AN *ECOSYSTEM SERVICES BASED* MODEL FOR THE RECLASSIFICATION OF URBAN USES IN PLANS. A DECISION SUPPORT FOR THE MINIMISATION OF SOIL CONSUMPTION

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1 | INTRODUCTION

Soil that is not artificially covered is capable of providing services with both direct and indirect benefits for humans. It is, therefore, essential to assess the impacts of different land-use and urban planning choices by estimating costs and benefits associated with different land-use scenarios and/or protection policies.

The dimensioning of municipal urban plans (Puc) sets the urban load, in accordance with the regulations, with the provisions contained in the *Provincial Territorial Coordination Plans* (PTCP) and on the basis of a careful analysis of the community's actual and irrepressible needs.

The possible transformations envisaged in the Pucs lead to two types of consequences: on the one hand, they constitute a potential income for the municipal coffers in terms of taxation on building land and buildings constructed and in terms of urbanisation charges; on the other hand, the transformation of the land entails the definitive loss of the numerous and very valuable *Ecosystem Services* (ES) that it is able to provide.

These are defined by the *Millennium Ecosystem Assessment* (MA, 2005) as the multiple benefits provided by ecosystems to humankind and are divided into four categories: life support, provisioning, regulation and cultural values. A variety of approaches to assessing the ES provided by different land covers can be found in the literature. Some of them are based on matrices that, based on the opinion of experts (such as physical geographers, forest scientists and environmental engineers), associate each land cover class with a score related to the level of performance offered by each ES (Costanza et al., 1997; De Groot, 2010; Burkhard et al., 2012; Rodriguez, Armenteras & Retana, 2015; Santolini et a., 2015).

The change in land cover from its natural state to artificial cover is technically termed *land consumption*. Forms of consumption range from total loss of the soil resource to partial loss of ES functionality. *urban densification* is also a form of land consumption insofar as it involves the introduction of new artificial cover in urban areas (Munafò, 2021).

Zeroing net soil consumption means, therefore, avoiding the sealing of agricultural and open areas and, for the residual component that cannot be avoided, compensating it by renaturalising an area of equal or greater extent in order to restore its capacity to provide ES (EC, 2016).

When considering soil as a *resource*, it is necessary to distinguish between land cover and land use.

The term *land cover* refers to the biophysical cover of the earth's surface, while land use refers to the actual biophysical state of the soil, related to its use in human activities. The latter is, therefore, defined according to the present and planned functional dimension and urban use (Directive 2007/2/CE).

A change of land use (and even less a change of land use provided for by a town planning instrument) may not alter the functions of the land and its capacity to provide SE and, therefore, not represent real land consumption.

«The relationship between land consumption and population dynamics confirms that the link between demography and urbanisation and infrastructural processes is not direct and there is a growth of artificial surfaces even in the presence of stabilisation, in many cases decrease, of residents» (Munafò, 2021: 45).

From this, the importance of correctly sizing Pucs, carefully balancing the need for new areas for human activities with the preservation of ES, aiming to achieve *settlement efficiency* (Fasolino, Coppola & Grimaldi, 2020).

2 | Urban land use, taxation and reclassification of land

Taxation is playing an increasingly decisive role in urban planning. Municipalities, in the absence of state resource transfers, are increasingly using Pucs as a tool to increase the tax base and keep their budgets afloat, encouraging urban expansion.

The zoning of a piece of land influences its tax regime. In particular, there is a clear difference in the taxation attributable to agricultural or building land. For both of them, there is the *own municipal tax* (IMU)[1] to which the tax for indivisible services is added for *building land* (TASI)[2]. In addition, while for agricultural land the IMU is calculated taking into account the cadastral value, for building land this tax takes into account the market value which, unlike the former, is not a static value. It is, in fact, estimated on the basis of the territorial area in which it is located, the buildability index, the permitted use, the charges for any work to adapt the land necessary for construction, and the average prices found on the market from the sale of similar areas (DLgs n. 504/1992, art. 5). As a result, the tax burden is heaviest on owners of building land.

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[1] IMU came into force with Article 13 of DL 201/2011 - Decreto Salva Italia.

[2] TASI is governed by Law 147/2013, paragraph 669 et seq.

The need to reclassify land, i.e. to transform it from building land to agricultural land, is growing, both because of the fiscal effects just outlined and because of the increased sensitivity to environmental issues, closely intertwined with climate change issues, and the need to curb (stop) land consumption.

Attention to the issue translates, in some cases, into the introduction of specific procedures through which municipalities are empowered to restore to agricultural or natural use soils intended for urban uses, through their urban reclassification, at the proposal of the citizens concerned. An example of such practices can be found in the Veneto Region where, with Regional Law no. 4/2015, art. 7, green variants were introduced for the *reclassification of building areas*.

3 | MODEL FOR THE RECLASSIFICATION OF LAND USES

The model outlined is configured as a decision-support tool to be used in the choice of land for transformation, downstream of the Puc sizing or in a periodic revision of the same, to ensure a more rational use of the land and the safeguarding of the ESs it is able to provide. The methodology for reclassifying urban land uses is divided into 4 macro-phases.

The first of these is oriented towards the formal assessment of transformable areas and is conducted through the analysis and superimposition of graphical documents (such as base maps, geognostic maps, etc.), satellite images and comparison with field surveys.

Macrophase 2 is oriented towards the classification of soils according to the ES they provide. For this purpose, starting from the matrix of Burkhard et al. (2012), a new evaluation matrix is constructed, called *Matrix ES*, to be applied to the transformable areas identified in the previous macro-phase. The scores contained therein are applied to the different land covers of each area of interest as follows:

$$PP_{ES,Aj} = \frac{\sum_{i=1}^{n}(St_i * ES)}{\sum_{i=1}^{n} St_i} \quad (1)$$

in cui:

- $PP_{ES,Aj}$= score given to all ES of the j-th transformation area, with j=1,…,z;
- S_{ti}: land area of the i-th land cover indicated in the Agricultural Land Use Map (CUAS) and present in the transformation area under consideration;
- $ES = \frac{\sum_{k=1}^{m} ES_{CLC}}{m_{SE_{CLC}}}$ = score attributed to the ES associated with 1 hectare of each land cover in the transformation area under consideration.

The results obtained are spatialised and classified into five classes (C) of ES quality: very low (C1), low (C2), medium (C3), high (C4), very high (C5), inversely proportional to the ES values (VSE), which are respectively 5, 4, 3, 2, 1.

The third macro-phase introduces the *function of controlling efficient land use* (F_{CUES}):

$$F_{CUES} = V_{ES}*w_1 + II_I*w_2 + II_E*w_3 + A_U*w_4 + P_{NA}*w_5 + P_{SF}*w_6 \quad (2)$$

in cui:

- V_{ES} = value of ES, varying from 1 to 5;
- II_I = internal settlement integration, with values of: 0 (none); 0,5 (partial); 1 (complete);
- II_E = external settlement integration, with values of: 0 (none); 0,5 (partial); 1 (complete);
- A_U = adjacency to primary urbanisation, with values of: 0 (none); 0,5 (partial); 1 (complete);

- P_{NA} = proximity to motorway junctions (in km), with a value of: 0 (distance (d)> 2); 0,5 (1<d<2); 1 (d<1);
- P_{SF} = proximity to railway stations (in km), with a value of: 0 (d>1); 0,5 (0,5<d<1); 1 (d<0,5);
- w_i = weight of the i-th parameter, with values: w1= 0,5 and w2=w3=w4=w5=w6= 0,1.

The FCUES thus defined can take values from 1 to 10. The function is inversely proportional to the usefulness of reclassifying land. The lower its value, the higher the convenience of reclassifying the land use of the compartment under consideration in order to achieve a more rational land use.

The fourth macro-phase is oriented towards the selection of areas to be reclassified according to urban load, FCUES values and PPSE. If FCUES values are equal, the choice falls on the areas that have a lower PPSE

4 | MODEL APPLICATION[3]

4.1 | Case study selection

The model was applied to the municipality of Mercato San Severino, in the province of Salerno, selected as a good example of the use of urban planning forecasts as a tool to balance budgets, often at a loss.

For the case study, this expedient, which was used extensively in the Puc[4], has generated discontent among citizens, leading to the emergence of specific committees formed by land owners demanding a declassification of their land from building to agricultural land. In the *Intervention Planning Acts* (API), implementation tool of the Puc, 44 urban planning subdivisions are planned, of which: 17 *Areas of Rehabilitation and Completion* (ARC), *12 Integrated Transformation Areas* (ATI), *6 Areas of Productive Transformation* (ATP) e *9 Strategic Transformation Areas* (ATS) (Fig. 1).
In the Puc, the residential requirement is calculated according to the possible increase in the number of households and, over a ten-year period, considering an average number of members per household of 3, amounts to 1,664 dwellings. In addition, by simulating the implementation of the residential subdivisions, for which a number of rooms (Nv) of 5,664 (coinciding with 5,664 inhabitants (ab)) is planned, it can be seen that the number of dwellings actually planned by the Puc is higher than required and amounts to 1,888 dwellings.

The PTCP of the Province of Salerno suggests estimating this need using possible population growth as a benchmark[5] (and not the increase in the number of households) and envisages for the metropolitan area of Salerno, Valle dell'Irno and Picentini the settlement of a maximum of 18,000 households/accommodations in the period 2009-2019.

[3] The data collection contained in this section and the numerical and graphical elaborations are by Rocco Salvati.
[4] Puc approved by the City Council in 2010 and by Decree of the President of the Province of Salerno in 2012.
[5] See Articles 123, 124 and 125 of the Technical Implementation Rules of the PTCP.

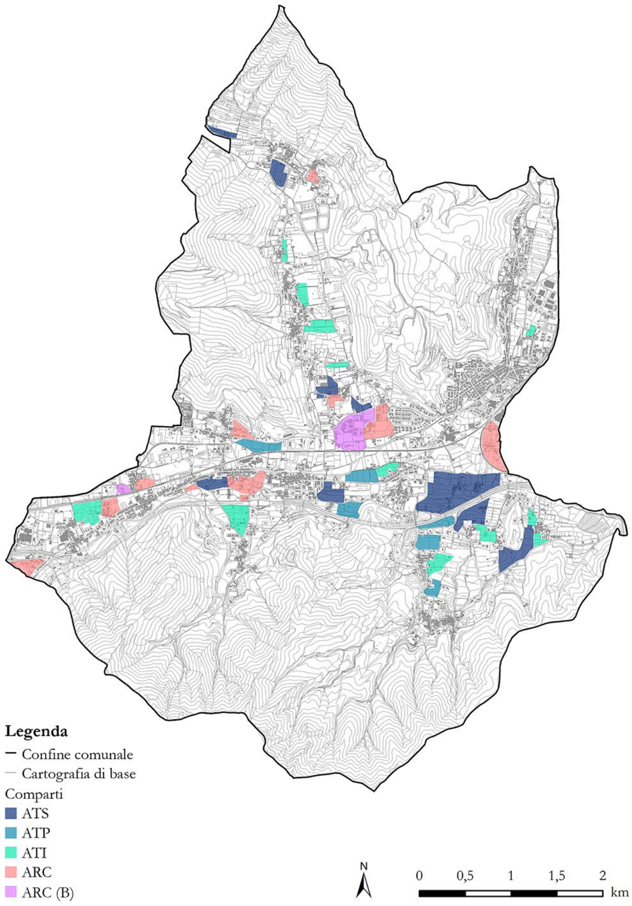

Fig. 1 | Compartments on base maps.

The particular method of calculating residential requirements adopted for the case study results in an overestimation of the same, which is more than 10% of the maximum load provided by the PTCP for its area.

With regard to the productive and tertiary sectors, although compartments are planned (ATP and ATS respectively), no dimensioning is found. The Puc only reports an analysis of the change in local units and employees over the period 1991-2001. The data show a decrease in both for the manufacturing sector and a decrease in local units against a slight increase in employees for the tertiary sector.

4.2 | Compartment selection and settlement load verification

The application covered all the subdivisions defined in the API except for those for which no reclassification was found to be necessary because they were associated with soil coverings whose ESs were respectively: very low or already impaired (ATS-8 Costa Cava, ARC 5 Capoluogo 1, ATI-10 Pandola); already affected by a project or undergoing transformation (ARC-6 Capoluogo 2, ARC-9(B) Curteri 2); already transformed (ARC-8(B) Curteri 1); those in respect of which any intervention is deemed not to be compatible (ARC-16 Capoluogo 3, non-compatibility established in relation to the variant to the Sarno Basin Authority's Stralcio Plan).

The focus in this contribution is only on residential areas (ARC and ATI) although the application of the model has also covered the production and tertiary sectors.

The evident oversizing of the Puc led to the introduction of a preliminary step to recalculate the urban load by considering, in the assessment of residential needs, the possible demographic increase, as established by the PTCP.

This operation returned an expected resident population value (P_{pr}) as of 2018 amounted to 23,599 inhabitants, with a demographic change since 2008 of 2,214 inhabitants and a residential need value of 914 dwellings.

4.3 | Classification of soils and selection of compartments to be reclassified

The next step involved the classification of the soils included in the compartments under attention, according to the ES they provide. The scores $PP_{ES,Aj}$ were evaluated using the relationship (1). The values thus obtained were then spatialised and classified into five quality classes: C1, C2, C3, C4, C5 (Tab. 1, Fig. 2).

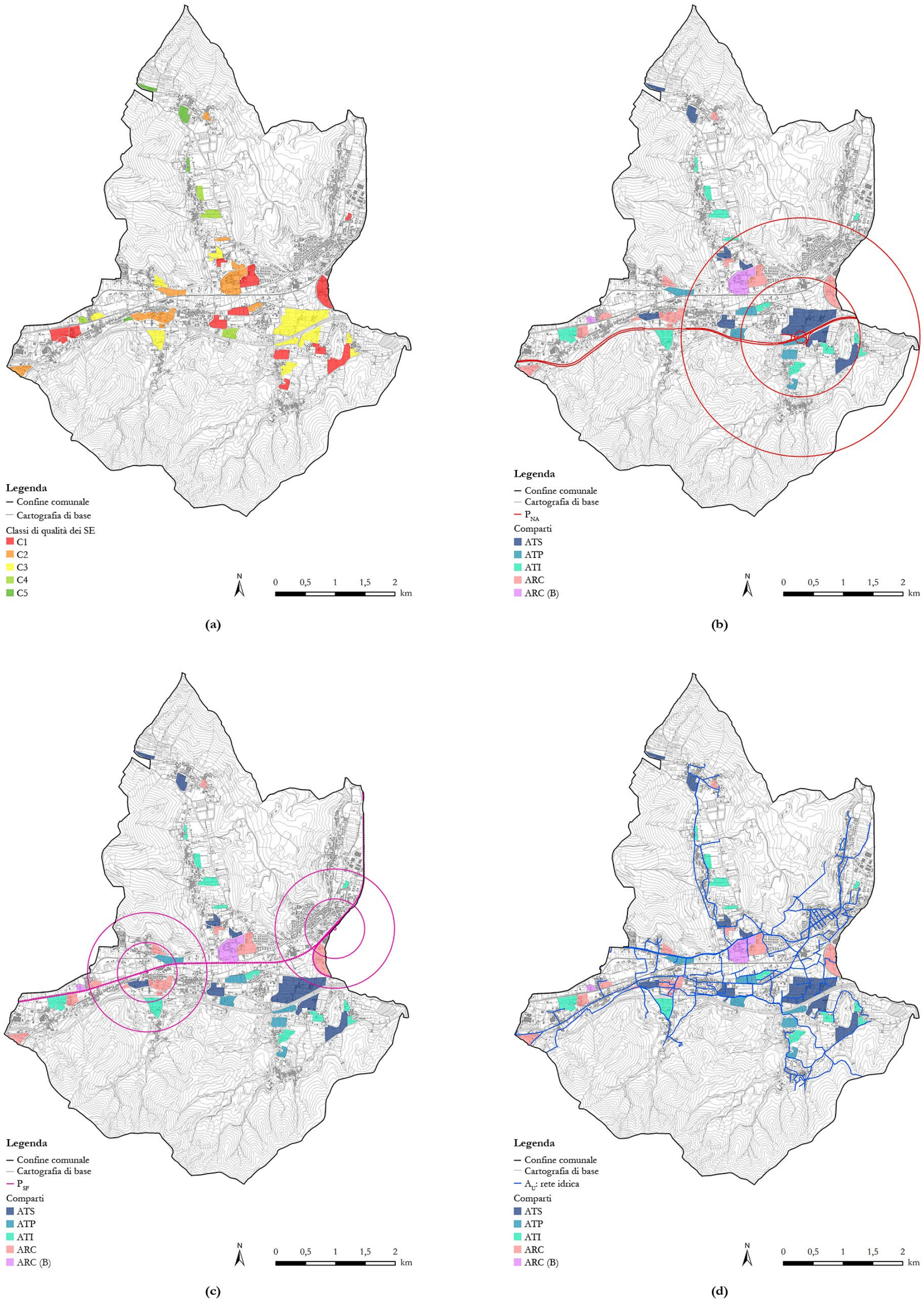

Fig. 2 | a) Quality classes of ES; b) P_{NA}; c) P_{SF}, d) A_U: water network.

Next, it was calculated the F_{CUES}, according to the report (2) (Tab. 1, Fig. 2). As established during the outlining of the model, the number of residential subdivisions to be reclassified or reduced was assessed taking into account the urban load envisaged by the Puc and the need to correct its values oversized in function of the real needs of the population and the area under consideration, appropriately selecting areas according to the values of F_{CUES} e P_{PSE}.

The urban load check carried out above makes it possible to state that only 2,742 of the 5,664 rooms planned in the Puc are actually needed. Therefore, 2,922 rooms were reduced from the planned ones, selecting 8 of the 21 examined subdivisions as to be reclassified: ATI 1, ARC 17, ATI 2, ATI 3, ATI 4, ATI 8, ATI 11, ATI 7 (Tab. 2, Fig. 3).

ATI 7 and ATI 15 recorded the same FCUES value, but different PPSE and C values. Specifically: 49.00 and class C3 for the former; 49.40 and class C2 for the latter. Therefore, between the two, ATI 7 was chosen as the one to be reclassified, as it is characterised by a lower PPSE, that is an higher quality of SE and to be preserved.

Tab. I | Classification of compartments according to V_{SE} e F_{CUES}.

N	API	PP_{ES}	C	V_{ES}	II_I	II_E	A_U	P_{NA}	P_{SF}	F_{CUES}
1	ARC 1-Piemonte	49,00	C2	4	0,5	0,5	1,0	0,0	0,0	6,0
2	ARC 2-Lombardi	47,40	C1	5	0,5	0,5	1,0	0,5	0,0	7,5
3	ARC 4-S. Vincenzo	47,00	C1	5	1,0	1,0	1,0	0,5	0,0	8,5
4	ARC 7-Ferrovia	48,10	C1	5	1,0	0,0	1,0	1,0	0,5	8,5
5	ARC 10-S. Angelo	49,00	C2	4	1,0	0,5	1,0	0,0	1,0	7,5
6	ARC 11-Costa	49,60	C3	3	1,0	1,0	0,5	0,0	1,0	6,5
7	ARC 12-Piro 1	49,30	C2	4	0,0	0,5	1,0	0,0	0,5	6,0
8	ARC 14-P. Del Galdo	47,20	C1	5	0,5	1,0	1,0	0,0	0,0	7,5
9	ARC 15-Rosto	49,00	C2	4	0,5	0,0	1,0	0,0	0,0	5,5
10	ARC 17-Ospizio	51,70	C5	1	0,0	0,0	1,0	0,0	1,0	3,0
11	ATI 1-Galdo dei Carifi	52,81	C5	1	0,0	0,5	1,0	0,0	0,0	2,5
12	ATI 2-Carifi-Torello 1	51,30	C4	2	0,0	0,5	1,0	0,0	0,0	3,5
13	ATI 3-Carifi Torello 2	50,60	C4	2	0,0	0,5	1,0	0,0	0,0	3,5
14	ATI 4-S. Martino	48,70	C2	4	0,0	0,0	0,5	0,5	0,0	5,0
15	ATI 5-Curteri	48,80	C2	4	0,0	0,5	1,0	1,0	0,0	6,5
16	ATI 6-Monticelli	47,20	C1	5	0,0	0,5	1,0	1,0	0,0	7,5
17	ATI 7-Oscato	49,40	C3	3	0,0	0,5	1,0	1,0	0,0	5,5
18	ATI 8-Corticelle	50,40	C3	3	0,0	0,5	1,0	0,5	0,0	5,0
19	ATI 9-Campo sportivo	47,00	C1	5	0,0	1,0	0,0	0,0	0,5	6,5
20	ATI 11-Acquarola	49,90	C3	3	0,5	0,0	1,0	0,0	0,5	5,0
21	ATI 12 - S. Eustachio	47,20	C1	5	0,0	0,5	1,0	0,0	0,0	6,5

Tab. II | Selection of compartments to be reclassified.

N	API	PP_{ES}	C	V_{ES}	F_{CUES}	N_v	N_{vr}^*
1	ATI 1-Galdo dei Carifi	52,81	C5	1	2,5	173	173

2	ARC 17-Ospizio	51,70	C5	1	3,0	40	213
3	ATI 2-Carifi-Torello 1	51,30	C4	2	3,5	529	742
4	ATI 3-Carifi Torello 2	50,60	C4	2	3,5	842	1584
5	ATI 4-S. Martino	48,70	C2	4	5,0	194	1778
6	ATI 8-Corticelle	50,40	C3	3	5,0	378	2156
7	ATI 11-Acquarola	49,90	C3	3	5,0	312	2468
8	ATI 7-Oscato	49,00	C3	3	5,5	33	2921
9	ARC 15-Rosto	49,40	C2	4	5,5	453	-
10	ARC 1-Piemonte	49,00	C2	4	6,0	102	-
11	ARC 12-Piro 1	49,30	C2	4	6,0	41	-
12	ARC 11-Costa	49,60	C3	3	6,5	89	-
13	ATI 5-Curteri	48,80	C2	4	6,5	458	-
14	ATI 9-Campo sportivo	47,00	C1	5	6,5	126	-
15	ATI 12-S. Eustachio	47,20	C1	5	6,5	592	-
16	ARC 2-Lombardi	47,40	C1	5	7,5	73	-
17	ARC 10-S. Angelo	49,00	C2	4	7,5	111	-
18	ARC 14-P. Del Galdo	47,20	C1	5	7,5	45	-
19	ATI 6-Monticelli	47,20	C1	5	7,5	351	-
20	ARC 4-S. Vincenzo	47,00	C1	5	8,5	108	-
21	ARC 7-Ferrovia	48,10	C1	5	8,5	392	-
*Nota: N_{vr}= Number of rooms to be reduced							

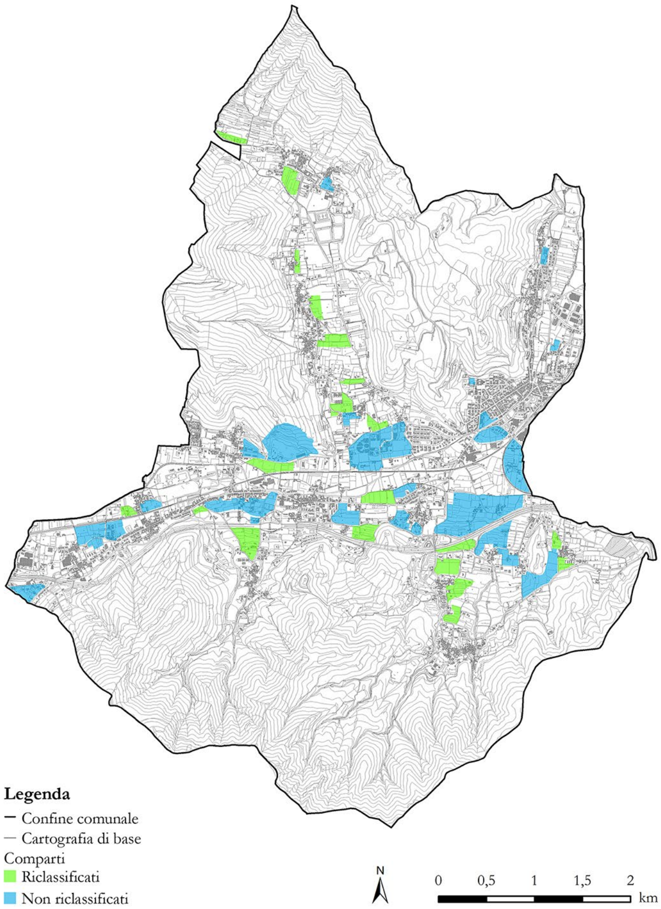

Fig. 3 | Identification of segments to be reclassified.

5 | Summary assessments and perspectives

For some time now, municipalities have been using urban planning forecasts as a tool to balance their budgets and cope with the lack of state funding and the current economic crisis. This approach, however, conflicts with the need to reduce land consumption and safeguard ESs.

This contribution proposes a soil reclassification model that can be used as a decision support tool for administrations in the identification, in municipal urban plans, of transformation areas that meet the needs of the community without excessive soil consumption.

The model outlined, due to its structure and purpose, can be replicated in any territorial context and could also be exploited within the Strategic Environmental Assessment (SEA) process, finding its specific place within the contents of the Environmental Report (EA).

The need to reduce soil consumption can no longer be ignored. An indispensable regulatory framework should support a new approach to planning, rewarding virtuous municipalities in protecting soil resources and ensuring an effective subsidiary relationship between municipalities.

Municipal budgets could be supported by appropriate forms of territorial and fiscal equalisation. This presupposes a virtuous model in which municipal taxation is no longer exclusively managed by individual authorities, but by means of a tax-distributive system to cover the budgets of municipalities that have greater difficulties than others without resorting to the consumption of free land.

It is also essential to introduce a SEA process, with assessment mechanisms that make the economic costs of the various scenarios explicit, also with reference to ecological and social aspects, in order to make public decision-makers accountable and to make the community aware of the economic and environmental costs associated with the various actions so that it can make conscious choices in safeguarding the common interest.

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