial Multi-Criteria Analysis was used.
One of RDP targets was to encourage the use of environmental practices of farms, based on organic and integrated farming. The paper is organized as follows: following a short introduction, the case study is presented. The "Methodology" section, following a literature review, introduces the methodology used. In the "Results" section results of the model applied to the case study are provided. Finally, the last section is dedicated to conclusions.

Case study

The case study is conducted in the region of Tuscany. The population density in Tuscany is equal to 163.6 inhab./Km²: a population of 3,761,616 inhabitant is distributed on an area of approximately 23,000 Km². The most populated areas are located in the north (in the province of Florence) which includes 373,446 inhabitants (ISTAT, 2013). The morphology of 90% of the territory is hilly and includes mountain areas that strongly characterize the landscape. The primary sector occupies 2.7% of the total occupied areas of Tuscany, and includes approximately 45,000 workers. The case study includes all farm of Tuscany region that receive agri-environmental funds: payments are related to measure 214a1 (Organic Agriculture) and measure 214a2 (Integrated Agriculture) of RDP 2007-2013.
The symbol "Euro-leaf" designates the food produced with organic methods (Figure 1). While the symbol "Agriqualità" indicates the food produced by integrated methods (Figure 2).

Figure 1. European logo "Euro-leaf". Organic food

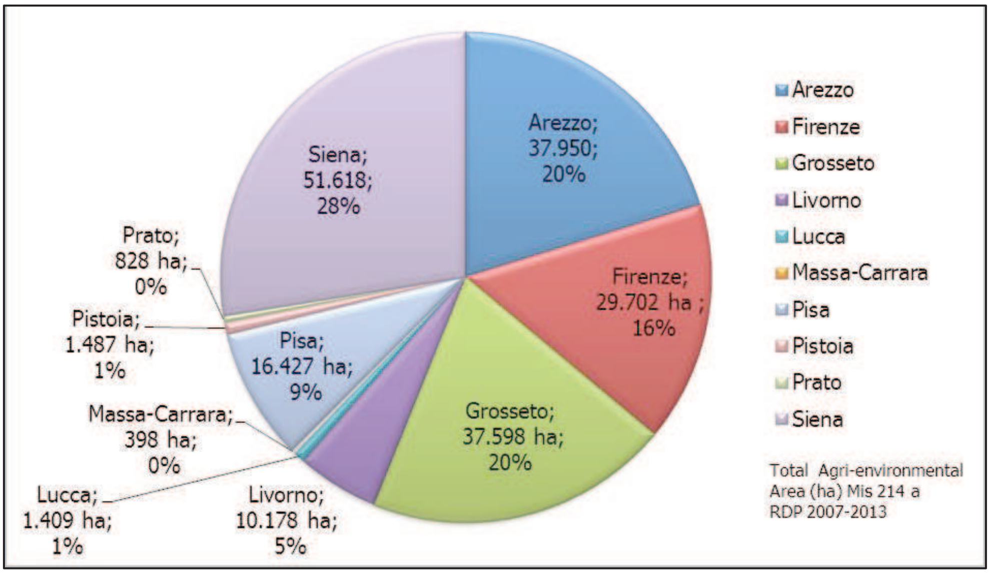
Source: European Union (Reg. UE N. 271/2010).

Figure 2. Logo "Agriqulità". Integrated food

Source: Tuscany Region. (L.R. 25/99)

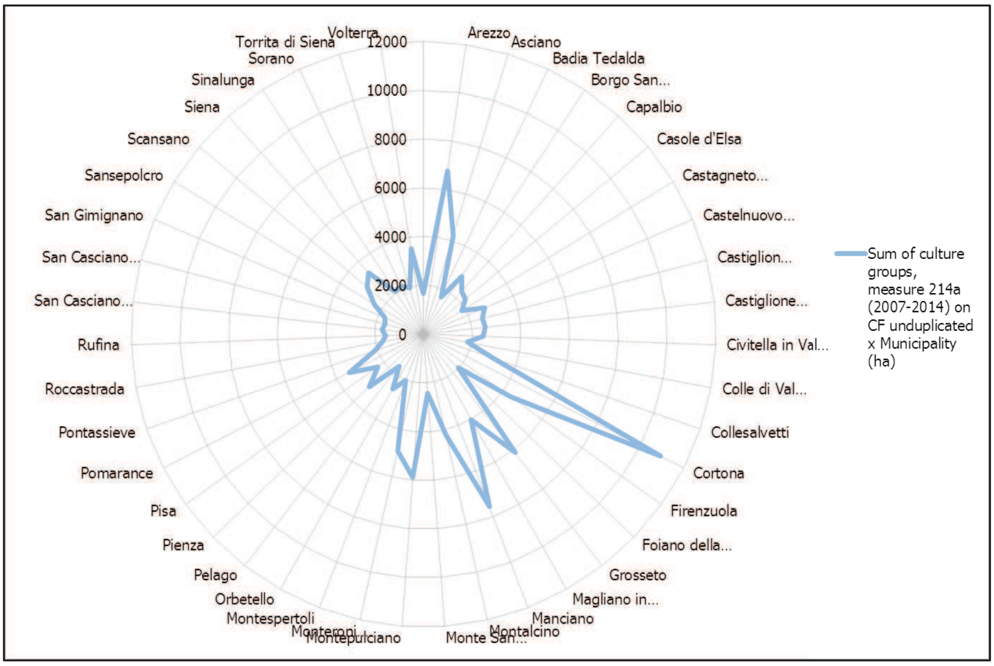
The areas related to measure 214a1 (Organic Agriculture) are mainly covered by cereals and forage crops, while the areas related to measure 214a2 (Integrated Agriculture) are mainly covered by cereals, forage crops and vineyards. Siena is the province with the highest agri-environmental areas, followed by Arezzo, Grosseto, and Florence (Figure 3).

Figure 3. Province with more agri-environmental area



Source: own elaboration

Figure 4. Municipalities with more agri-environmental area



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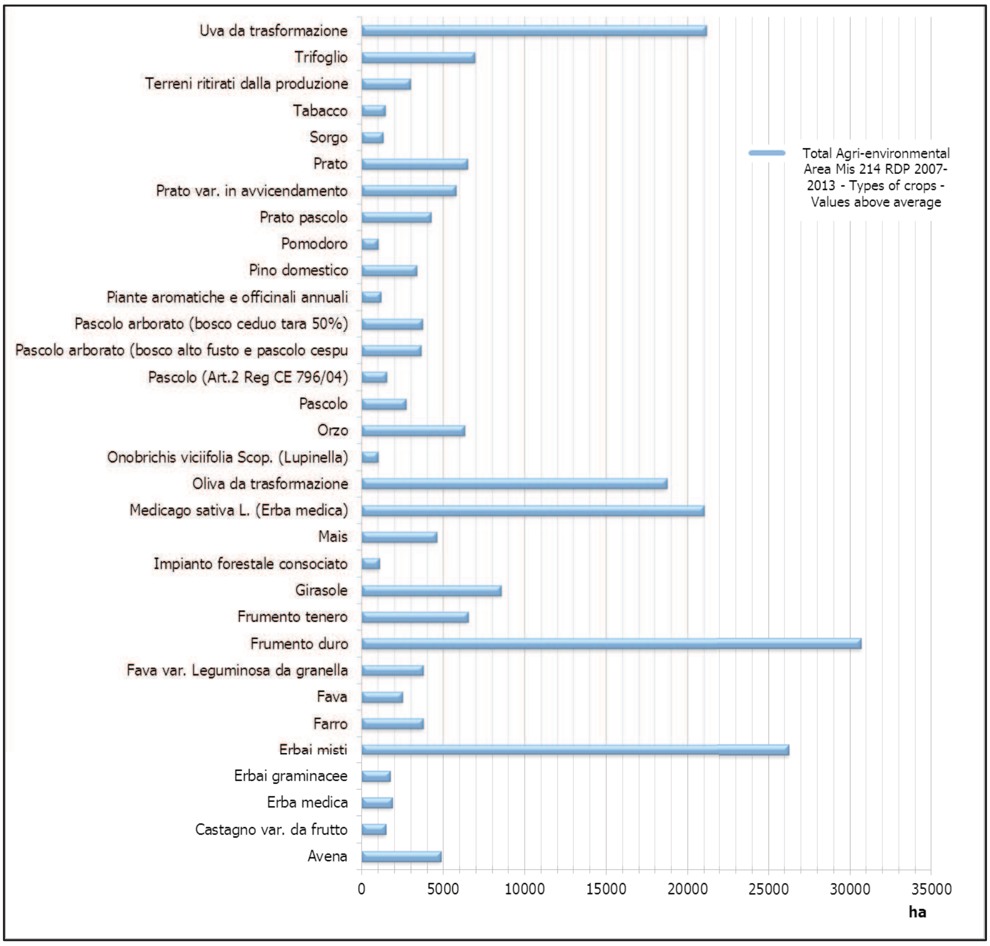
At municipal level, Cortona, Arezzo, Manciano and Grosseto, have the largest surface area of agri-environmental commitment (Figure 4).

The surfaces included in the agro-environmental awards, are subdivided according to the type of crops, and are mainly represented by wheat, alfalfa, grapes, olives and sunflower (Figure 5).

Figure 5.Type of crops, agri-environmental area



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Method

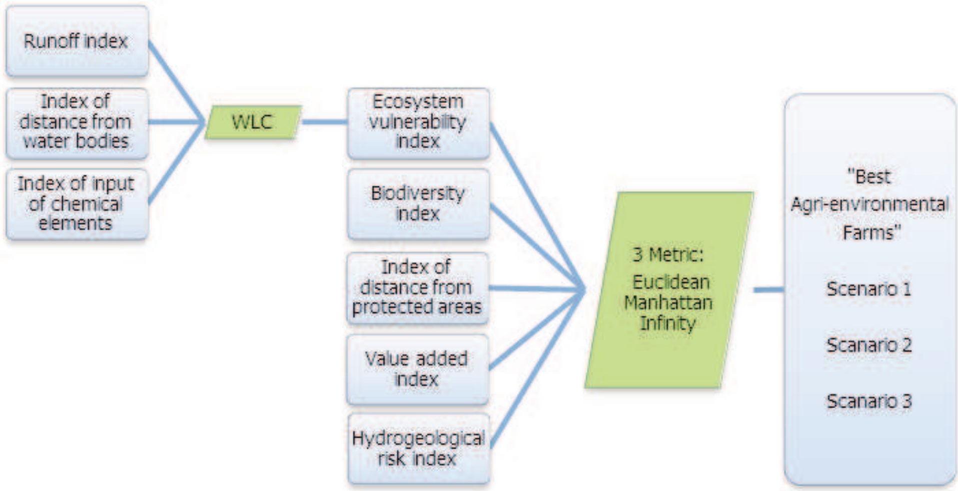
The literature is rich with works focused on the evaluation of agri-environmental measures with different approaches and levels of detail. Padel et al., Nicholas et al., De Maya et al., underline the complexity of agri-environment measures at national scale (Padel et al., 1999; Nicholas et al. 2006; Ruiz de Maya et al., 2011). At the regional scale Ministry of Agricultural, Food and Forestry Policies (Mipaaf) produces an annual report on intermediate evaluation of RDP. Romano (Romano, 2006) proposes the use of agri-environmental indicators to measure the impact of policies on the territory. Pagnotta et al. analyse if RDP objectives are coherent with the distribution of EU funds, with an analysis in Tuscany (Pagnotta et al., 2014).

Unlike previous works, the present paper is based on Spatial Multi-criteria Decision Analysis that combines Multi-criteria Decision Analysis (MCDM) with Geographical Information System (GIS).
Multi-criteria Decision Analysis (MCDM) is a methodology commonly used to support decision makers that have to face numerous and conflicting evaluations. MCDM aims at highlighting these conflicts and deriving a way to reach a compromise through a transparent process.
MCDM is based on two processes: Multi-Objective Decision Making (MODM) and Multi-Attribute Decision Making (MADM). The framework of Spatial Multi-criteria Decision Analysis is divided into 3 main fields, GIS field, MCDM field, and GIS-MCDM field. The latter combines GIS with and MCDM.
The GIS field represents the choice of decision problem where its "actors" (public or private administrations, stakeholders) define the goal; this phase relies on the available data.
The MCDM field is the core of the methodology allowing to choose the best alternative. Some Multi-Criteria rules are available for this purpose. These are divided into two main methods: compensatory methods and non-compensatory methods. The two methods are represented by an overlay process of compensatory or non-compensatory operators.
To determine the evaluation criteria (qualitative and quantitative factors in order to give a value to area or something else): each evaluation criteria must be associated to territorial entities and must appear in the thematic layers; the result is represented into a criteria map obtained after an overlay processes. Each criteria is represented by increasing or decreasing the values that show different measurement scales (most common is 0 to 1 scale). Stakeholders choices represent alternatives and are represented by pixel values (raster map) or point, line or polygon values (vector map) while constrains are represented by Boolean maps. GIS-MCDM field are represented by final maps, that it's the combination of the previous steps with MCDM rules.
Spatial Multi-criteria Analysis uses the potential of GIS to solve multi-criteria models in order to support decision-making in spatial planning processes and to get results that are easy to interpret (Malczewski 1999 and 2004). This methodology is appropriate for territorial analysis and is widely adopted in the literature (Van Der Merwe, 1997; Joerin et al., 2001; Lachassagne et al., 2001; Bernetti and Fagarazzi, 2002; Geneletti, 2003; Geneletti, 2010; Roetter et al., 2005; Malczewski, 2006; Baja et al., 2007; Bell et al., 2007; Karnatak et al., 2007).

Application Model

To define a structure of multi-criteria analysis, Malczewski (Malczewski, 1999) proposes a model by which the decision problem (in this case represented by the identification of farms deserving of agri-environmental funds in plausible scenarios for future programming RDP), is analyzed through alternatives (all organic farms and integrated in Tuscany), evaluated through economic and environmental objectives, and quantified by qualitative or quantitative indicators. Figure 6 shows the logical steps of the method adopted.

Figure 6. Indicators used



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The choice of the objectives and their quantification through multidimensional indicators

The quantification of organic and integrated farms in terms of economic and environmental aspect required an exam of Rural Development Plan's objectives (conservation of biodiversity in agro-ecosystem, reduction of exploitation and pollution of water resources, reduction of erosion and loss of soil fertility, conservation and landscape protection).

The aim was to define appropriate indicators able to express the degree of impact these farms have over the territory.

For this purpose the following indicators were selected :

7. runoff index;
8. index of distance from water bodies;
9. index of input of chemical elements;
10. ecosystem vulnerability index;
11. biodiversity index;
12. index of distance from protected areas;
13. value added index;
14. hydrogeological risk index.

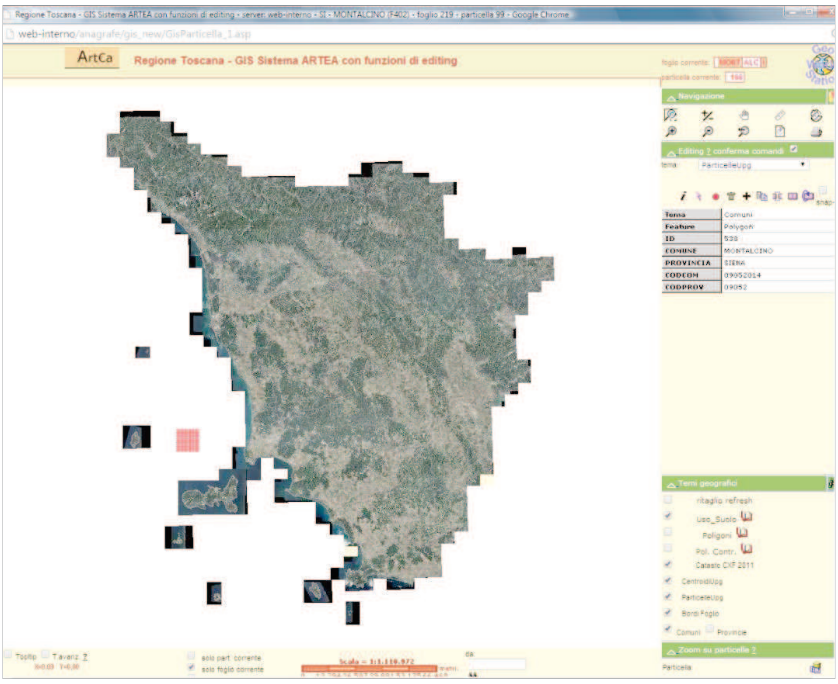
The following databases were used to obtain an archive of raster maps, with resolution 100x100 meters:

- *Database* ARTEA including information of farms that receive agro-environmental funds (214a1 "Organic farm" and 214a2 "Integrated Farm"). This was elaborated relying on the extraction of data from the ARTEA Information System (SI), integrated with details on corporate structure and their technical and economical characteristics;
- *Shapefile* ARTEA. Maps of areas under agri-environmental commitments with geo-referenced details (individual cadastral particles). Each farm receiving funds for measure 214a1 and 214a2, uniquely identified, have been linked to polygon data relating to land use. The values of cultures identified by photo-interpretation were extracted from ARTEA Information System - Tuscany Regional Agency for Agricultural

Payments (GIS ARTEA), (Figure 7, 8, 9). The data used were more than 1 million polygons and allowed to geo-reference all agri-environmental crops in Tuscany.

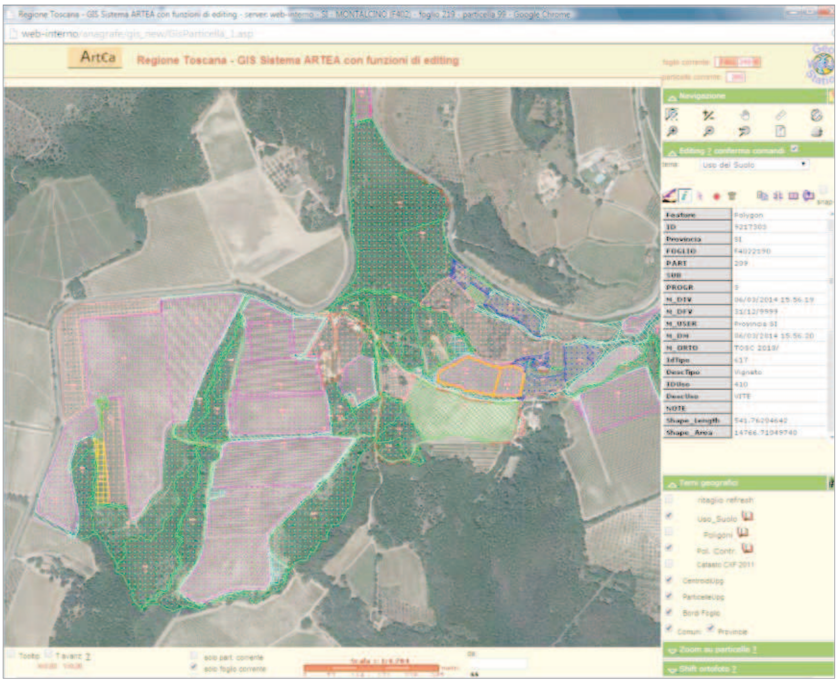
- VI° General Agricultural Census (ISTAT, 2013);
- Digital Terrain Model (DTM) of Tuscany

Figure 7. Orthophotos of Tuscany region - GIS ARTEA



Source: GIS ARTEA

Figure 8. Orthophotos of Tuscany region, land use (polygons)



Source: GIS ARTEA

Figure 9. Orthophotos of Tuscany region, land use (polygons)

Source: GIS ARTEA

Successively, for each indicator a raster cartography was produced as follows:

- map of permeability;
- map of distance from water bodies;
- map of chemical input;
- ecosystem vulnerability map;
- biodiversity map;
- map of distance from protected areas;
- value added map;
- map of hydrogeological risk.

Runoff index

The intensive agriculture has allowed crop increase, but also introduced many environmental problems, such as: loss of soil fertility, pollution of groundwater and surface water, increase in energy consumption, and loss of biodiversity. This current situation proved to be unsustainable.

The evaluation of service water drainage runoff is exhaustively developed in the literature (Asciuto et al., 1988; Corrado et al., 1988; Guo et al., 2001; Merlo and Croitoru, 2005; Baumann et al., 2007). Most of the scholars have worked on soil permeability, among which Simsek et al. who proposed an approach that takes into account the vulnerability of the groundwater contamination (Simsek et al., 2006).

To calculate the runoff related to exceptional events, "Kennessey method" was adopted (Kennessey, 1930). Through this method it is possible to classify a repository based on physiographic and climatic data.

From an ecological-environmental point of view and with regards to pollution, a high value of the runoff index (High *CK*) would guarantee a major land permeability, avoiding favoring groundwater contamination from chemical inputs used for agricultural activity.
Using three parameters, it is possible to calculate the average annual runoff coefficient or runoff index (*CK*) of the case study area (Equation 1):

$$CK = CA + CP + CV \qquad \text{Equation 1}$$

where
CK = annual runoff coefficient
CA = slope
CP = permeability
CV = land use

High *CK* values indicate elevated surface runoff, and low *CK* values indicate high values of deep infiltration.
The resulting values were standardized according to the aridity coefficient (Equation 2):

$$Ia = [P/(T+10) + 12\,p/t]/2 \qquad \text{Equation 2}$$

where
Ia = aridity index
P = annual average precipitation
T = annual average temperature
p = precipitation of driest month
t = temperature of driest month

Resulting values were subsequently processed into values between 0 and 1 (Table 1).
Results (Table 1) show a lower permeability for high values of *CK* (darker colors). It favors lower pollution of groundwater and of rivers. This is due to a reduced infiltration of polluting chemicals.

Table 1. Runoff coefficients

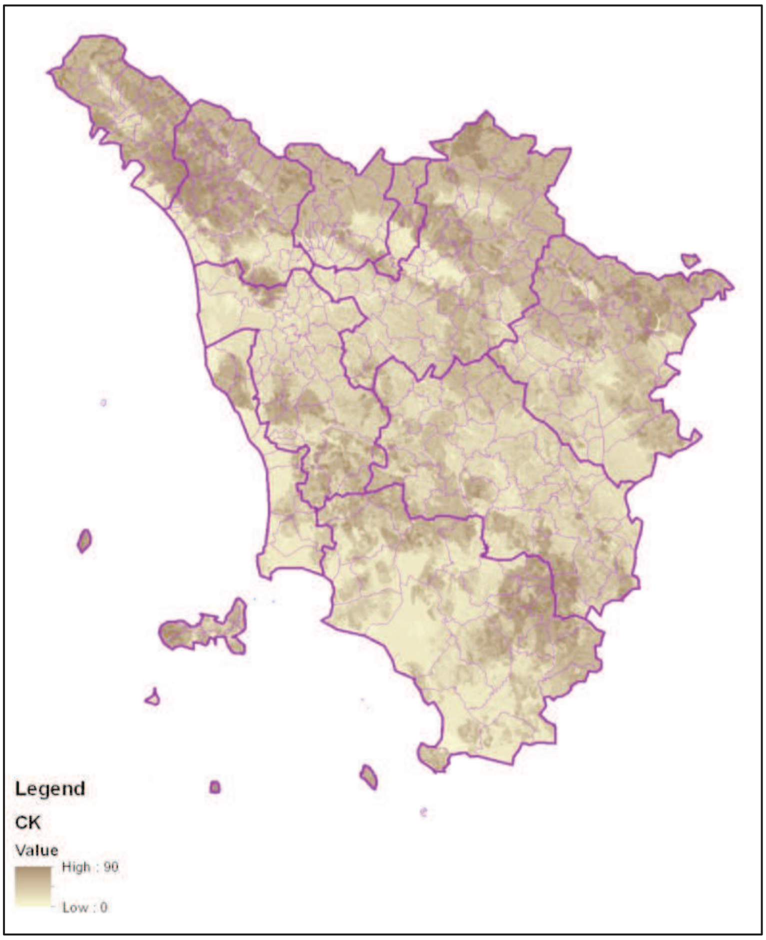
		Ia < 25	**25 ≤ Ia < 40**	**Ia ≥ 40**
		Permeability		
1	very low	0.21	0.26	0.30
2	low	0.16	0.21	0.25
3	average	0.12	0.16	0.20
4	high	0.06	0.08	0.10
5	very high	0.03	0.04	0.05
		Slope		
1	≥ 35%	0.22	0.26	0.30
2	10% ≤ s < 35%	0.12	0.16	0.20
3	3.5 ≤ s < 10%	0.01	0.03	0.05
4	≤ 3.5%	0.00	0.01	0.03

Table 1 (continues). Runoff coefficients

		Ia < 25	**25 ≤ Ia < 40**	**Ia ≥ 40**
		Land use		
1	Rocks	0.26	0.28	0.30
2	Pastures	0.17	0.21	0.25
3	Agricultural areas	0.07	0.11	0.15
4	Forest	0.03	0.04	0.05

Source: own elaboration

Figure 10. Map of permeability



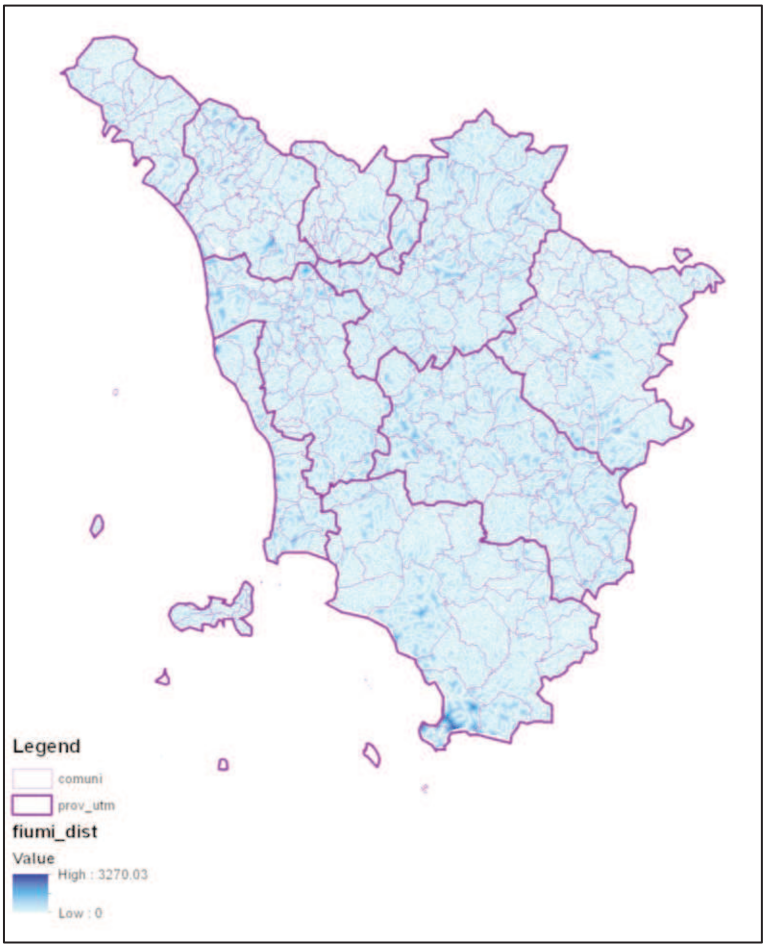
Source: own elaboration

The map shows that areas with a higher runoff index and increased water protection (dark color - *CK* = 90) are found mainly in hilly and mountainous region. Particularly affected are the provinces of northern Tuscany, Massa-Carrara, Lucca, Pistoia, the north of Florence, north-west of Arezzo's province on the borders with the Apennines, and the area of Mount Amiata in the province of Grosseto.

Index of distance from water bodies

Considering that agriculture, especially if practiced using conventional methods, affects the amount of pollution of water bodies, it is possible to underline that companies far from rivers tend to be a source of minor pollution. This is confirmed by several studies reviewed in the literature.

Figure 11. Map of distance from water bodies



Source: own elaboration

The use of agricultural land represents one of the principal reasons behind the contamination and habitat deterioration of European rivers (Davies et al., 2009). In this context agri-environment measures would reduce the negative effects of agricultural impact over water courses. Superficial contamination that does not include contamination of groundwater, has been the subject of numerous studies. Poole et al. (Poole et al., 2013), propose evaluating ecological efficiency of agri-environment measures with respect to distance between bodies of water (more distance, less pollution).

The map depicting the distance from bodies of water (Figure 11), was created by calculating the Euclidean distance (in meters) from water basins.

Darker colors represent a greater distance, and consequently the best situation (lowest pollution).

These values are evident in the southern part of the province of Arezzo, particularly in the towns of Arezzo, Castiglione Fiorentino, Cortona and in Valdichiana. The same occurs in the east part of the province of Siena, mainly in the towns of Colle di Val d'Elsa, Casole d'Elsa and Radicondoli.

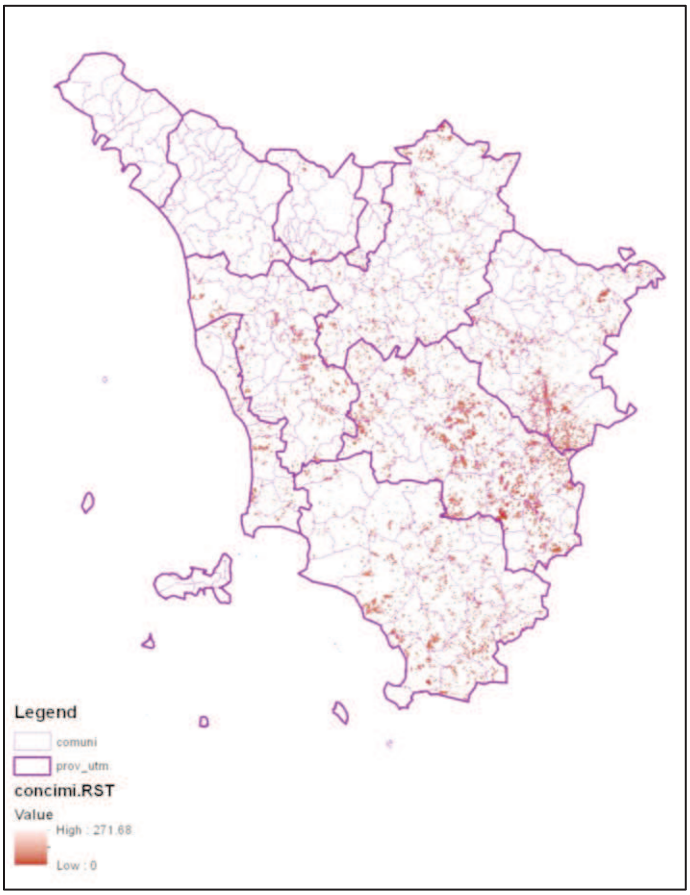
Additional areas, where a greater distance from bodies of water is clear, are found in the south of Grosseto's province, particularly in the towns of Massa Marittima, Grosseto and Orbetello.

Index of input of chemical elements

The objectives of an adequate fertilization are the fulfillment or maintenance of a vegetative-productive balance of crops, and the improvement of the chemical and physical soil characteristics, by avoiding an excessive input of nutrients and thereby protecting the quality of water bodies (Gomiero et al., 2011).

The map of chemical input (fertilizers, pesticides and herbicides) shows differences in contributions between conventional methods, integrated and organic; it was created starting with the analysis of payment justifications awards by the RDP related to agri-environmental funds, and included in Attachment 1 of Tuscany Region Rural Development Plan for period 2007/2013 (RDP 2007/2013 – version 8, December 2011) (REGIONE TOSCANA, 2011).

Figure 12. Maps of chemical inputs



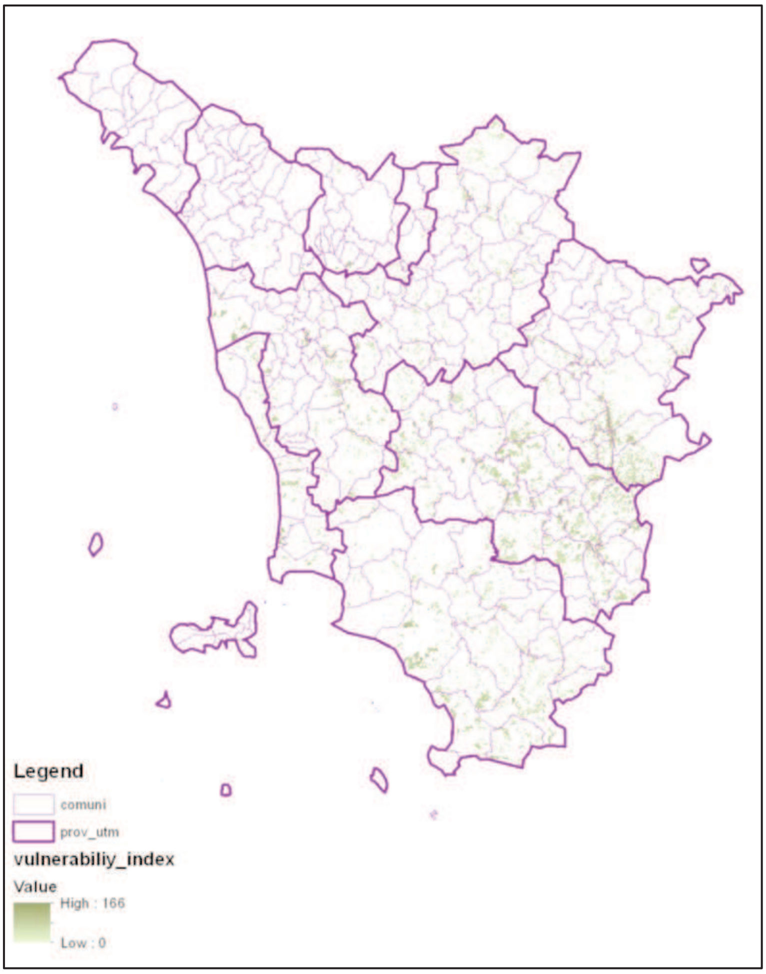
Source: own elaboration

The differences in chemical inputs, are expressed as lower quantity added and fewer treatments carried out, depending on three cultivation methods (organic, integrated, conventional): they were calculated using projected costs in income statements of different crops, and values of data sheets for technical and agronomic standards.
Darker colors (Figure 12) indicate a greater difference of chemical elements to soil (between conventional, integrated and organic farms): they represent the best results from environmental impact point of view.
Significant situations are mainly represented by organic farms, as compared to integrated farms. This is due to more stringent and constraining rules applied on organic farming, and in line with the principles of environmental protection and reduction of pollution characterizing the latter.
Areas with higher values, (farms with lower contribution of fertilizers, pesticides, and herbicides) are located in the province of Siena (municipalities of Sovicille, Monteroni d'Arbia, Asciano and Montepulciano). Also in the province of Arezzo, in the town of Arezzo, Marciano della Chiana. In the province of Grosseto, especially in the south, in the towns of Grosseto, Manciano, Capalbio, Magliano in Toscana and Orbetello.

Ecosystemic vulnerability index

The ecosystem vulnerability map was found by applying simplest additive aggregation method of Weighted Linear Combination (WLC) (Malczewski, 2000). Runoff index, index of distance from water bodies and index of chemical input were used.
Three maps were overlaid to obtain a final map showing the vulnerability of ecosystem (Figure 13). Raster cartography allows to highlight different areas, through the use of color scales.
Weighted Linear Combination (WLC) is one of methods allowing compensating and determining the value of each alternative, defined by pixels, as average value of each criterion multiplied by relevant constraints (Malczewski, 1999).
This method allows the evaluation of the layers to be combined to determine a single layer formed by the union of the other ones.
Darker values (Figure 13) are relative to organic and integrated farms with less impact on territory: these farms are mainly located on less permeable soils, far away from rivers, and providing smaller amounts of chemical inputs to the ground (maximum difference between inputs from conventional agriculture and inputs from biological/integrated agriculture).
Highest values in the map are present particularly over the entire province of Siena, especially in central areas, corresponding to the municipalities of Castelnuovo Berardenga, Asciano, Monteroni d 'Arbia and Buonconvento. Other areas with high values are located in the south part of Arezzo’s province, in Castiglione Fiorentino, Cortona and Foiano della Chiana.

Figure 13. Map of ecosystem vulnerability



Source: own elaboration

Biodiversity index

The biodiversity, guaranteed by high diversity of landscape, is considered as a fundamental value to be protected and secured, because it can also get the performance of other functions, such as maintenance of soil fertility and beauty of landscape, and erosion control. In order to analyze the biodiversity, an index that analyzes different composition of land use, using Shannon index was created (Equation 3).

$$S = -\sum_{j=1}^{s} p_j \cdot \log p_j \qquad \textit{Equation 3}$$

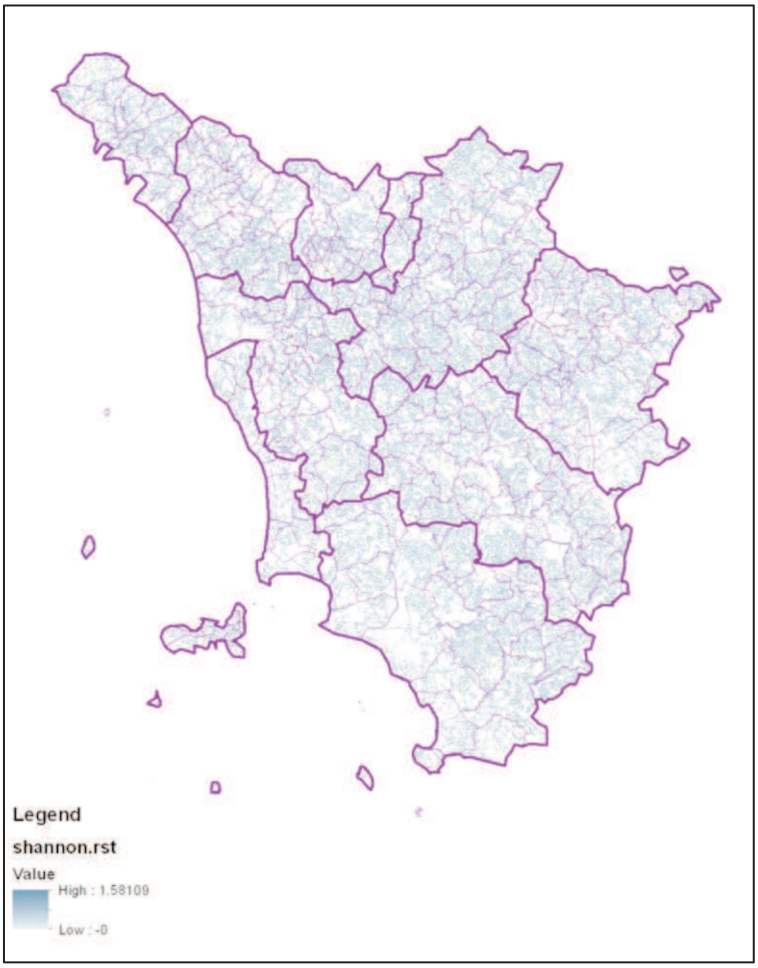
where

S = index of Shannon

p_j = areas occupied by use of soil *j-th*

s = number of land uses in affected area

Figure 14. Map of biodiversity



Source: own elaboration

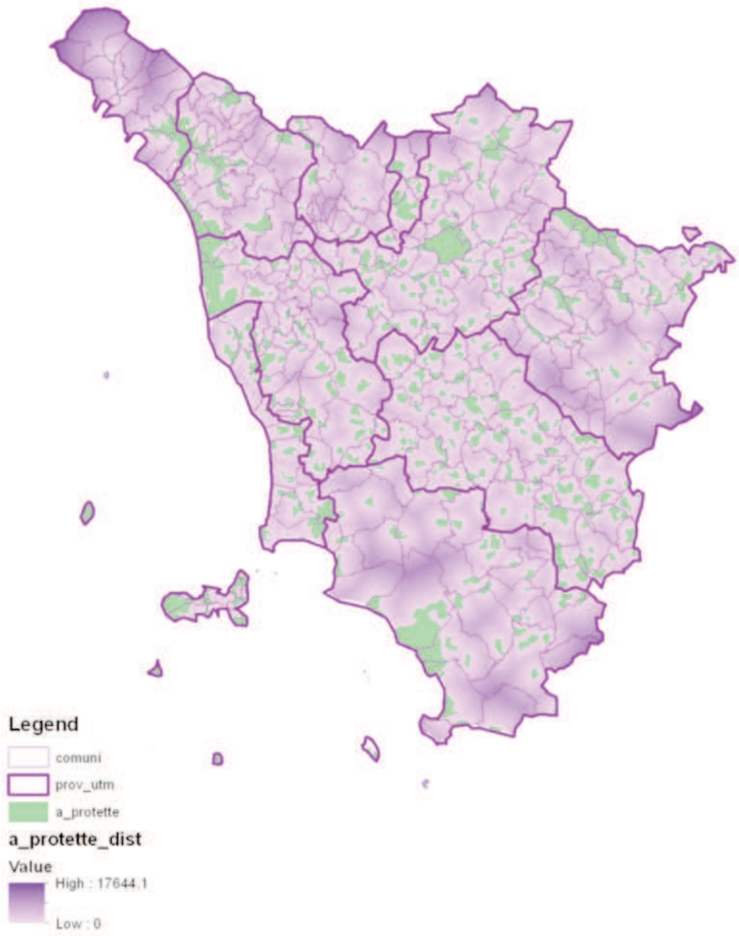
Corine Land Cover with area of 3x3 pixels was used.
Shannon index is the best known diversity index which represents one of the most used ways to synthesize information contained in the structure of a community animal or plant (Shannon, 1948).
Using it is possible to highlight areas the most heterogeneous according land use. A varied mosaic of different land uses guarantees the presence of a large number of species.
The results (Figure 14), show values from 0 to 1.58. The darkest value, represents the largest biodiversity of land use.

Index of distance from protected areas

Some studies take into consideration the way protected areas are managed with more restrictions, can affect on growth in unit costs of production, in marginal corporate structures for the yields, both for the position and the market (Marinelli and Bernetti, 1994).
The decision-maker is interested in enhancing the farms inside the protected areas or that are contiguous, selecting qualitatively the farms according to the distance.

Dataset provided by Tuscany Region, General Management, Government of the territory (Geographical Information System and Environmental), were used.

Figure 15. Map of distance from protected areas



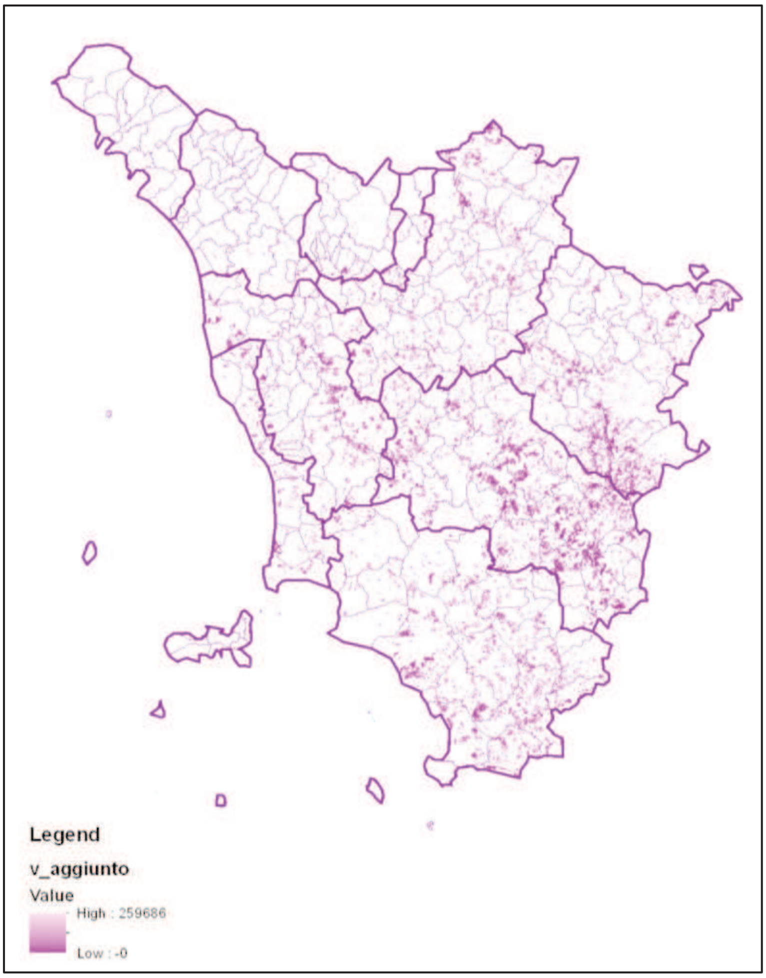
Source: own elaboration

The unit of the map (Figure 15) is in meters and refers to a specific distance from protected areas for each pixel.
Darker colors indicate greater distance from the protected areas. Values go from 0 Km, when the land fall within areas or are contiguous, up to more than 17 Km.

Value added index

The value added is the first margins of income statement that indicates how much revenue produces the characteristic management of a company. Policy Maker seeks to safeguard farms with a lower value, which requires support to avoid the risk of abandonment.
Business value added less is often connected to small farms with lower ability to produce income.
These companies may give up farming and territorial defense.

Figure 16. Map of added value



Source: own elaboration

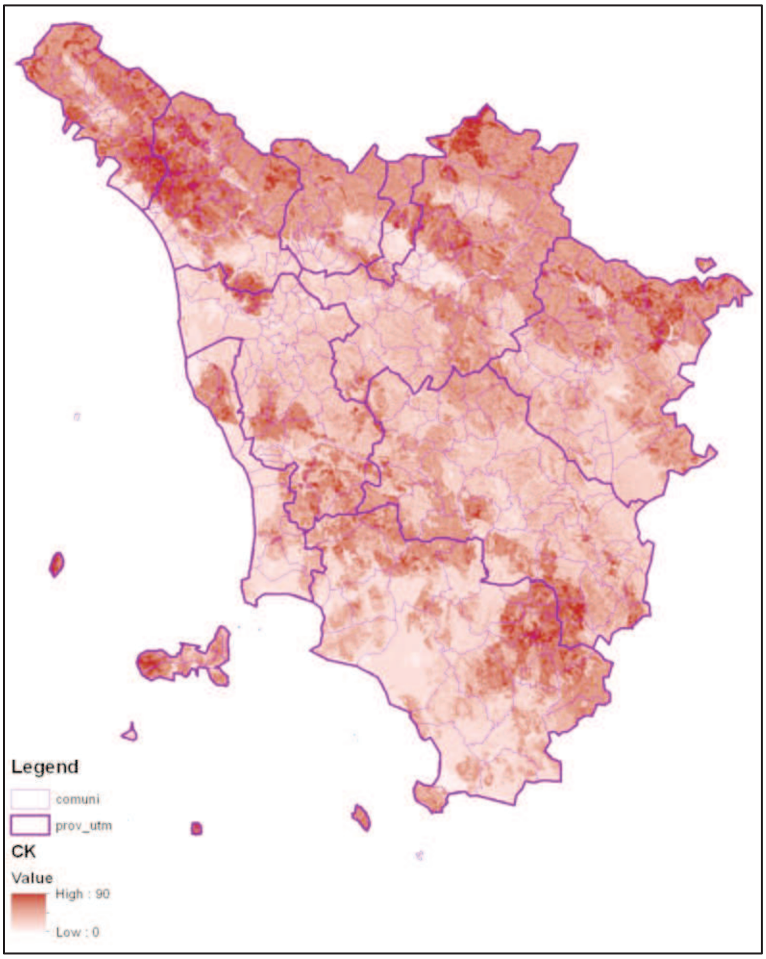
Policy Maker can know in advance which farms are more marginal, identifying them by income.
The added value was estimated by processing data for hectare and OTE (Technical Guidance Statement), as reported in RICA's database. The calculation was made after deduction of Community aid received (Casini and Scozzafava, 2013).
Dark pink value shows farms with lower value added. Almost all of agri-environment farms show a very low added value, with a more intense concentration in the province of Siena and Arezzo.

Hydrogeological risk index

In Tuscany hydrogeological instability is a tangible risk in all areas of hills and mountains, particularly the ones lacking vegetation.
Approximately, 65,000 hectares of cultivated areas have a slope of more than 15% (risk of erosions is consistent).
Tuscany has a lot of areas affected by hydrogeological instability, such as landslides and areas with widespread processes of soil erosion.

The calculation of the hydrogeological index allowed the creation of a risk map.
CK high = areas with lower permeability, with higher geological risk due to potential flooding due to low infiltration of surface water.
The map (Figure 17) shows a risk of soil erosion and hydrogeological on large parts of the cultivated area. High runoff index promotes a high geological risk.
In practice, to have impermeable soil does not promote infiltration of surface water which can lead to possible alluvial events.

Figure 17. Map of hydrogeological risk

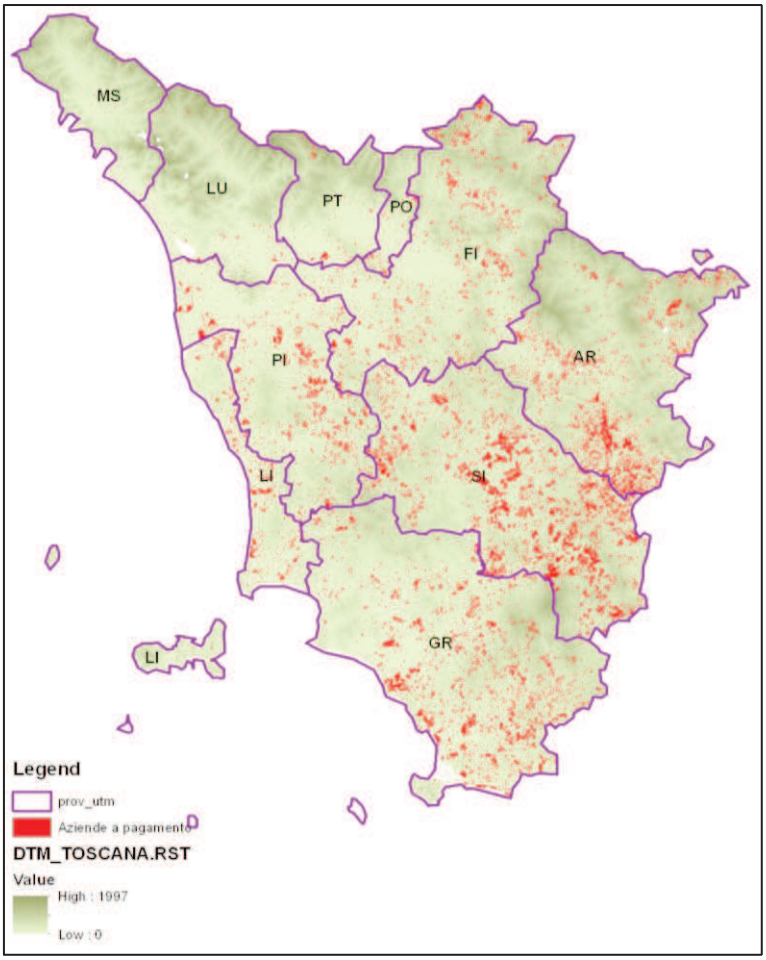


Source: own elaboration

Aggregation of the indicators

The aim is to create more thematic maps related to hypothetical scenarios of agri-environmental aids distribution in Tuscany, for future Community programs.
Decision-maker can make target selections with a high precision (farms level).
A possible scenario was created, where it was assumed a budget reduction of 50% of EU funding.
The first step was the geo-referencing of farms with payment for environmental measures of RDP 2007/2013 (Figure 18).

Figure 18. Map of Agro-environmental farms paid with RDP 2007-2013



Source: own elaboration

The map shows all farms (total of 5,013) that received funding from agri-environmental measure 214a1 "Organic Farming" and 214a2 "Integrated Agriculture", since 2007 (first year of RDP's implementation) to 2014 (last year).
To define the "best agri-environmental farms" from environmental perspective, located in Tuscany, indices were aggregated with multi-criteria rules based on three metrics (Euclidean, City-block and Infinite), and depending on the distance from '"ideal point".
Three hypothetical scenarios were created.
The "theory of ideal decision-making" (Yu, 1973; Zeleny, 1974) is based on the concept of ideal solution. That solution, which is located nearest to an ideal value, realizes simultaneously all criteria (objectives). The greater is the distance from an ideal value, the lower is the degree of satisfaction obtained.
The aim is to find the solution nearest to the greater well-being, minimizing the distance that separates it from the choice of the Decision Maker.
The calculation of the distance from the ideal situation, can be analyzed through various metrics, 3 of which were used in this study.
In Euclidean metric, the calculation can be solved through Pythagorean theorem using the following equation:

$$d=\sqrt{(x_b-x_a)^2+(y_b-y_a)^2}$$ *Equation 4*

where

d = distance from ideal of alternative

x_a, y_a = coordinates of point a

x_b, y_b = coordinates of point b

Another method is the method of Manhattan or the city-block distance (Equation 5)(Zeleny, 1982)

$$d_j=\sum_{1}^{n} v_{nj}$$ *Equation 5*

where

d_j = distance from ideal of the alternative j-th

v_{nj} = value of n-criterion of alternative j-th

Finally, the method that calculates distance with infinity or Chebychev metric.

$d_j = max\ v_{nj}$ *Equation 6*

where

d_j = distance from ideal of the alternative j-th

v_{nj} = value of n-criterion of alternative j-th

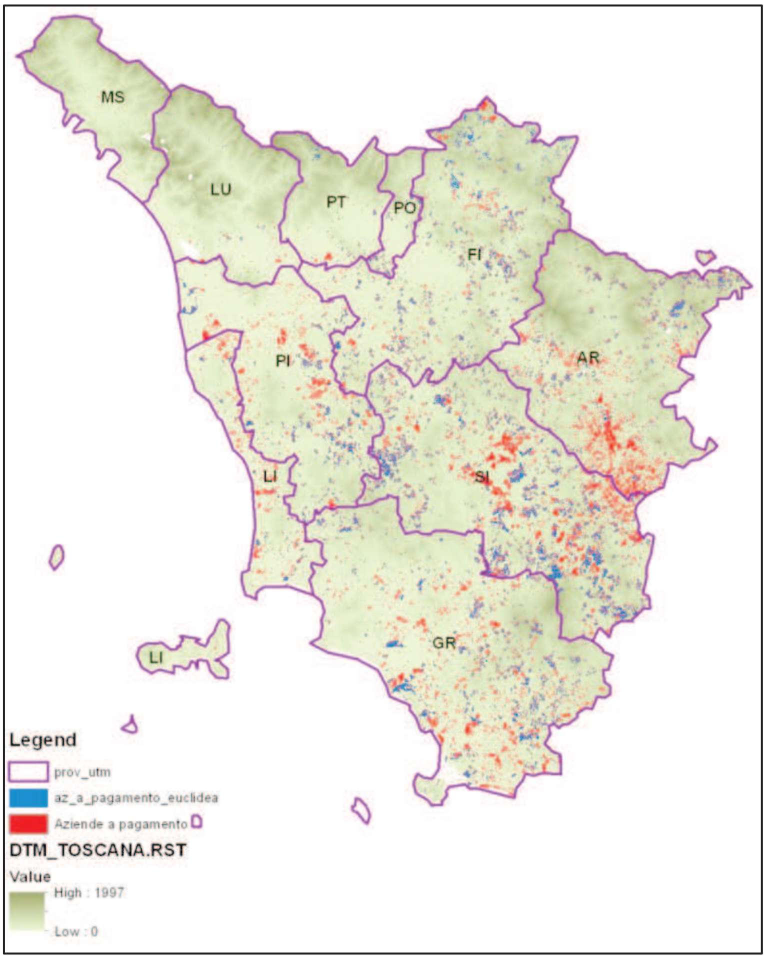
Results

By applying the 3 metrics to aggregate indicators 3 scenarios were obtained that are shown by maps of "best farms" and to be included in future RDP. Ideal farms have the greatest value for all goals. The Euclidean distance method and the Manhattan distance method are compensatory, with a low level reached by a criterion of an alternative date that may be offset by a higher level of another criterion. The infinity distance method is not compensatory, where low level of a criterion affects the final choice, because it is not offset by any high levels of other criteria.

Scenario 1, Euclidean metric

The number of the initial beneficiaries (5,013) represented the total number of beneficiaries from agri-environmental funding of RDP 2007-2013 who have joined agri-environmental contracts over a period beginning in 2007, until 2014.

Figure 19. Scenario 1



Source: own elaboration

Subsequently thanks to ARTEA's database, each beneficiary identified by CUAA (Unique Code Farm), has been linked to an amount of payments received for measures 214a1 (Organic Agriculture) and 214a2 (Integrated Agriculture).

The hypothesis of financial budget reduction was considered for agri-environmental funding. It established in a 50% decrease of total amounts allocated, the number of beneficiaries identified for "Scenario 1" (Euclidean metric), going from 5,013 initial farms, to 2,308, with 84,558.86 hectares under agri-environment commitment.

The map (Figure 19) shows significant changes between farms that have been entitled to agri-environmental funding of RDP 2007-2013, highlighted in red, and those who remain supported after the hypothesis of EU budget reduction, highlighted in blue.

The province with higher reduction is Arezzo, where almost all of the financed surfaces would disappear. The Province of Siena, would lose half of the surfaces. On the contrary the province of Firenze would be the one with a smaller decrease. The province with a higher reduction is Arezzo, where almost all of surfaces funded until now would disappear. The province of Siena, would lose half of its surfaces, while a smaller decrease will be experienced by the province of Florence.

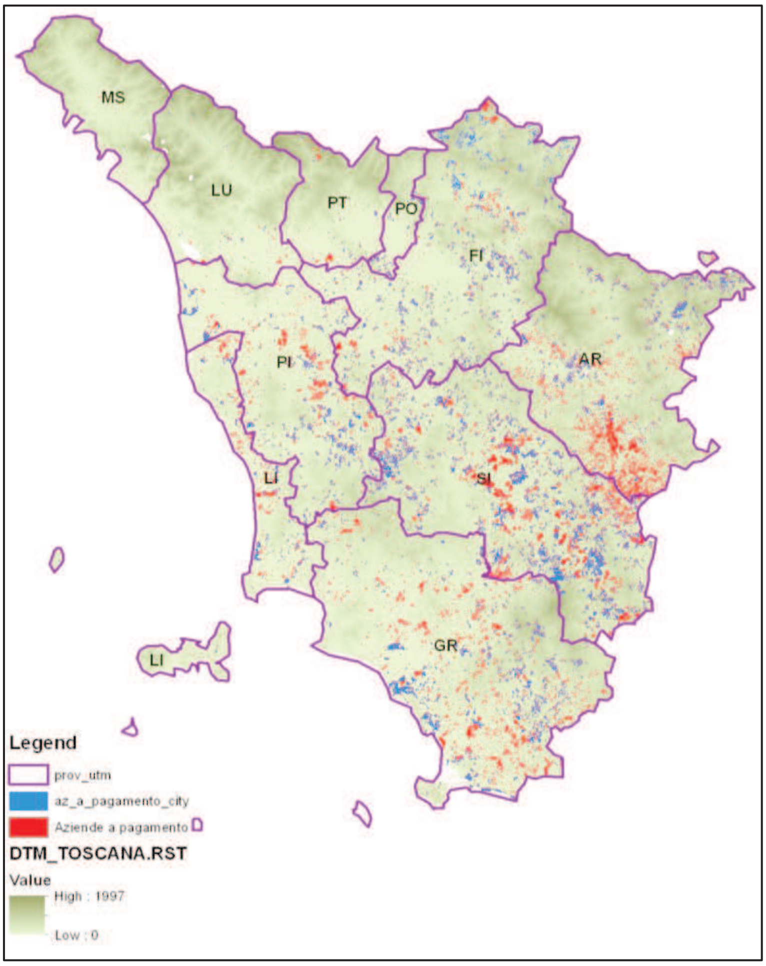
Scenario 2, city-block metric

In "Scenario 2", the number of beneficiaries identified using Manhattan's metric (city-block) was of 2,528 farms, with a total of 86,104.81 hectares of land under agri-environmental commitment.

Also here, the map (Figure 20) shows substantial changes.

The province of Arezzo, similarly to "Scenario1" has a more evident reduction. The province of Siena, would lose half of the surfaces, especially in its central-southern part. The province of Grosseto is highlighted by hypothetical reduction by half of surfaces, distributed throughout all area. In the province of Livorno, the reduction would affect most farms.

Figure 20. Scenario 2

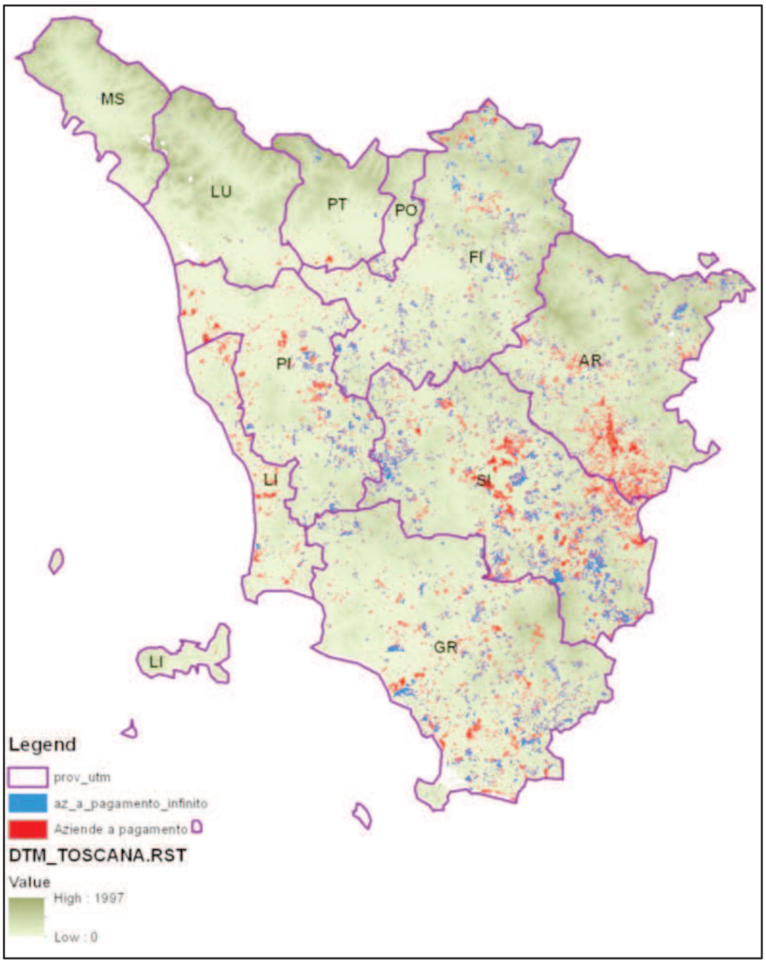


Source: own elaboration

Scenario 3, infinity metric

The results obtained with the infinity metric, show a total of 2,140 beneficiaries with 86,619.99 hectares.

Figure 21. Scenario 3



Source: own elaboration

Also, in the map of "Scenario 3", significant changes can be noticed (Figure 21). In the province of Arezzo the decline more marked, where both farms would disappear in the south and in the central area. In Siena's province, most of the agri-environmental area would disappear. The province of Grosseto, would be affected by a general reduction.

Analysis of 3 metric

The total amounts of expenses for 5,013 agri-environmental farms was € 35,494,773.07.
Taking into consideration the hypothesis formulated in this work, that considered a possible reduction of financial budget for agri-environmental payments (-50% of amount allocated), the total amount upon which a classification will be based according to three possible scenarios (calculated metrics distinct), is € 17,747,386.53.
Through the analysis of the outcomes of three metrics aggregation of indicators, it was possible to classify farms based on their environmental best attitude (Table 2).

Table 2. Numbers and amounts agri-enviromental farms according to 3 scenarios

Scenario	N. beneficiaries	Total amount (€)	Surfaces paid (hectares)
1- euclidean	2,308	17,731,221.81	84,558.86
2- city-block	2,528	17,746,119.75	86,104.81
3- infinity	2,140	17,742,314.09	86,619.99

Source: own elaboration

The results for the Euclidean distance, show a scenario with blurred signals. The number of beneficiaries identified has a result that is in the middle between the other two distances (2,308). This means that using this method, a reduction from 2,000 to 2,500 hectares of land with agri-environmental commitments, compared to the use of other metrics can be hypothesized.

The second scenario (city-block distance) shows some interesting results. The result shows a significantly higher value for the number of beneficiaries who would still get funding, However, concerning the surface area, a maximum value of commitment (in hectares) would be maintained.

Therefore, with these results we can assert that if Policy Maker, decide to use city-block distance, they might be able to fund, according to limits of hypothetical budget, a scenario formed by many farms with a small business size.

The results of the third scenario (infinite distance) show a very particular situation. In fact, the number of companies is the lower (2,140), but in contrast, the total areas under agri-environmental contract shows the greater value compared to all scenarios (86,619.99 hectares).

This last scenario could hypothesize a decision by Policy Maker, to direct funding towards few large companies.

Conclusions

The purpose of the research was to provide an analytical model adaptable to various local situations. The model would also be able to analyze the distribution and the impact of EU funding for measures of Rural Development Plan which provide surface aid.

The research has defined a suitable tool for effective assessments, with rapid use and very high spatial detail. Currently, from the methodological point of view, the assessment of agricultural policies effects, is often carried out with aggregate values (municipal level), generating interpretations not particularly defined.

The analytical model used is a Multi-criteria Geographical Analysis, through which multiple economic systems can evaluate environmental and territorial factor that can direct distribution of EU funding in examined areas.

Beneficiaries of agri-environment measures are rewarded for engaging in farming practices that provide more environmental benefit compared to conventional practices. They are paid for income losses and additional costs resulting from practices beyond mandatory requirements.

Therefore, the agri-environmental measures allow actions that provide a tangible improvement to environmental component in terms of agricultural quality.
However, these are difficult to assess, especially for their real effectiveness, because being complex, they constantly need more and more flexible evaluation tools.
In fact, their assessment is a key point in the justification of these actions which have granted significant financial resources. Looking at the past, often, compared with substantial resources invested, the expected results have not always been achieved.
By relying on GIS we have linked alphanumeric information of supported holdings, with geographic information relating to territory.
Companies adhering to agri-environmental contracts, frequently represent small farms located in marginal and hard lands, however that ensure a constant presence in territory.
Geo-referenced information is a strategic data for decision-maker that can program specific actions to limit damages caused by a possible abandonment of territories.
The possibility of using information originating from administrative sources (ARTEA - Agenzia Regionale Toscana per le Erogazioni in Agricoltura) allowed a complete reliability of results, coupled with in depth details.
Furthermore, using geo-referenced data referred to land-use of every farms represents also a high level of details.
Choosing companies "to be protected" by the Policy Maker, assumed in this work, allowed to select companies as the "best" in terms of achievement of some objectives (biodiversity, reduction of input chemicals, etc.) of RDP.
Assuming a possible financial budget reduction (-50% of amounts allocated for financing agri-environment), that might hypothetically occur in the next EU programming, three scenarios have been proposed in order to achieve a classification of agri-environmental farms.
Being able to make a targeted selection of beneficiaries in accordance with available resources, becomes very important when public resources are limited.
This study, which involved the use of three types of metrics for resolution of multi-criteria matrix (Euclidean distance method, City-block distance method, Infinity distance method), showed significantly different results.
The values obtained are changed according to the number of companies and hectares of UAA that remained interested by agri-environmental funding, leaving to Policy Maker a discretionary decision to maintain funding towards few large farms or to many small farms.
The methodology used will be a helpful tool to assist Policy Maker in their decisions during ex-ante, interim, and ex-post analysis, and also for new measures relating to the 2014-2020 EU program.

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