Chiara Mazzocchi[1], Guido Sali[1], Stefano Corsi[2], Fabio Villa[3]

[1] *Department of Agricultural and Environmental Sciences, University of Milan*
[2] *Department of Economics, Management and Quantitative Methods, University of Milan*
[3] *Department of Environmental Sciences, University of Milan-Bicocca*

E-mail: *chiara.mazzocchi1@unimi.it*
guido.sali@unimi.it
stefano.corsi@unimi.it
fabio.villa@unimb.it

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Land use change and agriculture role in managing green spaces: a methodology for land use change analyses

Land consumption is currently one of the major problems affecting green spaces, natural or agricultural. This issue is very important both for agricultural system functionality and, consequently, for its permanence. This paper proposes an analyzing tool of land use changes to support planning policies, in order to highlight the major determinants of land use that affect the permanence of agricultural activity. The case studies are Lodi, Milan and Monza Brianza Provinces, in Lombardy Region. One of the most important results are that exogenous variables, like population density or real estate value of residential buildings, are the most influencing agricultural land loss.

Introduction

Land consumption is currently one of the major problems affecting green spaces, natural or agricultural: both at European and global level urban expansion has become consistent and, in many cases, alarming. In Europe from the '50s to today's cities have expanded on average by 78%, while the population grew by only 33% (EEA, 2006). While decoupling between building and population growth may be due to changes in lifestyle (Heimlich and Anderson, 2001), on the other side public authorities hardly resort to rational and sustainable planning. But soil is a natural resource and nowadays its scarcity is one of the most important issues in European political debate and all over the world. Moreover, land agricultural availability is strictly linked to food security and to future perspectives in meeting the food needs (FAO, 2011).

In recent years both in all the Europe and more specifically in Italy, the land use change involved mainly rural areas where from 1990 to 2005 3,663,030 ha were lost (about 17% of the free surface recorded in 1990) with an average annual consumption of 244,000 ha (Emiliani, 2007). At regional scale, in recent years Lombardy is together with Veneto (Tempesta, 2008), one of the most built-up areas, with an increase of urbanized land of about 34,165 ha from 1999 to 2007, corresponding at a 11.3% of the total urbanized area of the Region (ERSAF, 2010). Lombardy is one of the most densely populated regions in Italy, although there are large differences between diverse areas:. scarcely populated areas in the moun-

tains and densely populated areas like Milan, classified by the OECD as the fifth most populous metropolitan area in Europe (OECD, 2006). Especially the peri-urban area of Milan is highly subject to land consumption due to the limited soil resources in comparison with the pressure of urbanization. The agricultural area surrounding a city is often more valuable for development, and agriculture is a low-profitability sector subject to gradual marginalization in comparison with other economic activities. This marginalization also affects the relationship between agricultural rent and rent resulting from land uses other than farming (Sali et al., 2013). Furthermore in recent years the problem of the change of use of land and the loss of agricultural land also affects not only peri-urban areas, as it was historically, but rural areas or rural deep areas. According to that the problem of agricultural land consumption is particularly considerable but the demand for regulatory policies remains unanswered, except for some rare initiatives. As regards the study of the land use phenomenon, although there are numerous studies in the literature the researches related to agricultural aspects are still scarce (Bernetti et al., 2006, Bernetti and Marinelli, 2010, Romano et al., 2013). The process of land use conversion is caused by different factors, both exogenous and endogenous to the agricultural sector, especially in peri-urban areas. In these areas, global exogenous factors, for example, urban pressure, encourage land conversion from agricultural to urban uses, while the structural weakness of agriculture enables easy conversion (Mazzocchi et al., 2014)

In fact, the farm competitiveness and the capacity to provide income is a necessary condition, although not sufficient, to the farm survival. The farm becomes a defense against land use changes: farms are among the few economic activities that preside the territory and govern it through their productive activities. Essentially they act as an obstacle, even a weak one, to urbanizing pressure. Which are the factors affecting the permanence of agriculture? This paper proposes an analyzing tool, the Sensitivity Index of Agricultural Land (SIAL),of land use changes to support planning policies, in order to highlight the major determinants of land use that affect the permanence of agricultural activity. The analysis is focused on farms and applied to the Lombardy case.

Data and methodology

As stated before, several factors influence agricultural activity, either favouring or hindering it. The factors that influence farm permanence may show the farmland sensitivity to land use change. In this study the goal is to analyze the effects of pressure factors on the agricultural system by using a complex farm scale indicator able to summarize multidimensional realities in a single tool (OECD, 2008, Gomez-Limòn and Sanchez Fernandez, 2010). The factors were been divided conceptually into two macro variables: "Farm structure", including the agricultural ones and "Relationships with the urban area", including the non agricultural ones. The agricultural variables summary the main strengths and weaknesses of farms and include:

a) Fragmentation of the farm area (F)
b) Economic Size Unit (ESU)
c) Multifunctional activities (M)
d) Total Agricultural Area (TAA)
e) Payments by CAP (P).
   The non agricultural variables define the relationship of the farm with the urban context and include:
f) Distance from the nearest urban area (DU)
g) Portion of farm property falling within protected areas (restrictions) (AP)
h) Residential density in the Municipality the farm belongs to (DA)
i) Average property value of residential property in the Municipality the farm belongs to (ARV).
   The fragmentation of the farm area is defined as the splitting of the property into smaller units that reduce the efficiency of the farm (Kalantari and Abdollahzadeh, 2008). The "breaking up" of the farm property creates numerous management problems: it implies greater distances to cover, loss of working hours, more difficult transportation of agricultural products (Bizimana et al., 2004). Moreover, it has been proven that fragmentation is inversely proportional to the distance from the city, which means that it probably occurs more frequently where the pressure of the built-up area is greater (Carrion-Flores and Irwin, 2004).
   The ESU express the business size of the farm. Multifunctionality is an activity of diversification that may represent a further revenue for the farm. In a peri-urban context, it also contributes to drawing the town population closer to rural areas, creating a network of consensus and relationships functional to the preservation of agriculture in the area.
   The TAA is represented by the farm agricultural area. The CAP (Common Agricultural Policy) subsidies are an additional income for the farm that benefits from them (Nickerson and Lynch, 2001, Key and Roberts, 2006, Shaik and Helmers, 2006). The distance from the town is defined in this paper as the average distance of the farm property from the closest city. This variable is used in the more important research projects in spatial models of land use conversion (Bell and Irwin, 2002; Carrion-Flores and Irwin, 2004), as it provides a relative measurement of the influence the urban area may have on its surrounding space. In fact, it is assumed that the smaller the distance from the city, the bigger the urban pressure on the farm property .As far as the AP variable is concerned, the restrictive tool provided by the farm property's falling within a protected area is a guarantee for the permanence of the farm in the area, because building is prohibited and therefore the choice of changing land use for building purpose is not viable. D is the population variable generally used to take into account anthropic pressure. Lastly, to measure the proneness to transformation of farmland into built-up land, the average value of residential buildings in the city the farm belongs to is employed (ARV).
   The construction of the indicator involved the weighting of the chosen variables (OCSE, 2008). For this purpose, the method of weighting in regression was used (Maggino, 2006; Mazzocchi et al., 2013). This method is based on a method of multiple regression created according to a dependent variable (**y**) and the set of

indicators selected, which perform the role of independent variables. The weight of the variables is calculated as the elasticity of the coefficients of the variables in the regression model. This method enables researchers to assess the actual incidence of variables on the examined phenomenon, validating the initial theory and the selection of variables made. For the aggregation of simple indicators, the linear approach was chosen, which is defined as:

$$CI_c = W_i I_{ic} \tag{1}$$

where n is the number of elementary indicators (variables)
CIc is the composite indicator for case c
Wi is the weight associated to the ith elementary indicator with i =1 and 0≤Wi≤1. In our case W_i is equivalent to the elasticity of the dependent variable in relation to each regressor.

The SIAL is managed through the Geographical Information System (GIS) which also enables researchers to obtain a cartographic representation of the results.

The data derived mainly from the Agricultural Information System of the Lombardy Region (SIARL), consisting of the data collected annually by the Region for the management of PAC contributions. The variable M was obtained from provincial databases on multifunctional farms. The ARV comes from Territory Agency data (2009). The variable DU is calculated by the use of GIS, as well as the variable F.

The chosen case studies are the Provinces of Milan and Monza Brianza and Lodi, in Lombardy Region: the first two are strongly urbanised (until 2008, this territory was the whole Province of Milan; the Province of Monza and Brianza has been established only in 2008), the third one is still quite rural, characterised by an intensive agricultural land use. The sample cover 2,969 farms of Milan and Monza Brianza Provinces and Lodi analysis is based on 979 farms.

We have chosen to analyze separately the two areas to highlight the different performance of the SIAL in geographically homogeneous contexts.

Results and discussion

Land consumption from 1999 to 2007 in the study area was used as the dependent variable in the regression model for the calculation of weighting coefficients. Each farm was associated with the degree of land consumption of the municipality in which it falls. For Milan and Monza Brianza Provinces correlation analysis shows that the variables more closely correlated to land consumption are: residential density (0.74), average value of properties (0.72) and, more narrowly, the average distance from the city, with a negative correlation of -0.1 (Tab 1.). For what concerns Lodi Province the variables most closely related to land loss are population density and average residential value, confirming the importance of non agricultural variables.

Table 1. Correlation analysis between Milano and Monza Brianza Provinces variables.

	ESU	P	M	DU	ARV	TAA	F	D	AP	CONS_AZ
ESU	1,000	0,571	0,105	0,047	0,003	0,090	0,009	-0,081	0,181	-0,016
P	0,493	1,000	0,104	0,026	0,024	0,079	0,003	-0,025	0,236	0,006
M	0,122	0,125	1,000	0,021	0,005	-0,028	0,004	0,007	0,123	0,005
DU	0,125	0,156	0,004	1,000	-0,076	-0,027	0,001	-0,212	0,077	-0,107
ARV	0,088	0,159	0,023	-0,149	1,000	0,070	-0,037	0,759	-0,015	0,716
TAA	0,122	0,129	-0,020	0,002	0,043	1,000	-0,015	0,074	-0,001	0,026
F	0,020	0,023	0,007	0,010	-0,025	-0,019	1,000	-0,023	0,004	-0,009
D	-0,042	0,035	0,014	-0,179	0,755	0,085	-0,027	1,000	-0,103	0,739
AP	0,196	0,240	0,128	0,094	0,006	0,008	0,007	-0,112	1,000	-0,012
CONS_AZ	0,021	0,064	0,013	-0,076	0,714	0,038	-0,005	0,742	-0,021	1,000

Table 2. Correlation analysis between Lodi Province variables.

	AP	DU	D	P	U	F	TAA	ARV	M	CONS_AZ
AP	1.000									
DU	0.144	1.000								
D	-0.064	-0.075	1.000							
P	0.043	-0.006	-0.096	1.000						
U	0.040	-0.009	-0.087	0.855	1.000					
F	0.025	0.081	-0.054	0.296	0.304	1.000				
TAA	0.073	0.124	-0.113	0.710	0.724	0.455	1.000			
ARV	-0.023	-0.060	0.727	-0.045	-0.024	-0.081	-0.031	1.000		
M	-0.015	-0.037	0.058	0.070	0.057	0.009	0.009	0.048	1.000	
CONS_AZ	-0.065	0.017	0.427	-0.042	-0.035	0.049	0.042	0.429	0.037	1.000

For Milan and Monza Brianza Provinces, the regression shows a not-statistically significance of four of the nine variables selected, M, P, F, ESU; for Lodi territory M, P, F are not statistically significant, and also DU. Regression results were performed only on the significant variables. The elasticity of the explanatory variables on the dependent variable was calculated; the effects on the dependent variable was used as weighted factors and introduced in the (1) formula .

A first result is referred to the surrounding areas of the city, in which a strong influence of the population density variable on land consumption is confirmed, as happens both in Milan surrounding area and in Monza city surrounding area (Fig. 1). In effect, high-density areas are usually harbingers of new urbanization

processes due to the residential demand expressed by a high population density (Mazzocchi et al., 2013). A similar phenomenon can also be observed in figure 2 with respect to the surrounding areas Lodi, despite the population density of the three major centers is very different.

Both for the two case studies ARV appears particularly significant confirming how the onset of urban rent is a dominant factor in guiding the transformation processes in a territory (Cavailhés et al., 2003). Thus, at least in a highly developed area, the urbanizing trend is greatly influenced by the closeness to built-up areas where property prices are higher, areas near to centers of attraction.

The difference in the regression significance of variables, with DU that hasn't statistically significance for Lodi area and ESU that hasn't it for Milan and Monza area, could be explained by the fact that in a more urbanized area, like those of Milan and Monza, DU is a crucial variable in terms of land use change, for the urbanizing pressure of built-up areas, while in more rural area, like Lodi, it assumes a smaller importance. At the opposite, in Lodi area ESU is statistically significant probably for the opposite phenomenon: urbanizing pressure is smaller than in

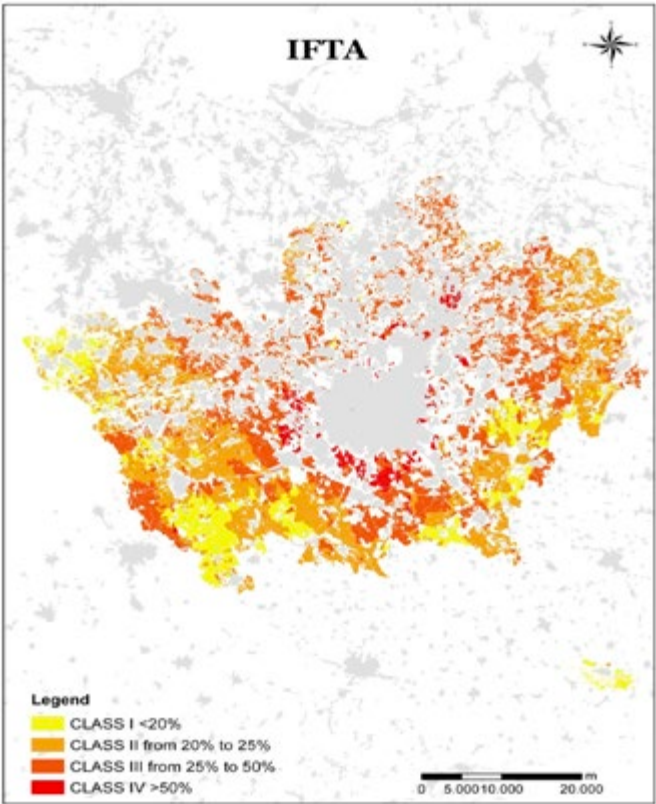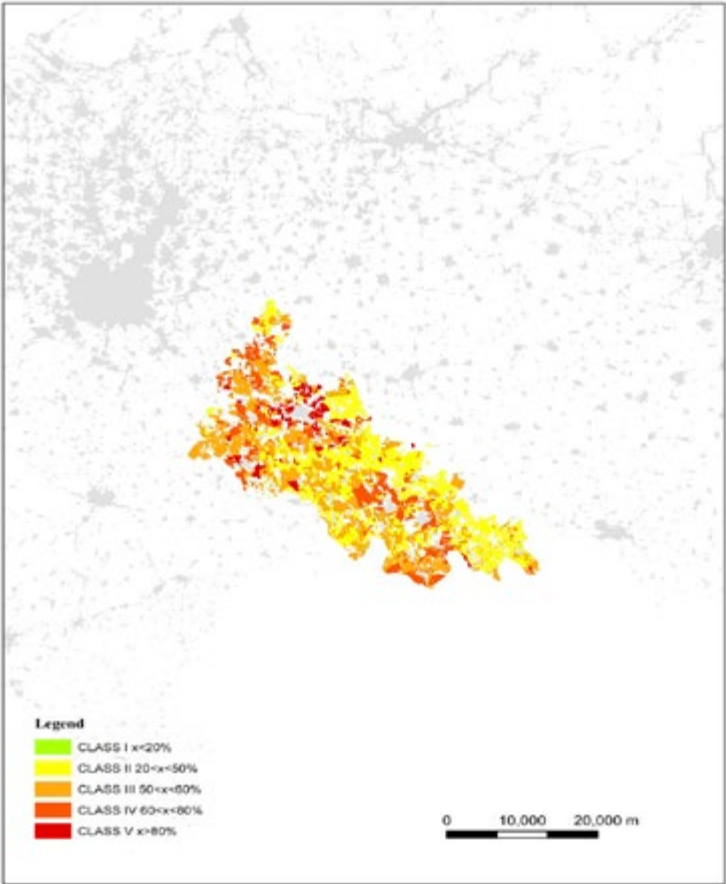Figure 1. Map of the indicator, Milan and Monza Provinces.

Figure 2. Map of the indicator, Lodi Province.

more densely areas, and an endogenous variable like ESU seems influences land consumption. The TAA in Milan and Monza e Brianza Provinces is negatively connected to land consumption: the relationship could suggest that more sizeable farm businesses work better than smaller ones as a tool against the advance of urbanization, possibly because they are stronger economically and less inclined to sell their land.

Maps 1 and 2 show the SIAL results for the Milan and Monza Brianza Provinces and Lodi Province, dividing farms into classes by the greater sensitivity of the agricultural land. The classes were determined based on the Jenks algorithm.

The effects of the variables were calculated for the average value of each variable.

Class I, in yellow or green, includes the farms that operate in an area with a minor risk of farmland loss, and class IV (Figure 1) or V (Figure 2), in red, includes the areas most exposed to the risk of farmland loss.

Essentially all of the farms falling within a highly sensitive agricultural area are located in the northern part of Province of Milan and Monza Brianza, while the farms belonging to class I are mainly located in the south and northwest. The geographical pattern observed here is based on a large centre of attraction, Milan, and a smaller one, Monza, as suggested by the two variables most related with the land consumption; therefore, the indicator is shifted towards the exogenous variables of the farm. Lodi Province clearly shows that the areas closest to the attraction centre of Milan suffer the influence of the city. As for the urban dense core of Milan also the agricultural parcels close to the urban center of Lodi show a higher fragility than the others. In particular it's possible to highlight that the eastern part of Lodi area shows a low sensitivity to land loss.

Conclusions

In conclusion, the model can be reproduced and can be a useful tool for policymakers to analyse and manage the territory. The link between permanence of agriculture, represented by the presence of active farms in the area, and land use planning, seems to be confirmed by the results of the model, that indicates the non agricultural factors as the most influencing land use conversion from agricultural to urban uses. From a methodological point of view the use of different variables in the two cases study represents a critical element of the present work that must be overcome in the near future also thanks to different models of weighing of the variables.

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