

The Design of an Urban Atlas to Spread Information Concerning the Growth of Anthropic Settlements in Basilicata Region

Giuseppe Faruolo, Luigi Santopietro(✉), Lucia Saganeiti, Angela Pilogallo, Francesco Scorza, and Beniamino Murgante

School of Engineering, Laboratory of Urban and Regional Systems Engineering (LISUT), University of Basilicata, Viale Dell'Ateneo Lucano 10, 85100 Potenza, Italy
giuseppe.far88@gmail.com,
luigi.santopietro@studenti.unibas.it,
{lucia.saganeiti,angela.pilogallo,francesco.scorza,
beniamino.murgante}@unibas.it

Abstract. Social, demographic and economics transformations occurred in Basilicata Region (Italy) since 1950's, have been developed transformations not always linked to effective and sustainable urban planning tools. A general research gap regards the tools for assessing such effectiveness of planning. In this work we describe the preliminary design of a thematic Atlas presenting Basilicata Region results achieved in previous researches concerning urban growth and consequently land use changes. On the bases of a territorial information system developed by LISUT research group we analyzed urban growth since 1950 comparing it with recent phenomena of RES (renewable energy sources) plants settlement occurred since 2000. Such spatial information, evaluated through fragmentation indexes, are compared with socio-economic data at municipal scale. The results are a comprehensive picture of local settlement development trends that allows to communicate evidences of current planning system including urban planning tools, sectorial planning (operating at regional scale), public investments program evidences. The Atlas will be published for Basilicata Region area (Italy) as a model in order to analyze and compare other European Regions.

Keywords: RES · Fragmentation · Sprinkling

1 Introduction

Urban expansion produces heavy externalities on environmental components of the territory, we may affirm that the nature, the intensity and the extension of such impacts strongly depends on the quality of urban and territorial plans and their implementation process. These phenomena produce land consumption, in terms of the loss of natural or agricultural land in favor of anthropic settlement. In recent decades, in urban and rural areas, urban expansion has generated a strong fragmentation of the landscape. Often city boundaries are unrecognizable, dispersion of settlement generate urban areas

© Springer Nature Switzerland AG 2020
O. Gervasi et al. (Eds.): ICCSA 2020, LNCS 12255, pp. 214–225, 2020.
https://doi.org/10.1007/978-3-030-58820-5_17

where unsustainable criticalities in terms of urban services develop continuously and consequent quality of life declines. Sprawl and sprinkling phenomena are two ways of urban expansion. A shared definition of sprawl phenomenon is given by many authors [1–4] as *"the spreading of urban developments (such as houses and shopping centers) on undeveloped land near a city"* (Merriam Webster) [5], while sprinkling phenomenon can be defined as, "a small quantity distributed in drops or scattered particles" [6]. Each phenomenon gives as result fragmentation, that in Italy is mainly expressed by the sprinkling. The spatial configuration of sprinkling is connected to a scattered and pulverized settlement of buildings and concerning the case of Basilicata Region, this phenomenon is empathized by the installation of RES plants.

This research lays the groundwork for a careful evaluation of the settlement stock and effects that the spread of RES has generated. We should assume that the spread of RES technology installations (particularly on portions of natural and semi-natural territory) cannot be considered as a win-win process [7, 8]. In fact, there is a significant system of values (even economic and potentially speculative) linked to such transformations in which the achievement of collective (we could say global) energy sustainability goals corresponds to the development of an economy guaranteed by public income that leads to the consumption of environmental resources (soil, landscape, ecosystems).

The complexity of arguments and analysis related to soil consumption (or land take) [9–11], have to be simplified in order to make it accessible not only to expert users, but mainly for citizens and decision makers in order to gain effective communication and to reinforce the awareness concerning externalities on environmental and landscape values [12, 13].

An Atlas could represent an effective tool in order to show spatial analysis and research results concerning this complex domain connected with settlements typologies and dynamics at local scale through simple and reliable indicators showing current trends.

In this sense a set of simple indicators has been adopted to present, in the Atlas, the results of the assessment concerning territorial fragmentation due to anthropogenic settlement. The methodology suggested by the authors, combine the detail location of the RES plants with the evolution of settlement respect to the evolution of the population.

In this way, the Atlas may cover a structural information gap that does not enable the decision makers, stakeholders interested in the process, or citizens to understand and know the changes taking place.

2 Previous Research Results Towards a Comprehensive Communication Box

LISUT research group widely applied in urban development research field [8, 14–19]. The main case study area is the Basilicata region. These studies, on one side, considered specific research question, on the other side allowed to develop a wide informative asset related to "settlement stock" in Basilicata. Such information, through Atlas project, will be valued to provide expressive interpretative tools allowing to identify

relationship between settlements system and main territorial planning issues in Basilicata region. Among actual emerging arguments: management of natural risks, protection/enhancement of natural and ecosystem resources [20], management of productive industrial sites and remediation policies of decommissioned industrial sites.

2.1 Study Area

Basilicata Region is located in the South of Italy (Fig. 1). It covers about 10.000 Km^2, and it has a population of 562.869 inhabitants (ISTAT [21], 2019). Only between years 2018-19 the population is decreased by 4249 inhabitants (ISTAT [21], 2019), while, according to ISPRA report 2019 [22] there was an important transformation from rural to sub-urban areas or urban areas, in the period 2016–2018, with an increment about 1, 48% of new urban areas. In addition, since 2010, a large part of the territory has been affected by the installation of RES plants, and at the end of 2017, the number of RES plants was 2122, including wind turbines and photovoltaic fields with a total power output of over 1000 MW.

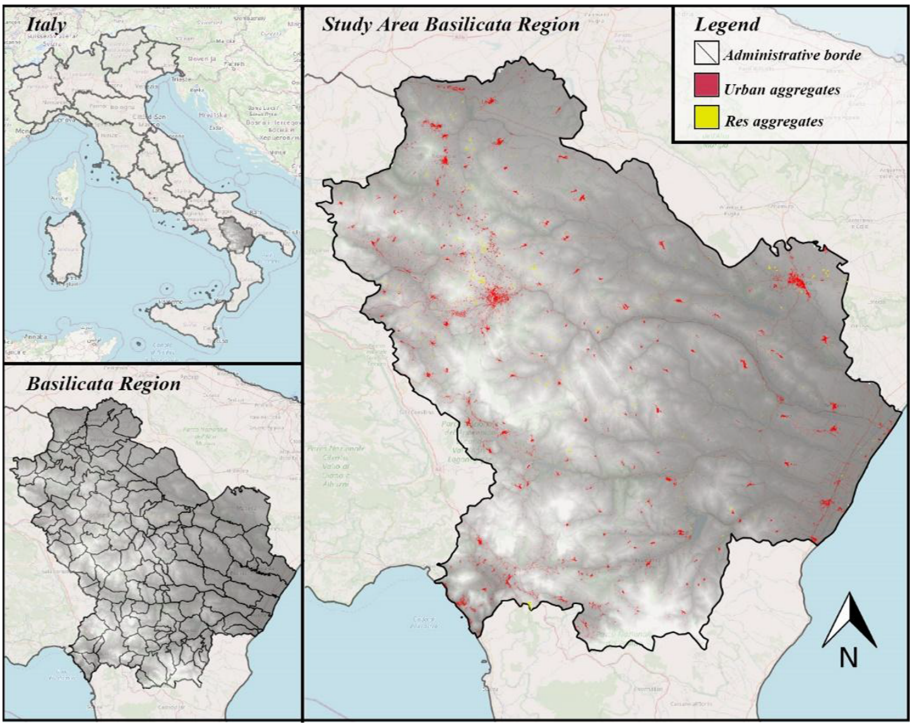

Fig. 1. Basilicata region study area

Starting from the data and results deriving from researches developed at regional scale by Saganeiti et al. [7, 8, 15], the Atlas has the objective to organize information in order to make it expressive at a different scale: the Municipal scale. Using the methodology described above, into the Urban Atlas the fundamental step is the calibration of the grid. In fact, there was a research about the best size of the grid cell to choose, applying SPX index. Testing different values of step length for the grid, the value of 250 m has been chosen because is the more appropriate to describe the fragmentation. Smaller grid resolutions (below 250 m as example 50 m) have been excluded because they are not able to describe properly fragmentation at municipal scale, and are not useful to draw up indicators for the Urban Atlas (see Fig. 2).

Using a grid cell with a step length of 250 m, the SPX index is computed for every municipality of Basilicata Region, considering the evolution of settlement respect to the evolution of the population and the growing of RES plants. In this way, the information is collected into an information database to municipal scale, which forms the Urban Atlas.

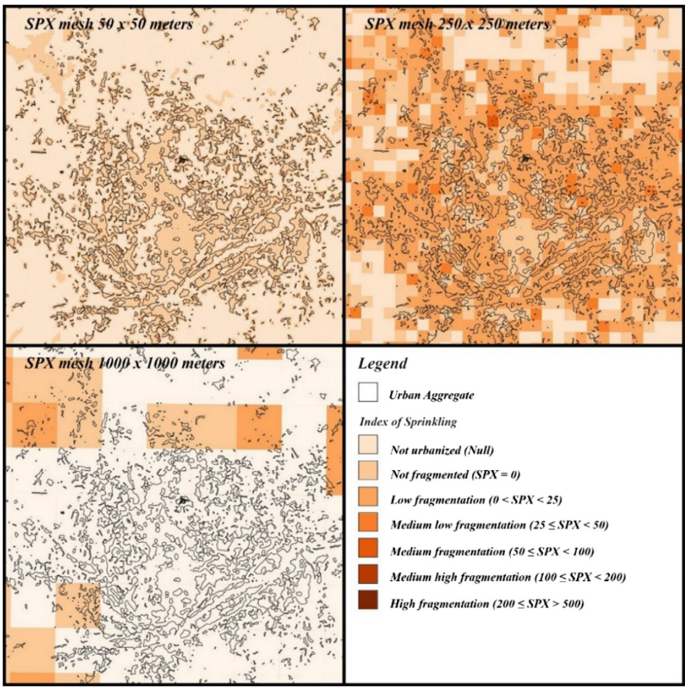

Fig. 2. Comparison between SPX calculated on three different meshes

2.2 Urban Settlements Growth

The urban settlements growth baseline is related to Saganeiti et al. [15]. The buildings are classified for five temporal phases and characterized for their intended use (residential or other use). For each municipality of the region, for the five times phases,

were calculated two indices: population density D_p and total amount of residential buildings per hectare D_b. Only for residential buildings, D_b is calculated. In Table 1 the results are collected for whole region and for each of the considered periods.

Table 1. Variation of population and buildings in the Basilicata region over time.

Year	Population (No.)	Residential buildings [B_R] (n)	D_p (Inhabitants/ha)	D_b (B_R/ha)
1950	627,586	117,687	0.63	0.12
1989	610,186	238,603	0.61	0.24
1998	597,468	269,019	0.60	0.27
2006	591,338	285,072	0.59	0.28
2013	578,391	297,810	0.58	0.30
2017	570,365	311,494	0.57	0.31

Observing data between 1950 and 2017, in 108 of 131 municipalities a decreasing of population not matches a corresponding decreasing urban expansion, on the contrary there was a positive trend. In most municipalities, the expansion of housing is not proportionate to demographic change This result is useful to Atlas because remarks that the development of settlements was not related to a real housing need Table 2.

Table 2. Areas [he] occupied by different typology of buildings in the six time phases considered.

Year	Agricultural buildings	Public buildings	Commercial buildings	Industrial buildings	Residential buildings
1950	150	49	0,9	28	1469
1989	3540	3538	3389	287	7079
1998	4057	4047	3884	476	8110
2006	4344	4343	4297	611	8687
2013	4578	4577	4439	655	9153
2017	4578	4577	4441	669	9272

2.3 Mapping of RES Plants in Basilicata Region

Starting from study area, we move on to the characterization of the process of construction of the space dataset of the plants with reference to the sources used and the territorialization procedures. Therefore, is proposed an exemplification for the formation of the territorial units to assess the areas interested by the installation process of RES plants. Through essential geo-processes, the areas of influence of individual installations and territorial aggregates are obtained, to which a descriptive function of the effects in terms of territorial fragmentation is attributed. Based on these preliminary elaborations, the main fragmentation indices proposed in the literature for RES implants were calculated. The results were compared with those relating to the evaluation of the settlement system already developed in previous research works [14, 15].

2.4 A Comprehensive Picture for the Basilicata Region

Starting from 1950's, the population of Basilicata Region has gradually decreased. Instead, from 1990 to date there is a change in trend between urban aggregates and population (Table 3). From 2006, a significant increase of soil consumption has been given by RES surfaces (see Fig. 3). SPX index has been computed for different areas of grid cell of 0.025 km^2. SPX index has been computed in two different steps: first the SPX is computed for Basilicata Region, then SPX is clipped for every Municipality boundary, to eliminate local errors due to the Municipality boundary.

Table 3. Population, Aggregates buildings surface (**Abs**), Aggregates surface RES Area (**AsA RES**)

Year	Population (No.)	Abs (he)	AsA RES (he)
1950	627,586	3328	–
1989	610,186	10475	–
1998	597,468	12758	
2006	591,338	14492	565
2013	578,391	15530	866
2017	570,365	15908	1719

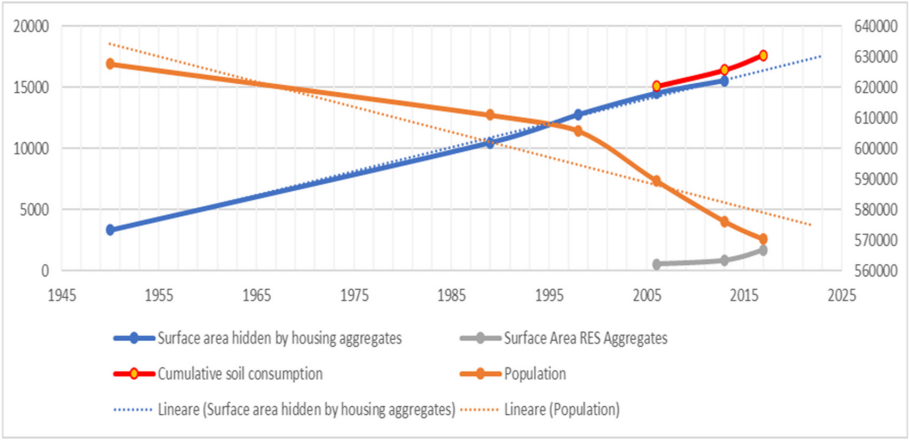

Fig. 3. Correlation between population, surface area hidden by housing aggregates, surface area RES aggregates and cumulative soil consumption

3 Data Processing for Urban Atlas

The data processed, present for each Municipality multiple elaboration. The elaborations were carried out for the years 1950, 1989, 1998, 2006, 2013, 2017, they are:

1. Evolution of the buildings and urban aggregates;
2. Evolution of RES plants for the years 2006, 2013 and 2017;
3. The table showing territorial surface occupied by building stock for usage categories;
4. The graphs that compare the building stock with the evolution of RES installations, compared to the evolution of the population;
5. Sprinkling index with mesh 250 x 250 m, of the building stock combined with RES plants.

In the following figures are presented, as prototypes, some elaborations drawn up for the municipality of Avigliano.

In Fig. 4, is represented the evolution of urban aggregates from 1989 to 2013, where it is possible note the continuous increase of the same at the expense of land consumption, with zooms on some areas of interest, where this phenomenon has occurred more.

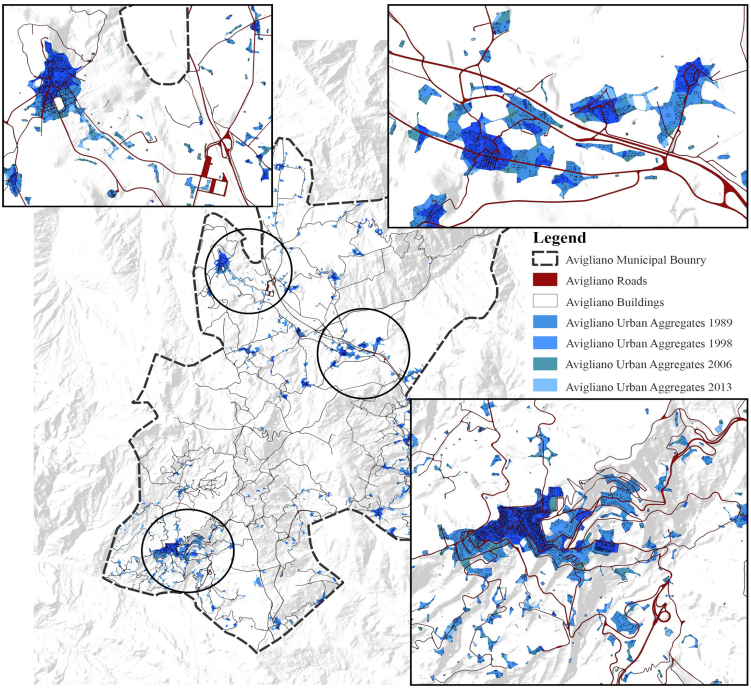

Fig. 4. Urban expansion of avigliano aggregates from 1989 to 2013

In Fig. 5, the evolution of the urban aggregates from 1950 to 2013, with the aggregates of wind turbines and photovoltaic plants (representing RES plants expansion) from 2006 to 2017.

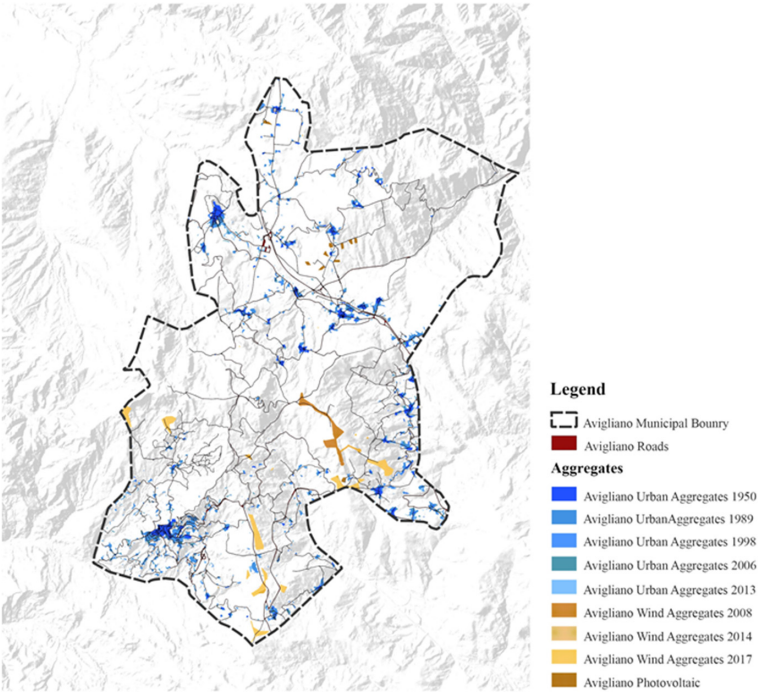

Fig. 5. Urban expansion combined with expansion of RES plants

For each municipality, there is a summary table showing data concerning surfaces occupied by building stock divided per building use categories (see Table 4), while in a graph (see Fig. 6) are compared building stock with the evolution of RES installations, related to evolution of population

Table 4. Areas [he] occupied by different typology of buildings in the six time phases considered for Avigliano municipality.

Year	Agricultural buildings	Public buildings	Commercial buildings	Industrial buildings	Residential buildings
1950	3.02	1.27	0.33	0.96	25.06
1989	9.06	1.94	0.33	7.31	50.52
1998	11.08	2.52	0.33	32.60	55.67
2006	12.63	2.52	0.33	41.75	58.91
2013	13.15	2.53	0.33	43.15	63.20
2017	14.08	3.03	0.41	60.68	85.29

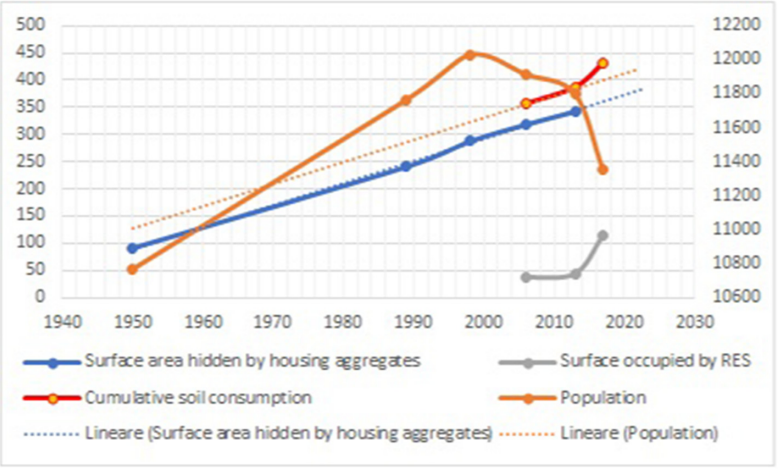

Fig. 6. Correlation between population, surface area hidden by housing aggregates, surface area RES aggregates and cumulative soil consumption for avigliano municipality

In Fig. 7, is represented urban fragmentation, through the sprinkling index. In this case the urban fragmentation is related to 2013, where it is possible notice an important fragmentation in different parts of the territory, due to the increase sometimes of urban aggregates, but more and more frequently from the evolution of RES plants.

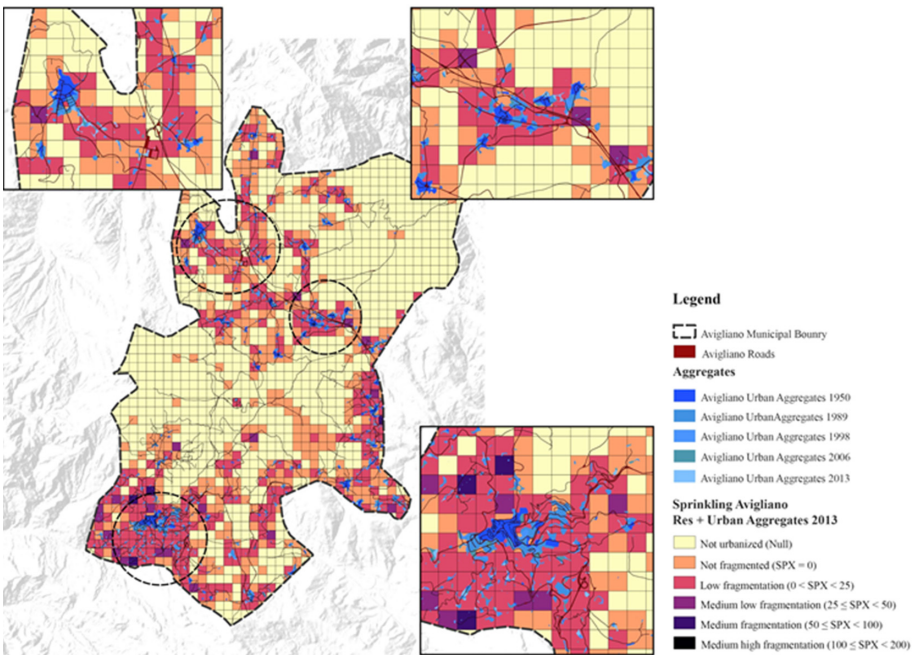

Fig. 7. SPX of avigliano municipality related to year 2013

4 Conclusions

The Atlas lays the foundation for develop sustainable policies in territorial planning and engagement of public and private actors [13, 23–25]. Fully in the line with the goals of New Urban Agenda [26], the Atlas provides guidelines to a rational use of soil resource [27, 28].

Computing carried out, showed what is the status actually of the fragmentation and it's a framework exportable to other case study to improve the methodology. An interesting future perspective is a comparison between two different scenarios: the first business as usual and the second planning actions to achieve the reduction of fragmentation or compaction of the urban areas.

Atlas can help to understand how RES have contributed to the transformation of urban system with inevitable consequences on the landscape. The use of Urban Atlas can be related to different aspects:

- To be a tool for local administrators, helping them to know the status and the evolution of land consumption or land use;
- Define regulatory frameworks having Regional value, with the aim to achieve the (ambitious) goal of zero land consumption;
- As base-line to monitoring land consumption (or land use) and to planning in several sectors (energy, landscape, environment…)

Concerning the spatial evaluations included as basic data in this work, future research development perspective concerns the improvement of the methodology with the fragmentation caused by infrastructures in the region, not valued in this work.

Future perspectives are oriented to realize a web-based platform where users are able to visualize and retrieve data available structured in a GIS model. The idea is dissemination of the data through a free consulting services in order to allow the majority of potential users (not only expert users) to take advantages from the Atlas. The technological tools we are oriented to adopt is a web gis portal including OCS standards for maps and geodata sharing on the internet.

Therefore the aim is to structure a GIS model in a co-design view [29] as help desk to decision making (public administration) with two specific functions:

- Territorial planning and knowledge of developments of urban fragmentation, in order to reduce or mitigate the effects of urban expansion,
- Planning actions aimed to increase urban fragmentation, supporting decisions undertaken by stakeholders or public administration.

In addition, considering or not a web platform as a dissemination tool, the data collected into the Atlas has to be updated both in terms more accurate time steps and in terms of multi-scale resolution.

References

1. Herold, M., Couclelis, H., Clarke, K.C.: The role of spatial metrics in the analysis and modeling of urban land use change. Comput. Environ. Urban Syst. **29**, 369–399 (2005)
2. Galster, G., Hanson, R., Ratcliffe, M.R., Wolman, H., Coleman, S., Freihage, J.: Wrestling sprawl to the ground: defining and measuring an elusive concept. Hous. Policy Debate. **12**, 681–717 (2001)
3. Hasse, J.E., Lathrop, R.G.: Land resource impact indicators of urban sprawl. Appl. Geogr. **23**, 159–175 (2003)
4. Jaeger, J.A.G.: Landscape division, splitting index, and effective mesh size: new measures of landscape fragmentation. Landsc. Ecol. **15**, 115–130 (2000)
5. Urban Sprawl| Definition of Urban Sprawl by Merriam-Webster, https://www.merriam-webster.com/dictionary/urban sprawl, Accessed 04 May 2020
6. Romano, B., Zullo, F., Ciabò, S., Fiorini, L., Marucci, A.: Geografie e modelli di 50 anni di consumo di suolo in Italia. Sci. e Ric. **6**, 17–28 (2015)
7. Saganeiti, L., Pilogallo, A., Faruolo, G., Scorza, F., Murgante, B.: Territorial fragmentation and renewable energy source plants: which relationship? Sustain. **12**, 1828 (2020). https://doi.org/10.3390/su12051828
8. Saganeiti, L., Pilogallo, A., Faruolo, G., Scorza, F., Murgante, B.: Energy landscape fragmentation: basilicata region (Italy) study case. In: Misra, S., et al. (eds.) ICCSA 2019. LNCS, vol. 11621, pp. 692–700. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-24302-9_50
9. Scorza, F., Pilogallo, A., Saganeiti, L., Murgante, B.: Natura 2000 areas and sites of national interest (sni): measuring (un) integration between naturalness preservation and environmental remediation policies. Sustain. **12**, 2928 (2020). https://doi.org/10.3390/su12072928
10. Scorza, F., Saganeiti, L., Pilogallo, A., Murgante, B.: GHOST PLANNING: The Inefficiency of Energy Sector Policies in a Low Population Density Region. Arch. DI Stud, URBANI E Reg (2020)
11. Scorza, F., Pilogallo, A., Saganeiti, L., Murgante, B.: Comparing the territorial performances of renewable energy sources' plants with an integrated ecosystem services loss assessment: a case study from the basilicata region (Italy). Sustain. Cities Soc. **56**, 102052 (2020). https://doi.org/10.1016/j.scs.2020.102082
12. Murgante, B., Botonico, G., Graziadei, A., Sassano, G., Amato, F., Scorza, F.: Innovation, technologies, participation: new paradigms towards a 2.0 citizenship. Int. J. Electron. Gov. **11**, 62–88 (2019). https://doi.org/10.1504/IJEG.2019.098814
13. Pontrandolfi, P., Scorza, F.: Sustainable urban regeneration policy making: inclusive participation practice. In: Gervasi, O., et al. (eds.) ICCSA 2016. LNCS, vol. 9788, pp. 552–560. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-42111-7_44
14. Saganeiti, L., Pilogallo, A., Scorza, F., Mussuto, G., Murgante, B.: Spatial indicators to evaluate urban fragmentation in basilicata region. In: Gervasi, O., et al. (eds.) ICCSA 2018. LNCS, vol. 10964, pp. 100–112. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-95174-4_8
15. Saganeiti, L., Favale, A., Pilogallo, A., Scorza, F., Murgante, B.: Assessing urban fragmentation at regional scale using sprinkling indexes. Sustain. **10**(9), 3274 (2018). https://doi.org/10.3390/su10093274
16. Amato, F., Martellozzo, F., Nolè, G., Murgante, B.: Preserving cultural heritage by supporting landscape planning with quantitative predictions of soil consumption. J. Cult. Herit. **23**, 44–54 (2017)

17. Martellozzo, F., Amato, F., Murgante, B., Clarke, K.C.: Modelling the impact of urban growth on agriculture and natural land in Italy to 2030. Appl. Geogr. **91**, 156–167 (2018)
18. Amato, F., Maimone, B.A., Martellozzo, F., Nolè, G., Murgante, B.: The effects of urban policies on the development of urban areas. Sustainability. **8**, 297 (2016)
19. Di Palma, F., Amato, F., Nolè, G., Martellozzo, F., Murgante, B.: A SMAP supervised classification of landsat images for urban sprawl evaluation. ISPRS Int. J. Geo-Inf. **5**, 109 (2016)
20. Lai, S., Zoppi, C.: The influence of natura 2000 sites on land-taking processes at the regional level: an empirical analysis concerning sardinia (Italy). Sustain. **9**, 259 (2017). https://doi.org/10.3390/su9020259
21. Istat.it, https://www.istat.it/, Accessed 28 April 2020
22. SNPA, R.: Consumo di suolo, dinamiche territoriali e servizi ecosistemici. (2019)
23. Dvarioniene, J., Grecu, V., Lai, S., Scorza, F.: Four perspectives of applied sustainability: research implications and possible integrations. In: Gervasi, O., et al. (eds.) ICCSA 2017. LNCS, vol. 10409, pp. 554–563. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-62407-5_39
24. Scorza, F., Grecu, V.: Assessing sustainability: research directions and relevant issues. In: Gervasi, O., et al. (eds.) ICCSA 2016. LNCS, vol. 9786, pp. 642–647. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-42085-1_55
25. Scorza, F., Pontrandolfi, P.: Citizen participation and technologies: the c.a.s.t. architecture. In: Gervasi, O., et al. (eds.) ICCSA 2015. LNCS, vol. 9156, pp. 747–755. Springer, Cham (2015). https://doi.org/10.1007/978-3-319-21407-8_53
26. The New Urban Agenda - Habitat III, http://habitat3.org/the-new-urban-agenda/, Accessed 19 March 2020
27. Las Casas, G., Scorza, F., Murgante, B.: New urban agenda and open challenges for urban and regional planning. In: Calabrò, F., Della Spina, L., Bevilacqua, C. (eds.) ISHT 2018. SIST, vol. 100, pp. 282–288. Springer, Cham (2019). https://doi.org/10.1007/978-3-319-92099-3_33
28. Las Casas, G., Scorza, F., Murgante, B.: Razionalità a-priori: una proposta verso una pianificazione antifragile. Reg. Sci. **18**(2), 329–338 (2017). https://doi.org/10.14650/93656
29. Moura, A.C.M., Campagna, M.: Co-design: digital tools for knowledge-building and decision-making in planning and design. Disegnarecon **11**(20), 1–3 (2018)