Osvaldo Gervasi · Beniamino Murgante · Eligius M. T. Hendrix · David Taniar · Bernady O. Apduhan (Eds.)

LNCS 13376

Computational Science and Its Applications – ICCSA 2022

22nd International Conference
Malaga, Spain, July 4–7, 2022
Proceedings, Part II

Part II

Springer

Lecture Notes in Computer Science 13376

More information about this series at https://link.springer.com/bookseries/558

Osvaldo Gervasi · Beniamino Murgante ·
Eligius M. T. Hendrix · David Taniar ·
Bernady O. Apduhan (Eds.)

Computational Science and Its Applications – ICCSA 2022

22nd International Conference
Malaga, Spain, July 4–7, 2022
Proceedings, Part II

Springer

Editors
Osvaldo Gervasi
University of Perugia
Perugia, Italy

Eligius M. T. Hendrix
Universidad de Málaga
Malaga, Spain

Bernady O. Apduhan
Kyushu Sangyo University
Fukuoka, Japan

Beniamino Murgante
University of Basilicata
Potenza, Potenza, Italy

David Taniar
Monash University
Clayton, VIC, Australia

ISSN 0302-9743 ISSN 1611-3349 (electronic)
Lecture Notes in Computer Science
ISBN 978-3-031-10449-7 ISBN 978-3-031-10450-3 (eBook)
https://doi.org/10.1007/978-3-031-10450-3

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Differences and Incongruences in Land Take Monitoring Techniques

Barbara Lopatriello[1], Lucia Saganeiti[2(✉)], and Beniamino Murgante[1]

[1] Laboratory of Urban and Regional Systems Engineering (LISUT), School of Engineering, University of Basilicata, Viale dell'ateneo Lucano 10, 85100 Potenza, Italy
beniamino.murgante@unibas.it

[2] Department of Civil, Building-Architecture and Environmental Engineering, University of L'Aquila, Via G. Gronchi, 18, 67100 L'Aquila, Italy
lucia.saganeiti@univaq.it

Abstract. The new European standards and directives on land take raise critical issues concerning the techniques for measuring and monitoring the phenomenon in order to achieve the targets fixed. The directive "No Net Land Take by 2050", makes it necessary to homogenize both the terminology used to define land take or consumption and the standardization of a computational methodology for its quantification. In order to achieve the goals, set by the EU regarding land take and soil sealing, it is necessary for EU member states to produce comparable data. It is essential to use the same data sources with standardized coding and to share the same meaning of the concept of land take. Therefore, with the aim of highlighting the criticalities and inconsistencies arising from the use of different techniques and datasets for monitoring land take, we will analyze, first, different definitions of land take derived from institutional sources including the European Environment Agency (EEA); then to each definition we will associate the corresponding land cover classes derived from the Copernicus Corine Land Cover (CLC) project. For the quantitative analysis we will use continuous and discontinuous datasets (raster and vectors) whose results will be compared with the data of the annual report on land take of the Superior Institute for environmental protection and research of Italy (ISPRA 2020).

Keywords: Land take · Corine land cover · Land consumption

1 Introduction

The great loss of soil and ecosystem services is one of the biggest challenges that Europe is already facing for several decades [1]. The extreme importance of the soil issue stems from its being considered a non-renewable resource (at least in the short term) and whose transformations are, therefore, irreversible [2]. The "uncontrolled" consumption of soil, resulting from processes of anthropization and soil sealing, produces economic, social, and environmental damages, reducing or destroying the capacity of soil to perform its basic ecosystem functions, with consequent impacts on biodiversity [3–6]. For these reasons, the sustainable management of soils, their preservation and the protection of

O. Gervasi et al. (Eds.): ICCSA 2022, LNCS 13376, pp. 271–277, 2022.
https://doi.org/10.1007/978-3-031-10450-3_22

biodiversity are issues that in recent years are assuming particular importance in the field of territorial planning, land governance and in all those disciplinary contexts that show a particular sensibility towards issues related to environmental, social and economic sustainability [7]. Moreover, the recent territorial transformations due to the extreme effects of climate change have made the topic of considerable public interest [8]. To approach these challenges, the European Community has set several targets to be achieved (by now in the short term) including zero net land take by 2050 (EU Environment Action Programme to 2020 (7th EAP) [9–12]. The definition and implementation of such policies, rules and actions aimed at reducing land take appears to be as urgent and priority. In this regard, the recent recovery and resilience tool approved by the European Union (in order to cope with the crisis generated by the pandemic spread of COVID - 19), Next Generation EU and subsequent recovery plans at the national level such as the National Recovery and Resilience Plan (PNRR) [13], are also concerned with the environment, sustainability and the fight against climate change.

In Italy, land take has never been addressed in a systematic way. In 2021 there are countless drafts and proposals of laws with the common objective of limiting soil sealing, but which have never passed to the next level, that of transformation into law. In fact, in recent years the legislative proposals have succeeded each other without ever completing the discussion and approval process, postponed, sometimes depreciated in their basic principles, and completely covered by the amendments [14, 15]. Land take is defined by the Superior Institute for environmental protection and research (ISPRA) as the growth of artificial land cover at the expense of agricultural, natural and semi-natural areas. This definition corresponds to a change in land cover classes from non-artificial (natural or semi-natural) to artificial land cover (consumed land). The main and most impactful component of land take is soil sealing as it poses an increased risk of flooding and water scarcity, contributes to global warming, threatens biodiversity and is particularly worrying when fertile agricultural land is covered [16].

Among the main phenomena related to land take, are to be mentioned certainly, those related to settlement dispersion such as urban sprawl (more popular and known phenomena) [17, 18] and urban sprinkling (phenomena prevalent in internal areas of the Mediterranean context) [19–22]. These are urban transformation patterns characterized by low or very low population and settlement density indices that result in unsustainable land use. These phenomena, in fact, lead to, increased infrastructuring with consequent exploitation of agricultural or natural areas and increased management costs of technological and transport networks [4, 5]. These urban transformation patterns are not sustainable both from an environmental and economic point of view because they tend to consume a limited resource, converting those soils intended for other uses or with a different vocation (agricultural or natural) into artificial soils. In addition to the direct negative effects related to the amount of land take, the indirect effects are related to the total dependence of mobility on private cars, resulting in increased pollution, overall economic and social inefficiency, dependence on fossil fuels and mining [23, 24]. These phenomena have been fueled by the weakness, or (in some cases) total absence, of measures and policies to limit the phenomenon of land take, increasingly favoring the occupation of vacant land distant from urban centers rather than reconstruction or redevelopment within established urban areas [25, 26].

From this synthetic framework, it emerges the need to address the issue of land take in a systematic way, proposing a computational methodology that allows to quantify the phenomenon and compare it at national level first, and then at European level. In this article it is proposed an analysis of the datasets currently available for the quantification of the phenomenon of land take with interpretations of some definitions related to it and from official sources including the Environmental European Agency (EEA) glossary [27]. The purpose is to highlight the differences and incongruences arising from the use of different techniques and datasets for monitoring land take. For the quantitative analysis we will use continuous and discontinuous datasets (raster and vectors) whose results will be compared with the data of the ISPRA 2020 report.

2 Land Take in Italy, Definitions, and Monitoring System

At the national level, land monitoring activities in terms of land use, coverage and consumption are ensured by the National System for Environmental Protection (SNPA). The methodology adopted for analysis, using since 2015, in a unitary and homogeneous way on a national scale, the Sentinel satellite images produced by the European Copernicus Program. In 2015, the first national map of land take at very high resolution was produced. From the ISPRA report on land take 2018 [28], the land take is divided into two categories: permanent and reversible with an additional third level classification (for reversible) that has been detailed and refined over the years based also on the latest texts of the legislative proposal under discussion in the Senate Committees. In this paper we take as a reference for a final comparison of the results the ISPRA 2020 report from which emerges an estimate of land take, between 2018 and 2019, equal to 57.50 km^2 and an amount equal to 5.60 km^2 of restored areas (from other uses to natural use), i.e., that amount of areas identified as reversible consumed soil. Soil consumption monitoring methodologies are further complicated by the absence of an unambiguous definition of land take at European level. The presence of various definitions, sometimes very dissimilar from each other, makes it difficult to measure the phenomenon, whose non-univocity at European level makes the results incomparable. In this regard, three definitions of land take from EEA reports and glossaries were analyzed in this paper. Based on the definitions, Corine Land Cover (CLC) land cover classes with level III and IV detail were associated [29, 30]. The CLC level III at year 2018 and the dataset in vector and raster format with 100 m resolution were used to calculate the areas. The CLC level IV detail is only available for some thematic insights and, in this case was useful to highlight differences in definitions that, with a total national coverage would lead to a substantial difference in the calculation of land consumption. The aim of the work is to highlight incongruences in the results obtained by considering different definitions of land take.

3 Land Take Surfaces Based on Different Definitions

Table 1 shows the three definitions identified with their respective references and in the last columns the CLC classes identified for each of them. The first definition: (1) consumption of land cover, whose source is the EEA glossary [27], has been divided into two parts to highlight the different components. The first part of the definition contains point a while the second contains points b and c together. Points b and c of the definition are different, since point b considers extensive agriculture, while point c considers intensive agriculture. This distinction is possible only with the IV level of CLC with which class 2.1.1.1 refers to intensive crops while class 2.1.1.2 to extensive crops and for this reason in the calculation of the occupied area the two points are used jointly. The second definition: (2) Land take (Glossary EEA [27]), unlike the first definition, which refers to land consumption, considers the "taking" of land or, more appropriately, the occupation of land by infrastructure and related facilities. This definition is specific to infrastructure and should therefore be referred to with a different terminology that includes the infrastructure itself. The third definition: (3) land take (European Union [16]) describes land consumption as an increase in settlement areas over time. Therefore,

Table 1. Selected definitions of land take/consumption and assignment of land cover classes based on CLC III and IV levels.

Num.	Definition	CLC III level	CLC IV level
1	***Consumption of land cover*** means: **(a)** The expansion of built-up area which can be directly measured;	1.1.1 1.1.2 1.1.3 1.2.1	1.1.1.1 1.1.2.1 1.1.2.2 1.1.2.3 1.1.3.1 1.1.3.2 1.2.1.1 1.2.1.2 1.2.1.3 1.2.1.4
	(b) the absolute extent of land that is subject to exploitation by agriculture, forestry or other economic activities; **(c)** the overintensive exploitation of land that is used for agriculture and forestry EEA glossary [27]	1.3.1 1.3.2 2.1.1 2.1.2 2.4.4	2.1.1.1 2.1.1.2
2	***Land Take***: the area of land that is taken by infrastructure itself and other facilities that necessarily go along with the infrastructure, such as filling stations on roads and railway stations EEA glossary [27]	1.2.2 1.2.3 1.2.4	1.2.2.1 1.2.2.2 1.2.2.3
3	***Land take*** also referred to as land consumption, describes an increase of settlement areas over time. This process includes the development of scattered settlements in rural areas, the expansion of urban areas around an urban nucleus (including urban sprawl), and the conversion of land within an urban area (densification). Depending on local circumstances, a greater or smaller part of the land take will result in actual soil sealing [16]	1.1.1 1.1.2 1.4.1 1.4.2	1.1.2.1 1.1.2.2 1.1.2.3

this classification includes rural settlements, urban areas and everything related to them (green areas, area for sports and recreation). It is interesting to note that, in the same definition, the terms land take and land consumption are used almost interchangeably.

Based on each definition of land take, the calculation of the corresponding surfaces was performed with both vector and raster data. Due to the different level of structuring of the two databases, there are some differences whose results are shown in the table below.

Table 2. Surface determination based on selected definitions

Definition Num.	Vector Surface [ha]	Raster Surface [ha]	Δ [ha]
1(a)	15.205	14.954	1,68
1(b)	82.689	82.451	0,29
2	560	517	8,32
3	12.570	12.321	2,02

Table 2 shows the surfaces calculated (on a raster and vector basis) according to the chosen definitions of land take and their associated CLC classes. Considering that the vector surfaces have resulted, for each definition, greater than the raster ones, the Δ represents the percentage difference of the raster compared to the vector. It means that, for example, taking definition 1(a) the raster data produces an underestimation of land consumption equal to 1.65% of the vector data. It should be noted that the area of land consumption related to the definition 1(c) was not analyzed because its specificity required the IV detail level of the CLC, not available for the totality of the study area considered.

The highest differences (Δ) emerge in definition 2 concerning the land covered by infrastructure. This occurs because in the raster data only the linear elements with such an extension as to cover at least 50% of a cell are detected and, consequently, all linear elements of minor entity (secondary roads of small size in terms of width of roadway) are excluded.

4 Discussions and Conclusions

In the ISPRA 2020 Report, consumed soil is defined as the total amount of soil with artificial cover and all classes of permanent and reversible soil consumption are indicated in the relative classification. Moreover, the new classification system no longer considers interventions related to the conduct of agricultural activity in which the natural conditions of the soil are ensured. The database is very detailed and refers to data available within the Copernicus Program, in particular to the Sentinel-2 mission which provides multispectral data with a resolution of 10 m. Thanks to this large availability of data, from last year the quantification of land consumption made by ISPRA has been increasingly refined, being able to detail the results obtained by specifying coverage classes and types of land consumption (reversible, irreversible and permanent).

In order to highlight the main differences in the dataset, a comparison was made first on a national basis, then on a provincial basis (for brevity we do not report all the results on a provincial level), considering the set of two of the definitions listed above, in which only surface completely impermeable are considered (definition 1(a) and definition 2). This results in a difference of 35%, a banal result if we refer to the different resolution of the two databases.

Positive and negative differences emerge from the comparison. The negative differences are attributable to the configuration of urbanized areas, which in most cases are compact and of big dimensions. The positive differences are instead attributable to dispersed spatial configurations and small dimensions of urban settlements. In fact, the spatial resolution of the CLC dataset, contrary to those used by ISPRA, does not allow the identification of small size urban areas. On the contrary, on compact and large spatial configurations of urban settlements, CLC overestimates the land consumption compared to ISPRA.

From the calculation of land take in accordance with the different definitions identified in this research it emerges that the type of data used (vector or raster) involves differences in the average result of 3%. In addition, each definition of land consumption involves a different and not negligible result.

The comparison with the land consumption of the ISPRA 2020 report is not significant since the level of detail of the databases used are not comparable at all. This shows how, even though at the national level the research on soil consumption is continuing with good results, identifying accurate definitions and allowing to divide the phenomenon into different sub processes, at the higher level of governance, the European one, this result becomes not comparable. The most used databases at European level for monitoring land consumption are CLC or ATLAS (with a higher level of detail) but without any unambiguous definition of the phenomenon. Urban ATLAS dataset is very detailed but does not have uniform coverage. Data is only available for cities that are provincial capitals.

References

1. Couch, C., Leontidou, L., Petschel-Held, G.: Urban sprawl in Europe: landscapes, land-use change & policy. Plan. Pract. Res. **25**(2), 273–274 (2007)
2. EEA: Land and soil in Europe (2019). https://doi.org/10.2800/779710
3. Pilogallo, A., Saganeiti, L., Scorza, F., Murgante, B.: Assessing the impact of land use changes on ecosystem services value. In: Gervasi, O., et al. (eds.) ICCSA 2020. LNCS, vol. 12253, pp. 606–616. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-58814-4_47
4. Freilich, R.H., Peshoff, B.G.: The social costs of sprawl. Urban Lawyer **29**, 183–198 (1997). https://doi.org/10.2307/27895056
5. Manganelli, B., Murgante, B., Saganeiti, L.: The social cost of urban sprinkling. Sustainability **12**, 2236 (2020). https://doi.org/10.3390/su12062236
6. Beniamino, M., et al.: A methodological proposal to evaluate the health hazard scenario from COVID-19 in Italy. Environ. Res. **209**, 112873 (2022). https://doi.org/10.1016/J.ENVRES.2022.112873
7. Bencardino, M.: Land take and urban sprawl: drivers e contrasting policies (2015). https://doi.org/10.13128/BSGI.V8I2.339

8. Anderegg, W.R.L., Goldsmith, G.R.: Public interest in climate change over the past decade and the effects of the 'climategate' media event. Environ. Res. Lett. **9**, 054005 (2014). https://doi.org/10.1088/1748-9326/9/5/054005
9. Brown, L.A.: The city in 2050: a kaleidoscopic perspective. Appl. Geogr. **49**, 4–11 (2014). https://doi.org/10.1016/j.apgeog.2013.09.003
10. Cobbinah, P.B., Aboagye, H.N.: A Ghanaian twist to urban sprawl. Land Use Policy **61**, 231–241 (2017). https://doi.org/10.1016/j.landusepol.2016.10.047
11. United Nations, Department of Economic and Social Affairs, Population Division: World Urbanization Prospects The 2018 Revision (2018)
12. European Union: FUTURE BRIEF: No net land take by 2050? (2016). https://doi.org/10.2779/537195
13. Piano Nazionale di ripresa e resilienza #NextGenerationITALIA (2021)
14. Munafò, M.: Consumo di suolo, dinamiche territoriali e servizi ecosistemici. Edizione 2020. Report SNPA, no. 15, 224 (2020). 978-88-448-0964-5
15. Munafò, M. (a cura di): Consumo di suolo, dinamiche territoriali e servizi ecosistemici. Edizione 2019. Report SNPA, 08/19 (2019). 978-88-448-0964-5
16. European Commission: Guidelines on best practice to limit, mitigate or compensate soil sealing (2012). https://doi.org/10.2779/75498
17. Brueckner, J.K.: Urban sprawl: diagnosis and remedies. Int. Reg. Sci. Rev. **23**, 160–171 (2000). https://doi.org/10.1177/016001700761012710
18. Nechyba, T.J., Walsh, R.P.: Urban sprawl. J. Econ. Perspect. **18**, 177–200 (2004). https://doi.org/10.1257/0895330042632681
19. Romano, B., Zullo, F., Fiorini, L., Ciabò, S., Marucci, A.: Sprinkling: an approach to describe urbanization dynamics in Italy. Sustainability **9**, 97 (2017). https://doi.org/10.3390/su9010097
20. Saganeiti, L., Favale, A., Pilogallo, A., Scorza, F., Murgante, B.: Assessing urban fragmentation at regional scale using sprinkling indexes. Sustainability **10**, 3274 (2018). https://doi.org/10.3390/su10093274
21. Saganeiti, L., Mustafa, A., Teller, J., Murgante, B.: Modeling urban sprinkling with cellular automata. Sustain. Cities Soc. **65**, 102586 (2020). https://doi.org/10.1016/j.scs.2020.102586
22. Romano, B., Fiorini, L., Zullo, F., Marucci, A.: Urban growth control DSS techniques for de-sprinkling process in Italy. Sustainability **9**, 1852 (2017). https://doi.org/10.3390/su9101852
23. Gonzalez, G.A.: Urban sprawl, global warming and the limits of ecological modernisation. Environ. Politics **14**, 344–362 (2007). https://doi.org/10.1080/0964410500087558
24. Johnson, M.P.: Environmental impacts of urban sprawl: a survey of the literature and proposed research agenda. Environ. Plan. A Econ. Sp. **33**, 717–735 (2001). https://doi.org/10.1068/a3327
25. 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. 34–55 (2020). https://doi.org/10.3280/ASUR2020-127-S1003
26. Romano, B., Zullo, F., Marucci, A., Fiorini, L.: Vintage urban planning in Italy: land management with the tools of the mid-twentieth century. Sustainability **10**, 4125 (2018). https://doi.org/10.3390/SU10114125
27. European Environment Agency: EEA Glossary—European Environment Agency. https://www.eea.europa.eu/help/glossary/eea-glossary. Accessed 23 Nov 2020
28. Munafò, M. (a cura di): Consumo di suolo, dinamiche territoriali e servizi ecosistemici. Edizione 2018. ISPRA (2018)
29. Feranec, J., Soukup, T., Hazeu, G., Jaffrain, G.: Detailed CLC data: member states with CLC level 4/level 5 and (semi-) automated solutions. In: European Landscape Dynamics. CORINE L. Cover Data, pp. 307–334 (2016). https://doi.org/10.1201/9781315372860-41
30. Kosztra, B., Büttner, G., Hazeu, G., Arnold, S.: Updated CLC illustrated nomenclature guidelines. Service Contract No 3436/R0-Copernicus/EEA.57441 (2019)