Fragile Territories Around Cities: Analysis on Small Municipalities Within Functional Urban Areas

Chiara Di Dato (✉) and Alessandro Marucci

DICEAA, University of L'Aquila, Via Giovanni Gronchi 18, 67100 L'Aquila, Italy
chiara.didato@graduate.univaq.it

Abstract. Although many disadvantaged areas are remote and isolated, the others are close to dense urban areas. Then, these peri-urban areas are both peripheral and fragile and, often, they are fringes from urban areas, where the well-known urban-rural mix occur.

In recent years, the most fragile urban areas have experienced growing attention. Through the years policymakers have tried to face territorial disadvantages with the help of funds.

Law 158/2017 is one example. The Law proposes twelve criteria to identify and then select small municipalities to support. In 2020 a research proposed to convert Law's criteria into indicators. Combinations of indicators can identify different conditions of fragility. These combinations are useful starting point for further studies on small municipalities.

The present work uses data from the mentioned research for focusing on peri-urban areas. The case study is composed of small municipalities within three Functional Urban Areas (FUA) in Central Italy: L'Aquila, Perugia and Terni. Then, the paper points out the relationship between indicators of fragility and peculiar features of these areas.

Keywords: Peri-urban · Urban Atlas · Computational analysis

1 Introduction

Nowadays, researchers in urban studies became familiar with considering even less valid the urban-rural dualism as a territorial feature. In fact, a great variety of factors have contributed to expand borders of urban areas. Among the others, there are demographic and economic dynamics. Often, uncontrolled expansion has generated the well-known dispersed settlements of which structural problems are still under investigation [1–3].

Those complex urban areas that are not compact cities neither rural areas can be defined 'territories-in-between' [4] and they are well-known as peri-urban areas. Peri-urban is defined as the area between urban settlements and their rural hinterland. Peri-urban can include town and villages within urban agglomeration, and they are characterised by complex pattern of land use and landscape [5].

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The unsustainability of uncontrolled expansion is already evident [6]. In addition, as UN-Habitat advocates, peri-urbanization is an on-going process. Frequently, it implies growing land consumption unbound from real population growing [7, 8]. This is a main question in urban studies and researchers have implemented various methods for studying causes and consequences. As every process which involves land, peri-urbanization is a site-specific issue, and it varies depending on characteristics of geographical context [9–11].

However various approaches are valid for studying peri-urban areas, the attention should go to the power of urban policies in giving adequate support for territorial issues [12, 13]. Proper urban policies are necessary for recovering urban disease caused by dispersion.

Some examples from Italy may be useful. In recent years, various funds have addressed disadvantaged areas. Inner Areas (52% of Italian municipalities) are example of very specific and fragile territories to which the National Strategy for Inner Areas (SNAI) is addressed to [14]. Also, specific funds from National Recovery and Resilience Plan (PNRR) are allocated to 21 selected villages [15] to support sustainable development in less-favoured municipalities up to 5000 inhabitants with a recognisable historical centre.

Similarly, Law 158/2017 was born to give "Support measures for promotion of small municipalities and regulations for redevelopment and restoration of their historical centres". In Italy small municipalities (up to 5000 inhabitants) occupy around the seventy percent of the territory. A series of problems threaten these areas, such as the impoverish of natural resources and the abandonment of estates and artistic heritages.

The law aims to address most disadvantaged areas. In addition, it gives parameters that are interesting to analyze. Marucci et al. [16] have based research on Law 158/2017 for studying disadvantaged characteristics that conduct small municipalities to territorial fragility. The present work elaborates results of the research on a limited area. Then, it aims to add further consideration on typologies of urban settlement that characterize peri-urban areas. The study area offers diverse examples of urban-rural gradient. Then, the paper aims to start a discussion on results about fragility of peri-urban areas and urban settlements.

2 Case Study

The choice of the study area is linked to the LIFE IMAGINE UMBRIA Integrated Project. This LIFE Integrated Project aims to sustain integrated strategies for management of Nature2000 Network in Umbria Region [17]. Although the project refers basically to Umbria Region, the case study is here extended.

In particular, the paper aims to compare three areas from central Italy: Perugia, Terni, and L'Aquila. Central Apennines is the geographical context for the three cities. Perugia and Terni are in Umbria Region and L'Aquila is in Abruzzo Region. In recent years, this part of the Country has drawn attention because of the seismic events happened. Earthquakes of 2009 and 2016 have stroked this geographical area causing differential grades of damage, and then revealing high local level of fragility.

2.1 Functional Urban Areas

The study areas are Functional Urban Areas (FUA) in which the cities are included (Fig. 1). FUA are result of classification methodology produced by European Commission and the OECD (Organization for Economic Co-operation and Development). The data is available at Urban Atlas database [18], which provides pan-European comparable land cover and land use data for FUA. Elements in one FUA are one city (urban centre with at least 50000 inhabitants) and its communing zone (at least 15% of workers, who live in the commuting zone and work inside the city). Evidently, FUA is based on functional links between the city and suburban areas. In addition, it represents useful territorial unit for studying phenomena regarding urban centres.

2.2 FUA of Perugia, Terni and L'Aquila

FUA of Perugia extends for 1310,59 kmq with 281305 inhabitants, FUA of Terni has 1023,65 kmq for 171877 residents and FUA of L'Aquila extends for 1402,55 kmq with 98186 inhabitants. FUA of Perugia is the densest populated, whereas FUA of L'Aquila is the biggest in dimensions. FUA of Terni includes also three municipalities belonging to Rieti, in Lazio Region.

Within the three FUA mentioned, the analysis is conduct on municipalities up to 5000 inhabitants.

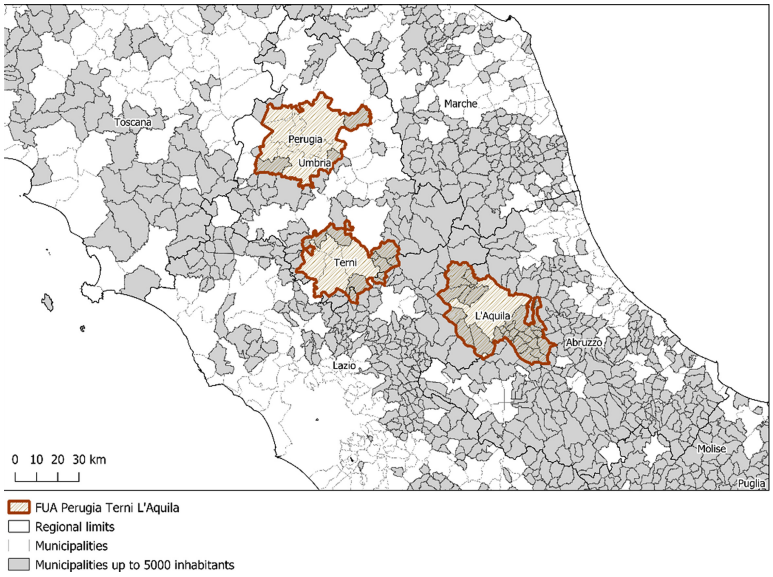

Fig. 1. Framework of Italian municipalities up to 5 000 inhabitants and the municipalities included in the FUA of Perugia, Terni and L'Aquila. The figure shows the extensive presence of small municipalities in the area considered (Central Italy).

The study area comprehends 39 municipalities (Fig. 2). Among these, 3 municipalities are part of FUA of Perugia (Valfabbrica, Bettona, Piegaro); 10 are part of FUA

of Terni (Polino, Arrone, Stroncone, Ferentillo, Montefranco, Acquasparta, Avigliano Umbro in Umbria Region and then Configni, Labro, Colli sul Velino which are in Lazio Region) and 26 are part of L'Aquila FUA (San Demetrio Ne' Vestini, Prata D'Ansidonia, Pizzoli, Poggio Picenze, Castelvecchio Calvisio, Montereale, Navelli, Ocre, Barete, Barisciano, San Pio delle Camere, Sant'Eusanio Forconese, Scoppito, Lucoli, Acciano, Villa Sant'Angelo, Tornimparte, Tione degli Abruzzi, Caporciano, Carapelle Calvisio, Capitignano, Cagnano Amiterno, Calascio, Fagnano Alto, Fontecchio, Fossa).

The total area analysed occupies about 1550 kmq. Perugia's small municipalities extend for 236,19 kmq. In the case of Terni, they occupy 391,23 kmq and for L'Aquila they are 929,78 kmq.

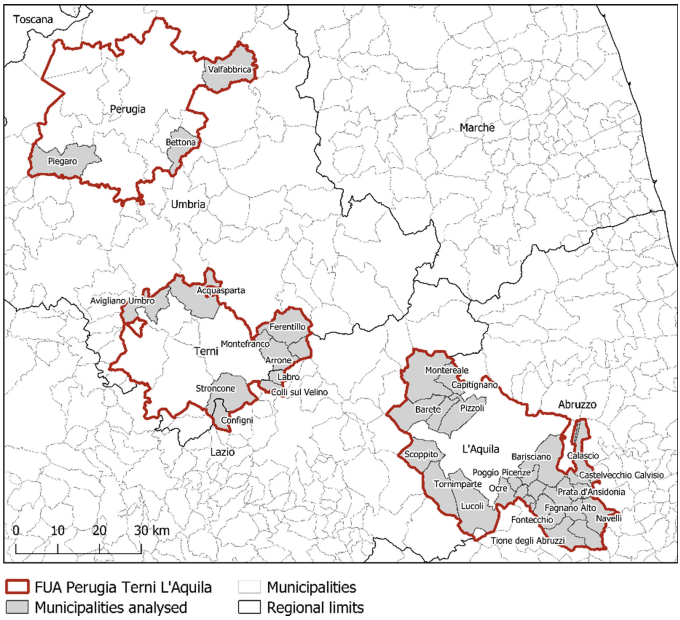

Fig. 2. Case study: Central Italy municipalities up to 5 000 inhabitants. The figure shows that the three FUA also comprehends municipalities not involved in the analysis.

3 Material and Methods

For the present work, analysis is conducted on the 39 municipalities mentioned. The analysis is based on results of research "Marginality assessment: Computational Applications on Italian municipalities" [16]. As mentioned, the research uses the parameters of Law 158/2017, which provides 12 criteria to identify areas affected by a disadvantaged economy, depopulation, and environmental issues.

The analysis has been conducted on 8 criteria and proper data are evaluated for each criterion. This selection has been considered acceptable also because the Law itself gives the same relevance to every criterion. Then, if every one of the criteria is equally valid

for accessing the fund, also selection of them can be representative of the areas' fragility. The list of criteria used in the research:

1. Hydrogeological instability (IndA)
2. Economic backwardness (IndB)
3. Strong population decrease (IndC)
4. Residential density low than 80 inhabitants per kmq (IndG)
5. Municipalities that are part of a mountain community or municipalities that implement together the basic functions (IndI)
6. Municipalities partially or totally included in a national park, a regional park, or other protected areas (IndL)
7. Municipalities created by fusion (IndM)
8. Municipalities included in peripheral or ultra-peripheral areas, as defined by National Strategy for Inner Areas (IndN)

Criteria analyses is done with open-source software (QGis). The base is data set of Italian municipalities (updated in 2017, the same year of the Law considered). It is integrated with the additional spatial or tabular data mentioned. Through this database every municipality receives one value per each criterion. The value is 1 if the municipality meets the reference criterion or value can be 1 if there is correspondence. The result are the sums of values each municipality got.

Then, the analysis of results obtained is processed using MATLAB software. The analysis permit to find 255 classes of possible combinations among the 8 criteria [16].

4 Results

Results are resumed in two sections. The first section highlights the most shared criteria among the municipalities analysed. Frequency is useful to detect the relevance of each criterion for the specific area. The second section highlights combinations of criteria. These sequences give the general picture of disadvantage condition in the study area.

4.1 Frequencies of Criteria

As evidenced by numerical correspondence of indicators (Fig. 3), there is a correspondence with criteria related to low residential density (IndG) and hydrogeological instability (IndA) in 33 municipalities out 39. Moreover, more than half of municipalities are affected by strong economic backwardness (IndB). Presence of half of the municipalities inside a national park or other protected areas (IndL) attests environmental relevance of the area considered. Also, population decrease (IndC) affects almost half of the municipalities. The remaining indicators are less significant.

As expected, correspondence with peripheral and ultra-peripheral areas (IndN) affected only few municipalities out 39 (the 3 municipalities Acciano, Tione degli Abruzzi, Calascio, all within the FUA of L'Aquila). In this sense, the proximity of study areas to the cities is determinant. In fact, the municipalities analysed are peri-urban areas in the fringe between high urbanised centres and more peripheral areas.

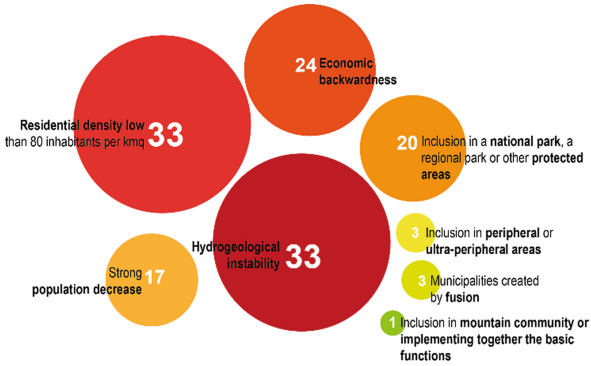

Fig. 3. Bubble chart of frequencies of each criterion. The chart shows how many times each criterion appears within the case study. Bigger dimensions and darkness colours suggest the prominence of the criteria in the area.

Focusing on singular municipalities, only one municipality (Bettona) results in lack of correspondence to the criteria analysed (Fig. 4). Indeed, the FUA of Perugia has only three cases of small municipalities. The other two, Piegaro and Valfabbrica, have respectively 2 and 3 correspondences to the criteria.

FUA of Terni presents a mixed result, in which municipalities go from 1 (Labro) to 5 (Polino) criteria met.

Instead, municipalities in the FUA of L'Aquila proved to be the most affected by the criteria of disadvantages analysed. 14 municipalities out 26 have correspondence to more than 4 criteria (Acciano, Tione degli Abruzzi, Calascio, Castelvecchio Calvisio, Montereale, Navelli, Barete, Barisciano, Lucoli, Carapelli Calvisio, Capitignano, Cagnano Amiterno, Fognano Alto, Fontecchio). In the worst cases, Calascio and Tione degli Abruzzi have respectively 7 and 6 criteria.

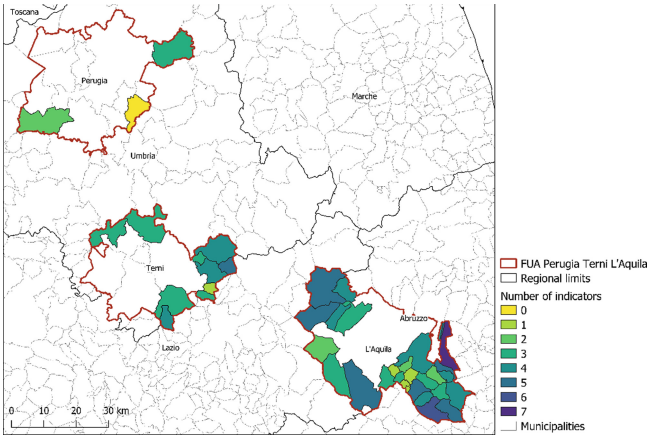

Fig. 4. Numbers of criteria met for each municipality

4.2 Sequences of Criteria

Various combinations occur considering specificity of criteria involved (Fig. 5). Among all the possible combinations, 19 sequences characterize the 38 municipalities (Bettona excluded). However, the conditions are heterogeneous because about half of combinations are isolated cases (11 combinations are valid only for one municipality). In other words, a quarter of the total municipalities observed has a specific condition of disadvantage generated by a singular combination of criteria.

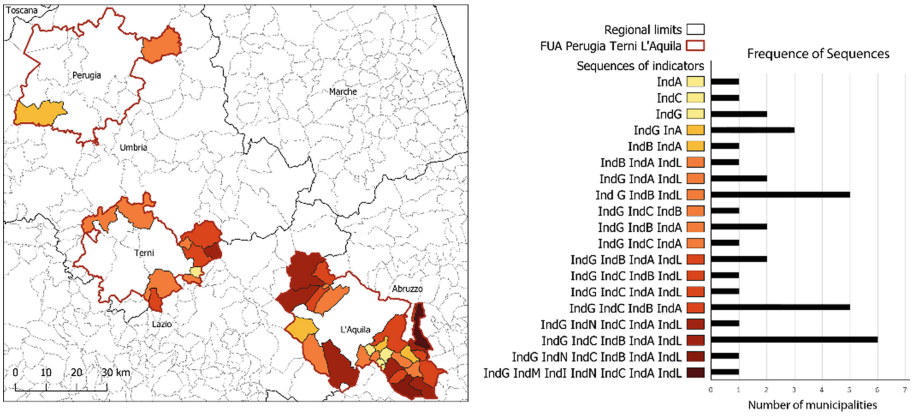

Fig. 5. Sequences of criteria. Map shows sequences for each municipality, going from less disadvantaged conditions (1 criterion, yellow coloured) to the most disadvantaged condition (7 criteria, dark red coloured). Bar graph shows the frequency of each sequence within the case study. Frequencies goes from 1 municipality to 6 municipalities involved. (Color figure online)

The sequence which has the highest incidence is IndG IndC IndB IndA IndL (Table 1). The 6 cases are almost in FUA of L'Aquila (5 municipalities: Castelvecchio Calvisio, Montereale, Lucoli, Cagnano Amiterno, Fagnano Alto) and then 1 case is in FUA of Perugia (Polino).

The following sequences with high incidence are IndG IndB IndA IndL and IndG IndB IndA. In detail, for IndG IndB IndA IndL more than half are in FUA of L'Aquila (Fontecchio, Barisciano, Barete), whereas the other two are in FUA of Perugia (Ferentillo, Arrone).

For the sequence IndG IndB IndA most cases are in FUA of Terni (Stroncone, Avigliano Umbro, Acquasparta), one case is in FUA of Perugia (Valfabbrica) and one other in FUA of L'Aquila (Tornimparte).

In particular, the three criteria IndG IndB IndA are present in the three most shared combination. Low residential density, economic backwardness, and hydrogeological instability are the main causes of disadvantage in the area considered.

Table 1. Detail of the 3 most frequent sequences

Sequences		Detail of Sequences	Incidence
IndG IndC IndB IndA IndL	IndG	Municipalities characterised by a **residential density low than 80 inhabitants per kmq**	6
	IndC	Municipalities affected by strong **population decrease** compared to the general census of 1981	
	IndB	Municipalities affected by strong **economic backwardness**	
	IndA	Municipalities included in areas affected by **hydrogeological instability**	
	IndL	Municipalities partially or totally included in a **national park**, a **regional park** or other **protected areas**	
IndG IndB IndA IndL	IndG	Municipalities characterised by a **residential density low than 80 inhabitants per kmq**	5
	IndB	Municipalities affected by strong **economic backwardness**	
	IndA	Municipalities included in areas affected by **hydrogeological instability**	
	IndL	Municipalities partially or totally included in a **national park**, a **regional park** or other **protected areas**	
IndG IndB IndA	IndG	Municipalities characterised by a **residential density low than 80 inhabitants per kmq**	5
	IndB	Municipalities affected by strong **economic backwardness**	
	IndA	Municipalities included in areas affected by **hydrogeological instability**	

5 Discussion

5.1 Local Disadvantaged Conditions

Although FUA share the same geographical context, some differential conditions can explain the results obtained. As seen, small municipalities in FUA of L'Aquila are the most numerous and the most fragmented. In these areas, frequency of criteria met is higher. Disadvantages relate both to loss of social opportunities and to fragile territories. Disconnection and isolation of the area could be one main reason. Indeed, some observations emerge in comparison with the other two cases analysed.

Firstly, Umbria's FUA are more connected to the nearest Regions, such as Lazio and Toscana. They are in a dense road network that crosses Central Italy from north to south. Between the two, Perugia is the highest connected. Moreover, its territory is the most densely urbanized among the three compared. Instead, Terni represents a middle ground. It has direct infrastructural connection between Umbria, Abruzzo, and Lazio Regions, but it has also environmental quality's areas in its surroundings. Differently, natural areas are the main feature of FUA of L'Aquila. Its infrastructural network is composed mainly by one axis (A24), which connects to Lazio Region at west and to coastal cities at east.

In fact, FUA of L'Aquila is immersed in a mountain system. This morphological condition deeply impacts on disadvantages, as the analysis has shown. Difficult connections and absence of diffuse services on territory can cause lack of economic development. Through the years, these aspects have led to concentrate resources in the city centre of L'Aquila at the expense of an even less developed surroundings. Comparing to the other two, FUA of L'Aquila has the highest level of fragility.

In this framework, further interesting data are about seismic risk. Some municipalities are part of the highly damaged areas in the recent earthquakes in Central Italy and they are mainly concentrated in L'Aquila or in its proximity. In detail, 9 of them are part of the so-called Seismic Crater: 5 municipalities are in FUA of L'Aquila (Barete, Cagnano Amiterno, Capitignano, Montereale, Pizzoli) and 4 are in FUA of Terni (Arrone, Ferentillo, Montefranco, Polino). This further criterium of disadvantage weighs on the overall fragile condition of these areas. This means also that these municipalities have received extra funds for recovering and that they are involved in plans for reconstructions. Evidently, specific and different funds are welcome.

However, diverse funds focalize on diverse territorial disadvantages, whereas functional planning strategies require organic and long-term vision. A structural assess of all fragilities and then a comprehensive and coherent territorial policy would be preferable.

5.2 From Disadvantaged Areas to Urban Settlements

The current work presents some characteristics related to fragility and disadvantages. It has been possible through the previous research on disadvantages in small municipalities. In fact, the reference analysis settles a framework in which each municipality fits. Disadvantages analysed cover mainly territorial aspects, economical background, and population dynamics. These results represent a coarse-grain layer of information. In fact, this categorization gives the overall picture of local urban conditions (Fig. 6).

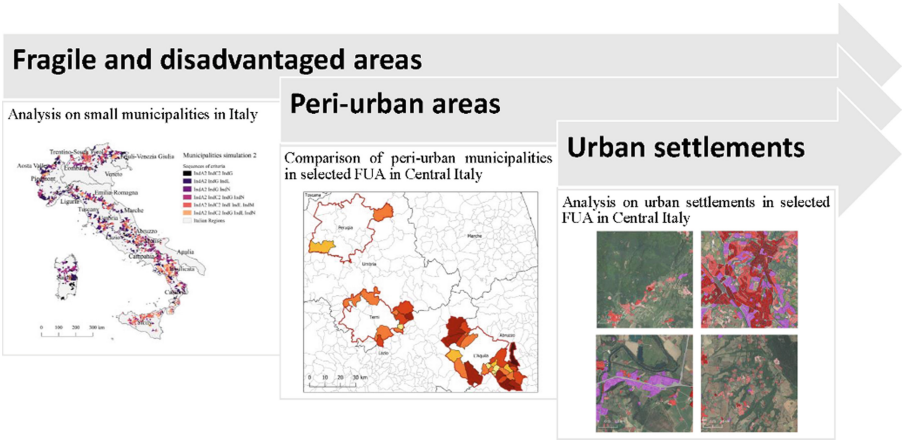

Fig. 6. The diagram shows phases in the research's workflow. It has started from the analysis on disadvantaged areas at national scale. The intermediate step is represented by the analysis on FUA of Perugia, Terni, L'Aquila. The third part on urban settlements is going to be developed.

Other types of analysis are needed for deepening further aspects. Indeed, peri-urban areas comprehend a series of elements readable through a more detailed scale. As instance, main differences in classification of peri-urban settlement regard context, dimensions, shape, and structure.

In future steps of the research, a first approach will consist in setting a window of defined dimensions for catching urban settlements at the same scale.

For this purpose, Urban Atlas will be used as base for finding recurring peri-urban settlement and then to classify them in categories. Of course, this tool is not sufficient, and it will be implemented, as instance with satellite images. Then, a fine-grained analysis on aspects at a detailed scale will be needed.

The on-going research is part of LIFE IMAGINE UMBRIA Project. Purposely, extracting models of peri-urbanization is one of the project's goals. Although in preliminary phase, the reasoning about connections of different scales and approaches seemed interesting to develop at this point.

One other aspect of the reasoning is linked to sustainability related to urban context. Indeed, among the other causes, urban structure and dispersion deeply impacts on land management [19]. This research opens also to comparisons in measuring settlements' performances. In perspective, this may be useful for evaluating sustainability of settlements (Fig. 7).

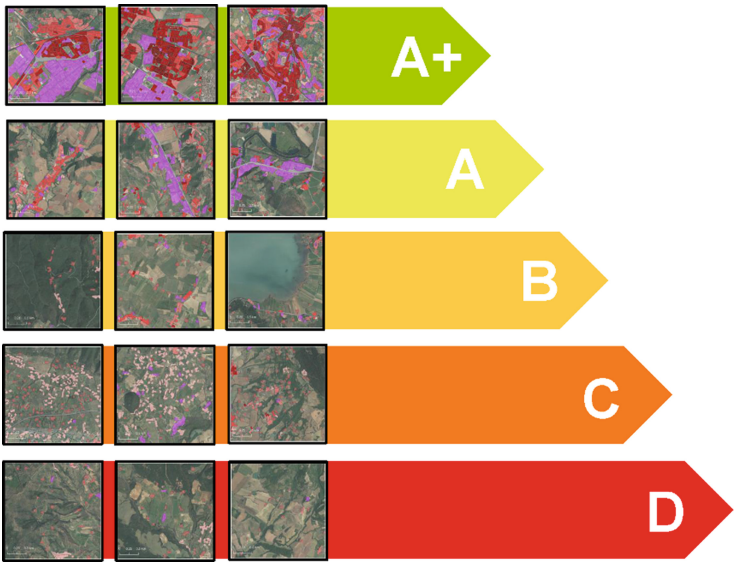

Fig. 7. Comparison among diverse types of land transformation in terms of sustainability. The figure refers to the typical scheme about energy class of buildings. It goes from cases of higher-performance in reducing consumption of land (A+) to the worst case in terms of dispersion (D).

6 Conclusion

As shown, some conditions of peri-urban areas are comprehensible considering limits of commuting zones as classified from Urban Atlas. The unit of FUA has been functional to investigate similar territorial conditions for different urban areas. Moreover, the case

study represents an interesting subject of further analysis. Then, considering a larger part of the related geographical area (Central Italy) may be desirable.

The case study has highlighted that local gradient of fragility can be combined with other analyses even if different in approach. In fact, the work is a first-step analysis for approaching multi-spectral problems of peri-urban areas. Forthcoming research will focus mainly on assets of urban settlements. In this perspective, the use of FUA is also functional for extending the comparisons on European territory, by virtue of urban information available in the Urban Atlas database.

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