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Saving Soil for Sustainable Land Use

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Abstract: This paper experiments with some costs-benefit analyses, seeking a balance between soil-take and buildability due to land policy and management. The activities have been carried out inside the MITO lab (Lab for Multimedia Information for Territorial Objects) of the Polytechnic University of Bari. Reports have been produced about the Southern Italian Apulia Region, which is rich in farmland and coastline, often invaded by construction, with a severe loss of nature, a degradation of the soil, landscape, and ecosystem services. A methodological approach to the assessment of sustainability of urban expansion related, on one hand, to "plus values" deriving from the transformation of urban fringes and, on the other hand to the analysis of the transition of land-use, with the aim of "saving soil" against urban sprawl. The loss of natural and agricultural surfaces due to the expanding artificial lands is an unsustainable character of urban development, especially in the manner in which it was carried out in past decades. We try to assess how plus value can be considered "unearned", and to understand if the "land value recapture" can compensate for the negative environmental effects of urban expansion. We measured the transition from farmlands and natural habitat to urbanization with the support of the use of some Geographic Information Systems (GIS) tools, in favor of a new artificial land cover in the region of Apulia, Southern Italy. Data have been collected at the regional scale and at the local level, producing information about land use change and increases of property values due to improvements, referring to the 258 municipalities of the region. Looking at the results of our measurements, we started an interpretation of the driving forces that favor the plus values due to the transition of land-use. Compensation, easements, recapture of plus value, and improvement are, nowadays in Italy, discussed as major land-policy tools for managing environmental and landscape preservation. The interplay between urban economics and environmentally sound regulations reveals some controversial issues in urban governance and nature preservation: perhaps some abstract regulations, conjoined with non-case-oriented urban policies, consider these keywords as the old chemists considered the Philosopher's Stone. The analyses show criticality emerging themes in emblematic cases, studied in some municipal contexts.

Keywords: sustainability; environmental evaluation; land use; soil sealing; soil take; land plus value recapture; matrix of transition

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1. Introduction

Soil is an important natural resource [1]. The Earth's surface works as the most important platform, by providing various functions for life [2]. A sustainable model of land management should pursue the right balance between economic development and ecological quality of our lives. A major danger for soil integrity is urban sprawl. Urban expansion comes in various forms and is linked to several urban dynamics. The growth of artificial soil causes a decrease of ecological functions accompanied by the rise of imperviousness or waterproofness [3]. When we plan our settlements, and when we manage our farmland, it should not be forgotten that soil is important for retaining biodiversity, and hydrological and biochemical balances, in order to pursue socially and environmentally sustainable development [4]. Actually, the current urbanization, with all of its dynamics, causes a deficit in the natural functions of our planet. For this reason, nowadays, scholars investigate the natural function of the soil by studying the ecosystem services that the soil provides, and try to find a balance between the ecosystem and economic activities on the Earth's surface [5]. We risk losing a piece of the natural water cycle, the outward chemical and pedological issues of the soil, or microorganism activities. Despite artificialization, this is due to the increase of some farmland or urban green parks and the absence of a negotiation between environmentally-oriented and economically-aware stakeholders [6]. In a few words, soil is both: the platform where economic activities find their connection with property and land transformation, and the platform that sustains the environment and provides, supports, and ensures ecosystem services [7]. The marginal increase of economic advantage often creates an unbalanced (as shown by Costanza et al. [8]) marginal loss of the ecological function of soils, in terms of climate regulation, biodiversity, erosion, and more. Such a lack of balance means that the plus value coming from the economic development of land is "unearned", as we will explain later. We can interpret, in some way, the interplay between the environment and land economics by looking at the change of soil surface and land uses [9].

1.1. Background

For a long time, planners and policy-makers, in the practice of planning and project appraisal, have tried to find relations between the assessments of environmental impacts with the estimate of economic effects of various models of urban development [10]. Due to the increasing concern about the preservation of land's natural function in recent years, new urban regulations have been tested in terms of reducing soil and environmental consumption, aiming to find a more correct balance between the dimension of urban sprawl and urban activities [11].

The first steps of town planning, practitioners turned towards environmental issues with some research programs in the 1970s, like the UNESCO-Program on "Man and Biosphere" (1971), and provided the introduction of the "ecological footprint", when researchers from Wageningen University found a way to link the loss of the natural environment with an indicator that became understandable not only for scholars, but also for common people [12]. In the 1990s, after the international conference in Rio de Janeiro, and the promotion of Agenda 21, the British "Town and Country Planning Association" and "Friend of the Heart" approached the problem in terms of urban planning, land use, property, transport, and energy, and published a well-known report [13]. On that occasion, Breheny emphasized the competitiveness of the "sustainable compact city", counterposed to urban sprawl. Some years after, the same Breheny started reflecting on feasible solutions to stop urban sprawl [14].

The assessment of soil take can be considered a further step for studies of this pioneering period: a measurement and a classification of land surfaces can describe the ecosystem services, the need for environmental resources can be described (as the ecological footprint is), and evaluation can provide a way of avoiding the dissipation of nature and soil in the planning process [15], by managing local models of urban development. Nowadays, we associate the physical soil take and urban sprawl with the idea of nature dissipation [16]. Imperviousness and artificialization of soil are mentioned as major causes of climate change, reduction of biodiversity, corruption of the landscape, and exposure to seismic and hydrological risks.

In the Italian context, the expansion of settlements interfering with the rural fringe of the city, the cultural rural landscape, and the coastline, represent a major criticality of soil take. Therefore, the most recent reports [17] provided by the Italian Higher Institute for Environmental Research (ISPRA), on artificialization of soil in Italy (dated 2015), approach all relevant forms of urban sprawl and infrastructure that are invading land. ISPRA especially underlines the impacts of waterproofness due to the continuous and massive occupation of the Italian coastline by settlements and infrastructure. Seasonal touristic settlements are considered a major cause of the loss of environmental and surface resources. The study of ISPRA reports that the ratio of waterproofing covers approximately 20% of the soil at less than 300 m from the coastline and approximately 15% of soil comprised between 300 and 1000 m from the coastline. Furthermore, ISPRA underlines, by a study on the hydrogeological risk in Italy [18], that the increase of imperviousness due to urban sprawl on the coastline is accompanied by hydrogeological vulnerability, coastal instability, and erosion in estuaries. A consequence of this is the depletion of the remarkable landscape heritage and ecosystem services. After coastlines, farmlands are the main victims of urban expansion [19]. The loss of farmland is associated with several issues, not only because of their ecological function. According to the UN Food and Agriculture Organization, since the beginning of the 1960s to the end of the 1990s, arable land and land under permanent crops in the world have increased by 155 million hectares to about 1.5 billion hectares. The main increase was in Latin America (over 50%). In the same period, the world population nearly doubled from 3.1 billion, to over 5.9 billion people. By implication, arable land per person declined from 0.43 ha in 1961–1963 to 0.26 ha in 1997–1999 [20]. The decline of arable lands and crops means a serious reduction of food supply in the world. Therefore, farmland preservation is important not only for guaranteeing a "filter-function" between heavy-artificial and natural environments, but also to ensure the product of its primary historic function of fighting against hunger.

Italy shows a medium-high population density and an amount of 0.4 hectares of farmland per capita (Table 1). It is clear that the high population density, with respect to the larger western countries, makes urban expansion a major question that should be managed in the best way. Even if the Italians are not the worst off among middle-high populated western developed countries, the current consistency of farmland does not guarantee the self-sustainability of the food supply for the Italian population. Even if the existing agri-food market and some derivative products (e.g., agricultural production for clothing, medicaments) benefit from positive trends, according to data provided by the Ministry of Agriculture, Italians lost approximately 20% of self-sustainment, due to the reduction of food production in 20 years.

Table 1. Hectares per capita of farmlands by country in 1996 (our elaboration from [21]).

Population Density		**Country**	**Ha Per Capita of Farmlands**
World Ranking Class	**People/km²**		
Low	3	Canada	2.14
Middle–low	30	United States	1.61
Medium	82	Spain	0.61
	100	France	0.57
Middle High	200	Italy	0.40
	260	U.K.	0.31
	400	The Netherlands	0.14

1.2. Aim of the Research

This paper reflects on both the ongoing and future steps of the investigation carried out in the observatory on saving soil at the MITO lab (Laboratory for Multimedia Information for Territorial Objects) of the Department of Civil Engineering and Architecture at Bari Polytechnic University. The main goal of our lab is to put into evidence the different modalities of land use connected with the environment and urban economics, by producing sets of data for open use [22] and free judgement on the Internet [23]. The application of geo-statistics models, until now, has not given unique interpretations; the current elaboration is based more on simple geoprocessing activities. The work, at the moment, aims to produce quali-quantitative analyses and open data on well-identified phenomena, such as the incidence of seasonal houses, and the use of extraordinary planning regulation in order to allow the birth of new settlements.

We consider that a first main step will be an attempt to identify those forms of land take that are more frequent in the context of study, and that have been generated by the thrust of land and property economics. The focus of our paper is, therefore, the analysis of the trade-offs between the loss of soil, having relevant environmental issues, and the driving forces coming from the property and construction market. Firstly, we produced a general reasoning about some spatial-economic indicators deriving from the analysis on land use transition, and then we tried to link this with the local economy. The study of land take and its detailed dynamics has already been presented in germinal studies oriented to profile and classify forms of urban sprawl [24]. A rough classification gave a better explanation of the never-ending pressures to expand a newly built environment, despite attempts to regenerate and re-use the existing one. Now, the aim of the research is to find a compromise between some easily evident property benefits existing in each local reality and unsustainable urban expansion. This attempt is exemplified by the analyses of some cases showing the inadequacy of some forms of betterment in planning.

2. Materials and Methods

2.1. Context of Study

The main area of our studies is the Region of Apulia (Figure 1) in the southern part of Italy.

Figure 1. In the figure the territory of Apulia is colored in red, on the southeastern coastline of Italy.

In the past, the main cause of urban expansion could have been identified with population growth. In the present, expansion is not easy to explain by direct connection with evident phenomena, such as demographic trends, at least for advanced western economies. In Italy and generally in Southern Europe, the new increasing trend is due to migration fluxes that do not always express a demand for new settlements [25]. Furthermore, housing stock is partially unutilized, or utilized only part-time. The quiescent housing stock denotes an inefficient balance between land take and environmental losses. The ineffective use of the existing offer of buildings is due to simple dynamics in the real estate market, where promoters look to new constructions that represent a more charitable occasion for a positive cost-benefit balance with respect to the rehabilitation of the existing stock. It still more convenient to buy new soil, than a built plot. The cost-benefit balance increases when moving towards urban perimeters where new plans involve an increase of land prices from some units of euros, to some tens or hundreds of euros per square meter.

The artificial surface at the regional scale in Apulia is less than 9%. We can look at two indicators describing the waste of soil and of built stock and, even better, the variation: the percentage of unoccupied housing stock as a whole, and the quantity of artificial soil per inhabitant. Unoccupied house stock are usually relevant near the coastline and in the interior mountain areas. The first is connected to the seasonal residential activity on the coast and in that part of the countryside that maintains farmlands of great landscape value. The second aspect is related, more generally, to a set of urban policies that favor the expansion of the external urban fringe.

Apulia has a great number of farms among Italian regions: its regional gross product coming from agriculture is relevant, and it has the highest olive and oil production. The oil product of Apulia represents, more or less, one quarter of the national production (370,000 hectares of olive groves, with a production of 800,000 tons in 2014). Grape production, as well, is relevant in the national panorama: the total product is about 1,833,600 tons (in 2011) and occupies 131,077 hectares. The farmland retains most of the landscape value. The regional territory is extended for more than 1,330,000 hectares, with only 1.5% being occupied by mountain, 43% hillside, and 55% flat land (Figure 2). Apulia was the first Italian region to approve the Regional Landscape Plan (RLP) conforming to the new Italian law on the preservation of cultural heritage (Act no. 47/2004) where farmlands having historical or landscape value have been preserved since 2015.

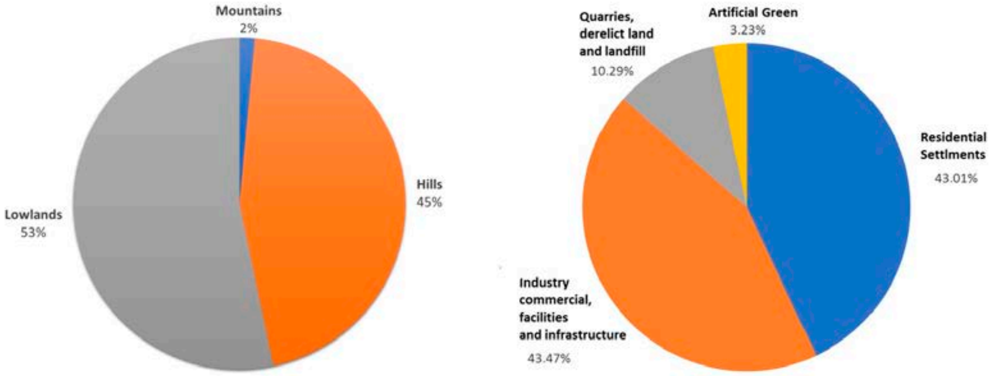


Figure 2. Distribution of elevation class and artificial coverage in Apulia.

In the countryside, the flat farmlands of "Capitanata" in the County of Foggia, the Murgia Highland, the Itrian Valley, and the Ionian Ravines show one kind of landscape where farmlands, urban settlements, and natural resources still maintain a balance. The rural landscape is made interesting by the appearance of typical constructions made of limestone. The Itrian Valley, in a special way, is one of the most important examples of these landscapes. Inside the Itrian Valley, is "settled farmland" (as it is called in the RLP), i.e., in the countryside, rural settlements are at the lowest density level, and agro-industry activities are well balanced with the traditional rural ones. Such types of farmland occupy a strainer-area between the countryside and the city. The peculiarity of settled farmland in the Itrian Valley is represented by the existence of special stone-made constructions named "Trulli". Trulli consist of a circular plant and a conic roof, and are built by hand-placed limestone, sometimes linked by plaster and tufa-made mortar. Due to the peculiarity of the landscape, the countryside of the Itrian Valley is suffering because of urban sprawl, which is due to the wish of its own inhabitants to spend the summer in the rural environments. The Itrian Valley is in the central part of the Apulian region, and its greater urban center, Martina Franca, is located in the countryside in a triangle surrounded by the cities of Taranto, Bari, and Brindisi.

At the same time, Apulia contains the largest coastline among Italian regions (about 784 km, 12% of the whole Italian coastline). The most populated settlements are on the coastline, alternating with rocky coast and sandy beach. Apulia, since it contains the most relevant coast in Italy, sees quite a relevant coastal invasion. The economy of sea fruition in Apulia has been characterized since the end of the 1970s, and the model of the single-family seasonal household was spread along the Apulian coast. It corresponds to the easiest way to build—with low-technological characters, and costs—touristic lodgments. Many pieces of the coast retain a high value of landscape and biodiversity, but are being spoiled by the economic demand for building new touristic settlements. The coastal municipalities cover about 30% of the extents of Apulia. The artificialization of soil between 2006 and 2011 has been near 35% of the whole region. Sixty-five percent of the coast is considered in the Regional Landscape Plan as a major piece of the "Core Areas for the Ecological Network for Biodiversity" and, therefore, is subject to primary protection. Despite this, in Apulia, a wide demand of coastal seasonal settlements concern land use and urban plans. The phenomenon has been a growing trend over the last decades due to the increase in the tourism flows. In Apulia, Salento is the most emblematic example [24,26]. According to the National Institute of Statistics (ISTAT), in 2014, approximately four million tourists showed some daily presence in Salento [27].

The Salento coast represents the tourist area of major interest with predominantly receptive systems composed of hotels, residences, guest houses, and bed and breakfasts. Salento is the location where we discover some of the highest proportions of land consumption due, mainly, to unauthorized housing.

2.2. Institutional Background

An important role in the evolution of soil take in Apulia (and all over Italy) is due to the regulations and laws that allow a fast increase of artificial soil, in favor of new urban expansion, based on formal acknowledgements between territorial institutions (state, region, and municipalities, depending on the case), despite the existing environment-concerned local planning regulations. Since the beginning of the 1970s, the Italian government has produced new institutional tools, aiming at ensuring the offer of soil for new industrial activities, in order to locate increasing labor forces or for new residential settlements in favor of the demand of popular housing. There was a period of migration towards northern cities and, generally, from small towns to larger metropolitan areas. The exploitation of manufacturing activities was the basis of the mainframe of new town planning policies, and workers' neighbors were created. The main answer to the need for soil was the "Law for Housing" no. 865 of 1971. The "Law for Housing" increased the possibility of expropriating soils for new settlements, independently from the indication of general urban master plans. In the planning system, two new instruments were introduced: the plans for "social housing" (EPSH) and for "productive settlements" (EPPS). A peculiar aspect of EPSH and EPPS is the character of "need and urgency", which acknowledges some actions that are not coherent with the local planning regulations, as the distribution of land use of artificial soil shows (Figure 3). Firstly, the municipalities can change their plan provision by authorizing a new land-use for productive settlements and social housing in countryside landscapes "in absence of immediately further available soil": in such cases, even the RLP has limited possibility to stop the expansion. Secondly, when public property is not available, the municipalities can expropriate private land with a quick procedure. The main consequence of this is the expropriation of soil for farmland (with a small property value) that becomes industrial or residential (with a high property value). This formal land-use change makes the land value (in €/m^2) increase by a minimum of 10 times and by a maximum of 100 times.

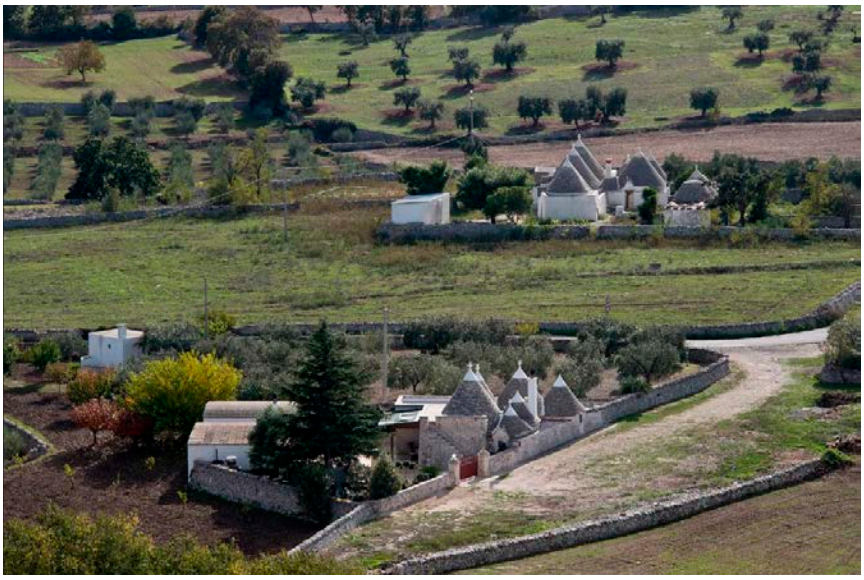


Figure 3. Farmland landscape of "Trulli" in the Itrian Valley (author: Matteo Lanzoni on Flickr).

A second instrument is the "Program Agreement" (PA) among regional and local institutions, introduced by Law no. 142/1990. The "Program Agreement" aims to instantly authorize the so-called "Activities of Public Interest". "Public Interest" can regard social facilities (hospitals, universities, power stations, roads, commercial harbors, pipelines, waste disposal, etc.), or private economic activities that are capable of increasing the offer of jobs in the so-called strategic sectors (e.g., tourist villages or harbors, golf courses). Many manufacturing activities in the countryside, touristic settlements and facilities on the coast, or popular quarters where farmland existed, were born, and still are, are springing up, thanks to these norms.

2.3. Data and Surveys

As stated in the introduction, most of the data have been elaborated by the MITO Lab at the Polytechnic University of Bari. Readable data for the Apulian regional territory in Table 2 have been calculated for each one of the 258 municipalities and will be published with a joint effort of the MITO Lab with the Centre of Research on Land Take (CRCS), managed by the National Institute of Urbanism (INU) and the Polytechnic University of Milan [28]. Data, and the indicators managed inside the "observatory for soil saving" of the MITO surveys for different aspects of "land consumption" and "soil take", aim to find the causes, and to consider the tools for reducing the phenomena. If we consider the different reports and studies on the matter, it shows that the concept and the measure of soil take is not defined uniquely in the literature. When using the term "land consumption" it is always necessary to specify what kind of changes are being referred to, moving always in the context of changes that determine the irreversible loss of all or some of the ecological functions of soils [16].

Table 2. Main measures of soil take in Apulia (source: Report on soil take, MITO Lab, Bari Polytechnic).

Artificial Use of Soil in Apulia		
Indicators	**Unit**	**Measures**
Population 2011	(inhab)	4,091,259.00
Surface	(Hect)	1,933,319.80
Artificial Surface 2011	(Hect)	165,607.41
Artificial Surface 2011	(%)	8.57
Artificialized soil 2006–2011	(Hect/year)	1886.37
Artificial Surface per capita	(m^2/inhab)	404.78
Unoccupied housing stock 2011	(Abs value)	520,441.00
Unoccupied housing stock 2011	(%)	25.54
Residential settlements 2011	(Hect)	71,229.31
Industrial, trade and infrastructure 2011	(Hect)	71,983.53
Mining areas, construction sites, landfills 2011	(Hect)	17,045.45
Artificial green non-agricultural areas 2011	(Hect)	5349.38
residential settlements 2011	(%)	43.01
Industrial, trade and infrastructure 2011	(%)	43.47
Mining areas, construction sites, landfills 2011	(%)	10.29
Artificial green non-agricultural areas 2011	(%)	3.23
Average sale price of housing stock 2016	€/m^2	1485

What we have done in our research is conduct analysis of the transition from one land use to another. The transition has been determined by common geoprocessing tools, such as the overlay of land use maps of different years, in order to put the changes into evidence. The main source is the regional land use map (RLUM). RLUM has been provided for 2006 and 2011, and the 2016 upgrade will soon be available. Maps are produced by the regional government, and are based on the land use nomenclature (Table 3) by CORINE (acronym of the European Program "Coordination of information on the environment") land cover (CLC). It is easy to understand that, in most cases, the waterproof built surfaces (dwellings, sheds, schools, or hospitals, etc.), or just covered surfaces (road network, parking areas, etc.), alternate with empty areas (gardens, fallow residual spaces, etc.) where the whole, or a piece of, ecological functions of the agricultural and natural soils have been kept. The size of the grid, used to develop the land use map, is important information. RLUM describes the land use on a basic grid unit of 50 × 50 m^2.

The economic dimension is depicted by the MLV (multiplier of land value), for a land use set in each municipality. Information has been drawn from the observatory of the property market by the National Tax Agency (OMI), and from various surveys provided by private national networks of real estate agencies. This investigation aimed to find a link between the occupation of land and socio-economic characteristics of property and construction markets in the local context. We see, in some way, that the creation of unearned plus value (to be recaptured) linked with the waste of soil, showed an example of inefficient use of land. The typical evidence of the waste of soil is in the seasonal use of the building stock, in the case of the regional coastline: seasonal users "duplicate their living environment" by keeping a main flat in the winter and a secondary flat in the summer.

Table 3. The class of soil coverage in the CORINE land cover classification, mainly utilized in the study.

Corine Land Classification	
First Level	**Second Level**
1. Artificial surfaces	1.1. Residential urban areas 1.2. Industrial, trade and infrastructure 1.3. Mining areas, construction sites, landfills and artifacts and derelict land 1.4. Artificial green non-agricultural areas
2. Agricultural areas	2.1. Arable 2.2. Permanent crops 2.3. Permanent meadows (grassland) 2.4. Heterogeneous agricultural areas
3. Natural environments	3.1. Wooded areas 3.2. Areas with shrubs and/or herbaceous 3.3. Open areas with sparse or no vegetation
4. Wetlands	4.1. Inland wetlands 4.2. Maritime wetlands
5. Water bodies	5.1. Continental waters 5.2. Maritime waters

2.4. Matrix of Land Use Transition

To analyze the change of land use, we consider two approaches. First, the "differential" approach is based on a general analysis of CLC referring to two different time lines; in this case it is possible to calculate the variation of the sum of a macro-class of surfaces between a given time line (for example all artificial surface variation). The method requires a database of information containing two vectors (a vector of land uses at time "i" and vector of land uses at time "j"), that restitute a general balance between artificial and non-artificial surfaces at time at "i" and at time "j". This method is sufficient to make global differences between coverage at both times "i" and "j", and the main information is about the global balance between losses and gains. The limitation is due to the impossibility of putting into evidence the single contribution of each decreasing coverage class in favor of each increasing coverage class. For example, if, during a decade, there was a loss of −300 ha of artificial green areas (CLC 1.4) in favor of housing settlements (CLC 1.1.), but 200 hectares of quarries (CLC 1.3) became artificial green areas and 100 hectares of quarries became industrial settlements (CLC 1.2), we can read only that +100 CLC 1.1, −100 CLC 1.4, +100 CLC 1.2 and −300 CLC 1.3, without knowing the internal transitions and we lose, therefore, the quali-quantitative dimension of the analysis.

The second approach attempts to follow each single "flow" trough a more complex "matrix of land use transition" (MLUT) [29]. The method requires a more complex geographical database (the GIS of soil covers). In order to use the method, a MLUT should be established with which the single streams by a cover i to j are distinctly countable from those from j to i or k to j (Figure 4). By doing so, it is possible to account for the losses for each class, before having a whole balance in the system. Furthermore, it is also possible to read the loss and gains of cover due to a relocation of the original covers. For example, the growth of forests in a region may be the result of a loss of wooded area in the lowlands and an increase in the highlands (with all different ecological and economic implications). In this case, the transition matrix enables the detection of any decrease in separate and distinct ways by increments, for instance, by weighting each change, taking into account a criterion of importance for each land cover class.

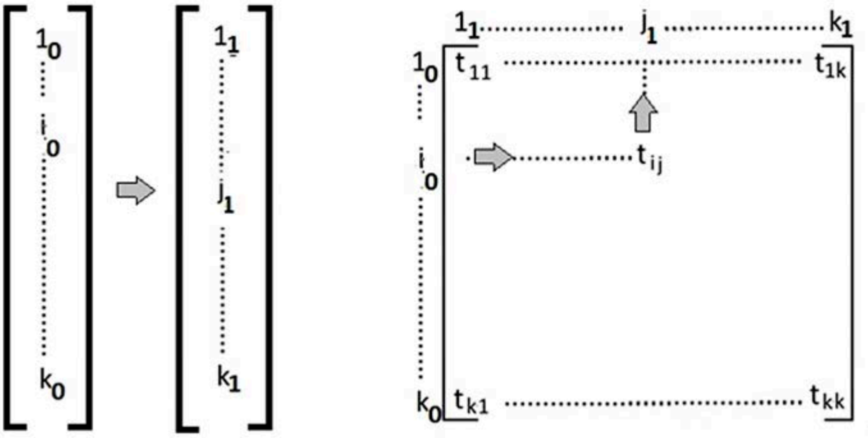


Figure 4. Two descriptions of transition: (**left**) two vectors showing the extension of each class of Corine Land Cover CLC [1,k] at time 0 and at time 1; (**right**) the transition from each CLC [1,k] at time 0 to each CLC [1,k] at time 1.

2.5. Matrix of Land Value Transition

We set a further transition due to a weighting system of the pressure given due to the demand of real estate development. This second transition was measured by the multiplier of land value (MLV). MLV is a measure of the effect due to the change from past to actual land use, or from actual to potentially planned new land use. The transition of values is represented in the second couple of rows, where the multiplier calculates the increase of value in the Equations (1) and (2):

$$\mathrm{V_{T2}} = \mathrm{Vu_{T1}} \times \mathrm{MLV} \times \Delta \mathrm{S_{Ha}} \tag{1}$$

$$\mathrm{V_{T2}} - \mathrm{Vu_{T1}} = (\mathrm{MLV} - 1) \times \Delta \mathrm{S_{Ha}} \tag{2}$$

where:

$\mathrm{V_{T2}}$: is the total value at the time 2;
$\mathrm{Vu_{T1}}$: is the unit value at the time 1;
MLV: is the multiplier of land value (MLV) from time 1 to time 2; and
$\Delta \mathrm{S_{Ha}}$: is the surface interested by the transition from the land use at the time 1 to the land use at the time 2.

The increase/decrease of buildability can generate a plus/minus value, and is a key to analyze the causes of seeking new soils. Buildability represents, as well, the main cause of risk due to artificialization by ordinary planning implementation and due, as well, to extraordinary interventions. For this reason, the indicator of transition represented by MLV is a good weighting of the plus-value deriving from soil change.

The change from agrarian to urban land use represents a classical example of plus-value generation due to an expansive planning process [30,31]. On such occasions the revenue's-costs ratio registers a strong improvement, due to the difference between the ex ante and ex post land value. The promoter buys a future possible buildable area at the sale price of agrarian soil, and when the promoter sells the same area just after it has been built, the ratio between the agrarian and buildable soil increases. Such a change often represents an unearned plus-value. Several traditional planning procedures supported such plus-value creation in the past. Most are imputable to the weakness of local administration in managing sustainable scenarios in conjunction with the pressures of entrepreneurs and land promoters. Looking at the artificial soil of Apulia, it can be observed that the artificial soil represents less than 10% of the land coverage: the environmental impact related to 10% of the artificial soil is very impressive and can affect the whole environment; as Fishel [32] affirms, although the amount of land may not be crucial, the way we use it is, especially in urban areas.

The matrix of transition for land use has been set to analyze the use while recollecting the sentence of Fishel. Starting from land use transition, a matrix of land value transition can be produced. The worst happens when the transition of soils are economically supported by high MLV, and, at the same time, create a heavy loss of environmental capital (Figure 5). In this case, the last transition for soil resources represents a change between a state of lower environmental risk of damage, to a higher one (Figure 5). The consequent impact is land degradation that can be multidimensionally assessed [33].

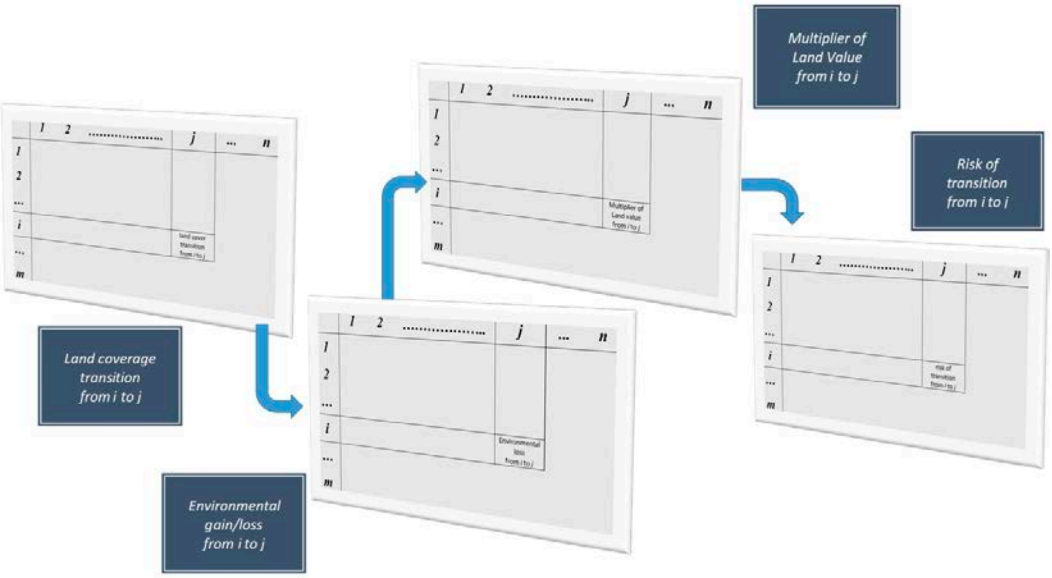


Figure 5. The environmental risk is higher when the combined transition of land coverage shows an environmental loss and an increase of land value.

2.6. Matrix of Correlation

The variety of data is evidenced by a correlation analysis between the indicators listed in Table 2, measured for all 258 urban municipalities in the region. The correlation index (CI) ϱ_{xy} is the well-known ratio between the statistical covariance of variables x and y, divided by the two standard deviations of x and y: the correlation index varies from −1 (inverse correlation) to 1 (direct correlation). Values near to 0 identifies small correlation (see Equation (3)).

$$\varrho_{xy} = \sigma_{xy} \left(\sigma_x \cdot \sigma_y\right)^{-1} \in [-1, +1] \quad (3)$$

2.7. Case Studies on Driving Factors at the Local Scale

As it is easy to understand, dynamics that generate new soil consumption are connected with the real estate market. The increase of land value due to town planning regulation is due to buildability deriving from new urban expansion, more than by renewing old properties. This assumed economic competitiveness of new expansion despite the rehabilitation will be proved. In the following paragraphs, we analyze the typical forms of transition of land use and we propose a method to quantify the economic phenomenon of the "unearned" land plus-value, and to measure the effectiveness of pursuing plus values. Then, we emphasize peculiarities emerging from our case study (Results). Finally, we judge the efficiency of some solutions, considering the real possibility of recapturing land plus-values, and comparing improvement for expansions with better reuse (Discussion and Conclusions).The case studies are as follows: (i) the maritime city of Porto Cesareo, where the highest percentage of unoccupied housing stock has been detected; (ii) the City of Martina Franca, the largest urban center of the Itrian Valley, with a relevant housing sprawl in a prized rural landscape; (iii) the City of Brindisi, where the highest coverage of solar farms has been found; and, finally (iv) the Regional Capital City (Bari), where most recent expansion has been produced by a "Program Agreement".

3. Results at the Regional Scale

The analysis of land use change at the regional scale indicates an increase of slightly less than ten thousand hectares of artificial soil in five years, from 2006 to 2011 (with 5.7% of the whole at 2011). In 2011, the artificial soil comprised 165,600 hectares, corresponding, more or less, to 8.6% of the entire surface of Apulia. If we consider the yearly increase of artificialization, this means that in less than one century, the consumption of natural soil can be duplicated: it could be considered a long timeline, but around 100,000 hectares were created in the 20th century. Data emphasize the heterogeneous distribution of artificial soil from the north to the south of Apulia: on one hand, the northern mountainous and the internal part of the region (around 5%–6% artificial on the whole surface) and, on the other hand, the central and southern peninsular part (around 10% artificial on the whole surface). Some results are as expected, such as the correlation (Tables A1–A5 in Appendix A) between the extension of residential settlements and population (CI = 0.88), or the correlation between each class of artificial cover (1.1 residential settlements; 1.2 industry, commercial services, and facilities; 1.3 quarries, landfill, and derelict areas; 1.4 urban artificial green areas; dating from 2011) with demographic size (the corresponding CIs are as follows: 0.75, 0.86, 0.69, and 0.41. It is clear that the highest values are correlating the activities more connected with human daily existence and activities (housings and commerce and industry sites).

Further connections are evidenced between activities and classes of artificial soil. A deeper study has been carried out with analyses on a subset of Apulian cities, according to geographical and demographic criteria. The study of correlation was carried out separately, with respect to municipalities with more than 50,000 inhabitants (15 municipalities), municipalities with less than 50,000 inhabitants (242 municipalities), municipalities with less than 15,000 inhabitants (186 municipalities) and, finally, between maritime municipalities, staying on the coastline with less than 50,000 inhabitants (58 municipalities). Among these subset analyses, two correlations show interesting aspects. The first interesting correlation is between residential artificial coverage for residential settlements (class 1.1) and unoccupied housing stock, as regards maritime municipalities (CI = 0.86). The same correlation is equal to 0.86 also for large-sized cities with more than 50,000 inhabitants. The CI is less relevant for small to medium-sized cities (0.76 for smaller than 50,000 inhabitants and 0.58 for smaller than 15,000 inhabitants). The second correlation that can be of some interest (even if 0.6 is not so high, in absolute terms), is between artificial surface per capita and unoccupied housing stock; the CI is 0.6 for marine municipalities with less than 50,000 inhabitants, while other aggregations of municipalities (large-sized greater than 50,000; small, under 15,000; and medium, under 50,000) have values varying between 0.31 and 0.52.

4. Results and Case Studies at the Local Scale

4.1. Land Take on the Coastline in Porto Cesareo

The first case is the area of Porto Cesareo. The territory of Porto Cesareo runs along a strip of land on the Ionic Sea (Figure 6). The town has 83% of residential stock devoted to seasonal use, which represent the worst data in the whole of Apulia. Furthermore, Porto Cesareo is included in the highest class of percentage of artificial soil in Apulia (around 50%). Figure 6 represents a cartogram (created using the Carto-DB® webtool for geographic data-figures [34]), by using data on artificial soil (%) and unoccupied housing stock (%). The diameter of blue bullets in the carto-map represents the percentage of unoccupied housing stock, and it is evident that, in the most frequented coast of Apulia, namely Salento, positioned in the southern part of the regional peninsula, has larger-sized bullets. Salento shows a degree of red deeper than the rest of Apulia: this testifies to a high degree of artificial coverage. Porto Cesareo is more or less at the center of the gulf that surrounds the Ionian Sea from the north, and belongs to the highest class of artificial soil, like Bari, Lecce and Taranto. The main difference is that Porto Cesareo has approximately 6000 inhabitants, and Bari, Taranto, and Lecce are the most crowded cities of Apulia (Bari is the most populated, with 320,000 people, Taranto has 190,000 people, and Lecce has 95,000 people). As a consequence, there is no possibility to expand the settlements. The coast is overcrowded with houses. The residual areas for seasonal houses are very few; therefore, land retains a very high property value (near 100 €/m^2).

Figure 7 represents the matrix of all transition of coverage according the second level of CORINE classification for the Municipality of Porto Cesareo (by MITOcs geoportal, realized at the MITO Lab). MITOcs Geoportal provides the same data for all municipalities of Apulia. The blue part of the matrix represents the "internal" transition from one class of "artificial" land cover to another class of "artificial" cover. The red part of the matrix represents the transition from "non-artificial" to "artificial" land cover. From the overall matrix of transition (Figure 7), we can insulate the sub-matrix (Table 4), keeping only the parts colored in blue and in red that show at least one value different from zero. In Table 4, we observe that the intersection representing all changes from all CORINE classes only amount to four artificial land classes. In other words, the rows in Table 4 represent the classes at second level of CORINE having at least one value of transition different to zero, with respect to the four classes of artificial coverage. In the case of Porto Cesareo, we see the transition from eight classes to the four artificial classes. The analyses show that the main transition is regarding new buildable areas of high density (for instance, long streams of seasonal housing on two or three levels).

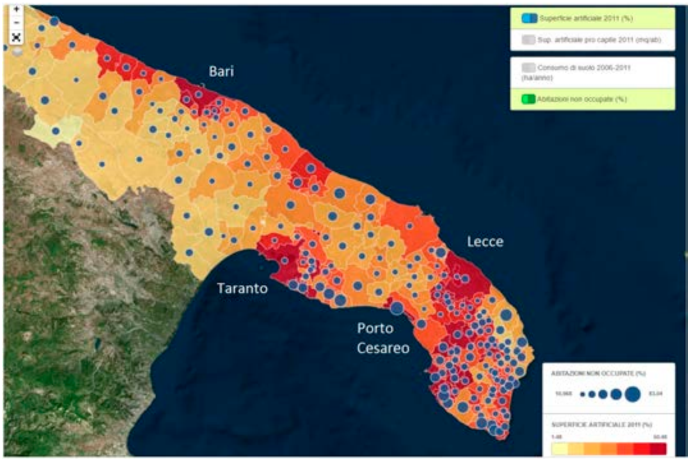


Figure 6. Carto-map showing the dimension of artificialized soil and of unoccupied housing stock (Data by MITO Lab).

The estimates on values of land change are resumed, and the property values after the transition were calculated by using the MLV. Table 4 shows the quantities of transitions: to simplify, the matrix is derived from the general table in Figure 7, reduced at rows and columns that show no null values. Table 5 shows the multipliers of land value for each transition (based on the appraisal of the property value for each class of land use). Finally, Table 6 shows the increase of land value after the change of land use for each transition (based on the average property value for each class of land use), such as from natural and artifical towards only artificial land use (using Equation (2)).

Table 4. Transition of land use extracted from table in Figure 7 (hectares): Porto Cesareo.

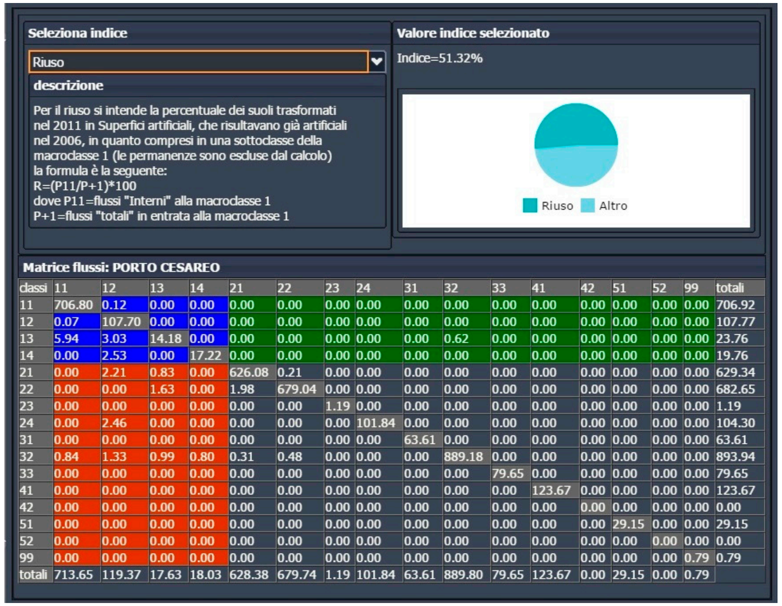
Transition to **Transition from (Hectares)**	**1.1. Residential Urban Areas**	**1.2. Industrial, Trade and Infrastructure**	**1.3. Mining Areas, Construction Sites, Landfills and Artifacts and Derelict Land**	**1.4. Artificial Green Non-Agricultural Areas**
1.1. Residential urban areas	0	0.12	0.00	0.00
1.2. Industrial, trade and infrastructure	0.00	0	0.00	0.00
1.3. Mining areas, construction sites, landfills and artifacts and derelict land	5.94	3.03	0	0.00
1.4. Artificial green non-agricultural areas	0.00	2.53	0.00	0
2.1. Arable	0.00	2.21	0.83	0.00
2.2. Permanent crops	0.00	0.00	1.63	0.00
2.4. Heterogeneous agricultural areas	0.00	2.46	0.00	0.00
3.2. Areas with shrubs and/or herbaceous	0.84	1.33	0.99	0.80

Table 5. MLV (multiplier of land value), and property unit value in 2016: Porto Cesareo.

Transition to **Transition from**	**Unit Property Value**	**1.1. Residential Urban Areas**	**1.2. Industrial, Trade and Infrastructure**	**1.3. MINING Areas, Construction Sites, Landfills and Artifacts and Derelict Land**	**1.4. Artificial Green Non-Agricultural Areas**
1.1. Residential urban areas	81.50 €/m^2	1	0.44	0.06	0.01
1.2. Industrial, trade and infrastructure	35.90 €/m^2	2.27	1	0.14	0.05
1.3. Mining areas, construction sites, landfills and artifacts/derelict land	5.00 €/m^2	16.3	7.18	1	0.61
1.4. Artificial green non-agricultural areas	1.88 €/m^2	43.40	19.14	2.67	1
2.1. Arable	1.32 €/m^2	61.94	27.28	3.8	1.43
2.2. Permanent crops	1.01 €/m^2	80.52	35.47	4.93	1.97
2.4. Heterogeneous agricultural areas	0.66 €/m^2	123.40	54.36	7.57	2.88
3.2. Areas with shrubs and/or herbaceous	0.66 €/m^2	123.40	54.36	7.57	2.88

Table 6. Land value increase in transition (loss/benefit in 2016): Porto Cesareo.

Transition to		**1.1. Residential Urban Areas**	**1.2. Industrial, Trade and Infrastructure**	**1.3. Mining Areas, Construction Sites, Landfills and Artifacts and Derelict Land**	**1.4. Artificial Green Non-Agricultural Areas**
Transition from	**Unit Property Value**				
1.1. Residential urban areas	81.50 €/m²	0	−€672	0.00	0.00
1.2. Industrial, trade and infrastructure	35.90 €/m²	0.00	0	0.00	0.00
1.3. Mining areas, construction sites, landfills and artifacts and derelict land	5.00 €/m²	€908,820	€187,254	0	0.00
1.4. Artificial green non-agricultural areas	1.88 €/m²	0.00	€458,942	0.00	0
2.1. Arable	1.32 €/m²	0.00	€580,788	€232,400	0.00
2.2. Permanent crops	1.01 €/m²	0.00	0.00	€640,590	0.00
2.4. Heterogeneous agricultural areas	0.66 €/m²	0.00	€11,312,656	0.00	0.00
3.2. Areas with shrubs and/or herbaceous	0.66 €/m²	€1,028,160	€709,688	€650,430	€150,400



Indice=51.32%

Per il riuso si intende la percentuale dei suoli trasformati nel 2011 in Superfici artificiali, che risultavano già artificiali nel 2006, in quanto compresi in una sottoclasse della macroclasse 1 (le permanenze sono escluse dal calcolo)
la formula è la seguente:
R=(P11/P+1)*100
dove P11=flussi "Interni" alla macroclasse 1
P+1=flussi "totali" in entrata alla macroclasse 1

Matrice flussi: PORTO CESAREO

classi	11	12	13	14	21	22	23	24	31	32	33	41	42	51	52	99	totali
11	706.80	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	706.92
12	0.07	107.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	107.77
13	5.94	3.03	14.18	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	23.76
14	0.00	2.53	0.00	17.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.76
21	0.00	2.21	0.83	0.00	626.08	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	629.34
22	0.00	0.00	1.63	0.00	1.98	679.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	682.65
23	0.00	0.00	0.00	0.00	0.00	0.00	1.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.19
24	0.00	2.46	0.00	0.00	0.00	0.00	0.00	101.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	104.30
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	63.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	63.61
32	0.84	1.33	0.99	0.80	0.31	0.48	0.00	0.00	0.00	889.18	0.00	0.00	0.00	0.00	0.00	0.00	893.94
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	79.65	0.00	0.00	0.00	0.00	0.00	79.65
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	123.67	0.00	0.00	0.00	0.00	123.67
42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.15	0.00	0.00	29.15
52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.79
totali	713.65	119.37	17.63	18.03	628.38	679.74	1.19	101.84	63.61	889.80	79.65	123.67	0.00	29.15	0.00	0.79	

Figure 7. Transition matrix for Porto Cesareo as extracted from MITO CS Monitor.

4.2. Impact of Seasonal Housing in Hural Landscapes: Martina Franca

In the same way, let us describe the evolution of soil take in Martina Franca. As already stated, Martina Franca is the largest center of the Itrian Valley. Urban sprawl affects the countryside by the enlargement of rural settlements by new construction that often afflict the typical landscape of Trulli farmland. The occupation of the countryside is mostly due to the same local inhabitants, who often own these seasonal farmhouses. Such autochthonous occupation is demonstrable by the use of a "dummy" variable, representing the anthropic pressure given by the costs of waste production and management (Figure 8), derived from the use of the LUIS (Land Use Intensity Seasonality [24]), measuring the seasonal variation in artificial land use intensity (under a summer peak assumption), by using monthly waste production as a proxy of intensity of use and environmental pressure, according to the formula:

$$\text{LUIS} = 100 \times (\text{AWP} - \text{MWP})/\text{MWP}$$

where:

AWP = waste disposal in August (maximum monthly peak);
MWP = average of waste disposal in one year.

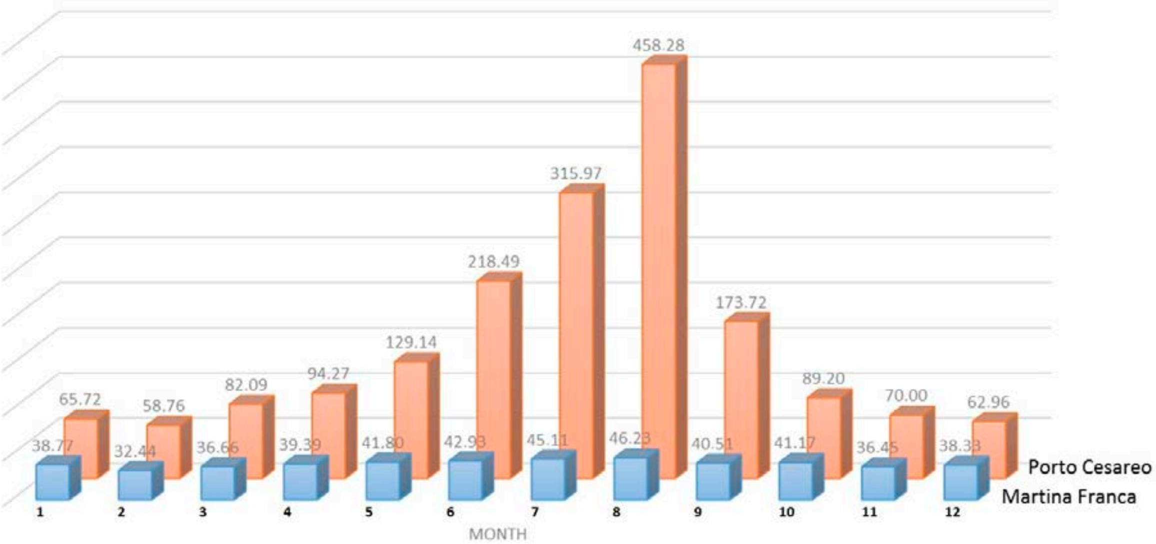


Figure 8. Comparison of monthly waste disposal between Martina Franca and Porto Cesareo.

In the context of Martina Franca, the MLV generates an increase of property values inside the "external ring" of the city more than in the countryside. This means that the rural landscape is at risk. When we interrogate the official geodatabase of the National Tax Agency of Revenues, named "Geopoi" we can observe (Figure 9B) that the higher value of housing stock is referring to the wider ring around the city, which is the area of major housing sprawl. The settlement's sprawl in the countryside is clear in the black image of Figure 9A. The matrix of transition (Table 7) shows a major change of land use from non-artificial to artificial soil (around 35 hectares) than between classes of artificial soil (less than three hectares). The artificialized soil is approximately four times greater than in Porto Cesareo. In the same way of Porto Cesareo, also for Martina Franca the MLV and the increase of land value are shown (in Tables 8 and 9).

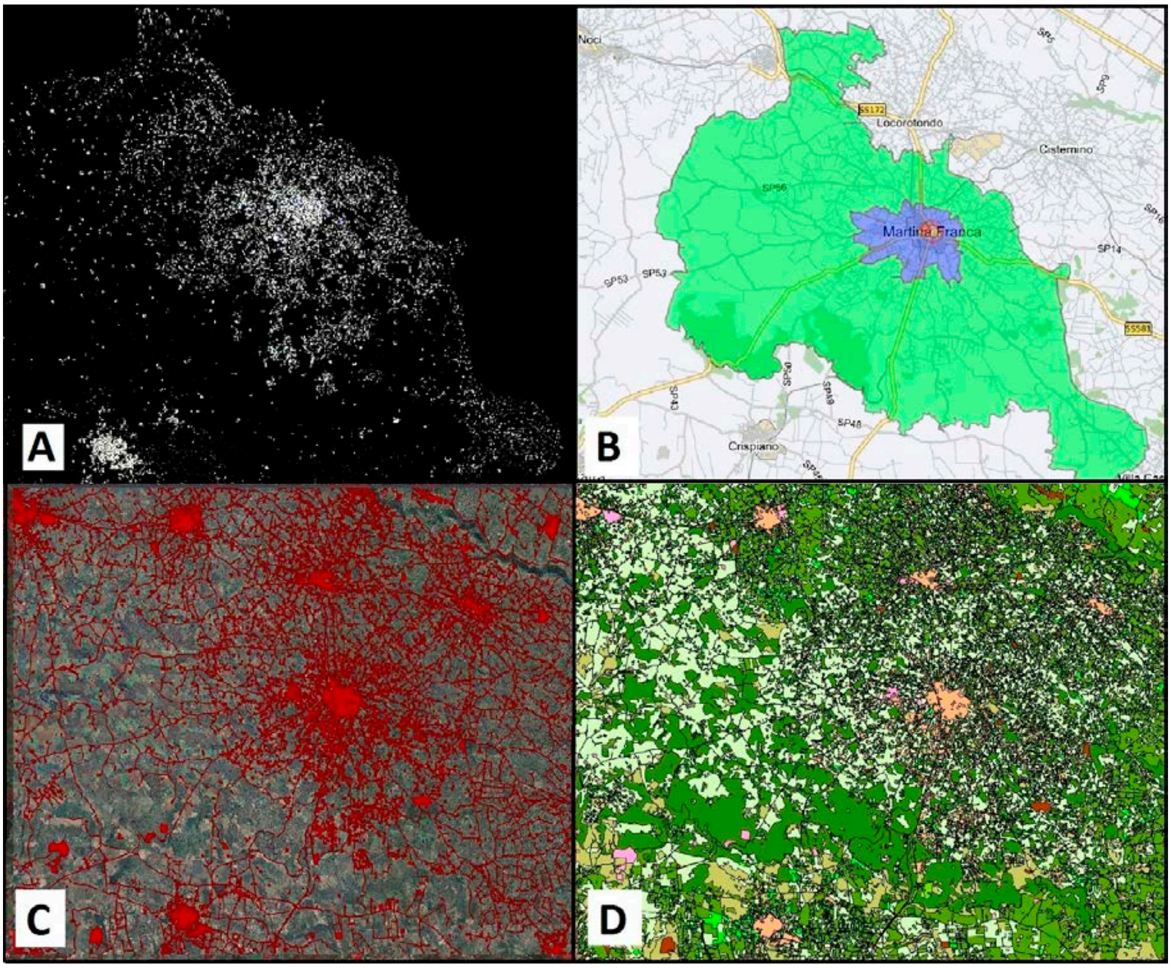


Figure 9. Martina Franca from four views: (**A**) artificial cover due to buildings (in white on black screen—without roads); (**B**) classes of property values (green: farm houses; violet: external belt; deep blue: internal belt; red: center; yellow: historic area); (**C**) artificial soil (in red) on satellite view; (**D**) land uses (deep green: wooden and crops; orange: residential settlements; pink: industry and commercial sites; soft green: shrubs, lawns, and pastures).

Table 7. Transition of land use (hectares): Martina Franca.

Transition to		1.1. Residential Urban Areas	1.2. Industrial, Trade and Infrastructure	1.3. Mining Areas, Construction Sites, landfills and Artifacts and Derelict Land	1.4. Artificial Green Non-Agricultural Areas
Transition from	**(Hectares)**				
1.1. Residential urban areas		0	0.00	0.11	0.00
1.2. Industrial, trade and infrastructure		0.04	0	0.00	0.00
1.3. Mining areas, construction sites, landfills and artifacts and derelict land		0.00	2.07	0	0.00
1.4. Artificial green non-agricultural areas		0.00	0.00	0.00	0
2.1. Arable		10.67	10.71	4.58	0.00
2.2. Permanent crops		2.98	1.10	0.00	0.00
3.1. Wooded areas		0.00	2.06	0.00	0.00
3.2. Areas with shrubs and/or herbaceous		1.04	2.58	0.00	0.00

Table 8. MLV and property unit value in 2016: Martina Franca.

Transition to		1.1. Residential Urban Areas	1.2. Industrial, Trade and Infrastructure	1.3. Mining Areas, Construction Sites, Landfills and Artifacts and Derelict Land	1.4. Artificial Green Non-Agricultural Areas
Transition from					
1.1. Residential urban areas	78.00 €/m^2	1	0.54	0.05	0.02
1.2. Industrial, trade and infrastructure	42.45 €/m^2	1.84	1	0.08	0.04
1.3. Mining areas, construction sites, landfills and artifacts and derelict land	3.53 €/m2	22.10	12.03	1	0.46
1.4. Artificial green non-agricultural areas	1.63 €/m^2	47.85	26.04	2.17	1
2.1. Arable	1.45 €/m^2	53.79	29.28	2.43	1.12
2.2. Permanent crops	2.61 €/m^2	29.89	16.26	1.35	0.62
3.1. Wooded areas	1.53 €/m^2	50.98	27.75	2.31	1.07
3.2. Areas with shrubs and/or herbaceous	0.73 €/m^2	106.85	58.15	4.84	2.23

Table 9. Land value increase in transition (loss/benefit in 2016): Martina Franca.

Transition to		**1.1. Residential Urban Areas**	**1.2. Industrial, Trade and Infrastructure**	**1.3. Mining Areas, Construction Sites, Landfills and Artifacts and Derelict Land**	**1.4. Artificial Green Non-Agricultural Areas**
Transition from					
1.1. Residential urban areas	78.00 €/m^2	0		€1050.2	0.00
1.2. Industrial, trade and infrastructure	42.45 €/m^2	€335.0	0	0.00	0.00
1.3. Mining areas, construction sites, landfills and artifacts and derelict land	3.53 €/m2	0.00	€228,227.8	0	0.00
1.4. Artificial green non-agricultural areas	1.63 €/m^2	0.00	0.00	0.00	0
2.1. Arable	1.45 €/m^2	€5,633,024.1	€3,028,344.8	€65,699.3	0.00
2.2. Permanent crops	2.61 €/m^2	€860,774.7	€167,908.0	0.00	0.00
3.1. Wooded areas	1.53 €/m^2	0.00	€550,949.0	0.00	0.00
3.2. Areas with shrubs and/or herbaceous	0.73 €/m^2	€1,100,832.9	€1,474,487.7	0.00	0.00

4.3. Program Agreements in Bari

Bari is the capital of the Apulia region, and is included in the group of metropolitan districts in Italy. The population from the 2011 Census was 320,475 inhabitants, accompanied with approximately 15,000 regular city users (workers and students), according to the National Institute of Statistics. The Municipal Masterplan provided, in 1977, a buildable area for more than 600,000 inhabitants (around 300,000 more than the present), mainly located in the more external fringe, and the last quartiers have been realized by "Program Agreements" (PA). PA consent was used to change the land use from artificial green areas to housing areas (is this example). This procedure of consent aims to increase not only the MLV, but to increase the stock of soil free for new construction areas, because the built part represents an addition to the existing, and still buildable, areas for the forecasts in the Municipal Masterplan. Transitions to residential uses (Table 10) are mostly due to PA; MLV is higher for residential uses (Table 11), but the greater increase of value is due to change of land use in industrial and commercial sector (Table 12).

Figure 10 shows a new settlement, due to the change in the largest PA of Bari, at three different dates: 2006–2011–2016 (as shown in the satellite view on the left) and represented by classes of coverage (on the right side of the image). The coverage change is identified as follows: the artificial soil in 2006 (sand color), the new residential expansion from 2006 to 2011 (red color), and from 2011 to 2016 (light brown color). The decision of the municipality to promote the PA was related to the only positive (but not sufficient) de-artificialization of soil (emerald green) on the bottom-right map, due to the high densification of buildings in the left part of the initial empty land, that contains the construction inside the current borderline of the built part of the city.

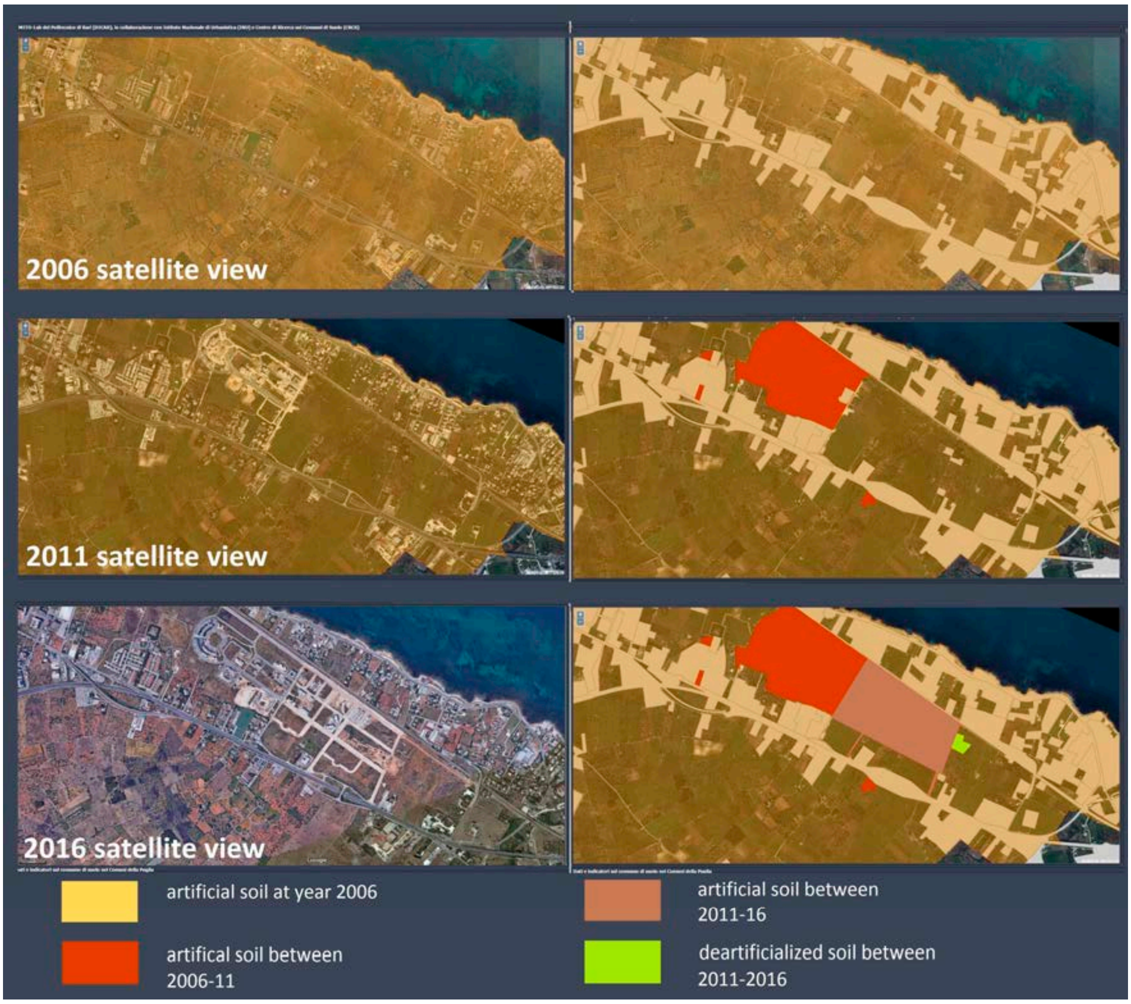


Figure 10. A new settlement due to the change of land use by a "Program Agreement", Law n.142 of 1990, Metropolitan Districts of Bari.

Table 10. Transition of land use (hectares): Metropolitan City of Bari.

Transition to Transition from (Hectares)	1.1. Residential Urban Areas	1.2. Industrial, Trade and Infrastructure	1.3. Mining Areas, Construction Sites, Landfills and Artifacts and Derelict Land	1.4. Artificial Green Non-Agricultural Areas
1.1. Residential urban areas	0	20.55	5.37	1.41
1.2. Industrial, trade and infrastructure	2.08	0	21.51	0.00
1.3. Mining areas, construction sites, landfills and artifacts and derelict land	5.05	29.52	0	0.00
1.4. Artificial green non-agricultural areas	0.00	1.98	0.00	0
2.1. Arable	2.18	18.65	72.30	4.84
2.2. Permanent crops	3.05	16.77	26.85	5.44
2.4. Heterogeneous agricultural areas	0.00	0.45	1.69	0.11
3.1. Wooded areas	3.57	0.69	1.32	0.00
3.2. Areas with shrubs and/or herbaceous	3.67	40.04	40.74	2.64
3.3. Open areas with sparse or no vegetation	0.00	1.24	0.00	0.00

Table 11. MLV and property unit value at 2016: Metropolitan City of Bari.

Transition to Transition from		1.1. Residential Urban Areas	1.2. Industrial, Trade and Infrastructure	1.3. Mining Areas, Construction Sites, Landfills and Artifacts and Derelict Land	1.4. Artificial Green Non-Agricultural Areas
1.1. Residential urban areas	123.04 €/m^2	1	0.47	0.10	0.02
1.2. Industrial, trade and infrastructure	58.30 €/m^2	2.11	1	0.21	0.04
1.3. Mining areas, construction sites, landfills and artifacts and derelict land	12.37 €/m^2	9.95	4.71	1	0.19
1.4. artificial green non-agricultural areas	2.39 €/m^2	51.48	24.39	2.45	1
2.1. Arable	1.40 €/m^2	87.89	41.64	4.19	0.08
2.2. Permanent crops	1.34 €/m^2	91.82	43.51	4.37	0.08
2.4. Heterogeneous agricultural areas	1.22 €/m^2	100.85	47.79	4.80	0.09
3.1. Wooded areas	1.93 €/m^2	63.75	30.21	3.04	0.06
3.2. Areas with shrubs and/or herbaceous	0.67 €/m^2	183.64	87.01	8.75	0.17
3.3. Open areas with sparse or no vegetation	0.65 €/m^2	189.29	89.69	9.02	0.18

Table 12. Land value increase in transition (loss/benefit at 2016): Metropolitan City of Bari.

Transition to		**1.1. Residential Urban Areas**	**1.2. Industrial, Trade and Infrastructure**	**1.3. Mining Areas, Construction Sites, Landfills and Artifacts and Derelict Land**	**1.4. Artificial Green Non-Agricultural Areas**
Transition from					
1.1. Residential urban areas	123.04 €/m^2	0	−€108,128.0	−€48,301.2	−€13,826.1
1.2. Industrial, trade and infrastructure	58.30 €/m^2	€23,097.6	0	−€169,460.4	0.00
1.3. Mining areas, construction sites, landfills and artifacts and derelict land	12.37 €/m^2	€451,805.6	€1,096,082.1	0	−€56,394.7
1.4. Artificial green non-agricultural areas	2.39 €/m^2	0.00	€463,187.4	0.00	0
2.1. Arable	1.40 €/m^2	€1,894,108.6	€7,579,892.9	€2,303,928.7	−€44,463.9
2.2. Permanent crops	1.34 €/m^2	€27,70,037.3	€7,128,501.5	€905,941.6	−€49,777.9
2.4. Heterogeneous agricultural areas	1.22 €/m^2	0.00	€210,541.0	€64,293.0	−€997.3
3.1. Wooded areas	1.93 €/m^2	€2,240,221.2	€201,530.1	€26,887.5	0.00
3.2. Areas with shrubs and/or herbaceous	0.67 €/m^2	€6,702,953.7	€34,440,376.1	€3,156,603.8	−€21,913.9
3.3. Open areas with sparse or no vegetation	0.65 €/m^2	0.00	€1,099,784.6	0.00	0.00

4.4. Solar Farms in Rural Landscape

The fourth case regards the rural landscape of Brindisi, capital of the county that has the same name as the city. The rural land around the city center is interesting due to the largest coverage due to solar farms. The use of photovoltaics in the Apulian Region has been widespread and represents more than half of the new coverage, located frequently in the highlands from Foggia to Brindisi. In the territory of Brindisi, the networks and areas for production and distribution of energy cover more than 8/10 of the transition of artificial soil from 2006 to 2011 [35,36]. Half of the preexisting coverage in 2006 is due to three power stations inside the border line of Brindisi (the power station "Federico II" of Brindisi is the second largest in Europe) [37,38], and the rest is due to the coverage of rural ground by solar panels. In the last five years, by the containment of the alteration in the landscape due to the RLP, some restrictions on land-use changes were raised, and the seeking of further plus values pushed the farmers to accept offers by ENI (that is, the National Energy Company) and not only by ENEL, to rent solar and photovoltaic panels on their soils. Solar farms, therefore, represent an alternative way to increase the MLV of non-buildable lands. The destiny of photovoltaics is related with public co-funding or detaxation, which disappeared in the last period. Figure 11 represents the whole soil transition in Apulia in the period 2005–2011. All transitions are colored in red, except for land use changes from rural to artificial soil for production and distribution of energy, which is colored in black. Looking at the territory of Brindisi (in the circular window), it is evident that outside the city borders the transitions in red are the largest piece. In Figure 12, the phenomenon is more evident. In Table 13, we register the largest transition in Apulia, from rural land (2.1, 2.2, 2.4 CLC classes) to industrial uses (1.2 CLC classes), with 85% due to solar farms and power stations and, as consequence, the greatest MLV (Table 14) and the largest increase of land value (Table 15) due to the new industrial areas [36].

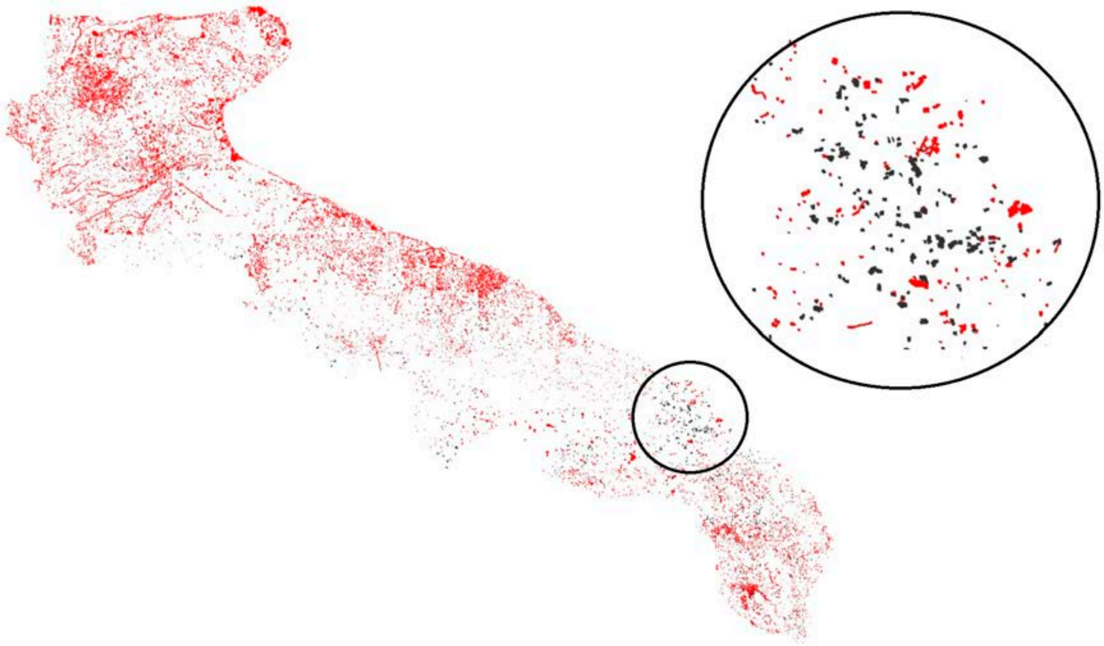


Figure 11. The transition from rural to solar farms in the countryside of Brindisi (see black areas inside the circle).

Figure 12. The transition from rural to solar farms in the countryside of Brindisi from 2006 (existing artificial coverage in white) to 2011 (new artificial coverage in red, mostly due to solar farms).

Table 13. Transition of land use (hectares): Brindisi.

Transition to Transition from (Hectares)	1.1. Residential Urban Areas	1.2. Industrial, Trade and Infrastructure	1.3. Mining Areas, Construction Sites, Landfills and Artifacts and Derelict Land	1.4. Artificial Green Non-Agricultural Areas
1.1. Residential urban areas	0	0.31	0.00	0.00
1.2. Industrial, trade and infrastructure	3.2	0.00	0.00	6.94
1.3. Mining areas, construction sites, landfills and artifacts and derelict land	3.83	11.95	0	0.00
1.4. Artificial green non-agricultural areas	0.00	0.00	0.00	0
2.1. Arable	14.32	445.31	17.69	0
2.2. Permanent crops	0.00	109.03	2.12	0.14
2.4. Heterogeneous agricultural areas	0.00	5.38	0.00	0.00
3.2. Areas with shrubs and/or herbaceous	6.4	0.97	0.00	0.00

Table 14. MLV and property unit value in 2016: Brindisi.

Transition to Transition from		1.1. Residential Urban Areas	1.2. Industrial, Trade and Infrastructure	1.3. Mining Areas, Construction Sites, Landfills and Artifacts and Derelict Land	1.4. Artificial Green Non-Agricultural Areas
1.1. residential urban areas	111.50 €/m^2	1	0.47	0.10	0.02
1.2. industrial, trade and infrastructure	69.71 €/m^2	2.11	1	0.21	0.04
1.3. mining areas, construction sites, landfills and artifacts and derelict land	22.30 €/m^2	9.95	4.71	1	0.19
1.4. artificial green non-agricultural areas	2.11 €/m^2	51.48	24.39	2.45	1
2.1. arable	1.41 €/m^2	87.89	41.64	4.19	0.08
2.2. permanent crops	1.28 €/m^2	91.82	43.51	4.37	0.08
2.4. heterogeneous agricultural areas	0.61 €/m^2	100.85	47.79	4.80	0.09
3.2. areas with shrubs and/or herbaceous	0.61 €/m^2	183.64	87.01	8.75	0.17

Table 15. Land value increase in transition (loss/benefit in 2016): Brindisi.

Transition to		**1.1. Residential Urban Areas**	**1.2. Industrial, Trade, and Infrastructure**	**1.3. Mining Areas, Construction Sites, Landfills, and Artifacts and Derelict Land**	**1.4. Artificial Green Non-Agricultural Areas**
Transition from					
1.1. Residential urban areas	123.04 €/m²	0	−€1161.9	0.00	0.00
1.2. Industrial, trade and infrastructure	58.30 €/m²	€19,183.5	0	0.00	−€67,299.4
1.3. Mining areas, construction sites, landfills and artifacts and derelict land	12.37 €/m²	€153,200.0	€254,058.1	0	0.00
1.4. Artificial green non-agricultural areas	2.39 €/m²	0.00	0.00	0.00	0
2.1. Arable	1.40 €/m²	€11,180,771.6	€215,706,900.7	€2,620,880.1	0.00
2.2. Permanent crops	1.34 €/m²	0.00	€58,288,460.2	€348,143.8	€907.8
2.4. Heterogeneous agricultural areas	1.22 €/m²	0.00	€6,094,393.4	0.00	0.00
3.2. Areas with shrubs and/or herbaceous	0.67 €/m²	€11,634,160.7	€1,098,803.3	0.00	0.00

5. Discussion

When the transition of land-use has coincided with the transition of property values, sufficient evidence was given to some dynamics that link property values, urban planning, and the never-ending soil take. Until the change of land use occurs between the acquisition of land and the introduction of property for sale in the real estate market, the multiplier effect will represent an important reason for entrepreneurs to demand new construction sites. The most relevant driving force in favor of artificialization is still due to the improvements that generate plus-value from the expansion of the construction market. In the urban residential context, the improvement is related mainly with the extraordinary measures for improving new settlements. Even if the MLV is high, the increase in economic residential settlements is decelerating, likely due to the new restrictive measures on ordinary planning regulations. Extraordinary plans and programmatic agreements represent the tools for economic driving forces to realize settlements despite the ordinary planning, but struggle to generate significant revenue, as in the past. Some forms of touristic/commercial and manufacturing expansion still have been practiced with the support of extraordinary plans and represent the most frequent source of plus values for entrepreneurs. In particular, this happens with photovoltaic coverage of soil in farmlands.

We can consider that the traditional expansion, due to a chaotic growth of settlements (like on the coastline) is a declining process, and we can say that, in that field, the worst may have been done. The environment, due to tourist demand for housing, was suffering principally before the last decade that we analyzed. The recent increase of the seasonal housing stock, in fact, was very slow and very small: the reason for this is that a great amount of soil change has already occurred: especially in the southern part of Apulia, where there is no longer easily accessible space for construction.

In the same time, the restrictions for land use have been increased in the planning system. The only way to elude the landscape protection rules was to act with extraordinary measures, in favor of economic development and domestic housing demand. However, if we look at the case of Bari, the construction bills (more less 27 millions of euros) account for one third of the sum of increase of stock value in five years of land transition to residential (more less 72 millions of euros in Table 16). The effect can be considered just a “windfall” [39]: a simple betterment with unsatisfying environmental compensation [40]. These measures were applied in the past for residential and productive settlements and, nowadays, are utilized for some touristic villages and small industrial settlements, but the main growth (more than 50% of the total) was in energy production, representing a prevailing new form of artificial coverage.

To counterbalance urban sprawl and artificialization, scholars suggest a set of actions: among them, in a special way we consider densification and land plus-value recapture, and we tried to assimilate the analyses of dynamics in the Apulian context [41]. The first one—densification—looks, in our region, to be convenient only in the case of building in free areas (e.g., after demolition, or after change of land use regulation, like in the cases of social housing [42] and Program Agreements [43]). It appears, more than the increase of volumes in elevation, that an increase of coverage of open spaces inside the built context, and sometimes worse, on the external urban fringe, occurs. The second one, the recapture of land plus-value by taxation, can favor the increase of the consumption of soil in the same way that the increase of pollution could have been caused by the application of the classical principle that “the polluter should pay”. We remind the reader that the principle “if industrial producers pollute the environment, then they should pay a bill” can be negatively reversed in the following assumption: “if the producers pay, then they can pollute” in the same way that “if constructors pay or compensate”, “they can cover the soil by new construction”. We can only consider land value recapture as an element of compensation of the environmental damage when fiscal obligations withdraw funding of urban retraining or improvement (if we reason in the light of weak sustainability). The examples that have been shown in this paper provide the idea that, when the soil take is due to the accumulation of actions, in a universe of small urban realities [28], it is very difficult for land value recapture to be effective. If we look at Figure 13, we notice the greatest increase of land value in Brindisi, due to modern occupation by solar farms, and the smallest increase in Porto

Cesareo, due to the oldest form of sprawl by the private market of seasonal housing, that does not find new means of expansion.

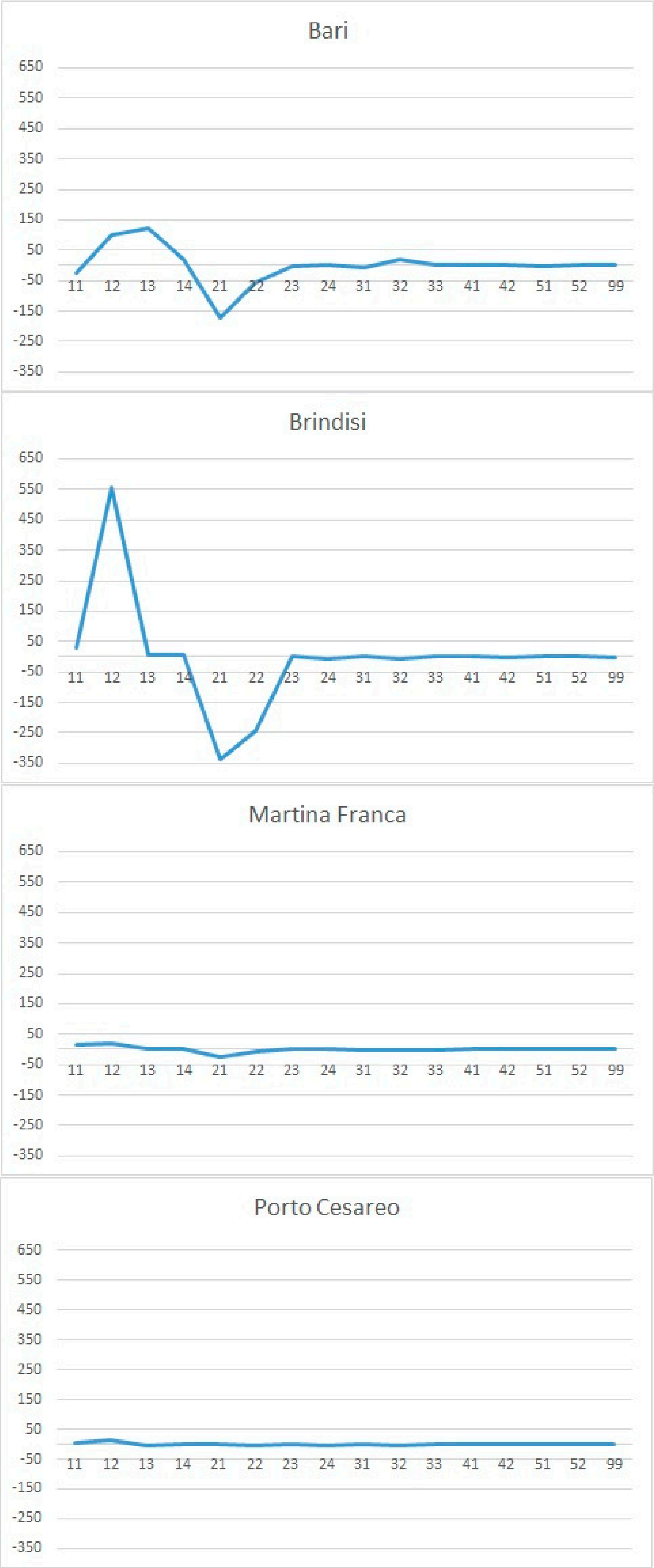


Figure 13. Variation of loss and increase of land cover for each category in the four case studies (Bari, Brindisi, Porto Cesareo, and Martina Franca).

At the same time, under the consideration of revenue as a benefit for local community and institutions (thanks to taxation and, or compensation by land value recapture), is represented the ratio between increase of land value and geographic and demographic unit (Table 16).

Table 16. Land value increase in transition (loss/benefit in 2016): Brindisi.

	Bari	**Porto Cesareo**	**Brindisi**	**Martina Franca**
Absolute increase of land value	€72,246,510.86	€5,353,018.00	€307,331,601.87	€13,109,533.13
Land value increase per hectar	€212,053.16	€235,711.93	€489,701.24	€345,533.29
Land value increase per inhabitant	€225.44	€943.26	€3423.16	€263.35

6. Conclusions

After a general introduction on the importance of saving the natural characteristics of soil, we showed the dynamics linked to the demand of land-change for human activities and, as a special case, keeping in mind the environmental impact of such phenomena on soil, the quantitative relevance of artificialization of surfaces in our context; that is, in the Apulia Region. We attempted to provide evidence of the basic measures of artificialization, with respect to each category of artificial soil, following CLC, the most common classification of land use coverage in Europe. We considered some major aspects that affect and encourage soil alteration by human activities, such as the increase of property value, due to the land-use change and the planning regulations that favor the growth of artificial coverage in order to achieve a supposed social economic advantage. Finally, through some examples, the critical relationship between forms of urban sprawl and artificialization processes have been shown, as regards new residential quarters, new productive/commercial areas in the external periphery of great urban centers, traditional seasonal housing in rural and coastal landscapes, and innovative (solar farms) sprawl in farmlands. After this primary investigation, we attempted to identify some parameters related to land value, which can support more detailed analyses on new economic drivers that can represent a menace for soil integrity, by the use of deeper analyses on land transition and land value transition, measured by the MLV. The analysis of some urban realities shows that the MLV can represent, more than measure, a gross increase of value, an indicator of efficiency of specific rent for each of our case studies. Secondly, MLV can be an indicator of efficiency in sharing benefits. The indicator in our analyses can be well represented by the increase of value per hectare and per inhabitant after land use transition. The greatest efficiency is due to a new use for existing soil resources: the installation of solar farms on the rural soil, which are removable, on one hand, and with the recovery of old rural buildings for new seasonal houses (with a small increase of artificial soil), on the other hand.

The future perspective is to undertake a massive study on indices of land use efficiency. It will be necessary to improve the quality of the information on property values, that were shown to be uncorrelated with the other variables and require case-oriented analyses.

Appendix A

Table A1. Correlation indexes between indicators of land use. Apulian Municipalities with more than 50,000 inhabitants.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Population at 2011 (ab)	1.00	0.51	0.88	0.25	0.61	−0.29	0.62	−0.21	0.79	0.84	0.67	0.71	−0.13	0.12	0.07	−0.07	−0.02
2. Surface (ha)		1.00	0.66	−0.34	0.59	−0.06	0.47	−0.02	0.45	0.73	0.56	0.46	−0.47	0.44	0.15	−0.08	0.06
3. Artificial surface 2011 (ha)			1.00	0.19	0.73	−0.14	0.73	−0.11	0.90	0.94	0.78	0.76	−0.14	0.11	0.12	−0.09	0.01
4. Artificial surface 2011 (%)				1.00	0.04	−0.13	0.13	−0.21	0.33	0.07	0.11	0.15	0.59	−0.60	−0.02	−0.07	−0.02
5. Artificialized soil 2006–2011 (ha/year)					1.00	−0.13	0.36	−0.20	0.53	0.80	0.60	0.48	−0.25	0.23	0.12	−0.13	0.00
6. Artificial surface per capita (sm/inhab)						1.00	−0.02	0.54	−0.13	−0.15	−0.04	−0.09	−0.21	0.17	0.09	0.05	−0.05
7. Unoccupied housing stock (no.)							1.00	0.34	0.82	0.57	0.50	0.63	0.04	−0.04	0.00	−0.01	−0.01
8. Unoccupied housing stock (%)								1.00	−0.01	−0.16	−0.17	−0.01	0.04	0.04	−0.22	0.14	−0.02
9. Residential settlements 2011 (ha)									1.00	0.73	0.62	0.71	0.13	−0.13	0.01	−0.09	0.00
10. Industry, commerce, facilities 2011 (ha)										1.00	0.72	0.67	−0.30	0.30	0.08	−0.10	0.02
11. Quarries, landifll and derelict areas 2011 (ha)											1.00	0.57	−0.29	0.05	0.58	−0.12	0.02
12. Urban Green 2011 (ha)												1.00	−0.11	0.02	0.03	0.44	−0.04
13. % Residential settlments 2011 (Hect)													1.00	−0.89	−0.36	−0.01	−0.02
14. % Industry and Infrastructure 2011 (Hect)														1.00	−0.06	−0.11	0.02
15. % Quarries, derelict and landfill areas 2011 (hect)															1.00	−0.16	0.01
16. % Artificial green 2011 (ha)																1.00	0.00
17. Property value																	1.00

Table A2. Correlation indexes between indicators of land use. Apulian Municipalities with more than 50,000 inhabitants.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Population at 2011 (ab)	1.00	−0.12	0.78	0.85	0.21	−0.13	0.74	−0.29	0.77	0.65	0.59	0.87	0.25	−0.08	−0.30	0.37	−0.05
2. Surface (ha)		1.00	0.15	−0.54	0.27	0.44	−0.19	0.05	−0.08	0.35	−0.03	−0.06	−0.50	0.68	−0.39	−0.49	0.44
3. Artificial surface 2011 (ha)			1.00	0.63	0.50	0.47	0.69	−0.16	0.88	0.92	0.80	0.87	0.16	0.06	−0.36	0.09	0.03
4. Artificial surface 2011 (%)				1.00	0.08	−0.14	0.77	−0.13	0.74	0.41	0.54	0.77	0.49	−0.41	−0.08	0.47	−0.30
5. Artificialized soil 2006–2011 (ha/year)					1.00	0.52	−0.10	−0.47	0.20	0.67	0.37	0.28	−0.28	0.37	−0.22	−0.23	0.08

6. Artificial surface per capita (sm/inhab)						1.00	0.15	0.31	0.33	0.50	0.43	0.22	−0.14	0.21	−0.12	−0.32	0.01
7. Unoccupied housing stock (no.)							1.00	0.36	0.86	0.41	0.56	0.87	0.47	−0.32	−0.22	0.53	−0.20
8. Unoccupied housing stock (%)								1.00	0.03	−0.30	−0.03	−0.01	0.12	−0.22	0.18	0.21	−0.17
9. Residential settlements 2011 (ha)									1.00	0.63	0.69	0.93	0.55	−0.32	−0.32	0.33	−0.02
10. Industry, commerce, facilities 2011 (ha)										1.00	0.68	0.66	−0.19	0.40	−0.42	−0.15	0.08
11. Quarries, landifll and derelict areas 2011 (ha)											1.00	0.71	0.07	−0.21	0.26	0.09	−0.05
12. Urban Green 2011 (ha)												1.00	0.38	−0.20	−0.30	0.51	−0.04
13. % Residential settlments 2011 (Hect)													1.00	−0.84	−0.09	0.43	−0.02
14. % Industry and Infrastructure 2011 (Hect)														1.00	−0.46	−0.42	0.15
15. % Quarries, derelict and landfill areas 2011 (hect)															1.00	−0.03	−0.23
16. % Artificial green 2011 (ha)																1.00	−0.19
17. Property value																	1.00

Table A3. Correlation indexes between indicators of land use. Apulian Municipalities with less than 50,000 inhabitants.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
1. Population at 2011 (ab)	1.00	0.56	0.84	0.07	0.63	−0.40	0.50	−0.22	0.69	0.80	0.45	0.41	−0.09	0.07	0.09	−0.12	0.00
2. Surface (ha)		1.00	0.67	−0.46	0.53	0.06	0.43	0.09	0.34	0.80	0.48	0.38	−0.51	0.46	0.19	−0.04	0.03
3. Artificial surface 2011 (ha)			1.00	0.07	0.68	−0.03	0.68	0.00	0.86	0.88	0.64	0.55	−0.09	0.02	0.19	−0.09	0.04
4. Artificial surface 2011 (%)				1.00	−0.04	−0.12	0.00	−0.21	0.28	−0.14	−0.01	−0.02	0.64	−0.65	−0.03	−0.09	0.01
5. Artificialized soil 2006-2011 (ha/year)					1.00	−0.06	0.34	−0.13	0.50	0.69	0.44	0.27	−0.23	0.20	0.15	−0.15	−0.02
6. Artificial surface per capita (sm/inhab)						1.00	0.08	0.52	−0.06	−0.05	0.12	0.02	−0.26	0.21	0.13	0.04	−0.05
7. Unoccupied housing stock (no.)							1.00	0.50	0.76	0.47	0.29	0.45	0.10	−0.10	−0.03	0.02	0.03
8. Unoccupied housing stock (%)								1.00	0.11	−0.08	−0.09	0.10	0.00	0.08	−0.22	0.13	−0.02
9. Residential settlements 2011 (ha)									1.00	0.55	0.39	0.47	0.30	−0.30	−0.01	−0.09	0.03
10. Industry, commerce, facilities 2011 (ha)										1.00	0.50	0.43	−0.38	0.37	0.12	−0.11	0.04
11. Quarries, landifll and derelict areas 2011 (ha)											1.00	0.28	−0.27	−0.03	0.72	−0.12	0.04
12. Urban Green 2011 (ha)												1.00	−0.07	−0.06	0.01	0.63	−0.03
13. % Residential settlments 2011 (Hect)													1.00	−0.89	−0.35	−0.02	−0.02
14. % Industry and Infrastructure 2011 (Hect)														1.00	−0.07	−0.10	0.01

15. % Quarries, derelict and landfill areas 2011 (hect)															1.00	−0.16	0.03
16. % Artificial green 2011 (ha)																1.00	0.00
17. Property value																	1.00

Table A4. Correlation indexes between indicators of land use. Apulian Municipalities with less than 15,000 inhabitants.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
1. Population at 2011 (ab)	1.00	0.28	0.75	0.25	0.42	−0.41	0.26	−0.31	0.68	0.56	0.32	0.33	0.15	−0.23	0.14	−0.01	−0.07
2. Surface (ha)		1.00	0.49	−0.50	0.37	0.22	0.26	0.18	0.00	0.82	0.37	0.27	−0.56	0.48	0.24	0.03	−0.01
3. Artificial surface 2011 (ha)			1.00	0.19	0.57	0.13	0.47	−0.02	0.75	0.77	0.64	0.46	0.00	−0.18	0.36	0.00	−0.07
4. Artificial surface 2011 (%)				1.00	−0.02	−0.16	0.04	−0.26	0.51	−0.22	0.00	−0.02	0.68	−0.70	−0.02	−0.10	−0.02
5. Artificialized soil 2006-2011 (ha/year)					1.00	0.07	0.17	−0.14	0.29	0.64	0.38	0.16	−0.20	0.12	0.24	−0.12	−0.11
6. Artificial surface per capita (sm/inhab)						1.00	0.19	0.49	−0.04	0.19	0.20	0.04	−0.38	0.33	0.17	−0.01	−0.11
7. Unoccupied housing stock (no.)							1.00	0.65	0.58	0.26	0.04	0.30	0.16	−0.15	−0.09	0.11	−0.01
8. Unoccupied housing stock (%)								1.00	0.05	−0.02	−0.14	0.08	−0.08	0.18	−0.24	0.12	−0.03
9. Residential settlements 2011 (ha)									1.00	0.28	0.15	0.31	0.52	−0.53	−0.03	−0.04	−0.07
10. Industry, commerce, facilities 2011 (ha)										1.00	0.49	0.33	−0.46	0.36	0.29	−0.04	−0.06
11. Quarries, landifll and derelict areas 2011 (ha)											1.00	0.18	−0.27	−0.08	0.77	−0.09	−0.02
12. Urban Green 2011 (ha)												1.00	−0.05	−0.12	0.02	0.77	−0.05
13. % Residential settlments 2011 (Hect)													1.00	−0.88	−0.36	−0.04	−0.03
14. % Industry and Infrastructure 2011 (Hect)														1.00	−0.08	−0.08	0.02
15. % Quarries, derelict and landfill areas 2011 (hect)															1.00	−0.16	0.01
16. % Artificial green 2011 (ha)																1.00	0.03
17. Property value																	1.00

Table A5. Correlation indexes between indicators of land use. Coastal Apulian Municipalities with less than 50,000 inhabitants.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
1. Population at 2011 (ab)	1.00	0.57	0.85	−0.05	0.56	−0.33	0.58	−0.17	0.75	0.86	0.69	0.41	−0.22	0.26	0.09	−0.10	0.11
2. Surface (ha)		1.00	0.68	−0.59	0.44	0.04	0.48	0.03	0.48	0.82	0.54	0.48	−0.57	0.57	0.14	0.14	0.22
3. Artificial surface 2011 (ha)			1.00	−0.05	0.67	0.09	0.80	0.15	0.94	0.91	0.78	0.53	−0.10	0.09	0.10	−0.02	0.16
4. Artificial surface 2011 (%)				1.00	−0.10	−0.01	0.05	0.09	0.17	−0.29	−0.15	−0.23	0.82	−0.75	−0.26	−0.30	−0.05
5. Artificialized soil 2006-2011 (ha/year)					1.00	0.01	0.45	0.05	0.61	0.66	0.52	0.30	−0.14	0.17	0.06	−0.07	−0.06
6. Artificial surface per capita (sm/inhab)						1.00	0.26	0.60	0.16	−0.05	0.06	0.12	0.12	−0.24	0.08	0.14	−0.07
7. Unoccupied housing stock (no.)							1.00	0.56	0.86	0.63	0.54	0.33	0.12	−0.10	−0.03	−0.09	0.25
8. Unoccupied housing stock (%)								1.00	0.29	−0.03	0.01	0.05	0.36	−0.32	−0.24	0.01	0.22
9. Residential settlements 2011 (ha)									1.00	0.74	0.70	0.40	0.18	−0.17	0.00	−0.12	0.14
10. Industry, commerce, facilities 2011 (ha)										1.00	0.67	0.54	−0.40	0.43	0.09	0.02	0.17
11. Quarries, landifll and derelict areas 2011 (ha)											1.00	0.23	−0.23	0.06	0.57	−0.17	0.15
12. Urban Green 2011 (ha)												1.00	−0.29	0.13	−0.14	0.71	−0.01
13. % Residential settlments 2011 (Hect)													1.00	−0.89	−0.42	−0.29	0.01
14. % Industry and Infrastructure 2011 (Hect)														1.00	0.10	0.09	0.02
15. % Quarries, derelict and landfill areas 2011 (hect)															1.00	−0.26	−0.07
16. % Artificial green 2011 (ha)																1.00	−0.01
17. Property value																	1.00

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