sous la direction de
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Villages et quartiers à risque d'abandon

Stratégies pour la connaissance, la valorisation et la restauration

TOME 1

FIRENZE UNIVERSITY PRESS

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Tome 2
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Tome 3
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Cultures pour la conservation et la valorisation du patrimoine à risque d'abandon en Maghreb et Moyen-Orient

Cultures pour la conservation et la valorisation du patrimoine à risque d'abandon en Italie

AGRI-INDUSTRIAL DYNAMICS AND SETTLEMENT HERITAGE AT RISK. THE CASE OF THE ALBENGA SUB-REGION

Giampiero Lombardini
Università degli studi di Genova-Italia

Densification processes of the settlement and rural areas (growth of greenhouse plants) in contemporary times - Source: GIS elaborations by the author of Liguria Region cartographic data.

The Albenga agricultural plain, together with the hilly territory of the valleys that converge into it, today is one of the most dynamic economic areas in Liguria. The long-standing tradition that has seen this peculiar regional area characterized by a strong agricultural component (competitive at national level and not only) has profoundly modified, starting from the post-war period, the settlement structures of the entire urban region, historically identifiable in the city of Albenga and in the settlements connected to it, as one of the most ancient Ligurian settlement environments. The intensive use of the land for agricultural purposes and then for productive and tertiary functions of the plain has determined the detriment of the more inland (in abandonment) valleys. Land take, conflicts in land use, environmental instability, abandonment of small inner villages, give back today the picture of a territory that is experiencing an environmental-settlement crisis that threatens the possibility of maintaining balanced economic and social arrangements. So, the urbanization and the agri-industrialization processes of recent decades has radically changed the original morphology of territorial systems. Recognize the traces of long-term urban form, first of all at a large scale (and then at the medium territoral scale), can help land planning actors in order to make settlements more sustainable and resilient. The aim of the paper is, in a fist step, to analyze the long-term urban plan for the territory of Albenga area. Settlements are analyzed together with the basic territorial structures that have generated them during the historic long period. The study starts from the diachronic reading of cycles of territorial development that have gradually formed the present settlement. The matrix elements that determine the shape of the settlements are, in the first instance, the paths and the plots (including land uses), detectable by comparing different historical maps. Subsequently the different built forms are classified into "morpho-territorial typologies". The representation of the settlement into different temporal stages is the result of processing carried out through the use of GIS and simulation models based on cellular automata and multi-agent systems. In a second step the contribution, starting from the the infra-regional scale, the contribution attempts a reconstruction of settlement dynamics during the period 1981-2020 which tends to highlight the constant loss of patrimonial value of the valley settlements (abandonment of the villages and shrinking of agricultural production areas, economic impoverishment of the most internal areas), is associated with an analysis of the local economic cycles which led to a transition from a condition of balanced polycentrism to a dissipative dispersion. The relationships that link economic dynamics (socio-economic production models), which in turn generate specific patterns of land uses and spatial configurations of the settlement constitutes the central nucleus of an infra-regional metabolic model centered on the assets and the risks associated with them.

Keywords: Settlement cycles, territorial heritage, risk, abandonment, regional modelling.

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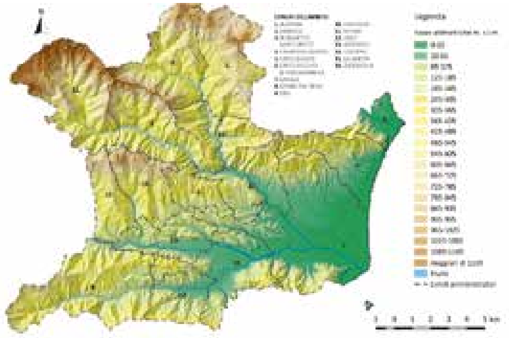
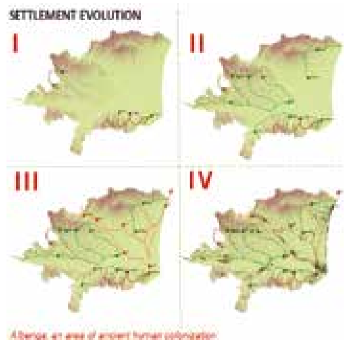




The Albenganese area (province of Savona) - Source: GIS elaborations by the author of Liguria Region cartographic data.

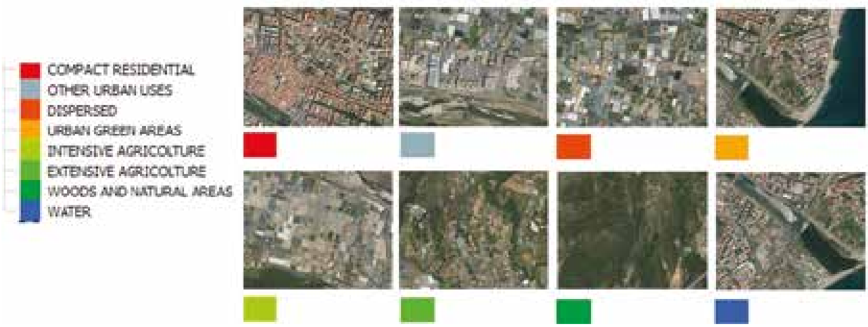
Territorialization cycles in the Albenganese area - Source: author's elaborations on Liguria Region cartographic data.

The study area: the Albenga valleys

The study area concerns a western region of Liguria (Albenga), characterized by the presence of an important coastal plain that was formed, from a geomorphological point of view, by the confluence of some mountain streams. It is one of the few flat areas in Liguria and its shape has influenced the forms of settlement over the centuries. The area is represented by the municipalities of the coastal cities and town of Albenga, Borghetto, Ceriale and the four valleys that make up the catchment area of the Centa river: the Lerrone valley, the Arroscia valley (limited to the Savona portion), the Pennavaira valley and the Neva valley. The four valleys have, within them, changing morphological and vegetational characters (Stringa, 1980): in particular, the latter aspect is closely connected to the exposure of the hilly slopes of the valleys. In fact, on the south-facing slopes there are crops, especially vines and olives; the northern slopes are characterized by chestnut woods or various essences. While the Lerrone and Arroscia valleys have wider and more inhabited landscapes, the Pennavaira and Neva valleys are wilder and with steeper slopes. The Lerrone valley rises from Villanova d'Albenga (where it joins the Arroscia valley) towards the Impero and Merula valleys (which it joins at the Ginestro pass), passing from the flat Villanova area to the hilly one of Garlenda and Casanova Lerrone. Most of the residential fabric is located on the south-facing slopes, as well as the most valuable crops of vines (especially in the municipality of Garlenda) and olive trees; on the north-facing slopes prevail the woods of various species such as oak, black hornbeam and ash, Aleppo pine and maritime pine, chestnut, as well as areas covered with tall scrub with strawberry trees and heather and shrubs with thorny broom and fragrant broom. In the portion of the Arroscia valley considered (limited to the Savona area), characterized by the presence of the municipalities of Ortovero, Onzo, Vendone and part of the municipality of Arnasco, the presence of man and agricultural activity is much more evident, however,

even here, in particular on the hilly slopes it is possible to find alternation of vineyards (especially in Ortovero) and olive groves with black hornbeam woods, various types of oak, maritime pine, black alder wood (riparian formation along the course of the stream). Unlike the wide and intensely inhabited landscapes of the Lerrone and Arroscia valleys, those of the Pennavaira and Neva valleys are very discontinuous, very steep and still wild. In the Pennavaira valley, in addition to olive groves and chestnut groves, there are woods of black hornbeam and ash, various types of oak, black alder wood.
Observing this territorial area, it can perceive the contrast between the agricultural environment of the flat area and that of the foothills and mountains. The territory of the district can in fact be divided according to three altimetry: the one between sea level and 50 meters above sea level, the one located between 50 and 150 meters above sea level and finally the real hilly and mountainous one. The flat portion of the area is located below 50 m above sea level, characterized by irrigated crops as well as by artifacts and structures deriving from the industrialization of agricultural activity, while between 50 and 150 m the foot-hilly area hilly, sees the dominance of the terraced territory with olive and vine crops. Above 150 meters, the hilly and mountainous landscape is mostly characterized by woods and bare rocks. One of the factors that unites the two areas is the presence of a strong pulverization of the agricultural property. A more in-depth analysis of the causes, which led to this fragmentation, highlights the substantial difference between the phenomenon in the two cases mentioned: in the plain, the agricultural division is the result of huge investments made on agricultural areas to intensify their exploitation (seizing the opportunities resulting from particularly favorable climatic conditions); in the hills and in the mountains, on the other hand, the physical component dominates, therefore the agricultural plot is obtained through the work of generations of farmers who cultivate the land even without obtaining surplus (except for olive and vine crops) and therefore coming to configure economies of mere family-based subsistence. These general conditions, the result of the symbiosis between man and the environment, also determine the characteristics of the settlement, organized according to two fundamental settlement typologies: the rural nucleus, composed of a fairly high number of dwellings (from 100 to 200) and with a rural area of rather large relevance characterized by a strong land splitting but by little or no presence of rural artefacts (except for small agricultural warehouses) and the agricultural 'villa', characterized by the unification of a few residential units within modest or very modest nuclei dimensions (with areas of agricultural relevance of much more modest size, characterized by terraced land arrangements consisting mostly of dry stone walls).

Both the land uses in the study are vector data and we've classified land uses into 8 categories.

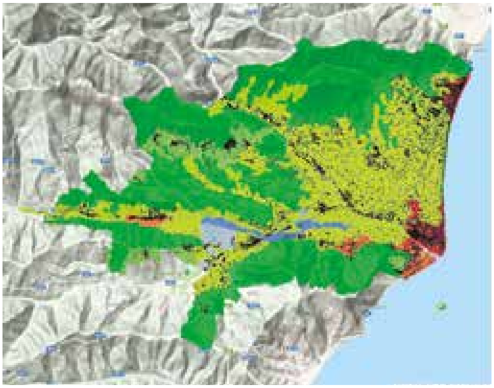


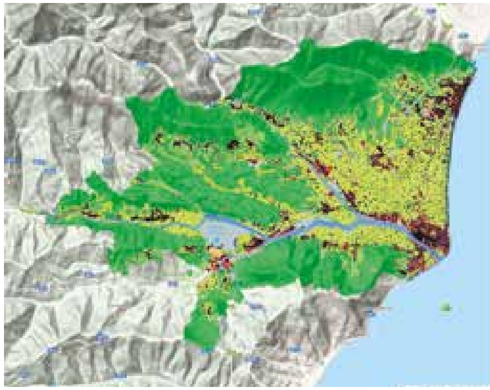
Land use changes 1992 -2015.

History of human occupation: the territorial cycles

The history of human occupation in the area is very ancient: if in Roman times the area had been characterized by an intense process of colonization (Albenga is a city of Roman foundation), the first settlements date back to at least a millennium prior to this phase. Subsequently, the lively agricultural and productive characteristics have been maintained and consolidated to this day.

The first phase of the settlement structure (3,000-2,000 years ago) is characterized by the presence of small residential areas on the hills, near the ridges (inhabited areas of the promontory). The second phase of the evolution of the settlements is characterized by the descent towards the valley of the settlements and the progressive occupation of the hills. This is the period in which large terraces are built for the cultivation of mainly olive trees but also, in this area, for horticultural products, fruit trees and, not rarely, arable land. It is the period (between 1000 and 1200) in which agricultural production consolidates and specializes. The paths that now descend from the ridges become valleys and intervals along the coast. The first long-distance foothills routes were also built. The third phase is characterized by the intensive occupation of the flat areas of the valleys. The agricultural structure now tends to occupy all the flat coastal areas and valleys, thanks to the drainage of the previously marshy areas and economically takes over the rest of the territory, to the detriment of the valley centers which are beginning to see important migratory flows towards the plains. and the coastal valley floors. The road network becomes dense and urban centers also increase in rank (population, markets, activities). In this period (1300-1950) a phase of organization of the territory also begins, which focuses on some new urban centers of foundation. The fourth phase coincides with the urbanization process of the modern era. Based on the settlement structures built in previous periods, agricultural activity becomes more and more intensive (industrialized agriculture)



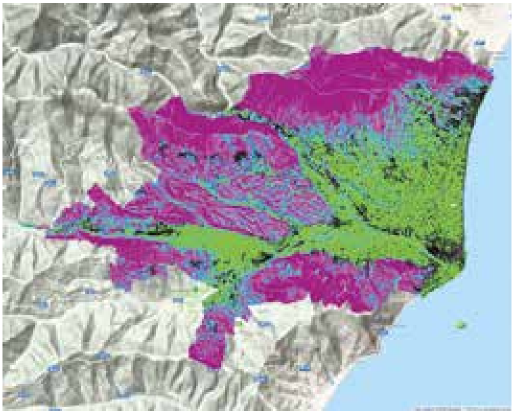


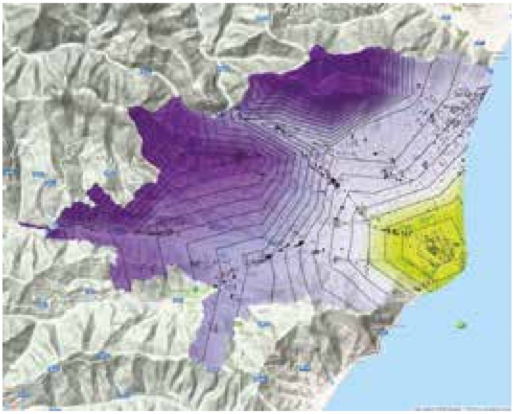
and this primary activity is flanked by various other functions such as trade and industry (mainly linked to the agro-food chain), which tend to occupy large areas with increasingly larger buildings.

As regards the period from the end of the Second World War to the present day, we can recognize two phases. The first phase of the modern era (1950-1975) is characterized by the strong presence of traditional agriculture conducted on small plots. Production is mainly concentrated on fruit and vegetables and the outlet market is mainly local. The other activities (which materialize in specific uses) are weak, with the exception of the residential function which emerges sharply during this period. The overall population is increasing (from 12,000 to 19,000 inhabitants). The second period (1975-1995) is characterized by a strong conversion of agricultural activity towards industrialized forms of production with large growth of greenhouse plants and specialized crops. Agricultural activities are now flanked by productive and commercial functions (which often compete with agricultural land) which tend to occupy large spaces, especially near main roads.

The quantitative growth of buildings continues. The population continues to increase, but at a slower rate: from 19,000 to 21,000 inhabitants. The third period (1995-2015) is characterized by a strong expansion of the tertiary sector, productive and commercial functions to the detriment of the rural area. More specialized agriculture resists and consolidates, but agriculture conducted in more extensive forms, on the one hand is replaced by new urban activities (increasingly widespread in the territory), on the other is subject to abandonment, with the consequent growth of forest and natural areas. The building development is remarkable and the population also continues to increase (from 21,000 to 23,000 inhabitants).

In contemporary times, therefore, the territorial structures (settlement fabric) are characterized by an increasingly accentuated post-metropolitan condition. The characteristics of



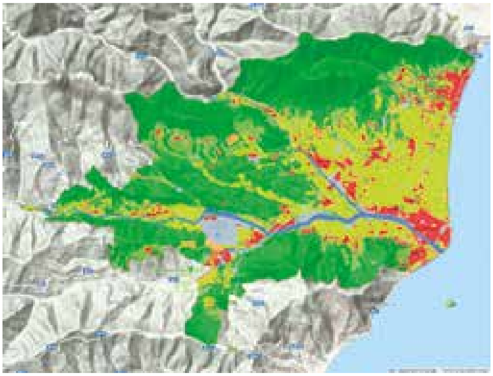


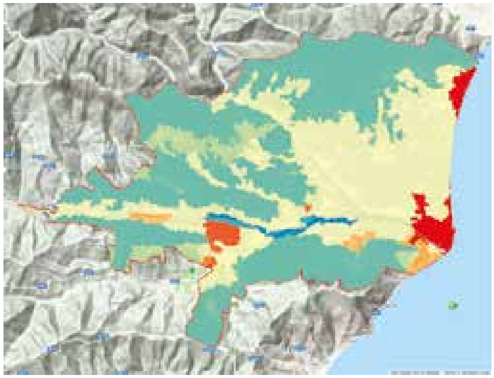
An example of two spatial variables (slope and accessibility).

Simulation model and land use changes projection.

this territory, as in other cases in Liguria and Italy, tend to be configured according to dynamics which, following the interpretation of E. Soja (2000), can be identified in a poly-nucleated urbanization, a substantial absence of dominant centers, a strong dispersion / diffusion phenomenon of the settlements, a constant fragmentation and segregation of land uses. The post-metropolitan territory (and the territory in general) can be read, in this case, as a succession of territorial settlement cycles. The material history of the territory is the history of the forms of its settlement and is not linear, but is characterized by cycles of innovation / consolidation, centralization / dispersion, occupation / abandonment, colonization / restructuring. Sometimes these settlement dynamics act simultaneously (they are synchronous), in other cases they alternate over time and differ in space (diachronic changes). The geographical space (the physical and morphological characteristics of the territory) conditions the different territorial cycles (especially the first cycles) which are always the result of an uncertain and unstable balance between population and environmental resources. The forms of settlement inherited from the past also condition future developments, sometimes placing themselves as constraints and sometimes as opportunities (reuse of previously modeled structures).

The post-metropolitan territory (and the territory in general) can be read as a succession of cycles of territorial settlement. The material history of the territory is the history of the forms of its settlement and is not linear, but it's characterized by cycles of innovation / consolidation, centralization / dispersion, employment / abandonment, colonization / restructuring. Sometimes these settlement dynamics act simultaneously (they are synchronous), in other cases they alternate over time and are differentiated in space (diachronic changes). The geographical space (the physical and morphological characteristics of the territory),





condition the different territorial cycles (above all the first cycles) that are always the result of an uncertain and unstable equilibrium between population and environmental resources. The forms of settlement inherited from the past also condition future developments, sometimes posing as constraints sometimes as opportunities (reuse of previously shaped structures).

Method for modeling land use changes

The most recent land use/cover change models are usually based on different empirical techniques (e.g., artificial neural networks, agent-based models, genetic algorithms) or statistical techniques (e.g., multi-criteria analysis, regression models) and underlying theories have significantly increased researcher's interest because they can (1) explore dynamic processes of the land use system; (2) build models of relationship among changes and spatial and non-spatial variables; (3) can make explicit the weight and the role that the different variables taken into account have in determining the changes in land use; (4) predict future land use development over space and time; (5) simulate trajectories of land use changes and feedback loops through the implementation of land use scenarios, and finally.

For the study of the succession of the different territorial cycles, the starting information base was constituted, by the analysis of changes in land use and land cover. Through the reading and analysis of variations in land use maps it is indeed possible to elaborate a description of the spatial structure of the settlement. The land use maps developed in this way are then the basis for developing simulations on possible future territorial structures. The method adopted allows to represent the dynamic settlement structure of a territory in an historic way, allowing to describe and observe the phenomena of centralization / dispersion, occupation / abandonment, colonization / restructuring.

Briefly, the workflow consists of the following steps:

Tab. 1
Spatial analysis of territorial cycles: steps of the proposed method.

Elaboration of data sets and land use and land cover maps in different time stages	Institutional open data maps, image interpretation of aerial photos, survey on site, GIS
Searching of the potential spatial variables	Spatial analysis thrugh GIS
Evaluation of the statistical correlation between land use change and explanatory spatial variables	Spatio - statistical indices: Pearson's correlation
Modeling the temporal transition rules between the different land use maps	Artificial Neural Network (ANN) (Multi-layer-perceptron)
Simulation of change through geosimulation methods	CA- Cellular Automata
Calibration and validation of the model results	CA- Cellular Automata

Tab. 2
Pearson's correlation among spatial variables.

Obtain landcover map for few time slices and a set of potential explanatory variables;
Calculate probabilities of transitions from class to class;
Build a model using ANN, logistic regression, Weights of evidence or Multi-criteria evaluation to describe transitions based on factor variables;
Use this model for forecasting;
Validate the result with real data.
More precisely, the proposed method consists of six processing steps:
A specific Plug-in of Qgis was used to model land use change: the so-called Molusce plugin. This plugin measures the percent of area change in a given year and provide transition matrix that shows the proportions of pixels changing from one land use/cover to another and the plugin carried out the area change map which present the change in the land, in our case staudy, from 1995 to 2015 in the 8 classes selected here. In order to run the simulation, MOLUSCE cam use Artificial Neural Network (ANN), Multi Criteria Evaluation (MCE), Weights of Evidence (WOE) and Logistic Regression (LR) methods. The result is to get a model of land use/cover transition potential. In this study it's been used the ANN method. A cellular-Automata Simulation was used in the plugin to forecast the change in land use based on the classified images. This model was based on previous change and not on any anthropogenic or natural processes.
In this study, the MOLUSCE was used to detect the change of land use between two period (1995 e 2015) and measure it by many variables such as slope, elevation, proximity to road network, accessibility. This study is also included a prediction of land use in the future, which is important to help urban planners in the process of decision making.

VARIABLES	Proximity	Accessibility	Slope	Elevation	Density	Form
Proximity road network	---	0,152	0,102	0,122	0,120	0,431
Accessibility to central city		---	0,507	0,613	0,537	0,356
Slope			---	0,635	0,372	0,238
Elevation				---	0,438	0,421
Settlement density					---	0,539
Settlement form						---

The data available for the period 1995-2015 allow us to calibrate a simulation model to realize some scenarios of possible transitions in land uses. Scenarios can be built starting from a definition of the main socio-economic trends (demographic, development potential of different economic sectors, development of innovative activities for the area - such as tourism -, the growth of alternative forms of agricultural production, such as those based on multi-functional agriculture.

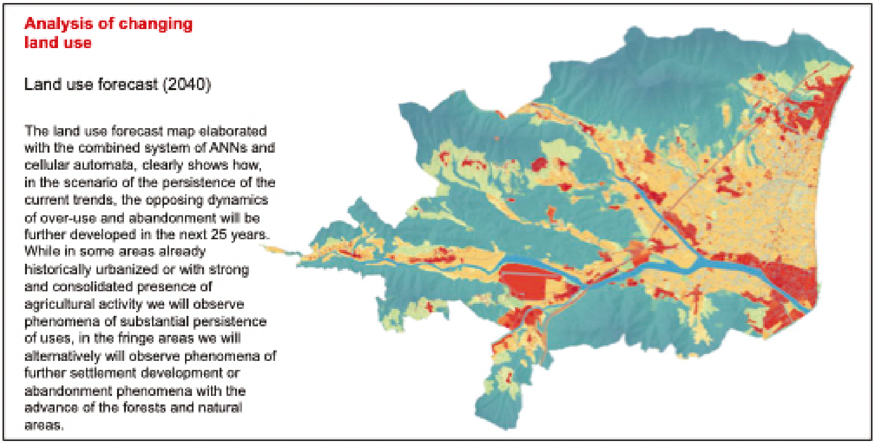
The main objective of the study is to examine land use and land cover (LULC) change between 1995 and 2015 and to estimate expected changes in the future. The specific aims are:

1. To detect change in LULC between 1995 and 2015 and the role of this change on morphological settlement evolution
2. To produce a change land use map of the study area and carry out a classification of morphological modifications "types";
3. To trains a model that predicts land use changes from past to present
4. To predict future land use changes derived from the model and the correlation with the spatial previously variables selected.
5. To use Cellular Automata simulation model to forecast change in land use.

The dynamics that can be considered to develop such territorial scenarios can be the following:

- conditioning and constraints induced by natural morphological conditions;
- current structure of the settlement;
- road network and its development potentials;
- planning system;
- accessibility with respect to the main service centers;
- general demographic dynamics;
- temporal projection of the different production sectors.

Land use forecast (2040).



Two land uses of study area were created using Qgis. Then a set of spatial variables were built. They have had to be maintained first in QGis to be the same pixel size, coordinate system and fixed scale (nominally 1:10.000). Then entire these data were put into MOLUSCE (a Plugin of Qgis developed by Asia Air Survey) that used to obtain land cover change map and to establish the trend of change for the study area.

Operational steps and simulation

The land uses were used in the study were vector data and classified into 8 categories: compact residential, other urban uses, dispersed settlement, urban green areas, intensive and extensive agriculture, forest and natural areas, water. Most of spatial variables were loaded in vector format, where the MOLUSCE deals with raster data. So, first thing was to convert all vector data to raster data to be able to deal with plugin. Other terms to deal with plugin is to set the same coordinate system for all layers. Applied resample process for all layers to determine the same pixel size, in this study the pixel size chosen is 5 x 5 mt.

1. 1° step - Inputs - Data preparing
   The initial (period 1: 1995) and final (period 2: 2015) land use/ land cover maps as well as spatial variables such as slope, road proximity, elevation, and settlement shape are loaded in the panel of spatial variables. The land use/ cover change information and the spatial variable are been used for modeling and simulating land use/ cover changes in area-studio. In this step, it was crucial checking geometry if all inputs matched (pixel dimension, coordinate systems, scale and so on).

2. Evaluation correlation

This step comprises three methods, namely the person's correlation, joint information uncertainty, and crammer's coefficient, which are used to check correlation among the spatial variables. The table 2 shows the correlation ratio between the five variables (slope, road proximity, elevation, built concentration and accessibility -isocrones-). It is noticed from the result that the slope and elevation layers are inversely related to the other variables, which are inversely affected. The roads often need an equal area in order to facilitate street construction. The other variables are linked by direct links.

3. Area change

In this tab, land use/ cover change and transition probabilities are computed. Also land use/ cover change map produced. The land use/ cover units have been expressed in hectares.

4. Transition potential modeling

The method for computing transitional potential map is Artificial Neural Network (ANN). This method uses land use/cover information and the spatial variable as inputs for calibrating and modeling land use / cover change. The resulting data show the correlation ratio between the six variables (slope, road proximity, elevation, built concentration and accessibility -isocrones-). It is noticed from the result that the slope and elevation layers are inversely related to the other variables, which are inversely affected. The roads often need an equal area in order to facilitate street construction. The other variables are linked by direct links.

5. Cellular Automata simulation

To build simulation maps, Molusce uses as a method of projection (among others) a neural network. In order to develop a network with adequate predictive capacity, it was necessary to train and test the ANN with different input data. Training involves presenting input values and adjusting the weights applied at each node according to the learning algorithm (e.g. back-propagation). ANNs were applied to the prediction of land use change in four phases: (1) design of the network and of inputs from 5 spatial variables and a spatial historical map; (2) network training using a subset of inputs; (3) testing of the neural network using the full data set of the inputs; and (4) using the information from the neural network to forecast changes. Transitional potential map, certaincy function, and simulated land use/ cover maps are generated under this process. The cellular automata approach is based on Monte Carlo algorithm.

6. Simulation

The MOLUSCE plug-in provides the tools to conduct an analysis of transformation potentials. In fact, starting from the change maps, the system "learns" through the ANN which are the highest probabilities, for each pixel, of permanence of the present land use or of its variation (and in which direction this variation might take place). The rules that are built through the ANNs consider the spatial variables that influence changes and their weight. Through other tools, such as multi-criteria analysis or logistic regression, we could also build different hypotheses of relevance (correlation) between the spatial variables considered and the process of change in land use. All these techniques can lead to a progressive refinement of the model's ability to predict potential future uses with an increasing accuracy.

Conclusions

The Land Transformation Model presented in this paper examines the relationship between 5 predictor spatial variables and land use changes. The model performs with a relatively high predictive ability (46%) at a resolution of 5x 5 mt. By developing 5 versions of the LTM, each with one of the variables removed, we could assess the relative contributions of each variable on model performance. Similarly, if we set up simulations according to a different set of (spatial) variables (one set for each scenario), we could obtain different forecast results, processing a real scenario analysis. A set of alternative scenarios could then form the basis for carrying out preferential analyzes with multi-criteria methods.
Using the ANN pattern file generated for the study area, we've applied the network file created from the control run to create a file with changing likelihood values for each location in the entire area. In order to obtain a reasonable result, we made several assumptions. First, we assumed that the pattern of each predictor variable remained constant beyond all the period. Spatial rules used to build the interactions between the predictor cells and potential locations for transition are assumed to be correct and constant over time. Third, the neural network itself was assumed to remain constant over time. Thus, the relative affect of each predictor variable is assumed to be stable. Finally, the amount of urban per capita undergoing a transition is assumed to be fixed over time. Given the availability of data (e.g. new roads, more temporal information about land use change and other variables), it is possible to relax many of these assumptions in order to examine the potential effect each of these assumptions have on the performance of model forecasts. In general, the simulation model is able to represent forms and dimensions of the change in land use and therefore the settlement structure of the area, highlighting what could be important trends in the near future, where the size of the dispersed settlement will go probably growing up.

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