



URBAN SPRINKLING: A DIFFICULT RECOVERY

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This study is a part of different research project:s

- National Database on Land take over the past 50 years
- SUNLIFE (LIFE13 NAT/IT/000371)
- other activities in collaboration with Umbria Region and «Biodiversity and Landscape Observatory»



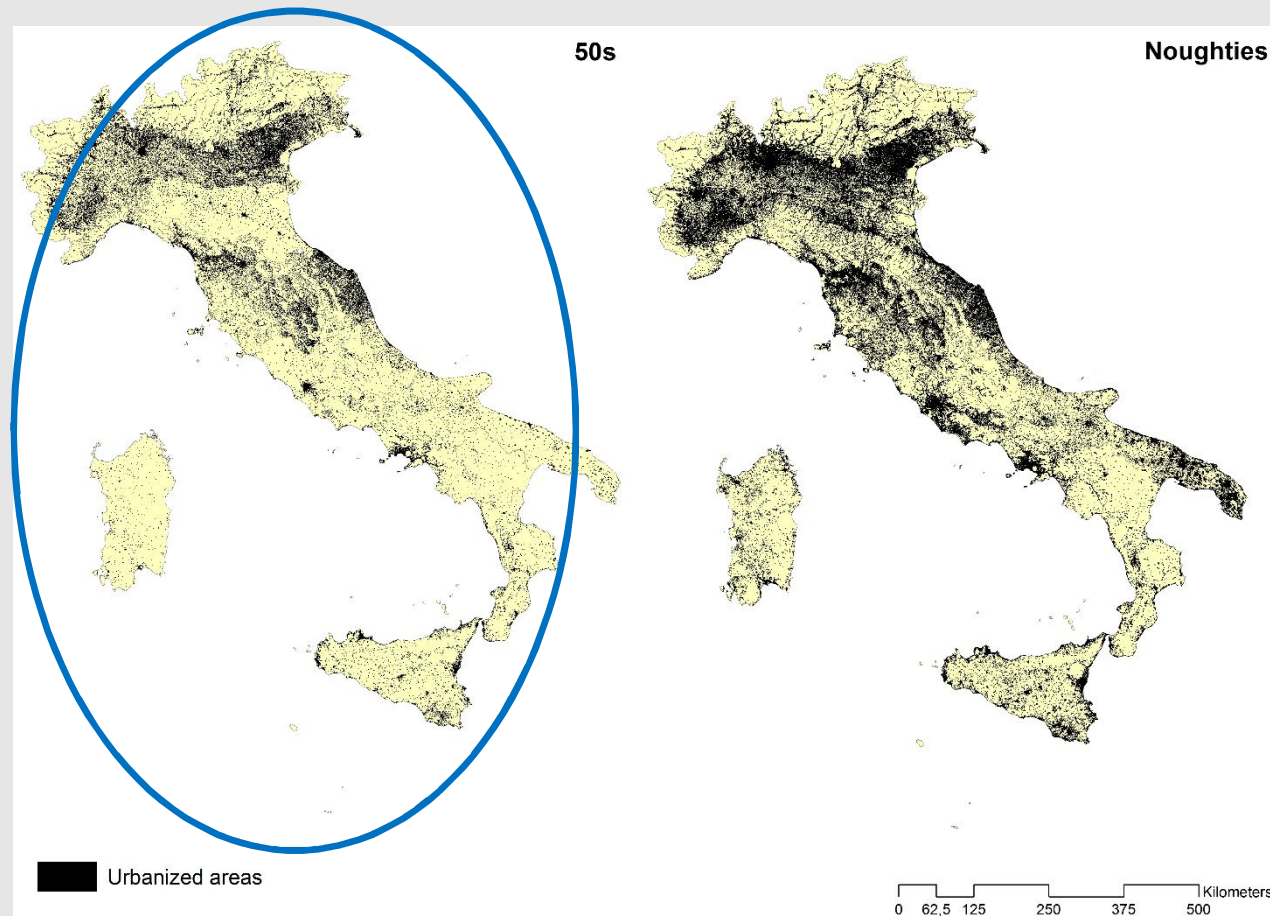
The role of Land planning in challenges of Anthropocene

Land take is one of the human activities that is changing inevitably the earth naturalness, moreover from various related studies it is clear how humans are a major factor in transforming the landscape. These studies also consider humans as geological and geomorphological agents, through settlement and widespread industrialization and urbanization, and they lead to the recognition of a new geologic time unit known as the Anthropocene. Indeed the Anthropocene is stratigraphically distinct from the Holocene and earlier epochs because the ecosystem's physical transformations, that can be measured in terms of their magnitude of impact and their rate, are much more extensive and fast. (Ellis & Ramankutty, 2008; Ellis et al., 2010; Ellis, 2011; Ellis et al., 2013; Crutzen, Stoermer, 2000; Crutzen, 2002; Price, Ford, Cooper and Neal, 2011; Hobbs, Higgs & Hall, 2013; Waters, 2016).

Moreover, according to consolidated scientific opinions, **land use caused by urbanization is one of the main causes of political and social conflicts** (Plotkin, 1987) **and altered environmental quality of land** (Ellis & Ramankutty, 2008; Sala et al., 2000).



Land take in Italy: models and trajectories



This study is part of the national research that the University of L'Aquila leads from 2006 and it regards the processing of data on Italian urban land transformation over the past 50 years and the effects in the areas of high environmental vulnerability. The historical data have been compared from a qualitative and quantitative viewpoint with the present-day geography of settlements; this comparison also shows the changes found in today's settlement-territorial structure.

Maps of the urbanized areas in Italy in the (left) 1950s and (right) noughties.

Research References:

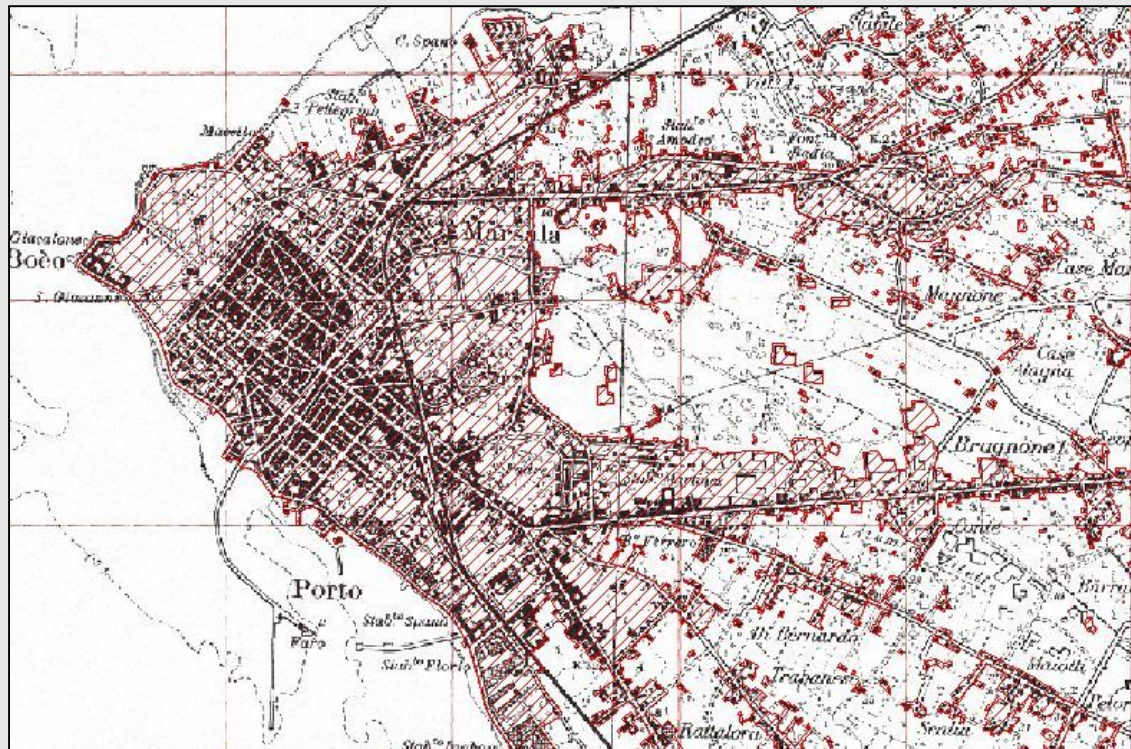
- Romano B., Zullo F., 2012. Land urbanization in Central Italy: 50years of evolution. *Journal of Land Use Science*, 9(2):143-164 DOI:10.1080/1747423X.2012.754963.
- Romano B., Zullo F., 2013. Models of Urban Land Use in Europe: Assessment tools and criticalities. *IJAEIS*, IGI Global volume 4(3):80-97, DOI:10.4018/ijaeis.2013070105.
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- Zullo F., Paolinelli G., Fiordigigli V., Fiorini L., Romano B., 2015. Urban development in Tuscany: Land Uptake and LandscapeChanges. *TeMA*, 8(2):183-201. DOI: [10.6092.1970-9870/2864](https://doi.org/10.6092.1970-9870/2864).
- Romano B., Zullo F., 2015. Half a century of urbanisation in Southern European Lowlands: a study on the Po Valley (Northern Italy). *Journal of Urban Research and Practice*. DOI:10.1080/17535069.2015.10778851.

Starting Data

The details of the used methods have already been described in various papers by Romano and Zullo (2010, 2012, 2014) during the development of national research on land take which began in 2006.

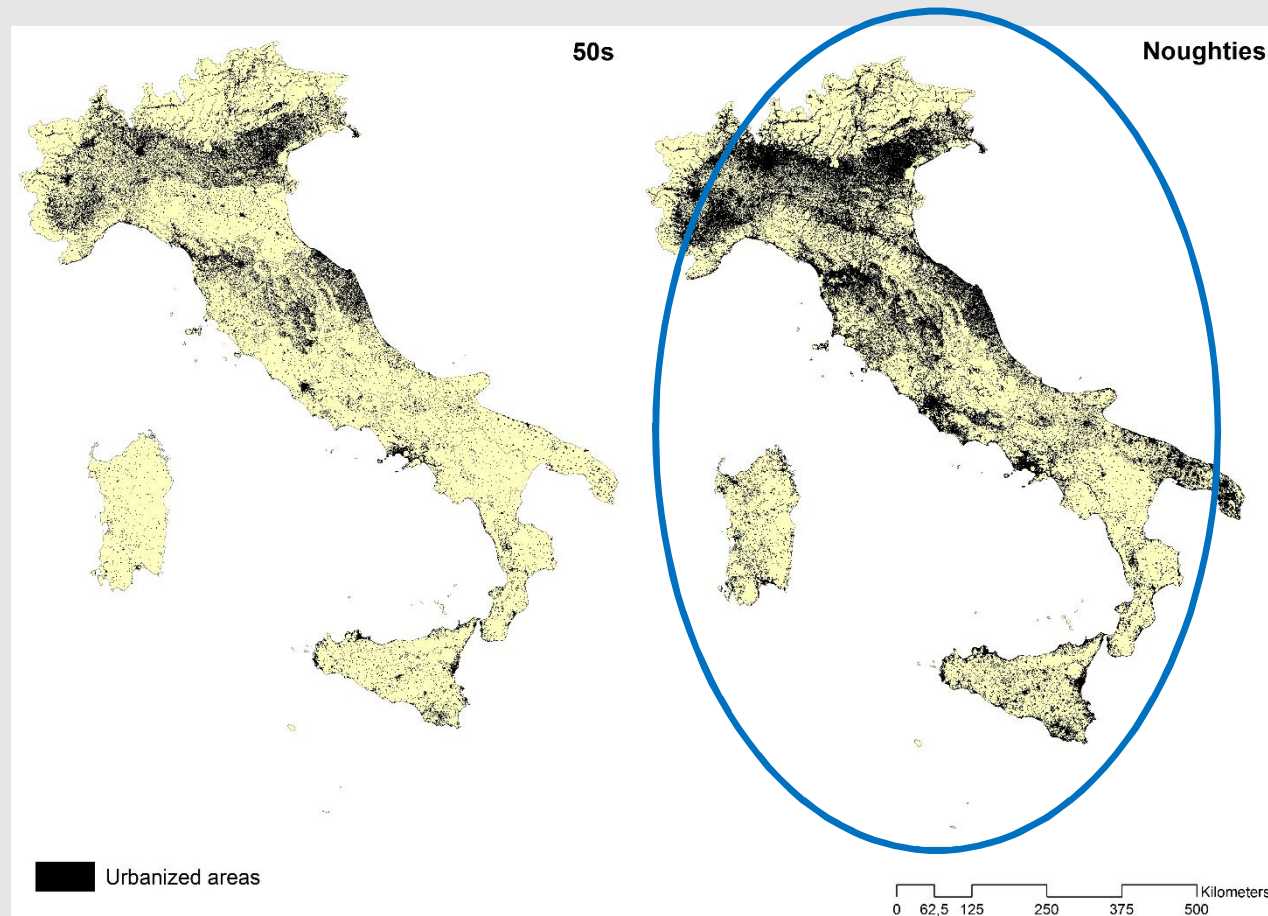
The urbanized areas in the 1950s were extrapolated from homogenous maps of the entire country using an appropriate GIS technique, in order to obtain comparable values for all Italian regions.

This is why, in the study presented we used Italian maps published on a scale of 1:25,000 by the Italian Military Geographical Institute (IGMI) between 1949 and 1962 (Figure below).



These maps are part of the 25V Series, plotted on a scale of 1:20,000, organized in 3,545 elements (tables) 7'30" longitude and 5' latitude in size, in Gauss's conformal representation and part of the national geodetic system (international ellipsoid oriented to Rome Monte Mario - ED40) with a kilometric grid in the Universal Transverse of Mercator conformal projection (ED50 European data).

Land take in Italy: models and trajectories



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Region	Website	Date of update	Acquisition scale
Valle D'Aosta	http://geoportale.partout.it/	Carta della natura (U - 2007 - ISPRA)/ Carta Tecnica Regionale (E - 2003)	1:50.000 / 1:5.000
Piedmont	http://www.geoportale.piemonte.it/cms/	Carta Tecnica Regionale (E - 2008)	1:10.000
Liguria	http://www.cartografia.regione.liguria.it/	Uso del suolo (U - 2012); Carta Tecnica Regionale (E - 2010)	1:10.000 / 1:5.000
Lombardy	http://www.cartografia.regione.lombardia.it/geoportale	DUSAF3 (U - 2009); Carta Tecnica Regionale (E - 1980-1994 aggiornate poi dai DbT)	1:10.000 / 1:10.000
Veneto	http://idt.regione.veneto.it/app/metacatalog/	Uso del suolo (U - 2006); Carta Tecnica Regionale (E - 2001 -2005)	1:10.000 / 1:5.000
Provincia di Trento	http://www.territorio.provincia.tn.it/portal/server.pt/community/cartografia di base/260/cartografia di base/19024	Uso del suolo (U - 2003); Carta Tecnica Provinciale (E - 2012/2013)	1:10.000 / 1:10.000
Provincia di Bolzano	http://www.provincia.bz.it/informatica/cartografia/geoportale.asp	Uso del suolo (U - 2001); Carta Tecnica Provinciale (E - 1981 - 1995)	1:10.000 / DB Multiscala (1:10.000; 1:5.000; 1:1.000)
Friuli Venezia Giulia	http://www.regione.fvg.it/rafvg/cms/RAFVG/ambiente-territorio/strumenti-per-conoscere/	Uso del suolo (U - 2000 Progetto Moland) Carta Tecnica Regionale (E - 2003 - 2006)	1:25.000 / 1:5.000
Emilia Romagna	http://geoportale.regione.emilia-romagna.it/it	Uso del suolo (U - 2008); Carta Tecnica Regionale (E - 2012)	1:10.000 / 1:10.000
Tuscany	http://www.regione.toscana.it/enti-e-associazioni/pianificazione-e-paesaggio/informazione-geografica	Uso e copertura del suolo (U - 2007 - 2010); Carta Tecnica Regionale (E - 2003)	1:10.000 / 1:10.000 - 1:2.000
Umbria	http://www.umbriageo.regione.umbria.it/canale.asp	Carta Geobotanica (U - 2002); Carta Tecnica Regionale (E - 1980 - 2001)	1:50.000 / Multiscala (1:2.000 - 1:1.000 - 1:500)
Marche	http://www.ambiente.marche.it/Territorio/Cartografiaeinformazioni territoriali.aspx	Uso del Suolo (U - 2001); Carta Tecnica Regionale (E - 1989 - 2000)	1:10.000 / 1:2.000
Abruzzo	http://www.regione.abruzzo.it/xcartografia/	Uso del suolo (U - 2000); Carta Tecnica Regionale (E - 2007)	1:10.000 / 1:5.000
Lazio	http://www.urbanisticaecasa.regione.lazio.it/cartografia_on_line/	Uso del Suolo (U - 2002); Carta Tecnica Regionale (E - 1984-1985)	1:10.000 / 1:10.000
Molise	http://cartografia.regione.molise.it/	Uso del Suolo (U - 2001); Carta Tecnica Regionale (E - 1994 - 2002)	1:10.000 / Multiscala 1:10.000 - 1:5.000 - 1: 2.000
Campania	http://sit.regione.campania.it/portal/portal/default/Home.jsessionid=FEBC2BEE0D9BA1A5275B2ABBD6F847	Carta di Utilizzazione Agricola dei Suoli (U - 2004); Carta Tecnica Regionale (E - 2007)	1:50.000 / 1:25.000
Basilicata	http://rsdi.regione.basilicata.it/web/guest/mappe-in-linea	Carta Tecnica Regionale (E - 2015)	1:5.000
Puglia	http://www.sit.puglia.it/portal	Uso del Suolo (U - 2006 2007 - Aggiornamenti 2011); Carta Tecnica Regionale (E - 2007)	1:10.000 / 1:5.000 - 1:2.000
Calabria	http://pr5sit.regione.calabria.it/web/pr5sit/home	Carta Tecnica Regionale (E - 2007- 2008); Uso del suolo (U - 2006)	1:5.000 / 1:10.000
Sicily	http://www.sitr.regione.sicilia.it/	Uso del suolo (U - 2007); Carta Tecnica Regionale (E - 2005 - 2007)	1:10.000 / 1:10.000 - 1:2.000
Sardinia	http://www.sardegna.geoportale.it/index.html	Uso del Suolo (U - 2008); Carta Tecnica Regionale (E - 1994 2000)	1:25.000 / 1:10.000

Starting Data

a Built-up land *BL*

surfaces covered by buildings and identifiable through the ground projection of the perimeter of the latter. Natural soil has been removed completely in order to build foundations.



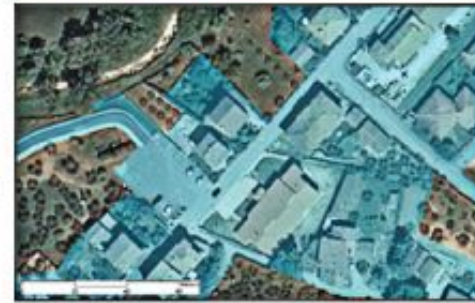
b Urbanised soil *US*

land used for urban functions, involving the replacement or retention of natural soil: it includes built-up land and land used for ancillary settlement functions, such as public and private gardens, sports facilities, unpaved roads and other service areas, either permeable or impermeable to water.



c Artificial land *AL*

areas where the natural layer has been replaced by other materials, either permeable or impermeable to water, to allow different uses: it includes parts of built-up land, but also streets, squares and parking lots (paved or permeable), as well as sports fields or excavation areas



d Sealed soil *SS*

surfaces covered by layers of impermeable material preventing the absorption of surface water. It includes built-up land and land used for other purposes that require paving, such as streets, squares and parking lots and all those cases where the natural soil layers are removed entirely and replaced by other materials that improve the stability and indeformability of surfaces.





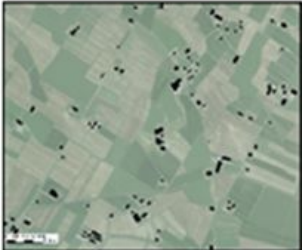
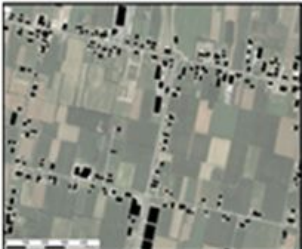
• REGIONAL LAND USE MAPS.

• CORINE LAND COVER.

Typologies of soil transformations.

Land take in Italy: models and trajectories

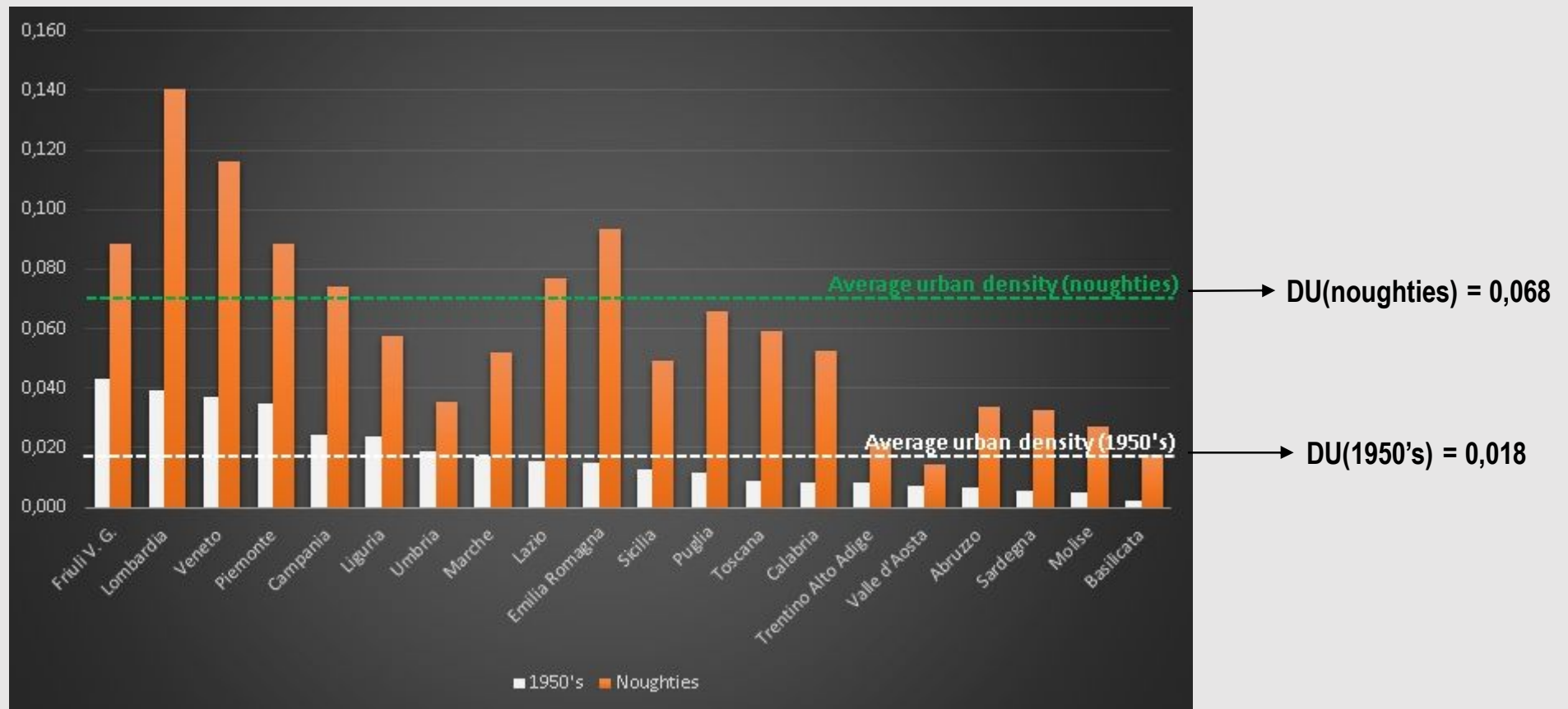
Data collected so far show a clear difference between the settlement patterns of the various countries; if worldwide it's possible to talk about "sprawl" (Gibelli & Salzano, 2006), in Italy and in some other countries (e.g. Balkans and Iberian peninsula) it's more appropriate to extend that terminology with a more appropriate and newly defined term.

		TERRITORIAL AND URBANISTIC PARAMETERS AVERAGE
	SPRAWL <i>(International Standard)</i> The urban fabric designed by parcelling plan, with single-family house and two-family house. There are coordinated interventions for the realization of collective spaces and services, often also in the buildings's architecture. This type of urban pattern is homogeneous for use.	BUILDING DENSITY: 6 dw/ha (between 10 and 20 dw/ha of site density, i.e. the density used at the individual lot level) RESIDENTIAL DENSITY: 20–25 population/ha BUILDING COVERAGE RATIO (BCR): 10–12 %
	SPRAWL <i>(Italian Coastal Model)</i> The urban fabric designed by parcelling plan, with multi-family house. This type of urban pattern is partly homogeneous for use.	BUILDING DENSITY: 12 dw/ha RESIDENTIAL DENSITY: 120–150 population/ha BUILDING COVERAGE RATIO (BCR): 25–30 %
	SPRINKLING <i>(Italian Extended Model)</i> Settlement to unaffected development, additive on historical matrix, with residential property partly one-family house. This type of urban pattern is irregular for use, with rural, residential, industry and tertiary functions.	BUILDING DENSITY: 0,1 dw/ha RESIDENTIAL DENSITY: 0,2–0,5 population/ha BUILDING COVERAGE RATIO (BCR): 1%
	SPRINKLING <i>(Italian Linear Model)</i> Settlement to unaffected development, additive on historical matrix, governed by the guidelines roads, with residential property partly one-family house. This type of urban pattern is irregular for use, with rural, residential, industry and tertiary functions	BUILDING DENSITY: 0,8 dw/ha RESIDENTIAL DENSITY: 1,5–2 population/ha BUILDING COVERAGE RATIO (BCR): 4%

According to the Merriam-Webster's dictionary, **urban sprawl** is "***the spreading of urban developments (as houses and shopping centers) on undeveloped land near a city***". It turned out that in Italy the urban density values can be better represented with another indicator, which is still in a development stage; it is called "***sprinkling***" and it can be defined as "***a small quantity falling in scattered drops or particles***". The differences between these two models of urban pattern are shown in the figure below.

Maps of the urbanized areas in Italy in the (left) 1950s and (right) noughties.

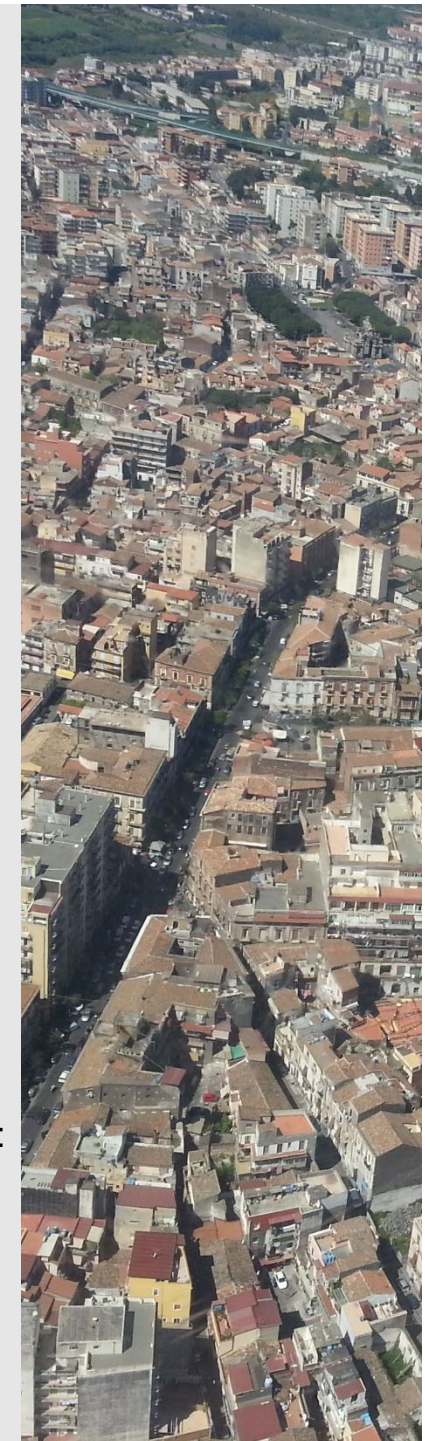
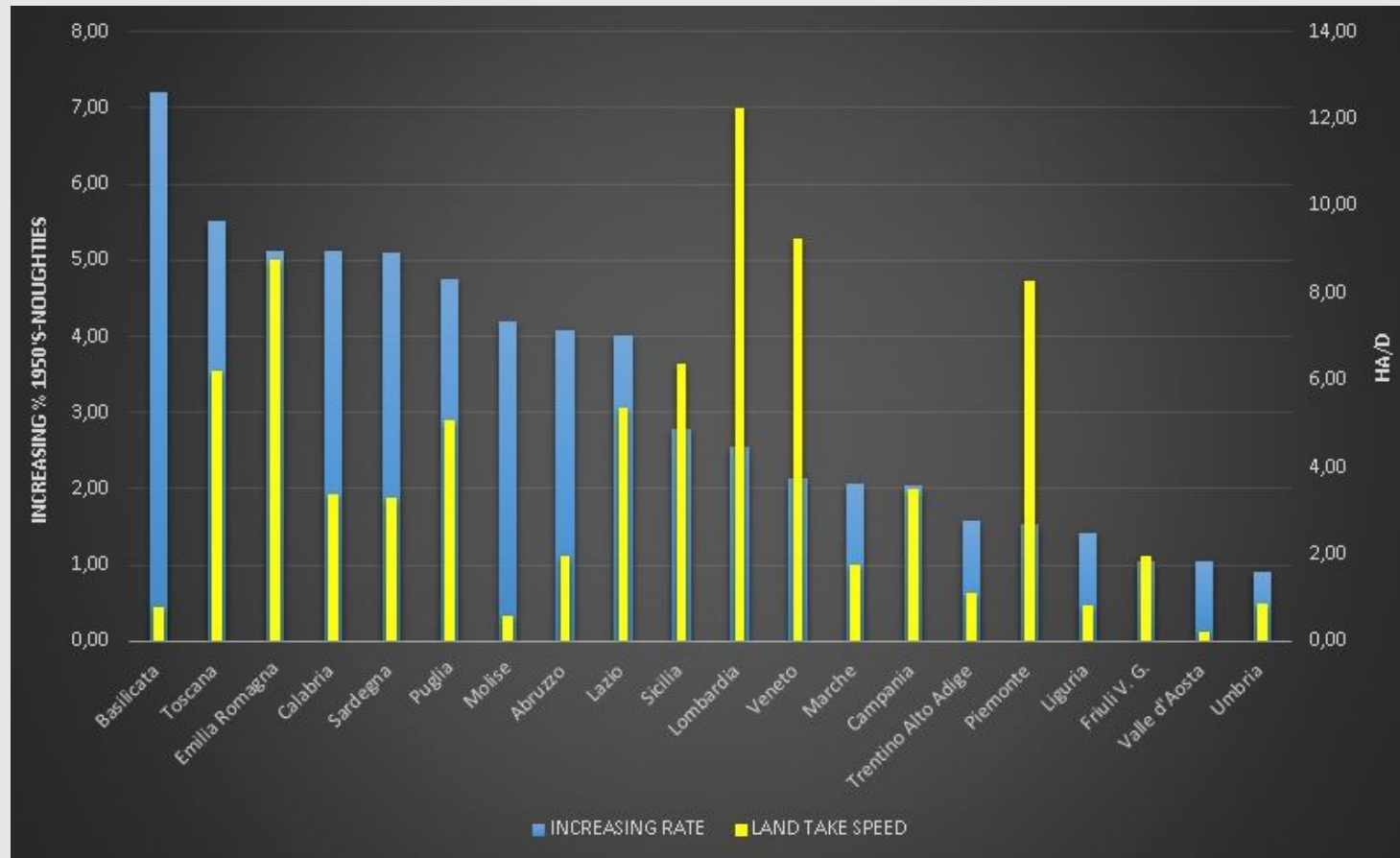
Italian Urban Evolution



The average urban density (DU), during the last 50 years, is increased quite much, by going from less 2% (in the 50's) to almost 7% (in the noughties).

In the 50's 12 regions were under the average regional urbanization density and in the noughties 15 are also below the new average regional value.

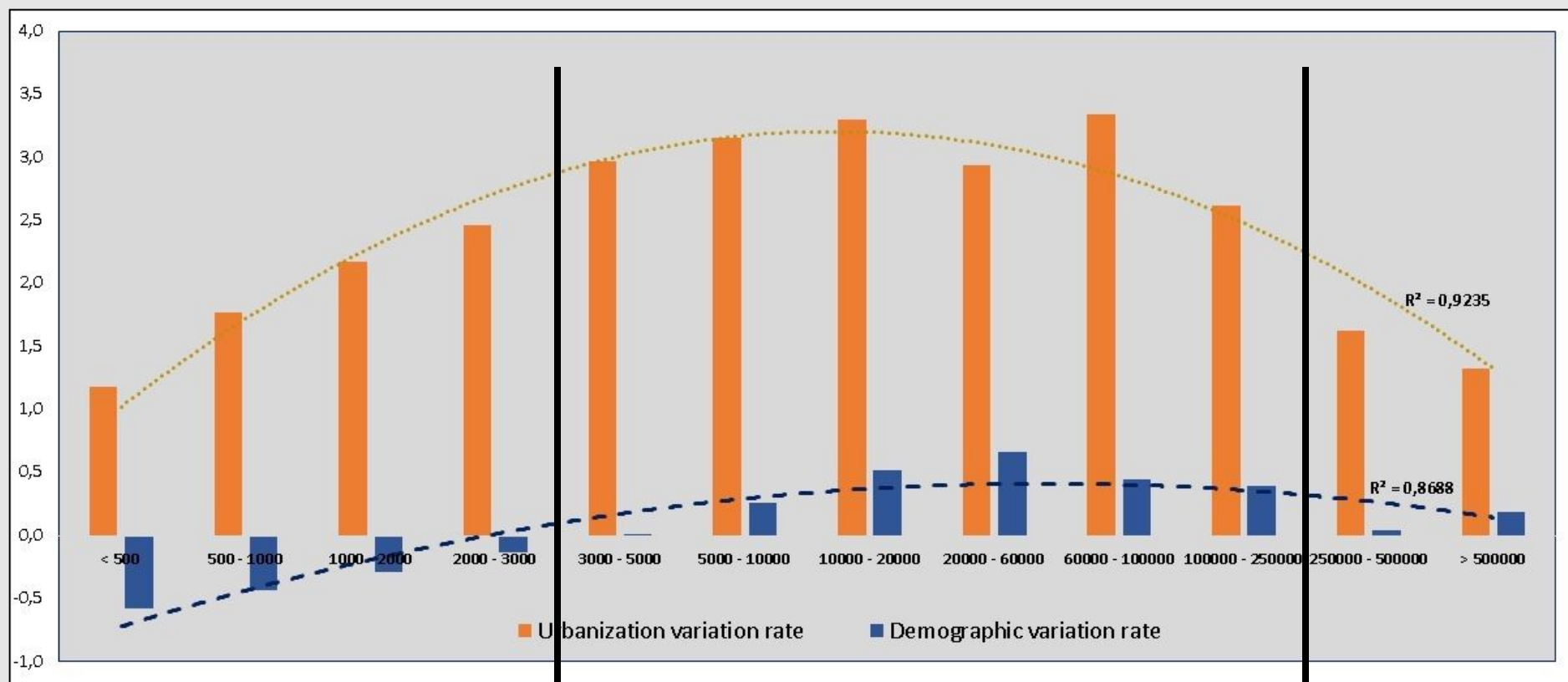
Italian Urban Evolution



In the noughties the Italian urbanized areas are about 2 millions of ectars (7% of entire national territory) with:

- 3,71 of increasing rate (about + 1,3 ha in 50 years)
- about 80 ha/day of land take speed.
- The average per capita urbanization in the 50's was nearly 115 m²/inh and in the noughties was about 360 m²/inh, according to the european average value.

Italian Urban Evolution



117% < Δ Urb < 247%

Δ Pop < 0

261% < Δ Urb < 330%

11% < Δ Pop < 66%

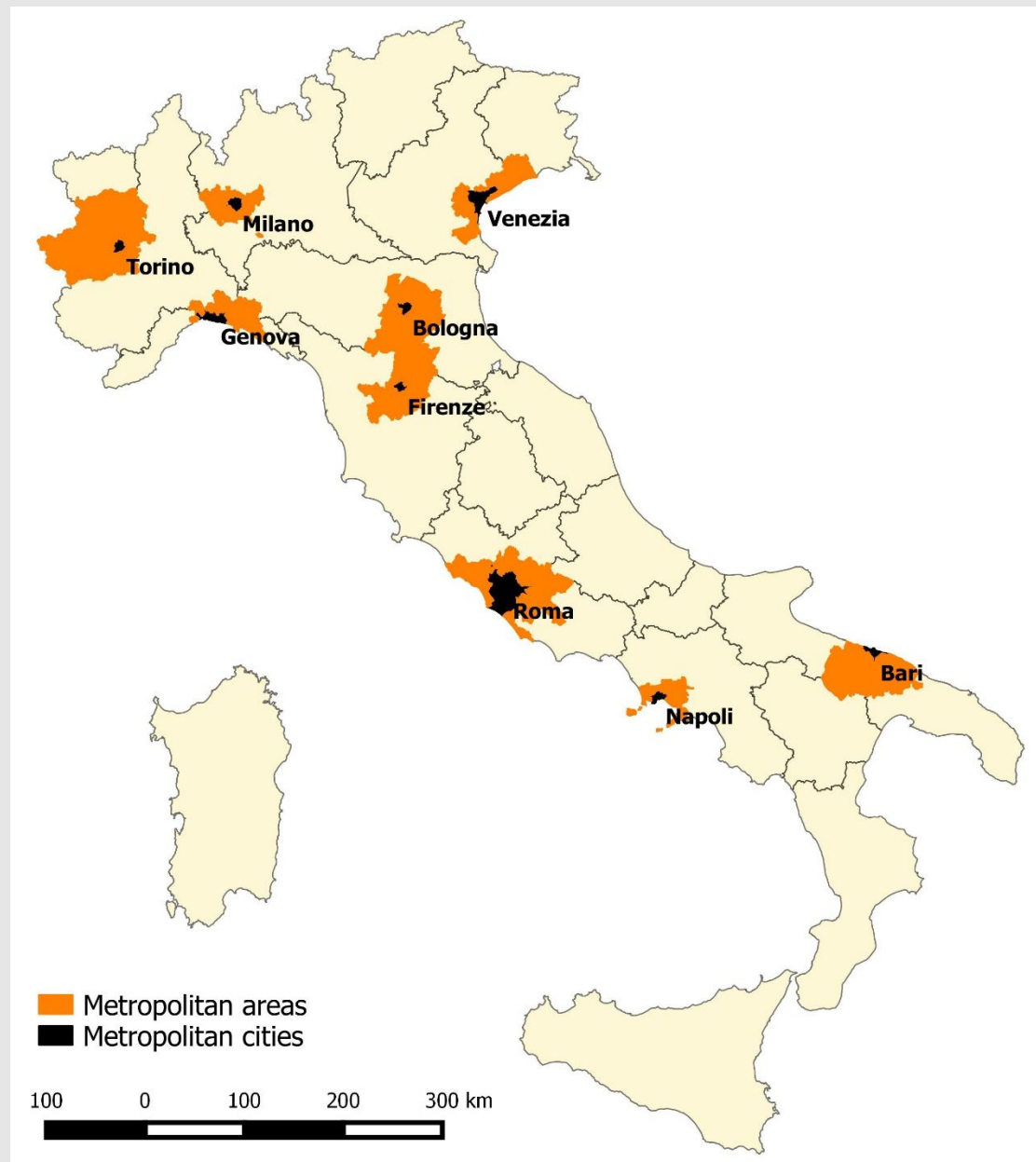
133% < Δ Urb < 162%

4% < Δ Pop < 19%

Metropolitan areas

In Italy there are 9 metropolitan areas:

- 5 in the northern regions
- 2 in the central regions
- 2 in the southern regions



Metropolitan areas

METROPOLITAN AREAS	Area (ha)	Urbanized area (ha)		Pop (1951)	Pop (2011)	TVU	TVD	Urban density (%)	
		1950's	Noughties					1950's	Noughties
Bari metropolitan area	374541,18	3957,21	21332,23	660183	931370	4,39	0,41	1,06	5,70
Bari	11738,57	1518,33	4653,23	268183	315933	2,06	0,18	12,93	39,64
Bologna metropolitan area	356187,88	2834,92	31207,05	423381	604906	10,01	0,43	0,80	8,76
Bologna	14085,64	2910,17	7673,7	340526	371337	1,64	0,09	20,66	54,48
Florence metropolitan area	341132,42	3053,86	21944,44	429916	615066	6,19	0,43	0,90	6,43
Florence	10231,72	1988,84	5006,92	374625	358079	1,52	-0,04	19,44	48,94
Genoa metropolitan area	159346,01	2909,59	6229,3	240443	269654	1,14	0,12	1,83	3,91
Genoa	24028,57	3098,59	6227,82	688447	586180	1,01	-0,15	12,90	25,92
Milan metropolitan area	139395,35	10799,04	48422,74	655533	1796297	3,48	1,74	7,75	34,74
Milan	18166,93	8932,66	14201,87	1274154	1242123	0,59	-0,03	49,17	78,17
Naples metropolitan area	105988,81	12314,58	30162,18	1070569	2092953	1,45	0,95	11,62	28,46
Naples	11901,51	4759,63	8675,05	1010550	962003	0,82	-0,05	39,99	72,89
Rome metropolitan area	407583,83	5517,03	37222,27	499277	1380290	5,75	1,76	1,35	9,13
Rome	128733,71	9365,92	39618,64	1651393	2617175	3,23	0,58	7,28	30,78
Turin metropolitan area	669689,91	28994,14	66723,45	713701	1368401	1,30	0,92	4,33	9,96
Turin	13000,95	8391,18	11287,86	719300	872367	0,35	0,21	64,54	86,82
Venice metropolitan area	205696,99	6752,25	25588,93	423559	585600	2,79	0,38	3,28	12,44
Venice	41589,3	2914,23	6891,11	316891	261362	1,36	-0,18	7,01	16,57

Demo-urban Dispropotionality Index

$$I_{ds} = \frac{\frac{S_{urb\ i}}{\sum_1^n S_{urb}}}{\frac{N_{inhab\ i}}{\sum_1^n N_{inhab}}}$$

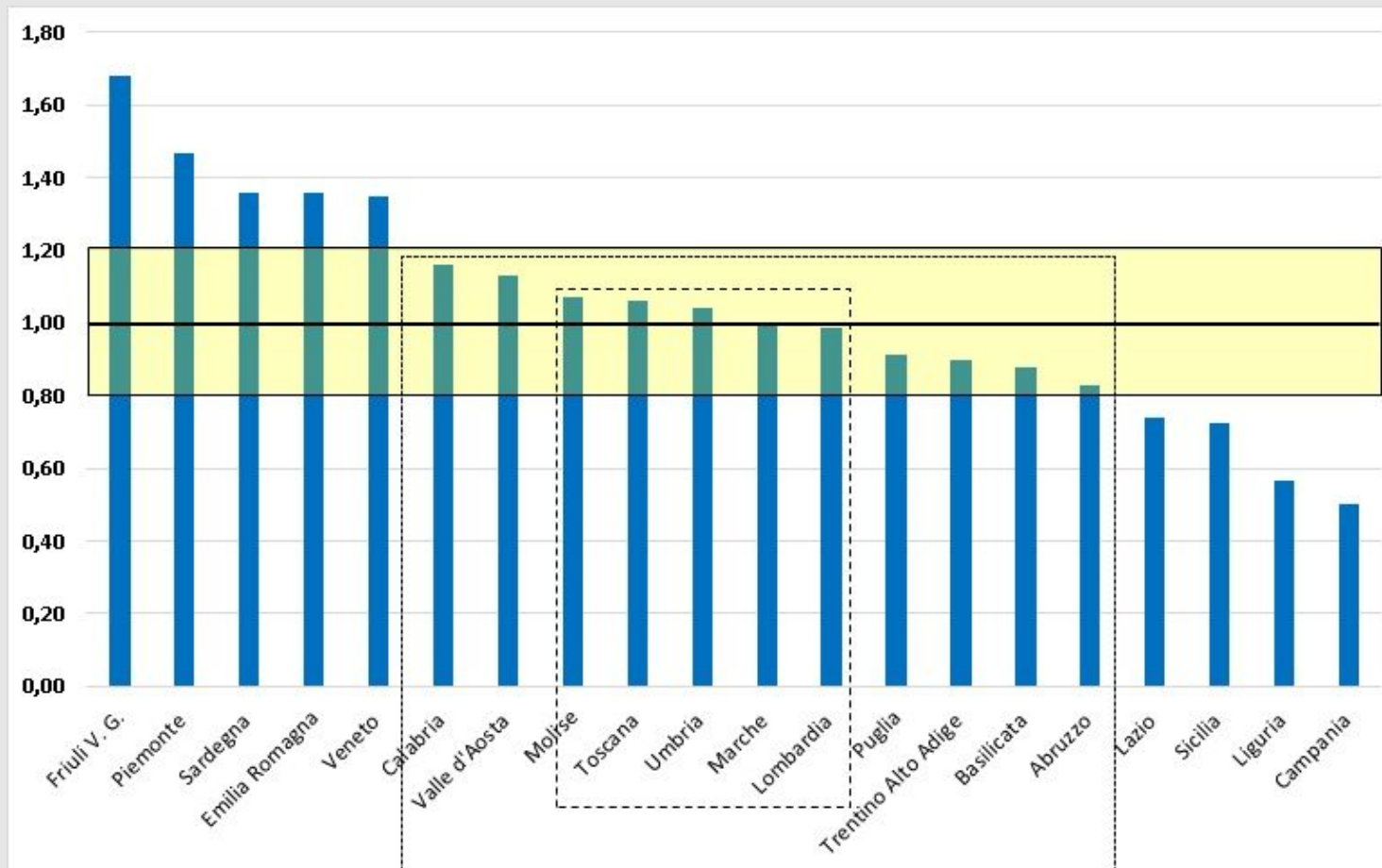
Where:

S_{urb-i} = urbanized area of the i-th territorial system considered

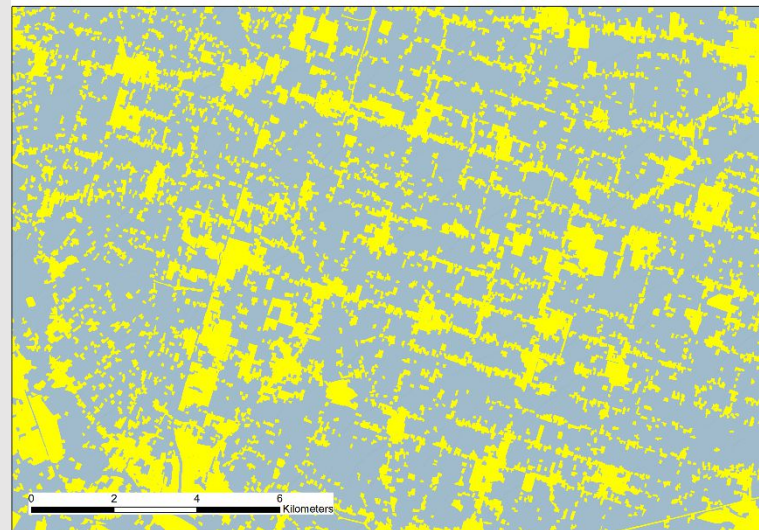
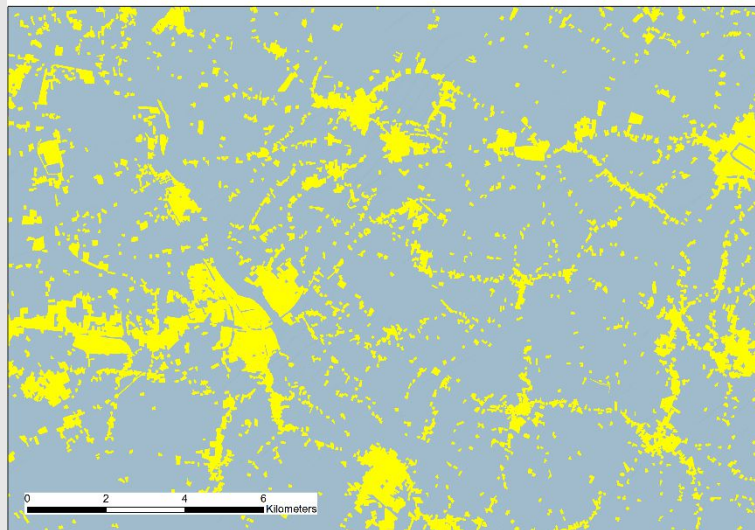
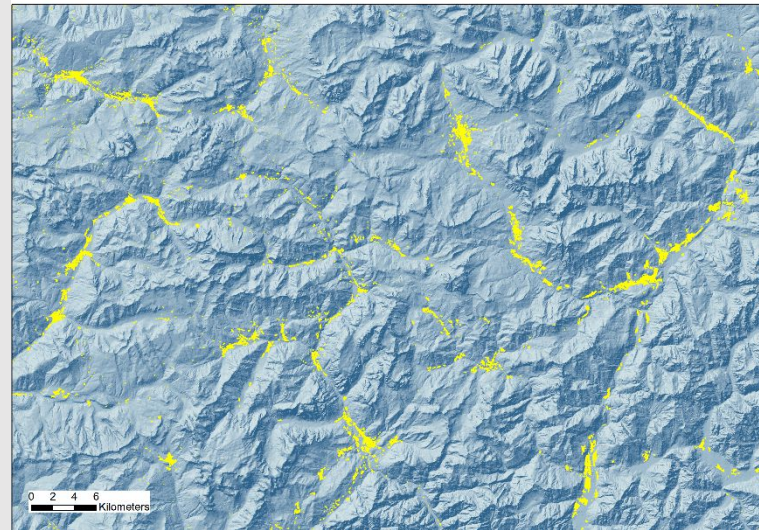
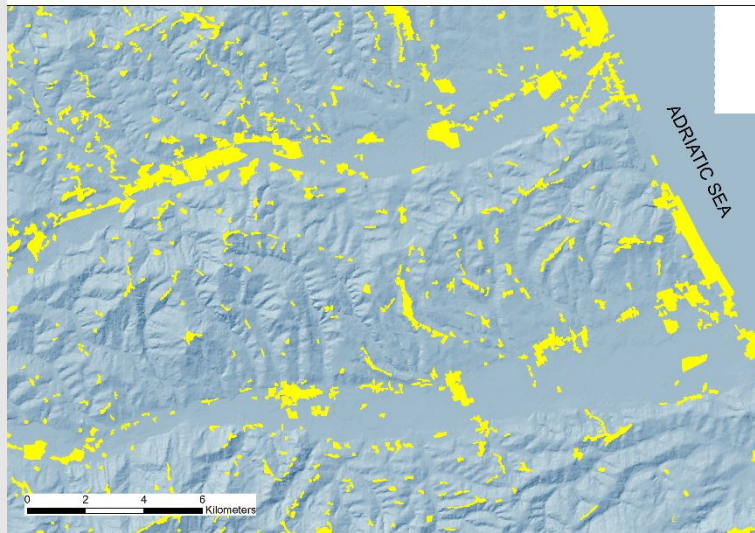
S_{urb} = total urbanized area of the territorial system considered

$N_{inhab-i}$ = number of inhabitants for the i-th territorial system considered

N_{inhab} = total number of inhabitants for the territorial system considered



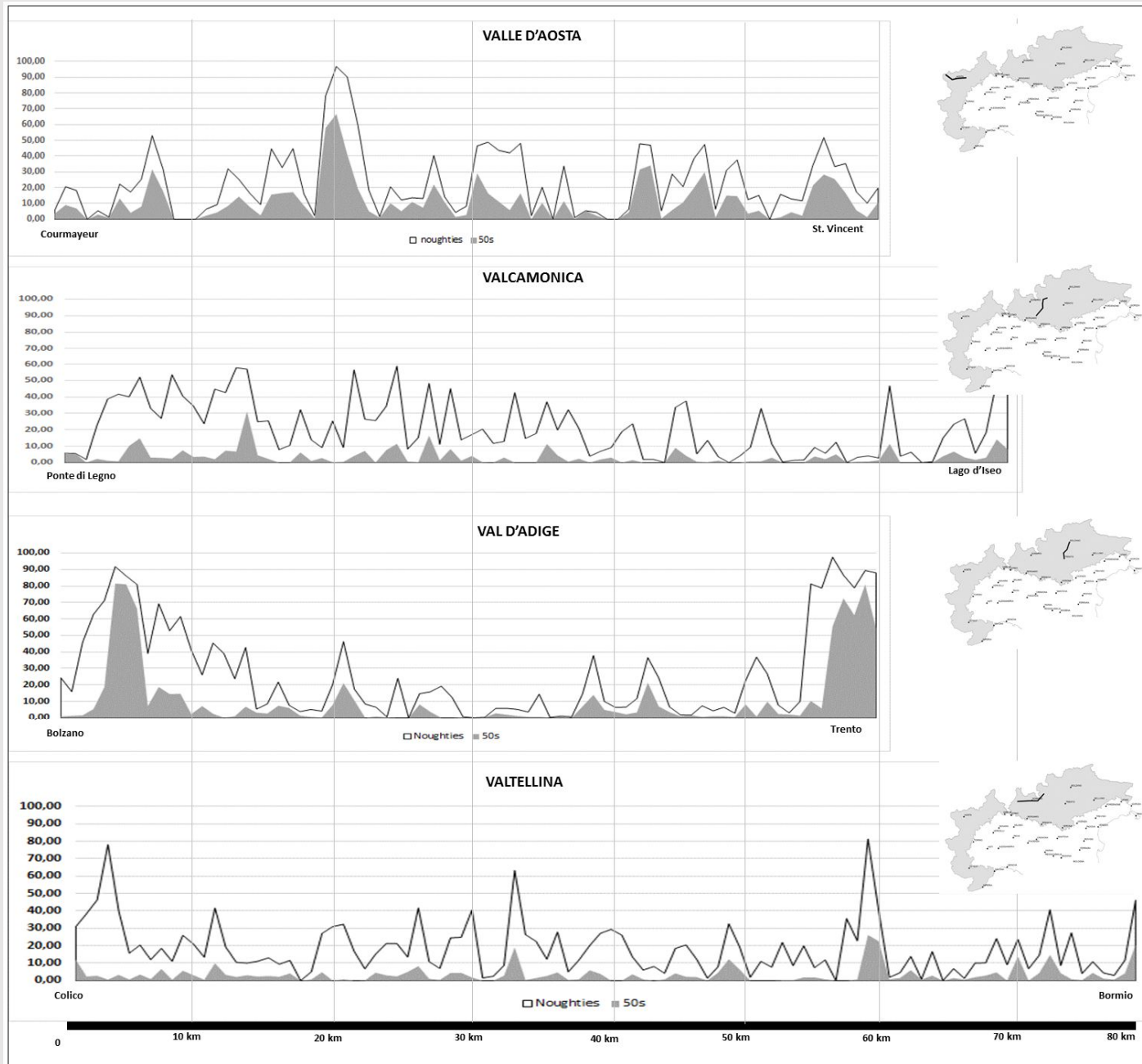
Relationship between morphology and urbanized areas



At the top: Morphologic linearization models in the valley and hilly area of the adriatic coast (left) and of the alpine valley (right).

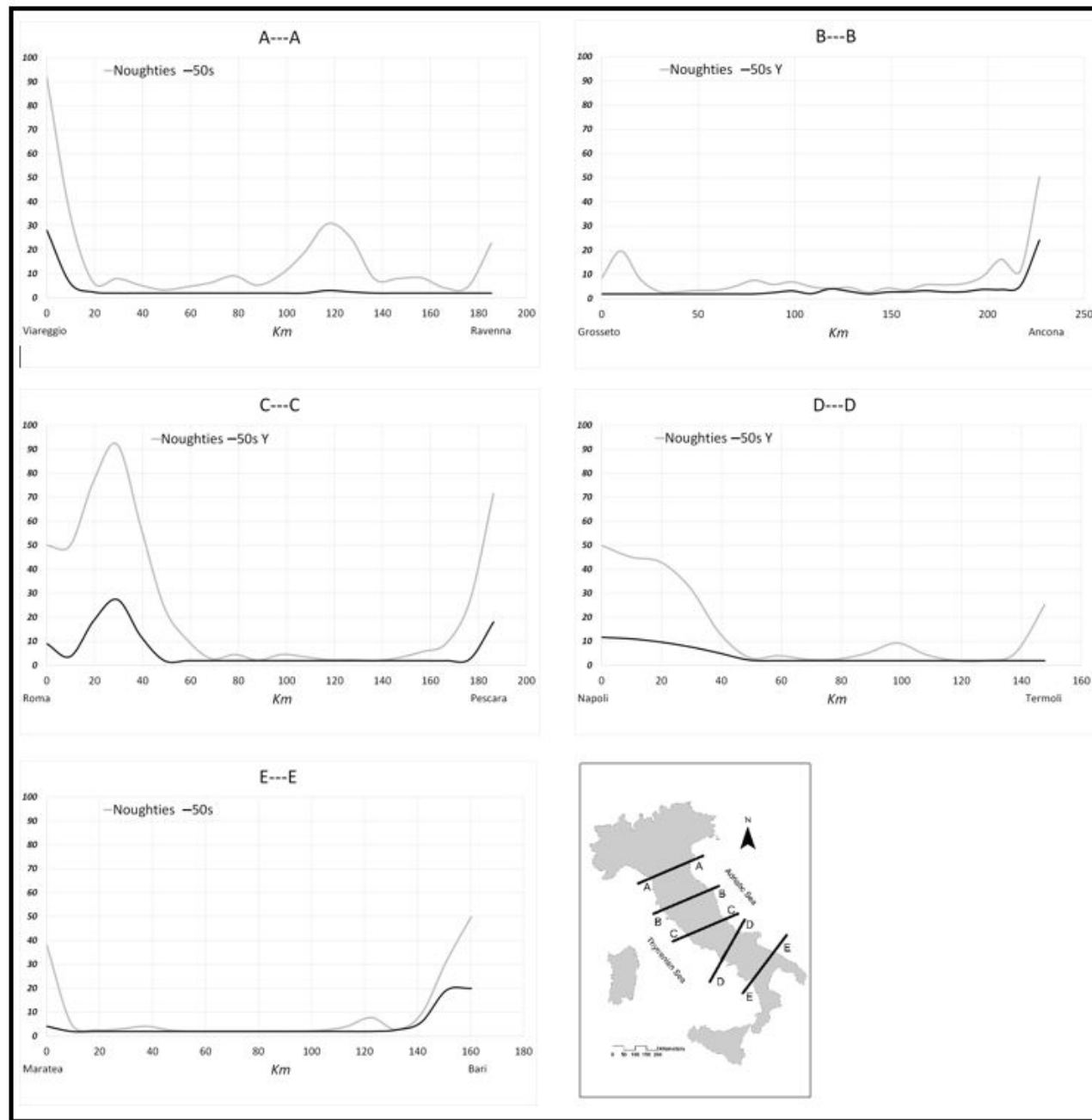
At the bottom: structural linearization and sprinkling models in the flat farming area (Padana's plain)

Relationship between morphology and urbanized areas



Increase of urban density along the alpine valley in the last 50 years.

Relationship between morphology and urbanized areas



Increase of urban density along particular section of Italian territory in the last 50 years.

Urban Evolution Models - Urban Dispersion Index

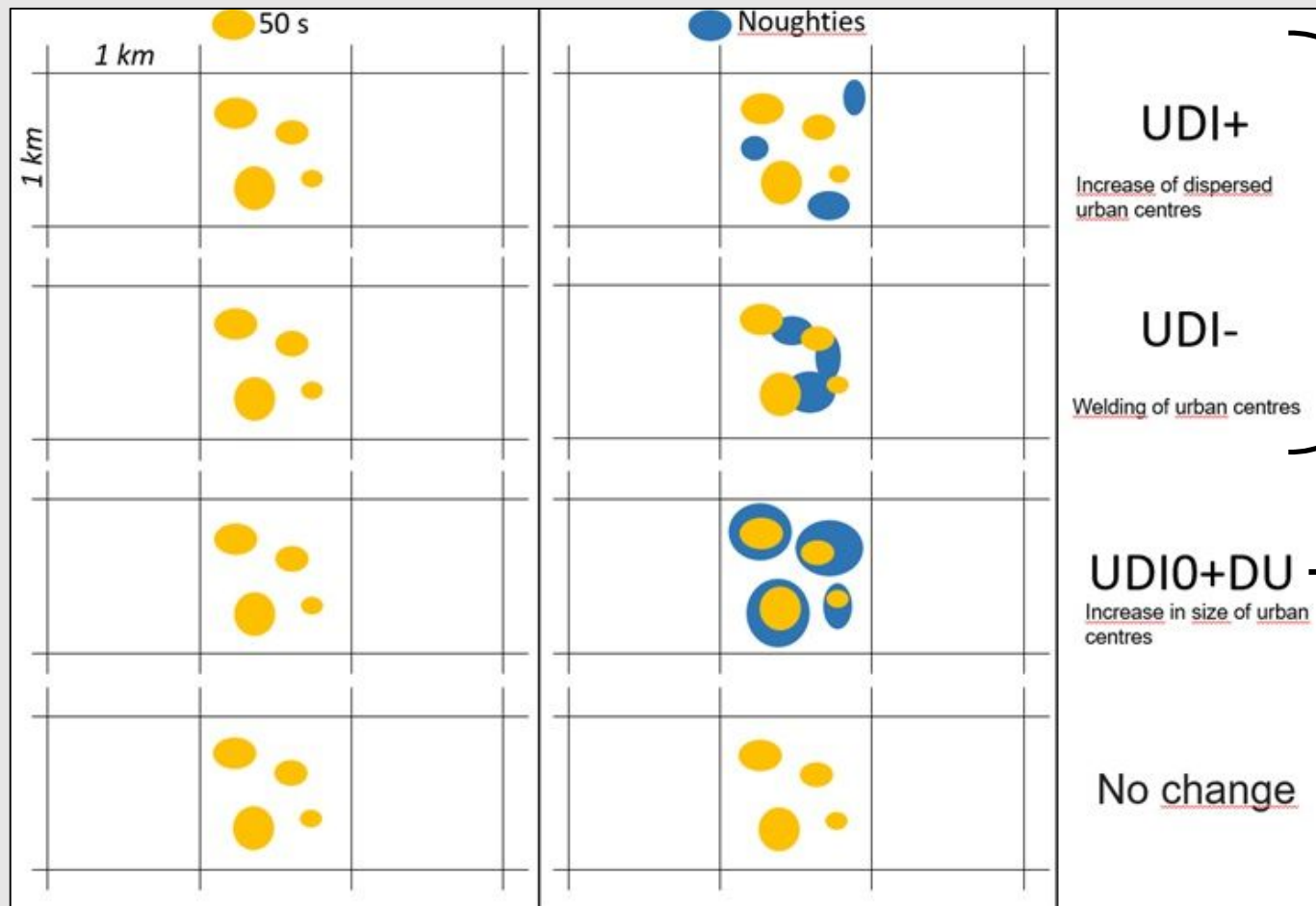
$$UDI = \frac{Nuc}{A}$$

Where:

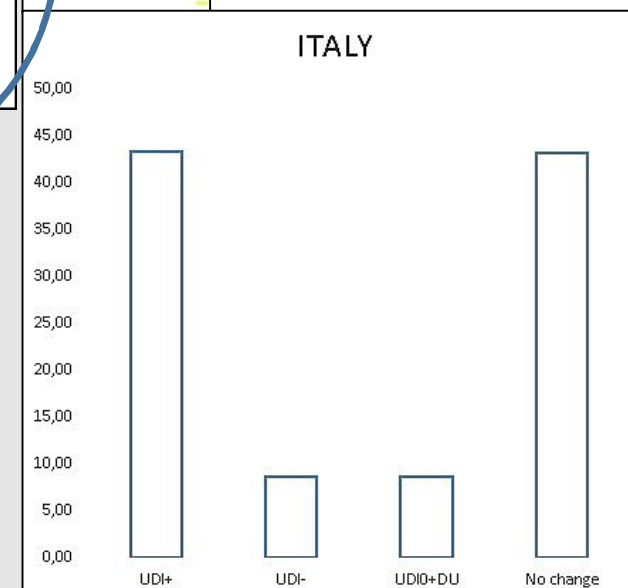
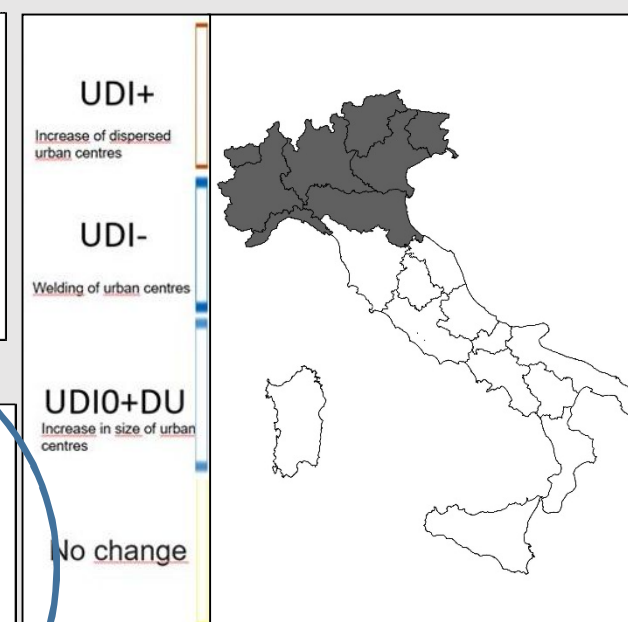
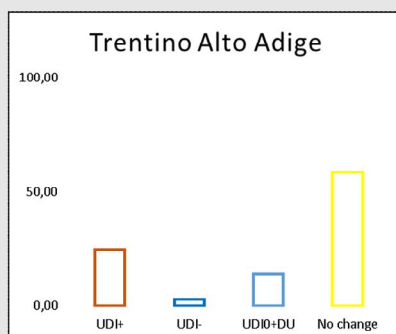
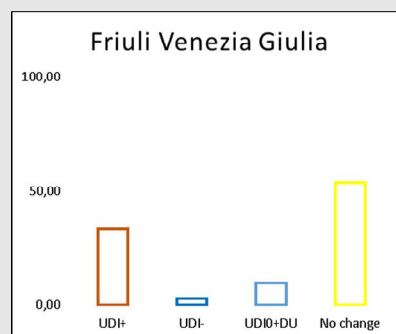
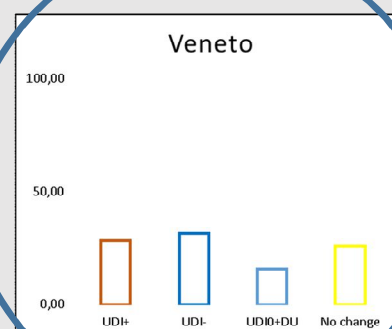
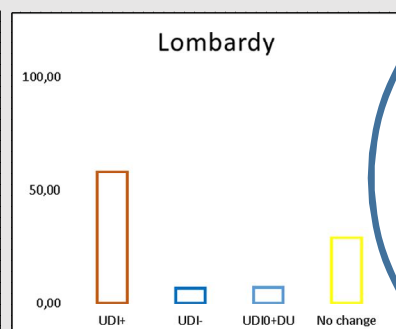
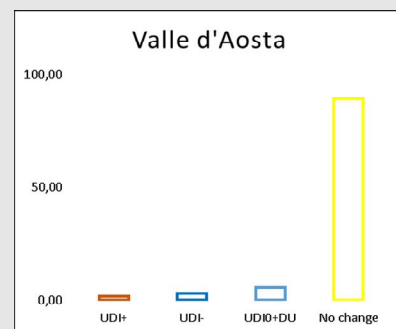
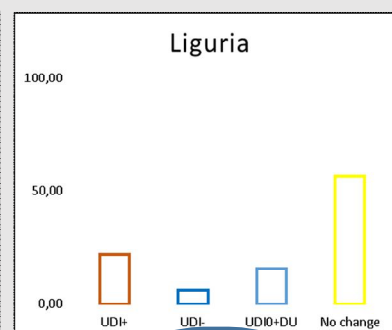
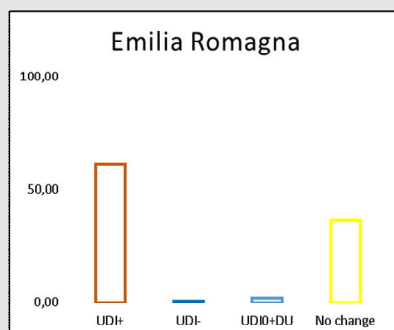
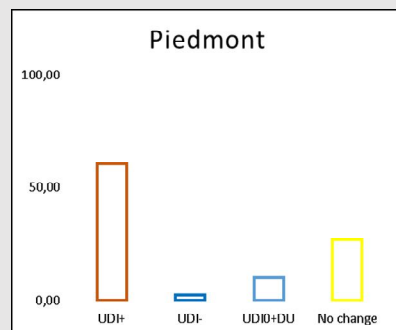
Nuc = number of urbanized nucleus

A = reference area (km²)

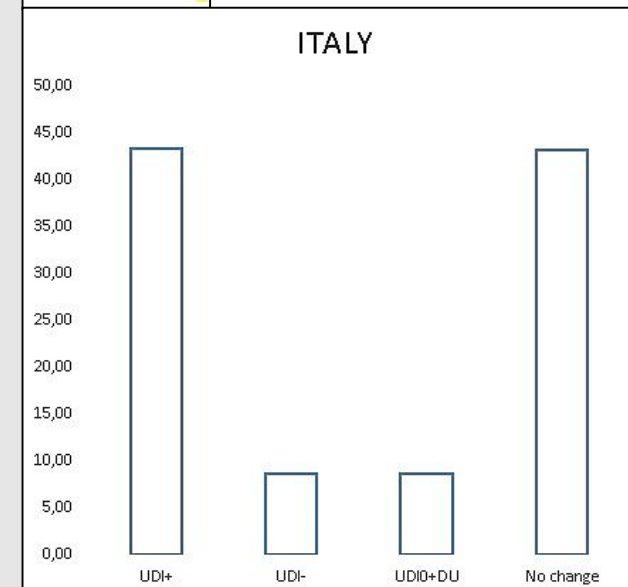
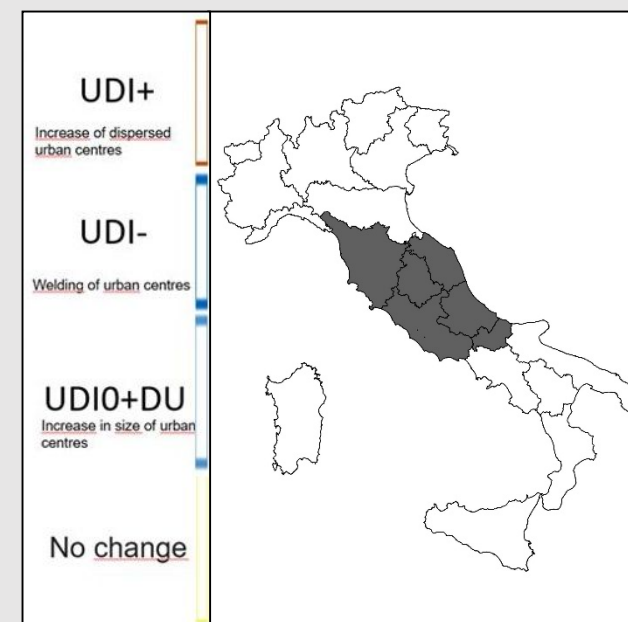
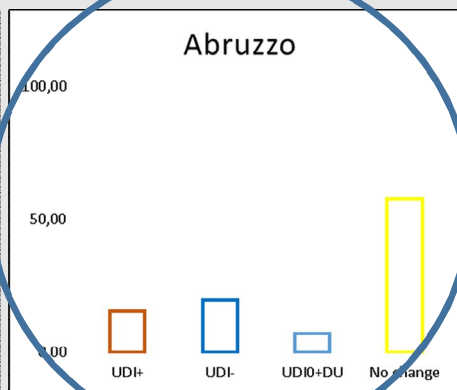
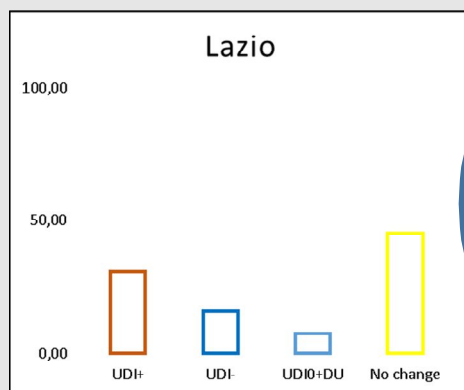
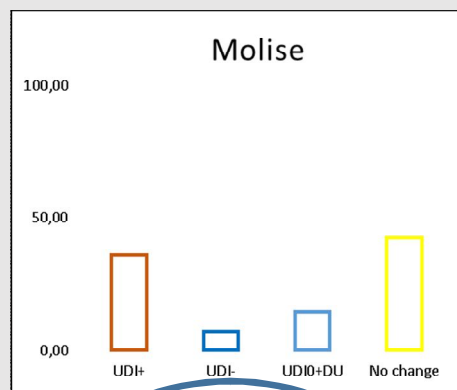
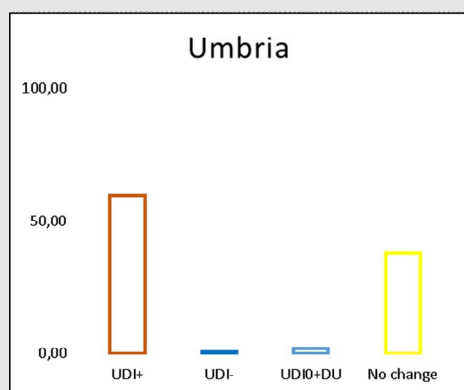
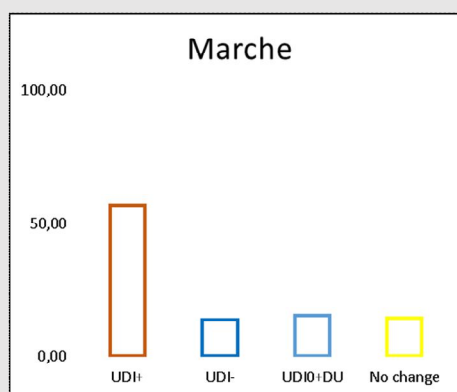
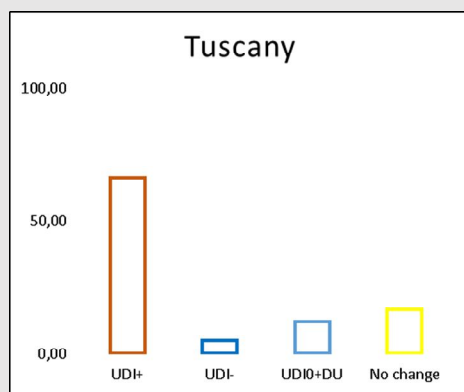
→ Evaluated, for all the Italian regions, on a discrete grid composed of 1x1km square cells



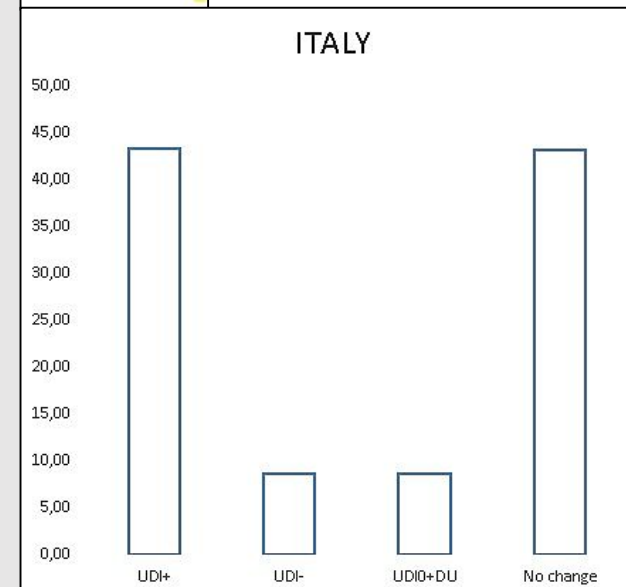
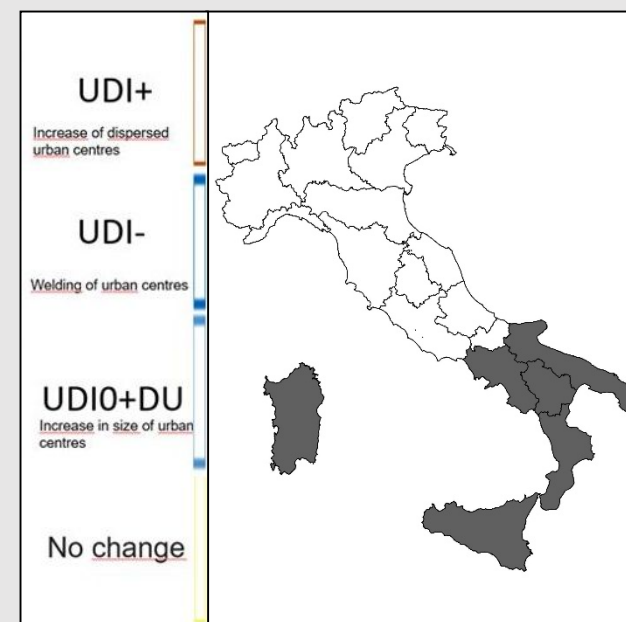
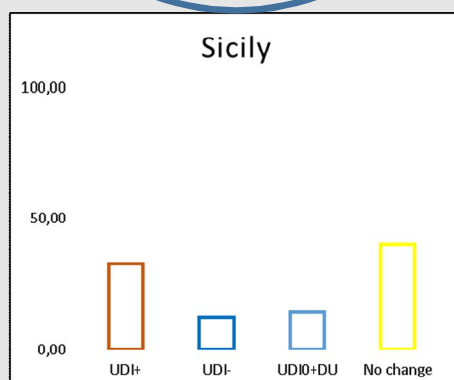
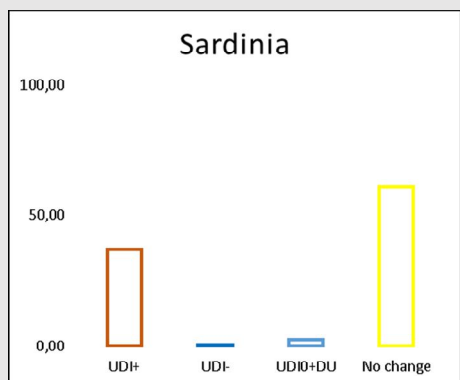
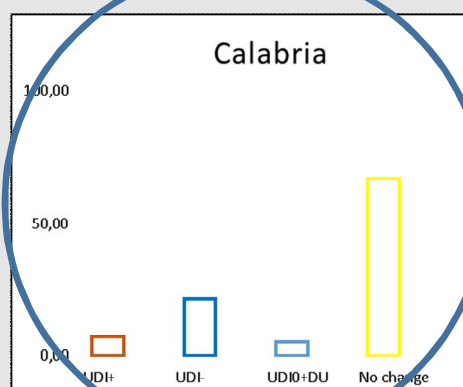
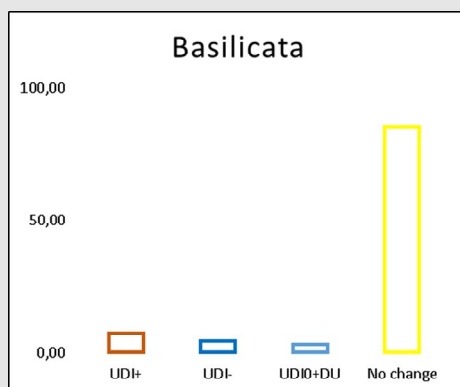
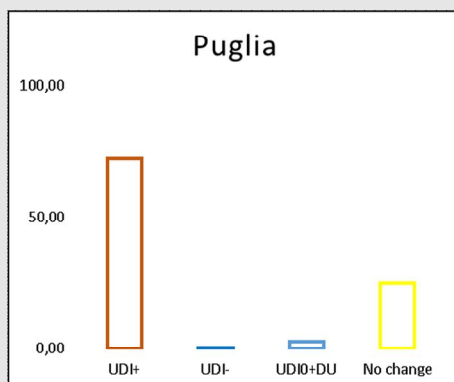
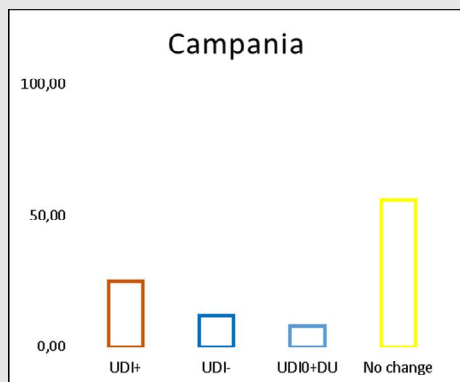
Urban Evolution in the northern italian regions



Urban Evolution in the central italian regions



Urban Evolution in the southern italian regions and islands



Sprinkling Index

$$SPX = \frac{\sum \sqrt{(x_i - x^*)^2 + (y_i - y^*)^2}}{R}$$

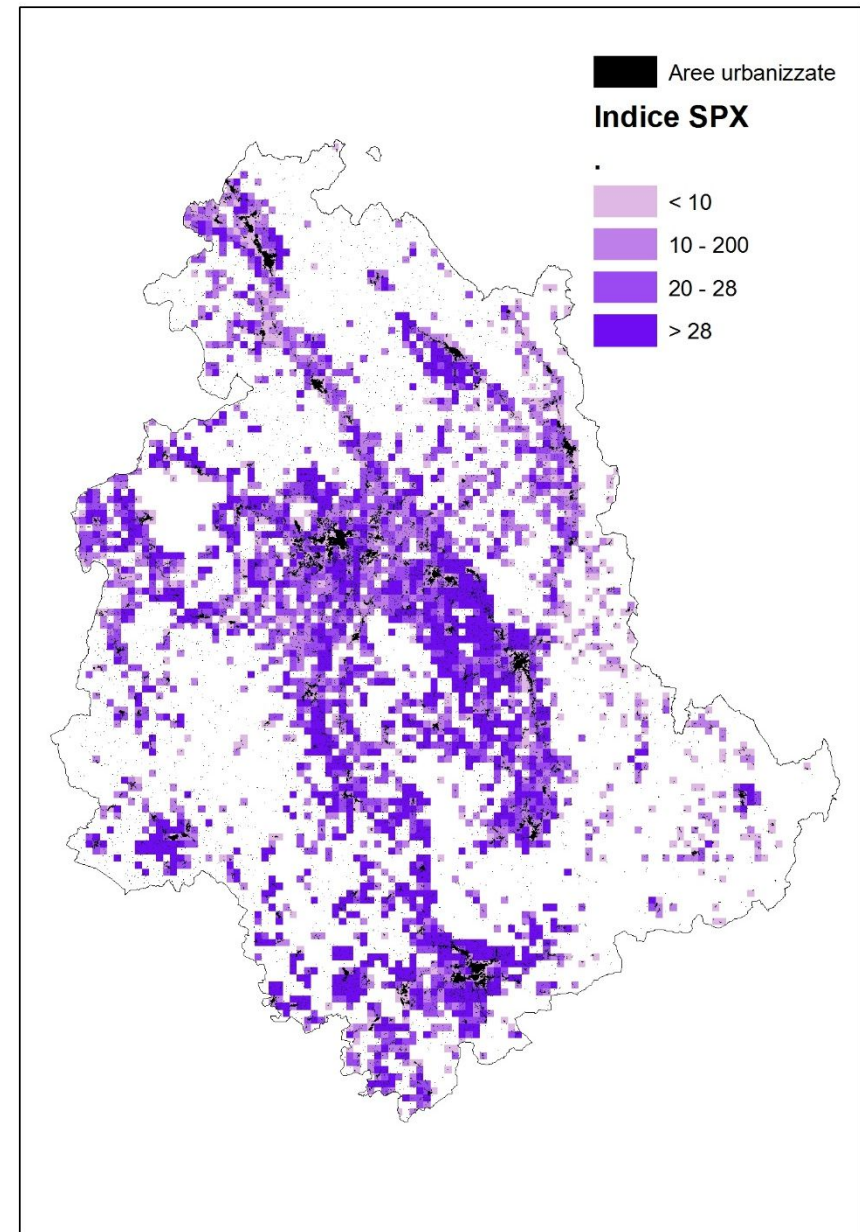
Where:

x_i e y_i = coordinate of centroid for each polygon

x^* e y^* = mean center coordinate

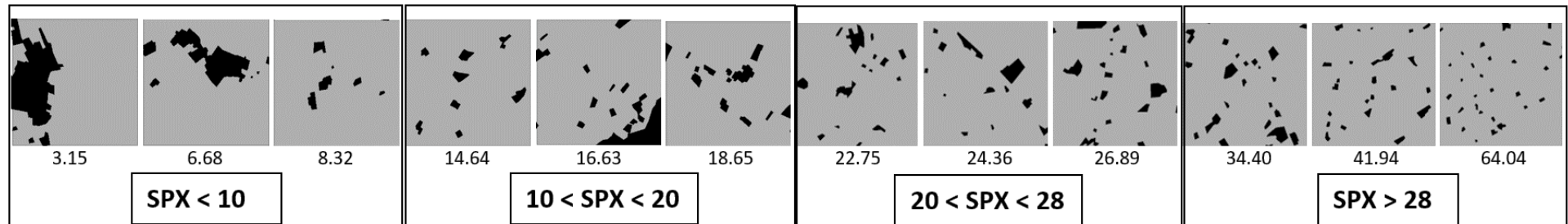
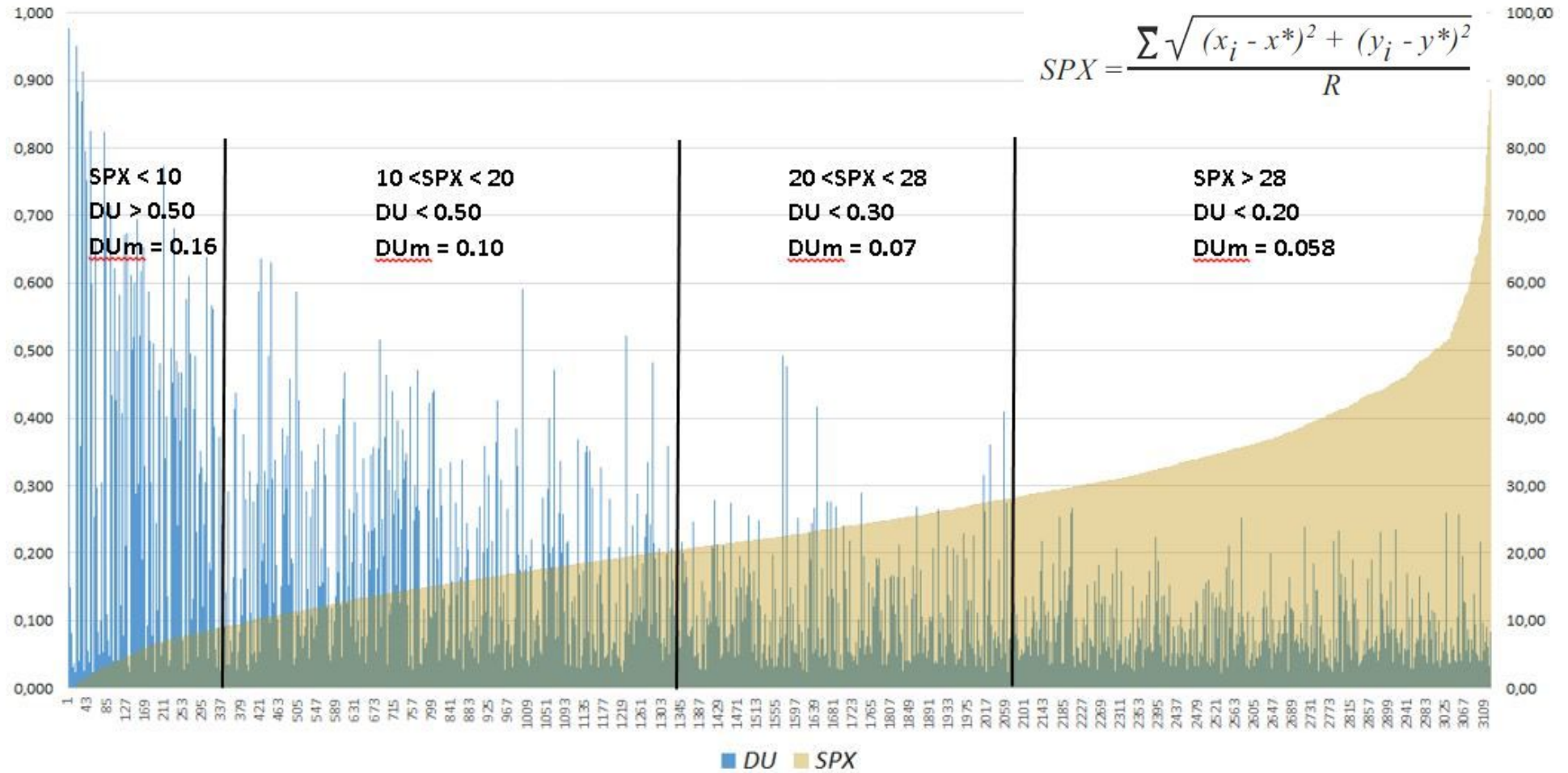
R = radius of the circular area similar to the sum of the total urbanized areas in a single cell

Evaluated on a discrete grid composed of 1x1km square cells.

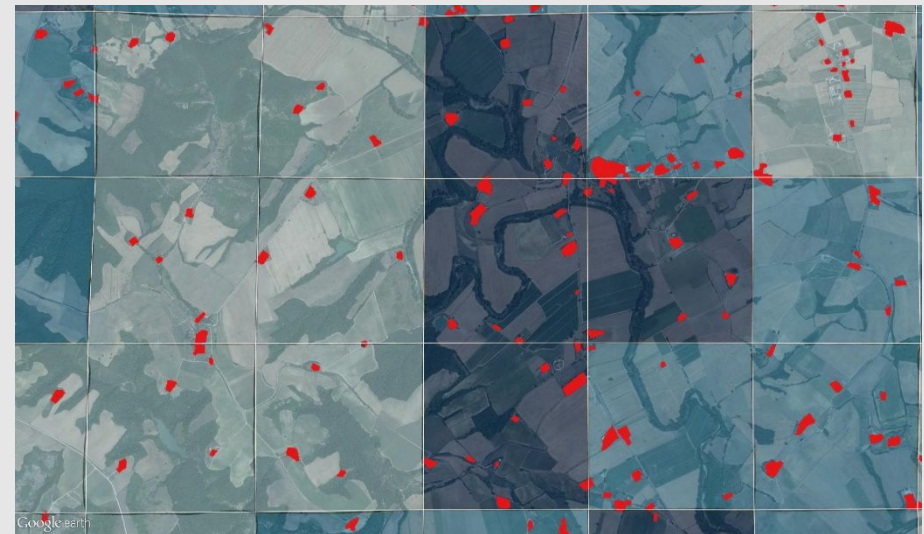
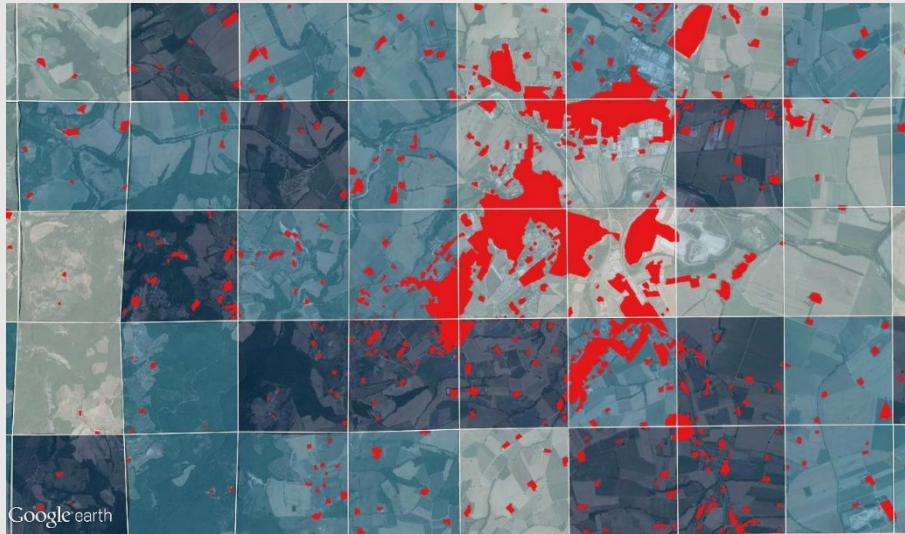


Sprinkling Index

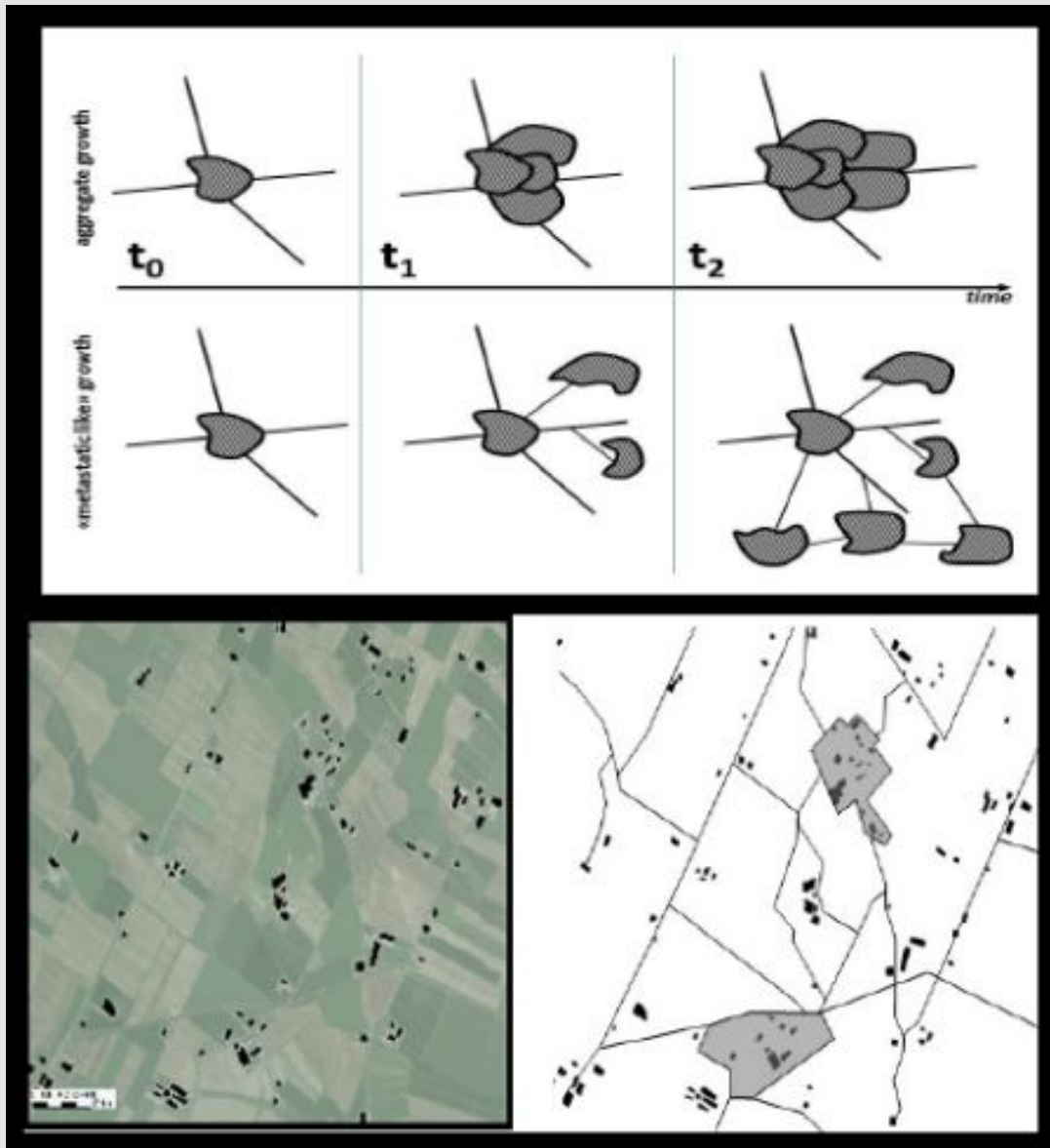
$$SPX = \frac{\sum \sqrt{(x_i - x^*)^2 + (y_i - y^*)^2}}{R}$$



Sprinkling Index



Conclusion



“URBAN INFILL”

as

Sustainable Practise

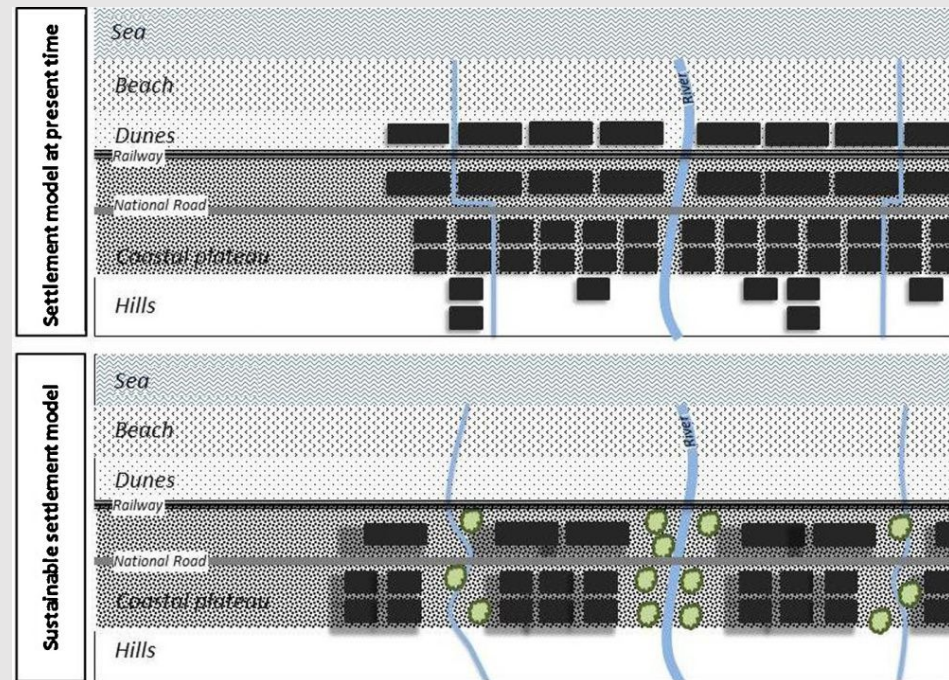
for

Sustainable City

Conclusion

The action, expressed in this figure, aims at the recovering, at least in part, of the greater sustainability; today it seems to be the only possible one to improve the ecological environmental conditions and mitigate hydrogeological risks for the coasts systems, now saturated by buildings.

It was possible to set up a map of the management responsibilities on the municipal and regional levels for the revising of future tendencies in urban planning in terms of sustainable governance.

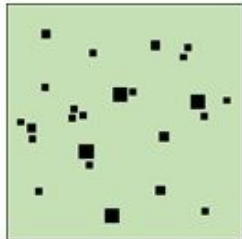
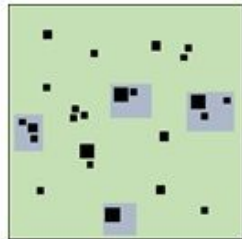
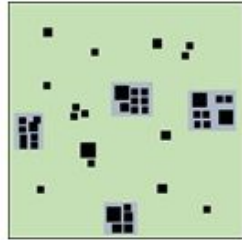
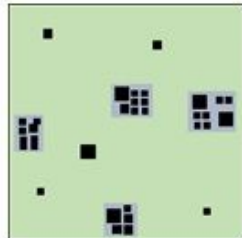


The authorities should take action by adopting tax, incentive policies for the conservation of residual free coast, using instruments that are already in the testing phase in some European countries, but also through the systematic implementation of environmental rehabilitation projects using abandoned areas.

It would be a good idea:

- to promote the systematic implementation of environmental rehabilitation projects using, for example, abandoned areas;
- to proceed with the total removal of derelict structures and the recovery of dunes and environmental continuity between sea and hinterland.

Conclusion

SPRINKLING - RECOVERY PLAN				
	ACTION	INSTRUMENT	TIME HORIZON	PATTERN
1	Stopping Urban Sprawl/Sprinkling	regulatory intervention/tax deduction	short-term	
2	Prioritised of functional ranking	strategic plan/operational plan	mid-term	
3	Densification/Infilling	operational plan/urban project	mid-term	
4	Shrinking	regulatory intervention/tax deduction	long-term	



URBAN SPRINKLING: A DIFFICULT RECOVERY

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Department of Civil, Construction-Architectural and Environmental Engineering – University of L'Aquila.

This study is a part of different research project:s

- National Database on Land take over the past 50 years
- SUNLIFE (LIFE13 NAT/IT/000371)
- other activities in collaboration with Umbria Region and «Biodiversity and Landscape Observatory»

