The Analysis of Rural Land Consumption through Areal Sampling Techniques

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Within the theoretical framework of analysing the patterns of change and current configurations of rural land-use, the present study aims to formulate a statistical area sampling methodology which can be applied on an inter-municipal scale to identify sample areas representative of the changes in landscape occurred over a given time span, particularly with respect to human-settlements and farming systems. Such a methodology makes it possible to obtain, from a detailed survey of the selected sample areas, results which can be extrapolated to the entire study area with a known degree of reliability.

Methodology

For the purposes of the present work, a target study area was chosen, known as the "Nuovo Circondario Imolese" (eastern part of the province of Bologna, Italy) in which the rural space has manifested notable landscape variations, particularly with reference to the post-World War II period. Based on the results of a critical analysis of the theoretical reference framework, a method for the stratified random sampling of the study area was worked out. The steps involved were the definition of an appropriate sampling frame, its stratification according to suitable criteria and variables, the extraction of the sample study areas, the investigation of the sample areas, and the inferential estimation of the parameters under study. The study area was subdivided along physical boundaries into the divisions adopted for the most recent population census (Istat, 2001). The landscape attributes chosen for the stratification were the current *land-use/land-cover* (Tassinari et al, 2007) and *land suitability for agricultural purpose* based on land capability (Klingebiel & Montgomery, 1961). The classes of the first variable are: urban land (class 1); arable crops (class 2); orchards, vineyards, vegetable gardens, plant nurseries, greenhouses (class 3); forest-pasture land, areas with sparse or absent vegetation, wetlands (class 4); water bodies and water courses (class 5). The classes of the second variable are: level land well suited for agricultural use (class a); level land less suited for agricultural use than class a areas (class b); hill-foot and hilly regions with an intermediate suitability for agricultural use (class c); hilly regions moderately suitable for agricultural use (class d); areas with low suitability for agricultural use (class e). The stratification of the study area is shown in figure 1a, where the numbers indicate the classes of land-use/land-cover, and the letters indicate the classes of land suitability. The area sampling methodology was calibrated with reference to the density of buildings (*building number density*, N_{bd}) and the proportion of the survey area occupied by buildings (*building cover density*, C_{bd}). The analysis of the aforesaid parameters was carried out in a GIS environment by a process of "backward updating" of vector databases (Tassinari and Torreggiani, 2006). The estimation procedure was carried out applying the developed statistical methodology over a significant time span: the period 1975-2005, corresponding to the more recent half of the period of interest for the research.

Results

The results of the study are represented by the stratification of the sample frame, the definition of the estimators of the parameters under study, the results of the surveys, and the inferential estimation of the parameters.

In particular, the variability of the parameters within each stratum was estimated on the basis of a pilot sample, selected with the method of permanent random numbers (Carfagna, 2007). The surveys conducted on the pilot sample corresponding to the results for the individual strata are shown in the histograms in figure 1b.

The parameter estimates obtained for the entire study area revealed an increase in the building number density of 16.9 buildings/km^2, corresponding to a 31% of the amount in 2005, and an increase in the building cover density of 5136 m^2/km^2, corresponding to a 44% of the density in 2005. The standard error evaluated on the entire sample was 2.7 buildings/km^2 for the parameter N_{bd} and 1229 m^2/km^2 for the parameter C_{bd}. Consequently, the confidence intervals computed for a significance level a of 5% were, respectively, 11.5–22.2 buildings/km^2 and 2590–7682 m^2/km^2.

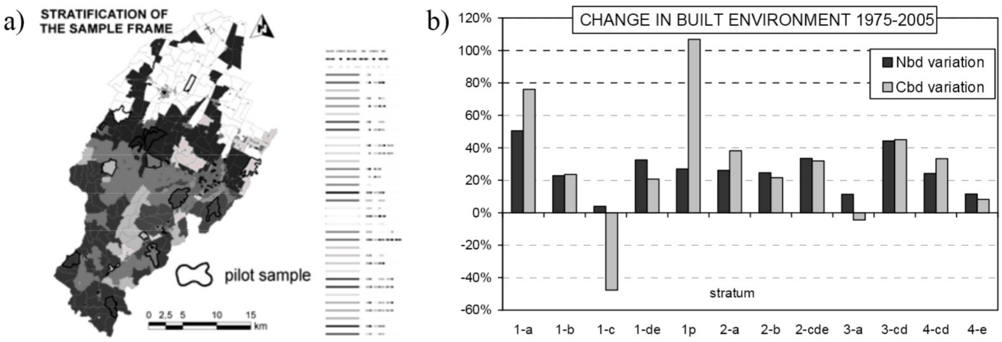

Figure 1. a) Map of the study area stratified, with the indication of the sample areas. b) Histogram of the relative variations of the studied parameters, referred to the values of 2005.

Conclusions

This work has led to the formulation of an analytical methodology, applied to a study area subdivided along physical boundaries, to extract a random stratified area sample for the purpose of assessing changes in the rural built system. The results showed that it is possible to estimate the changes in specific landscape features descriptive of land-use/land-cover patterns whilst significantly containing survey costs. The methodology, calibrated with reference to buildings, was used to extract and analyse a pilot sample of survey areas on the basis of specific statistical criteria. In future work, it should allow the precision of the estimates to be further refined by augmenting the size of the pilot sample to reach an optimum sample size, computed on the basis of descriptor parameters surveyed on the pilot sample and referenced to periods relevant to the study. The techniques adopted for the extraction of the sample also make it possible to optimise the efficiency of augmenting the sample size. The results confirmed the efficiency of the adopted sampling frame, with respect to a simple random sampling. The general validity of the developed methodology means it can be applied to a variety of landscape features, study areas and time intervals, following verification and, if necessary, redefinition of the stratification variables and the parameters under examination. Moreover, the broader theme of landscape change assessment calls for further consideration of the complex and manifold relations between the trends of the various natural and anthropic features, as well as the indepth study of cultural issues.

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