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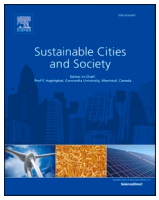

SDG monitoring framework for rural settlements mapping interactions with the Spanish Urban Agenda☆

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ABSTRACT

2023 is the midpoint between the adoption of the Sustainable Development Goals (SDGs) and the 2030 target date. Therefore, the scope must be effectively addressed because time is running out. Alignment with local agendas gives rise to the incorporation of measurable indicators since the relevant data are more closely linked to the territory itself. Currently, the Spanish Urban Agenda (AUE) is the only one that includes standards for municipalities with fewer than 5,000 inhabitants. Thus, its alignment is mainly focused on achieving SDG outcomes in rural settlements. Consequently, the aim of this paper was to understand the trade-offs, integrating the AUE into the "5Ps" of the SDGs and the "3 pillars" of sustainable development to have a decision-making tool. In this way, the descriptive local data of the AUE are used as indicators for the diagnosis of the SDGs. The methodology applied is the scientifically validated "RMap" methodology, consisting of knowing the context of the reference sources and locating the synergies of linkages. The main result is the SDG monitoring framework based on the AUE, with specific standard values for rural settlements, suitable to carry out voluntary local reviews (VLRs) for governments that until now, had no official reference data.

1. Introduction

Sustainable development (SD) as the standard-bearer of equity in the social, economic and environmental dimensions was defined in the Brundtland report, a document entitled "Our Common Future" (WCED, 1987). This interpretation of sustainability left its mark on all subsequent documents on SD until the last established: The 2030 Agenda for Sustainable Development (A2030), whose 17 Sustainable Development Goals (SDGs) are far-reaching global objectives adopted by all UN Member States in 2015 (United Nations, 2015). Due to the trade-offs involved, SDGs are framed in the five broad areas of the "5Ps" —People, Prosperity, Planet, Peace and Partnerships— as well as in the "3 pillars" of SD: economic viability, environmental protection and social equity (Sow, 2016) (Figure 1 and Table A.1). This structure is useful in providing a global vision of the current SD framework that helps to align the local agendas, since in 2023, only half the time remains to incorporate changes in our lifestyles and to promote the balanced development of our communities (Lak et al., 2021).

To implement the A2030, it is necessary to localise the set of indicators established by the UN. SDGs have a global dimension, although their ability to be implemented depends on the level of priority given by local systems and competition for resources within those settlements (Collste et al., 2017). The voluntary national, subnational and local reviews (VNRs, VSRs & VLRs) of the High-Level Political Forum (HLPF) quantify and measure the evolution and progress of SDGs and then allow us to identify which goals and targets are more advanced and which are limited in the established time frame and in different territories (UCLG, 2021; UCLG & UN-Habitat, 2020, 2021).

Despite the widespread acknowledgement to develop integrated approaches to SDGs implementation in towns, little progress has been

Abbreviations: A2030, The 2030 Agenda for Sustainable Development; AUE, The Spanish Urban Agenda (in its Spanish acronym); DLD, Descriptive Local Data of the AUE; FLG, First-Level Goals of the AUE; SD, Sustainable Development; SDGs, Sustainable Development Goals; SLG, Second-Level Goals of the AUE; VNRs, VSRs & VLRs, Voluntary National/Subnational/Local Reviews.

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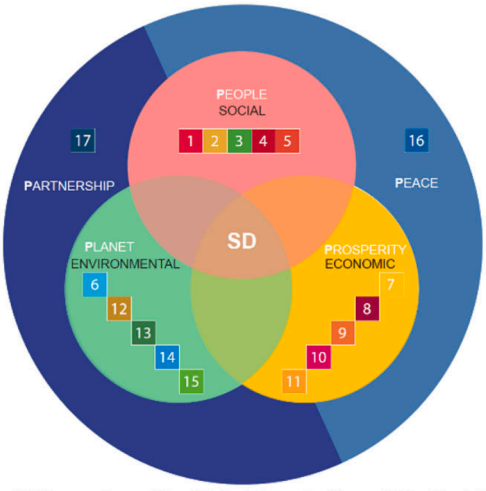

Fig. 1. SDGs in the 5Ps and in the 3 pillars of SD (created by the author based on United Nations, 2015).

Table 2
Visual synthesis of the cited papers from the relevant topics.

Scientific references	Relevant topics		
	Sust.	I. tools	Rural
(Costanza et al., 2016)	•	•	
(Folke et al., 2016)	•	•	
(Anderson et al., 2017)	•	•	
(Collste et al., 2017)	•	•	
(Diaz-Balteiro et al., 2017)		•	
(Gan et al., 2017)		•	
(Pradhan et al., 2017)	•		
(McCollum et al., 2018)	•		
(Nilsson et al., 2018)	•		
(Weitz et al., 2018)	•	•	
(Zinkernagel et al., 2018)	•	•	
(Allen et al., 2019)	•		
(Ameen & Mourshed, 2019)		•	
(Breuer et al., 2019)	•		
(Hély & Antoni, 2019)		•	•
(Huovila et al., 2019)		•	•
(Kompil et al., 2019)	•	•	•
(Pfeffer & Georgiadou, 2019)	•		•
(Salvia et al., 2019)	•		•
(Tan et al., 2019)	•		•
(Ulbrich et al., 2019)	•	•	•
(Valencia et al., 2019)	•		•
(Ajates et al., 2020)	•	•	
(Aquilino et al., 2020)	•	•	•
(Cai et al., 2020)	•		•
(Dalampira & Nastis, 2020)	•	•	
(Oliveira et al., 2020)	•	•	•
(Chalkidou et al., 2021)	•	•	•
(López et al., 2021)	•	•	•
(Tuholske et al., 2021)	•	•	•
(Wernecke et al., 2021)	•	•	•
(Workman & McPherson, 2021)	•	•	•
(Andries et al., 2022)	•	•	
(Blasi et al., 2022)	•	•	
(Mbah & East, 2022)	•	•	•
(Richiedei & Pezzagno, 2022)	•	•	•
(Toopshekan et al., 2022)	•	•	•
(Yamasaki & Yamada, 2022)	•	•	•
(Wątróbski et al., 2022)	•	•	
(Wei et al., 2023)	•	•	•

1 topics 2 topics 3 topics

achieved so far (Nilsson et al., 2018). Thus, there are still some difficulties in developing these reports (REDS, 2020). On the one hand, the latest global independent reports (Sachs et al., 2019, 2020, 2021, 2022) warn that countries are not successfully achieving all the SDGs. This fact has especially been highlighted in recent years, owing to the COVID-19 pandemic (Bock & Krzysztofowicz, 2021). Therefore, we will need to develop viable strategies, taking advantage of all available local tools in relation to other similar municipalities, both in the same country and internationally (UCLG, 2022).

On the other hand, Points 24 and 34 and Target 2.A and 11.A of the A2030 resolution (United Nations, 2015) emphasize that we cannot achieve the proposed goals without taking into account rural areas[1]. Even though the process of migration to cities, rural areas of the world comprise vast geographic regions where a significant population still lives. These inhabitants face emerging threats associated with climate change, poverty and widespread low quality infrastructure, such as, lack of transport, poor internet connection, unstable electricity, insufficient and second-class public services (Mihai & Iatu, 2020; Mundalo Allieu, 2019). The different settlements, due to other geographical and cultural origins, are mainly dedicated to economic activities typical of rural areas (the primary sector), linked to the physical characteristics and natural resources of their immediate environment (agricultural, livestock, forestry, fishing or sometimes mining). These distinctive features of rural areas make them more vulnerable to social, economic and environmental risks (Mallick et al., 2021; Rahmani et al., 2022; Wei et al., 2023).

SDGs involve a holistic approach where the basic daily needs of rural populations must be covered by reliable public services combined with sustainable development conditions to support regional economies and urban-rural linkages (Omer et al., 2022). Nevertheless, the high number of rural municipalities, in addition to their differential characteristics in terms of size and population, make it difficult to devise a monitoring framework (López-Goyburu & García-Montero, 2018). In order to facilitate international comparison, a coalition of six international organisations, including UN-Habitat, developed a method called "The Degree of Urbanisation" (Statistical Commission, 2020) that makes a new global definition of cities, towns and rural areas. Applying this method, the research focuses on the study of its “Rural cluster” category formed by “all contiguous cells with a density of at least 300 inhabitants per km^2 and a population between 500 and 5,000 in the cluster”. According to this, the UN considers that populations of less than 5,000 inhabitants are homogeneous and have similar characteristics worldwide.

In this sense, the Spanish Urban Agenda (AUE, using the Spanish acronym) constitutes **a working method and a process** for all stakeholders that intervene in the settlements who seek their equitable, fair and sustainable development. In addition, it not only contributes to the achievement of SDG 11, but also to the set of 17 SDGs with which it is transversely related. Consequently, the AUE plays a key role in the promotion and localisation of the SDGs thanks to the use of a standards system that eases the evaluation and follow-up of progress to prepare Local Action Plans (PALs, using the Spanish acronym) in any settlement, expanding it to a wider audience (MITMA, 2019a).

The AUE was adopted by the Spanish Council of Ministers on 22 February 2019 as a benchmarking tool with the aim that rural and urban areas of the national territory would move towards SD according to the

[1] “24. […] We will devote resources to developing rural areas …” (United Nations, 2015, p.7). “34. […] We will also take account of population trends and projections in our national rural and urban development strategies and policies” (United Nations, 2015, p.9). “2.a Increase investment, including through enhanced international cooperation, in rural infrastructure, …” (United Nations, 2015, p.16). “11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning” (United Nations, 2015, p.22).

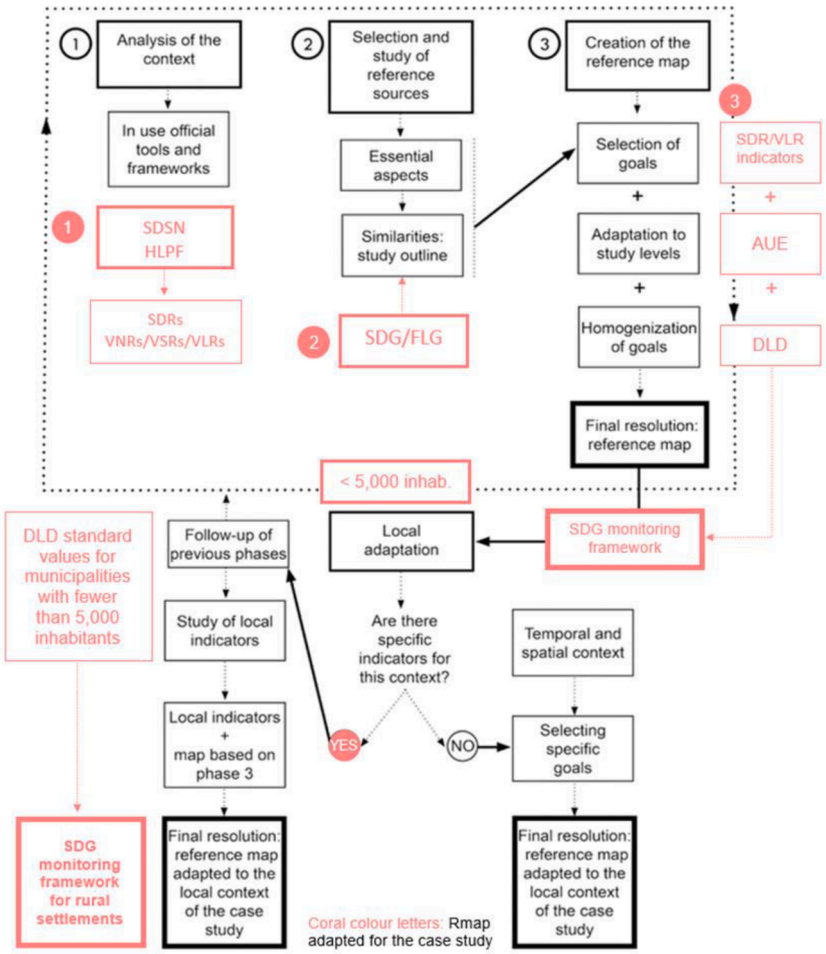

Fig. 2. Extrapolation of the RMap for its specific application to map interactions between the A2030 and the AUE (created by the author based on (Bote Alonso et al., 2022)).

A2030, the New Urban Agenda and the European Urban Agenda (MITMA, 2019b). To define the strategy to be followed by the Spanish municipalities, the AUE is organized around the Decalogue of the First-Level Goals (FLG)(Diaz-sarachaga, 2020) as shown in Table 1, which includes 30 Second-Level Goals (SLG) that support several lines of action undertaken by local and regional governments (LRGs). The linkage between the proposed aims and the current situation of Spanish cities and rural settlements is reflected in a set of descriptive local data (DLD) with the particularity of including standards for municipalities with fewer than 5,000 inhabitants (MITMA, 2021), among others (>100,000 inhabitants, 50,000 to 100,000 inhabitants, 20,000 to 50, 000 inhabitants, 5,000 to 20,000 inhabitants, and all municipalities with more than 5,000 inhabitants).

Given these circumstances, the objective of the present paper is to understand the trade-offs, integrating the AUE into the "5Ps" of the SDGs and the "3 pillars" of SD in order to have **a decision-making tool** for its global deployment which, in turn, is **an example of facilitating diagnostics**. To that end, the DLD are used as indicators for the diagnosis of the SDGs in a monitoring framework (Table B.1), developing the specific monitoring framework with standards values for rural settlements (Table 9) suitable for the preparation of VNRs, VSRs and VLRs for governments that until now, had no official reference data.

In the relatively short period since 2015, a lively discussion has emerged among researchers from various academic disciplines about the potential of the SDGs (topic 1) as a monitoring framework (topic 2) for rural areas (topic 3). Table 2 provides an overview of these issues and invites the reader to look at this tension over the years through a colour gradient based on whether there is 1 topic (red), 2 topics (yellow) or 3 topics (green). Therefore, specific consultations were sought (ScienceDirect, Web of Science and Sustainable Cities and Society journal) on the relevant topics identified during the research: sustainability or SDGs (Sust.), indicators or tools (I. tools) and studies of rural areas (Rural), which are not mutually exclusive (with different syntaxes within the keywords of the authors)[2], and were mapped following the snowball procedure (Wohlin, 2014).

On a sample of 2,808 articles published between 2015 and 2023 in Scopus (because it is suitable for mapping emerging phenomena), 40 references are selected (Table 2). This number of cited references corresponds to articles indexed in WOS (since it lists only articles published in top-ranked journals) mentioned in this research for various reasons, whether because they talk about the implementation of the SDGs, sustainability indicators, problems of rural environments, etc. Of these, 8 reference papers are from the SCS journal (with a total of 75 papers on some of the topics and 16 on all 3 topics). This does not represent an exhaustive context because it seeks to obtain an overview of the existing approaches through a visual synthesis of the cited papers. Documents used from official sources are discussed in section 2.

As a result, a revealing table appears with references grouped chronologically from 2016 (SDGs cover the period 2016–2030) where it can be seen that the combination of the three is something new which has begun to be considered for a few years, highlighting that the concept of

[2] (KEY (("sdg*") OR ("sustainability"))) *AND* (KEY (("indicator*") OR ("indicator tool*"))) *AND* (KEY (("rural area*") OR ("rural settlement*"))). Data were collected on January 11st, 2023.

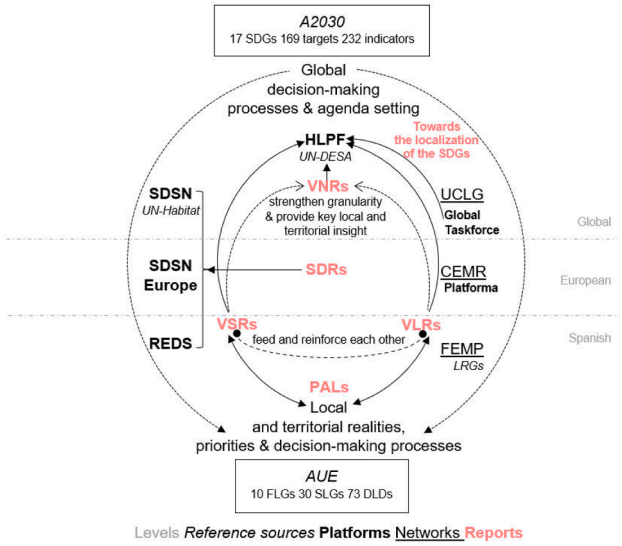

Fig. 3. Relationship between SDG progress reports and processes at distinct levels (created by author).

sustainable rural development is still in its infancy (Kompil et al., 2019; Toopshekan et al., 2022; Wei et al., 2023; Yamasaki & Yamada, 2022).

The first publications on SDGs assess the synergies and trade-offs of the goals only for an urban dimension. These relationships are developed with specific indicators, such as the index of sustainable well-being (Costanza et al., 2016), the spheres of sustainability (Folke et al., 2016), or the Venn diagram (Dalampira & Nastis, 2020). The most repeated approach is the analytical hierarchy process, a technique of aggregation methods based on the areas to be analysed (Ameen & Mourshed, 2019; Blasi et al., 2022; Diaz-Balteiro et al., 2017; Gan et al., 2017; Wątróbski et al., 2022).

Several studies discuss the potential of citizen observatories to contribute to the SDGs (Ajates et al., 2020; Anderson et al., 2017; Andries et al., 2022). In addition, the "iSDG" model is presented to analyse impacts (Collste et al., 2017; Weitz et al., 2018; Zinkernagel et al., 2018), although it does not address the scale and location of the interactions. Others (Allen et al., 2019; Breuer et al., 2019; Nilsson et al., 2018; Pradhan et al., 2017) also discuss SDG interactions without the lens of rural settlements. This fact confirms the urgent to develop new data in this field (Huovila et al., 2019; McCollum et al., 2018; Hély and Antoni, 2019).

To conclude, there are few studies about the SDGs as they pertain to our specific issue, but there are studies on similar topics: a special issue about the development of SDG indicators (Pfeffer & Georgiadou, 2019), on local problems faced by the SDGs (Salvia et al., 2019), on localisation processes (Tan et al., 2019; Valencia et al., 2019) or about the inefficiency of studies in rural regions (Cai et al., 2020). However, it can be seen how the most recent research considers the three relevant topics as a specific line of research of current and long-term interest (Aquilino et al., 2020; Chalkidou et al., 2021; López et al., 2021; Oliveira et al., 2020; Richiedei & Pezzagno, 2022; Tuholske et al., 2021; Ulbrich et al., 2019; Wernecke et al., 2021; Workman & McPherson, 2021).

Considering the observations mentioned above, these aforementioned studies in meaningful ways fill a notable gap in the sustainability literature in rural settlements. This research not only supplies substantial assistance for local governments and related administrations involved in the AUE, but also enriches the decision-making expertise that could be applied to other issues at the European and global levels.

The remainder of the paper is organized as follows: Section 2 presents the methodology, in which previous knowledge of the official frameworks and tools at the global, European, and Spanish levels is collected; the interlinkages between A2030 and AUE are assessed; and the criteria for synergies between DLD and SDGs are established. In Section 3, the FLG global deployment and SDG monitoring framework based on the AUE, with the standard values for rural settlements, are created and discussed. Section 4 concludes with an exposition of the strengths and weaknesses of the SDG framework developed, the limitations of this research and the lines of work for future investigation.

2. Materials and methods

This paper follows the specific methodology applied worldwide by the Sustainable Development Solutions Network (SDSN) and used by the AUE for the calculation of standard values (MITMA, 2021). Furthermore, to transform these technical indicators into SDG indicators, the RMap methodology[3] (acronym of "reference sources" and "map") is used to perform the adaptation for the case study (Bote Alonso et al., 2022). Official sources have been used to calculate the database, with advantages including open access, the provision of disaggregated information at the municipal level and periodic updates.

The extrapolation of the RMap for its specific application to map interactions between the A2030 and the AUE develops a three-phase process like the original RMap. The differences lie in the selection of sources based on SDGs and keywords related to the aspects to be studied, as briefed in Figure 2:

[3] RMap methodological framework is intended to homogenize and simplify the existing world of sustainability indicators, combining and integrating different frameworks and catalogues. This section is configured as an adapted scheme of the proposed original methodological framework, which is developed in depth through its implementation and discussion in: (Bote Alonso et al., 2022).

Table 3
Official tools and frameworks background.

Nº	SDRs and voluntary country-led reviews	● GL ■VNR	EU VSR	ES VLR	Reports
1	Shimokawa Town the SDGs Report (IGES, 2018)			■	1
2	The Sustainable Development Goals in 100 Spanish cities (Sánchez de Madariaga et al., 2018)			●	2
3	Gothenburg final city report (Valencia, 2019)		■		3
4	Sustainable Development Report 2019 (Sachs et al., 2019)	●			4
5	The 2019 Europe Sustainable Development Report (SDSN & IEEP, 2019)		●		5
6	Sustainable Development Report 2020 (Sachs et al., 2020)	●			6
7	The 2020 Europe Sustainable Development Report (SDSN & IEEP, 2020)		●		7
8	The SDGs in 100 Spanish cities (2nd edition) (REDS, 2020)			●	8
9	Europe Sustainable Development Report 2021 (Lafortune et al., 2021)		●		9
10	Sustainable Development Report 2021 (Sachs et al., 2021)	●			10
11	Handbook for the preparation of Voluntary National Reviews. The 2022 Edition (HLPF, 2022)	■			11
12	Sustainable Development Report 2022 (Sachs et al., 2022)	●			12

- Phase 1. A preliminary analysis of the A2030 and the AUE context is carried out to learn about the existing official frameworks and tools (Section 2.1).
- Phase 2. Reference sources are selected, and their interlinkages are examined to establish the study scheme between SDGs and FLG (Section 2.2).
- Phase 3. A global monitoring framework is generated through a selection of the SDR and VLR indicators from the reference sources, followed by an adaptation process of the AUE and a subsequent homogenization of the DLD (Section 2.3).

Finally, the SDG monitoring framework is located for municipalities with fewer than 5,000 inhabitants, indicating the standard DLD values for rural settlements (Section 3).

2.1. Phase 1: analysis of the context

This phase serves the research to align with its method and with its formulation of evidence-based indicators. To this end, official platforms and networks are identified (Figure 3). The aim is to obtain an overview of the existing approaches on the topic with information links to be updated annually, since the reports, which are generated each year, change the theme and scale of implementation. As a result, a compendium of the latest reports is analysed.

SDSN has developed a series of independent reports, the Sustainable Development Reports[4] (SDRs): 8 global editions, 10 regional editions and 12 subnational editions from 2015 to the present. These SDRs, including the SDG Index & Dashboards of SDSN Europe and SDSN Spain (REDS) complement the official SDG indicators and voluntary country-led review. Although articulated by UN-Habitat (United Nations Human Settlements Programme), the views expressed in these reports do not reflect the ideas of any UN organization, agency, or programme.

HLPF is the central UN platform for the follow-up and review of the A2030 and SDGs that takes place yearly in New York by UN-DESA (Department of Economic and Social Affairs of the United Nations). At the voluntary country-led review 2022 (VNRs, VSRs & VLRs), 11 countries presented results for the 1st time, 28 for the 2nd time, 3 for the 3rd time and 2 countries for the 4th time. This document (HLPF, 2022), together with the list of the 176 countries that have already submitted their reports, is available on the HLPF website[5].

In addition, United Cities and Local Governments (UCLG), on behalf of the global taskforce, has already facilitated and presented six reports[6] called "Towards the localization of the SDGs", at the HLPF. To date, there has always been a European report (VSRs and VLRs) that supplements the global taskforce report presented annually by the Council of European Municipalities and Regions (CEMR). Finally, although there exists no fixed working definition for VLRs, all documents produced by the Spanish Federation of Municipalities and Provinces (FEMP in its Spanish acronym) and the Local AUE Action Plans (PALs in its Spanish acronym) of the AUE thus far share a primary purpose: assessing and presenting advances on the fulfilment of the A2030 from a local standpoint and through a locally developed narrative (MITMA, 2019b).

Once the relationships have been established, their reports are studied, as shown in Table 3. On the one hand, with the SDRs, numbering a total of 30 to date, we can select all the subnational reports carried out in Spain (ES) (REDS, 2020; Sánchez de Madariaga, García López, & Sisto, 2018). Next, within the study period marked by the Spanish reports, from 2018 to 2022, the European (EU) (Lafortune et al., 2021; SDSN, 2019; SDSN, 2020) and Global (GL) (Sachs et al., 2019, 2020, 2021, 2022) levels were used to compare the three scales, obtaining a total of 9 study reports. On the other hand, due to the length of voluntary country-led reviews for the HLPF (more than 200), only one example of VLR that evaluates towns with fewer than 5,000 inhabitants (IGES, 2018), one VSR in Europe (Valencia, 2019) and the most recent VNR (HLPF, 2022) have been taken into account as types.

At the global level, the SDRs evaluate countries, and at the rest of the levels, only the specific role of cities is analysed for both metropolitan areas and major cities. Not even a review of the rest of the SDRs reveals studies of rural areas. However, for rural settlements, we have obtained the HLPF reports of VLRs from towns with less than 5,000 inhabitants.

[4] Accessible at www.sdgindex.org.

[5] Accessible at https://hlpf.un.org/vnrs.

[6] Accessible at www.gold.uclg.org/report/localizing-sdgs-boost-monitoring-reporting.

Table 4
Hierarchical structure of reference sources.

Reference sources	1st scale	2nd scale	3rd scale
A2030	17 SDG	169 targets	SDR/VLR indicators
AUE	10 FLG	30 SLG	73 DLD

Subsequently, the official document is analysed, where the two sources are related (MITMA, 2019a). Careful scrutiny of the targets set by the A2030 and the SLG of the AUE (2nd scale) served to determine the degree of consideration of the SDG with respect to the FLG provided by the AUE (1st scale) (Table 5). Ninety-one out of the 169 targets given by the A2030 are associated with the FLG of the AUE, that is, a 54% synergy

Table 5
Numbers of related SDG targets associated with FLG (MITMA, 2019a).[9]

SDG	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
FLG																		
1		•				•					••			•••	•••••••			15
2	•			••							•		•••					4
3	•		•								•••							8
4						••••••	•••••				•	••••						16
5			•						•		•							3
6	•••			•••	•••••					••••••	•							**18**
7	•	•			•			••••••	••			••						13
8											•							**1**
9					•				•									**2**
10				•							•	••				••••••••••	••••••	**21**
Total	6	**2**	**2**	6	7	7	5	6	4	6	**11**	8	3	3	8	**11**	6	

Scarce reciprocity | Strong connection | ●●● Numbers of targets associated

Table 6
Selection, adaptation, and homogenization of DLD from reference sources.

Reference sources	DLD
SDR (REDS, 2020)	**Selection** SDG2= 08,09,10; SDG3= 22; SDG8= 46,48; SDG9= 55,58; SDG10= 61, 63; SDG11= 70,73,74; SDG12= 79; SDG13= 83; SDG15= 90,92,93
VLR (IGES, 2018)	SDG1= Population, Homely; SDG2= Hunger, Agricultural; SDG3=Quality, Welfare; SDG4= Education, Activities; SDG5= Gender, Female; SDG6= Water consumption; SDG7= Energy; SDG8= Jobs; SDG9= Infrastructure; SDG10= Accessibility, Inequality; SDG11= Dwelling; SDG12= Efficiency, Sectors; SDG13= Change, Pollution; SDG14= Water areas; SDG15= Planned; SDG16= Undeveloped; SDG17= Urban planning
AUE (MITMA, 2019a; 2019b)	**Adaptation** FLG1= $SDG15^{SDG14}$, FLG2= $SDG1^{SDG4}$, FLG3= SDG13, FLG4= $SDG12^{SDG6\ SDG7}$, FLG5= SDG 3, FLG6= $SDG10^{SDG5}$, FLG7= $SDG8^{SDG2}$, FLG8= SDG11, FLG9= SDG9, FLG10= $SDG16^{SDG17}$
DLD (MITMA, 2021)	**Homogenization** 3.b, 10.b, 13.b, 17.b, 18.b, 18.c, 27.a, 27.b, 27.c, 27.d, 35, ST.01

Therefore, we will use SDRs to compare indicators from the Spanish context and VLRs to do so from rural settlements.

2.2. Phase 2: selection and study of reference sources

The second phase, according to the RMap methodology, consists of assessing the interlinkages between the selected reference sources, which in this study are the A2030 and the AUE. During the research, it was seen that the content and the application procedure in the different sources were similar, with a hierarchical structure organized into three scales (Table 4). The first scale includes the general lines of action of each source, understood as SDGs in the case of A2030 and FLG in the case of AUE. In the second scale, the general lines of action are specified and defined as "Targets" in the A2030 and SLG in the AUE. The third and last scale corresponds to monitoring the lines of action of each reference source through their corresponding indicators, which are simply identified as "indicators'' (applied in SDR/VLR) in the A2030 and DLD in the AUE.

(See Appendix A for extended information). SDG 11 and SDG 16 exhibited the highest number of related targets. In contrast, SDG 2 and SDG 3 showed only 2 targets. In terms of the FLG, FLG 6 and FLG 10 revealed the strongest connection with the A2030, with 18 and 21 associated targets, respectively. Instead, FLG 8 and FLG 9, with only 1 and 2 targets respectively, revealed scarce reciprocity with the A2030. Also, as indicated by the AUE, the 10 targets of SDG 11 are considered in the FLG.

2.3. Phase 3: creation of the SDG monitoring framework

The AUE offers 46 DLD[7] (39 + 7 ST[8]), which in turn are subdivided (32 simple and 14 composite indicators), making a total of 73 DLD. The DLD are a tool for decision-making and facilitate the establishment of territorial and urban objectives adapted to the reality of each territory, area or municipality. The data and indicators of the AUE are based on the DPSIR model (Driver-Pressure-State-Impact-Response) approved by the Organization for Economic Cooperation and Development (OECD) as a reference framework for the search of environmental indicators to facilitate evaluations and comparisons.

Each of the DLD is presented with a methodology that is based on international data, such as the Global SDG Indicators Data Platform, the Global Partnership for Sustainable Development Data, SDSN or Eurostat. Although, there is no doubt that the data available from local entities will be, fundamentally, the true drivers of the entire process (Appendix B). For this purpose, it will be necessary to advance in the creation of new standards which facilitates homogeneous reading and comparison. This common methodology consists of making means by selecting the value of the first quartile, the mean value, which is calculated with the median, and the value of the third quartile, since the maximum and minimum values can distort the range (MITMA, 2021).

Therefore, a monitoring framework is created by a selection of indicators of the reports according to their relationship, followed by a process of adaptation (applicable to ensure compatibility) and a subsequent homogenization (Table 6).

The selection process of the indicators used in the analysis has as a starting point the official reports taken as references (IGES, 2018; REDS, 2020) that have a direct relationship with the SDGs. To this end, the

[7] Accessible at www.aue.gob.es/recursos_aue/2021-09-01_anexo_datos_descriptivos.pdf.

[8] DLD that refer to territory **S**ubject to urban **T**ransformation have been distinguished as DLD.ST.

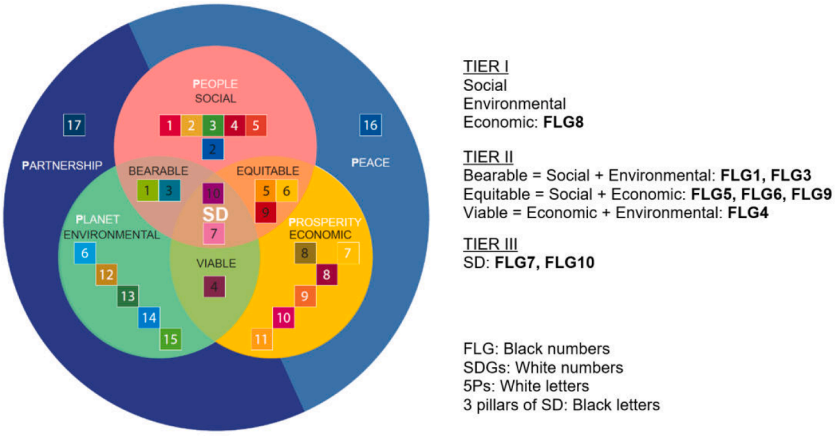

Fig. 4. FLG classified in the 5Ps and in the three pillars of SD (created by the author).

indicators that are the same as the DLD are selected, either by using the descriptive data themselves (18 of the 106 REDS) or because they are similar due to keywords and the description of the indicators for urban settlements. During the process of applying keywords, correspondences or relationships were established based on the authors' own knowledge (Avdiushchenko & Zajaç, 2019). Aware of this subjectivity in the assignment of 35 of the 73 indicators, the selection is validated through the adaptation stage.

For adaptation, the synergies between the SDGs and the FLG, shown in Table 5 from the official reference document (MITMA, 2019a) and expanded in Table A.2, have been studied. The criteria for granting an SDG per FLG are that it be repeated in more than one SLG, that the SDG has the highest number of related targets and that it is not SDG 11 (since the AUE is mainly based on SDG 11, this goal has a presence in all FLG). Therefore, we obtain a synthesis of the most repeated SDGs in each FLG. To conclude, as there are 17 SDGs and 10 FLG, the weakly connected SDGs (2, 4, 5, 6, 7, 14 and 17) have been distributed as complementary to other SDGs where they are the second most repeated. This adaptation serves to control whether the selection is correct and corresponds to any of the SDGs with synergies with the FLG established for each DLD. Finally, 12 DLD are homogenized, identifying common meanings, since they are complementary or similar to other DLD.

3. Results and discussion

The adaptation step of phase 3 above revealed that SDGs belong to different FLG. In other words, FLG are the sum of several SDGs. Therefore, as an assumption, FLG will be framed at a higher level of SD if the SDGs that compose them are in different spheres. Thus, as a first result, the classification of the FLG in the "5Ps" and the "3 pillars" of SD is proposed for its global deployment with the purpose of serving as a decision-making tool and an example of facilitating Diagnostics.

First, FLG are positioned depending on synergies with the SDGs. Intersections between the three pillars of SD determine a higher level of involvement that can be defined as viable (environmental and economic), equitable (social and economic) and bearable (environmental and social). Sequentially, the intersection of these dimensions is necessary to complete Tier III, known as SD (Dalampira & Nastis, 2020).

Based on Figure 1, Table 5 and Appendix A, the position of the FLG in the spheres can be obtained in Figure 4. If the sum of SDGs corresponds to one sphere, this FLG will be found at Tier I. Subsequently, if the related SDGs belong to two different spheres, FLG will be placed at Tier II, at the intersection of both. Moreover, if the FLG covers SDGs in the three SD pillars, it will be at the highest level and, consequently, it will be represented in the middle of the figure. SDG 11 is not considered in this result if there were more SDGs because, as it applies to all FLG, all of them would be located at Tier III.

The results show that the AUE and its FLG are at a higher level of implementation of SD than are the SDGs. Additionally, FLG cover all levels in a coherent and orderly approach, which suggests synergies and relationships among FLG themselves as well as with SDGs, both horizontally (between levels themselves), vertically (between various levels of involvement) and transversally (between different spheres at distinct levels).

In Table 7, DLD appear ordered by less to more closely related targets associated between FLG and SDGs according to the adaptation process conducted. Therefore, DLD with more synergies (those located at the end of the table) could be linked to other SDGs and leave room for possible adjustments to the framework. As a result, the disaggregated DLD are located, together with their respective normative directions. The following columns correspond to the framework creation process followed by the main column with the SDGs linked to each DLD. Finally, whether DLD have standard values is indicated.

In the control between selection and adaptation processes, DLD 16 is the only one that does not meet the requirement since SDG 3 is not within FLG 2 although "Quality of silence" is a health indicator according to a reference source (IGES, 2018). This differentiation can be explained by several factors that can be discussed for the rest of the DLD or for comparable indicators:

- It is an indicator without values, so the FLG may not be correctly assigned.
- The FLG (FLG2) has a weak connection with the SDGs and may not have taken possible interconnections into account.
- A single FLG for a DLD can be very restrictive for the range of comparable indicators that exist.
- As the AUE is based on SDG11, DLD that do not have standard values may be attributed to SDG11 (which belongs to FLG2).

However, the results of Table 7 are quite interesting for other studies, as they frame all DLD in the SDGs even though 23 of them do not yet have standard values for their analysis (see Appendix B). The creation of that table, therefore, goes beyond temporary impediments, since we can use it to locate the SDGs applying the DLD themselves or by adapting them to similar indicators to create other monitoring frameworks following the methodology developed.

Another interesting fact is the reflection of linkage to most relevant SDGs based on DLD synergies (Table 8). In general, the number of DLD for each SDG is stable between 9 and 5 indicators per SDG. However, if only those with values are selected, the number of indicators is unbalanced, varying between 8 and 2. For example, SDG 1^{SDG4} goes from 9

[9] Extended version in Table A.2 (Appendix A).

Table 7
SDGs linkages based on DLD synergies.

DLD	Normative direction	Reference sources Selection	Adaptation	Homoge.			SDGs linked	Standard values
		SDR	VLR	FLG	DLD			
16	16.a	descending		Quality	2		**SDG 3**	NO
	16.b	descending					**SDG 3**	NO
25		ascending		Accessibility	6		**SDG10**^{SDG5}	NO
36		descending	70		8		**SDG11**	NO
ST04		descending		Planned	1,2		**SDG15**^{SDG14}	YES
2	2.a	descending	90		1,3		**SDG15**^{SDG14}	YES
	2.b	ascending	10				**SDG8**^{SDG2}	YES
	2.c	ascending		Water areas			**SDG15**^{SDG14}	NO
	2.d	ascending	92				**SDG15**^{SDG14}	YES
3	3.a	ascending	09				**SDG8**^{SDG2}	YES
	3.b	ascending				3.a	**SDG8**^{SDG2}	YES
5		ascending	93				**SDG15**^{SDG14}	YES
17	17.a	ascending to limit	73		1,5		**SDG11**	YES
	17.b	ascending to limit				17.a	**SDG11**	YES
4		ascending		Undeveloped	1,10		**SDG16**^{SDG17}	YES
15		descending		Water consumption	2,4		**SDG12**$^{SDG6\ SDG7}$	NO
13	13.a	ascending		Population	2,6		**SDG1**^{SDG4}	NO
	13.b	ascending				13.a	**SDG1**^{SDG4}	NO
29		descending		Homely	2,8		**SDG1**^{SDG4}	YES
30		descending		Homely			**SDG1**^{SDG4}	NO
31		ascending	74				**SDG11**	NO
34		ascending to limit	79				**SDG12**$^{SDG6\ SDG7}$	YES
35		descending				36	**SDG11**	YES
18	18.a	descending	83		3,5		**SDG13**	YES
	18.b	descending				18.a	**SDG13**	YES
	18.c	descending				18.a	**SDG13**	YES
	18.d	descending to limit		Quality			**SDG 3**	NO
21		ascending		Welfare			**SDG 3**	NO
20		ascending		Accessibility	5,6		**SDG10**^{SDG5}	NO
19	19.a	ascending to limit		Infrastructure	5,7		**SDG9**	NO
	19.b	ascending		Population			**SDG1**^{SDG4}	NO
	19.c	ascending		Population			**SDG1**^{SDG4}	NO
	19.d	ascending to limit		Infrastructure			**SDG9**	NO
	19.e	ascending		Population			**SDG1**^{SDG4}	NO
28	28.a	descending	46		6,7		**SDG8**^{SDG2}	YES
	28.b	descending	48				**SDG8**^{SDG2}	YES
	28.c	descending		Female			**SDG10**^{SDG5}	YES
27	27.a	ascending			7,9	26.a	**SDG8**^{SDG2}	YES
	27.b	ascending				26.b	**SDG9**	YES
	27.c	ascending				26.c	**SDG12**$^{SDG6\ SDG7}$	YES
	27.d	ascending				26.d	**SDG12**$^{SDG6\ SDG7}$	YES
7		ascending		Planned	1,2,5		**SDG15**^{SDG14}	YES
32		descending		Homely	1,2,8		**SDG1**^{SDG4}	YES
ST02		descending		Undeveloped	1,2,10		**SDG16**^{SDG17}	YES
ST03		descending					**SDG16**^{SDG17}	YES
14		descending		Efficiency	2,3,4		**SDG12**$^{SDG6\ SDG7}$	YES
12	12.a	ascending		Welfare	2,3,6		**SDG 3**	NO
	12.b	ascending		Pollution			**SDG13**	NO
9		ascending to limit		Infrastructure	2,5,6		**SDG9**	YES
10	10.a	ascending to limit		Dwelling			**SDG11**	YES
	10.b	ascending to limit				10.a	**SDG11**	YES
11		ascending		Infrastructure			**SDG9**	NO
23		ascending	61		2,6,7		**SDG10**^{SDG5}	YES
24	24.a	descending	63				**SDG10**^{SDG5}	YES
	24.b	ascending					**SDG10**^{SDG5}	YES
	24.c	descending					**SDG10**^{SDG5}	YES
26	26.a	ascending	08		6,7,9		**SDG8**^{SDG2}	YES
	26.b	ascending	55				**SDG9**	YES
	26.c	ascending		Sectors			**SDG12**$^{SDG6\ SDG7}$	YES
	26.d	ascending		Sectors			**SDG12**$^{SDG6\ SDG7}$	YES
33		ascending to limit		Planned	1,2,4,8		**SDG15**^{SDG14}	YES
ST06		descending					**SDG15**^{SDG14}	YES
ST07		descending					**SDG15**^{SDG14}	YES
ST05		descending	58		1,2,6,7		**SDG9**	YES
37		figure		Urban planning	1,2,8,10		**SDG16**^{SDG17}	NO
38		<2008<					**SDG16**^{SDG17}	YES
ST01		ascending			2,5,6,8	8	**SDG11**	YES
22	22.a	descending	22		2,5,6,7,8,9,10		**SDG 3**	YES
	22.b	descending					**SDG 3**	YES
6		ascending to limit		Population	1,2,4,5,6,7,8,9		**SDG1**^{SDG4}	YES
8		ascending		Dwelling			**SDG11**	YES
1		ascending		Change	ALL		**SDG13**	YES
39		figure		Urban planning			**SDG16**^{SDG17}	NO
46							**73**	**50**

Table 8
Reflection of linkage to most relevant SDGs based on DLD synergies.

SDGs linked	DLD in total	Total	DLD with standard values	Total
SDG1^{SDG4}	6,13.a, 13.b, 19.b, 19.c, 19.e, 29,30, 32	9	6,29,32	3
SDG 3	12.a, 16.a, 16.b, 18.d, 21, 22.a 22.b	7	22.a, 22.b	2
SDG8^{SDG2}	2.b, 3.a, 3.b, 26.a, 27.a, 28.a, 28.b	7	2.b, 3.a, 3.b, 26.a, 27.a, 28.a, 28.b	7
SDG9	9, 11, ST05, 19.a, 19.d, 26.b, 27.b	7	9, ST05, 26.b, 27.b	4
SDG10^{SDG5}	20, 23, 24.a, 24.b, 24.c, 25, 28.c	7	23, 24.a, 24.b, 24.c, 28.c	5
SDG11	8, 10.a, 10.b, ST01, 17.a, 17.b, 31, 35, 36	9	8, 10.a, 10.b, ST01, 17.a, 17.b, 35	7
SDG12$^{SDG6\ SDG7}$	14, 15, 26.c, 26.d, 27.c, 27.d, 34	7	14, 26.c, 26.d, 27.c, 27.d, 34	6
SDG13	1, 12.b, 18.a, 18.b, 18.c	5	1, 18.a, 18.b, 18.c	4
SDG15^{SDG14}	2.a, 2.c, 2.d, 5, 7, ST04, 33, ST06, ST07	9	2.a, 2.d, 5, 7, ST04, 33, ST06, ST07	8
SDG16^{SDG17}	4, ST02, ST03, 37, 38, 39	6	4, ST02, ST03, 38	4
Less DLD	Same DLD	More DLD	73	50

DLD to 3 or SDG 3 from 7 to 2. Only SDG 8^{SDG2} maintains the same number of DLD and is able to analyse all of them. In addition, the low level of measurement of SDG 13, SDG 16 and SDG 17 is a trend that has been reflected in the reference documents and that is corroborated in this study. Finally, it is also verified that SDG 11 and SDG 15^{SDG14} remain at any scale of implementation so can help LRGs locate the SDGs.

The A2030 reveals a path that can lead to good practices and reliable results even if it does not offer universal or global certainties. Thus, there are many situations where the application of frameworks is not necessarily a solution due to a wide range of particular conditions at the regional and local level that must be taken into account (Mihai & Iatu, 2020). For that purpose, the DLD "*should be reviewed by the group that intends to use the indicators*" (Mitchell et al., 1995). The review and critical analysis in work groups with the stakeholders indicate the keys to identify the relevant challenges in the case study. Policies at various levels play a decisive role even if they are not always taking the best decisions in rural areas, so it is important that mechanisms, such as the SDG monitoring framework, should be generally available to have tools that, from a start, serve to study rural settlements.

In Table 9, local adaptation is shown with the concrete example of municipalities with fewer than 5,000 inhabitants. Pre-processing and selection of DLD widely applied by the AUE are introduced to exclude indicators without standard values and relate the DLD to the SDGs through the established synergies. Of the total, only 50 DLD have standards to compare with the values of the first quartile, middle and third quartile distinguished according to the range of inhabitants. The framework contains indicators from official sources, in use and contrasted, and therefore applicable, using the formulas, methodologies and sources provided by the AUE (see Table B1 in Appendix B).

As a result, the SDGs are in the first column, accompanied by their respective DLD with the new enumeration for the monitoring framework, the previous numbering given by the AUE and their descriptions. The next column corresponds to the measurement units. Finally, the standard values for rural settlements are indicated for each DLD. These columns are the main pieces for the monitoring framework because through their standards, the municipalities can be evaluated, analysed, and measured according to the level of progress achieved by each SDG.

Moreover, when considering the standard values by number of inhabitants and not by type of settlement, municipalities with fewer than 5,000 inhabitants have similar characteristics worldwide. Therefore, DLD standard values can be used for any rural settlement to follow-up and evaluate the progress of the SDGs. Even so, stakeholders are recommended to interpret the results obtained, since there could be variations for the *objective-acceptable-worse* values (Table 9), especially in developing countries (Mbah & East, 2022).

In addition, there are certain DLD that are considered "ascending to limit or descending to limit" that the AUE does not establish (Column Normative direction of Table 7). Those interested can set these limits and adjust the results obtained to each case study. However, in Table 9, these indicators take their mean value as the *objective* and, consequently, do not specify a limit per country that would make the monitoring framework lose its universality (Ajates et al., 2020; Richiedei & Pezzagno, 2022).

This analysis of progress is possible because all SDGs have been considered, although some have a weaker connection. At the time of executing the framework, it is established that all SDGs are valued in the same way, although SDGs 2, 4, 5, 6, 7, 14 and 17 appear complementary. The criterion of linking and the criterion that in the combined SDGs, the progress is equal for both are established by the synergies with the 10 FLG (MITMA, 2019a): Ending poverty (SDG 1) will mean a population with more resources and educational possibilities (SDG 4). The economy (SDG 8) in the primary sector (SDG 2) will be fundamental for rural settlements. Gender parity (SDG5) is intrinsic to equal opportunities (SDG10). Developing a circular economy (SDG 12) will also mean thinking about new forms of efficiency in the use of water (SDG 6) and energy (SDG 7). If we consider terrestrial ecosystems, maritime areas will benefit (SDG 14) since all waste ends up in the oceans. Finally, social justice (SDG 16) will be unfeasible without government partnerships (SDG 17).

However, in the application of the monitoring framework, discrepancies have been observed since not all DLD are incorporated:

- Although the AUE focuses on urban areas, DLD do not seem to cover important SDG issues such as waste, pollution, water, and the internet since the AUE does not have its own DLD for SDGs 4, 7 and 14.
- The ranges come from Spanish municipalities. But, the SDG monitoring framework is adapted to the "Degree of urbanisation" of rural areas that the United Nations Statistical Commission approved as the recommended method for international comparisons (Statistical Commission, 2020). Therefore, the AUE standards can be applied as comparison standards without national borders with respect to other countries in which there is also a global trend to assess depopulation in rural areas (CES, 2021).
- The framework serves to align local governments but is based on SDG 11; therefore, architects and town planners will have an important role.
- To supplement the framework, subregional governments must evaluate the SDGs at the territorial level with other descriptive data, where territorial, environmental and landscape realities are considered.

4. Conclusions

Monitoring the progress of the SDGs is gaining considerable prominence, especially in rural assessments. However, the lack of standard values and actual data makes measurement difficult. After analysing trends in sustainability, indicators, and rural areas, as well as existing official frameworks and tools, this article proposes a monitoring framework for the resolution of these challenges. The main theoretical and practical implications of the framework are the following:

- The A2030 is the reference document that defines goals and targets to be achieved by all countries worldwide in the coming years and

Table 9
SDG monitoring framework for rural settlements with fewer than 5,000 inhabitants applying AUE.[10]

SDGs	Nº	DLD	Description	Unit	Standard values[11]		
SDG1SDG4	1	6	Urban density. Number of inhabitants per hectare of urban land area	Ha/inhab	9.6	15.6	26.4
	2	29	Number of dwellings per 1000 inhabitants	Dwellings/Ha	498.6	582.6	728.3
	3	32	Variation in the number of households 2011-2021	%	1.3	13.1	31.5
SDG3	4	22.a	Population ageing rate	%	27.8	34.9	11.5
	5	22.b	Population senescence rate	%	11.5	14.9	19.0
SDG8SDG2	6	2.b	Cultivation area by municipality	%	14.2	38.7	70.4
	7	3.a	Municipal area destined for agricultural and forest holdings	%	0.06	0.15	0.33
	8	3.b	Area destined to agricultural and forest holdings with respect urban and urbanizable limit area	%	4.47	12.91	34.27
	9	26.a	Workers in the agricultural sector	%	11.6	28.6	50.0
	10	27.a	Establishments in the agricultural sector	%	1.3	15.9	33.3
	11	28.a	Percentage of total unemployed	%	6.4	9.2	12.7
	12	28.b	Percentage of unemployed between 25 and 44 years	%	31.8	38.7	46.4
SDG9	13	9	Urban compactness. Total built area per land area	m^2c/m^2f	0.31	0.42	0.60
	14	ST05	Percentage of land areas under development used for economic activities (industrial or tertiary) with respect to the total urban land	%	8.2	18.7	45.0
	15	26.b	Workers in the industrial sector	%	0.0	6.2	16.4
	16	27.b	Establishments in the industrial sector	%	0.0	6.0	13.3
SDG10SDG5	17	23	Percentage of foreign population	%	1.6	4.1	8.7
	18	24.a	Total dependency rate	%	50.8	59.4	73.3
	19	24.b	Child dependency rate	%	8.0	13.9	19.5
	20	24.c	Elderly dependency rate	%	36.4	50.4	70.2
	21	28.c	Female unemployment rate	%	47.3	54.9	63.0
SDG11	22	8	Dwelling density by urban land area	Dwellings/Ha	10.0	15.6	23.3
	23	10.a	Area of residential use per land area	m^2c/m^2f	0.20	0.28	0.41
	24	10.b	Built area for residential use with respect to the total	%	62.4	71.0	78.3
	25	ST01	Projected dwelling density in development areas	Dwellings/Ha	20.6	29.9	38.4
	26	17.a	Transport infrastructure area	Ha	7.7	17.6	38.9
	27	17.b	Percentage of area of transport infrastructure with respect to the municipal area	%	0.2	0.5	1.0
	28	35	Percentage of empty dwellings	%	10.6	14.9	20.2
SDG12 SDG6 SDG7	29	14	Percentage of the building stock by municipality with a seniority prior to the year 2000	%	57.1	68.9	77.4
	30	26.c	Workers in the construction sector	%	3.0	7.6	13.3
	31	26.d	Workers in the service sector	%	29.9	44.3	60.0
	32	27.c	Establishments in the construction sector	%	0.0	6.3	12.5
	33	27.d	Establishments in the service sector	%	6.4	9.2	12.7
	34	34	Percentage of secondary dwellings	%	8.4	15.3	25.1
SDG13	35	1	Population variation 2010–2020	%	-20.2	-12.3	-3.6
	36	18.a	Vehicles domiciled in the municipality per 1000 inhab.	Numbers	627.5	714.3	822.6
	37	18.b	Percentage of passenger cars	%	59.8	65.8	71.4
	38	18.c	Percentage of motorcycles	%	5.0	6.9	9.3
SDG15SDG14	39	2.a	Artificial coverage area by municipality	%	0.0	0.4	1.7
	40	2.d	Forest area and meadows area by municipality	%	20.0	55.3	78.9
	41	5	Green zones area per 1000 inhabitants	Ha/inhab	1.9	5.2	12.3
	42	7	Surface area of discontinuous mixed urban land	%	10.3	24.2	51.3
	43	ST04	Percentage of land areas under development for residential use with respect to the total urban land	%	11.2	23.2	46.1
	44	33	Growth of the dwelling stock 2011-2021	%	10.2	18.3	31.8
	45	ST06	Percentage of dwellings planned in development areas with respect to the existing dwelling stock	%	22.1	40.3	73.6
	46	ST07	Number of dwellings planned in the development areas by every 1000 inhabitants	Dwellings/Ha	148.9	306.8	684.2
SDG16SDG17	47	4	Municipal area of undeveloped land	%	0.0	85.4	98.9
	48	ST02	Percentage of development land areas with respect to the total urban land	%	0.0	14.7	49.3
	49	ST03	Delimited developable land with respect to the total urban land	%	0.0	5.5	36.1
	50	38	Date of the current urban planning figure in town	Date	76.5	<2008<	23.5

[18]Green colour shows the objective value; yellow, acceptable; and red the worst value depending on the normative direction.

substantiates other global initiatives. The AUE was linked to all 17 SDGs and 54% of the SDG targets. Taken together, the A2030 and AUE demonstrate how they can add value to each other by using multi-tiering for data generation.

- SDG monitoring framework:
  - is an average method, through comparison standards, for a greater data flow in rural settlements to obtain diagnoses, making decisions, taking actions and advancing the SDGs.
  - is a starting point for channelling aid into certain actions that come together in sustainability, since the consequences and results will be characteristic for each area, but the tool is global.
  - recognises rural settlements in the world, without national borders, so the settlements can advance regardless of the lack of data and standards for rural areas by their governments.
- Municipalities with less than 5,000 inhabitants have similar characteristics and challenges worldwide in terms of sustainable

Table A.1
SDGs (United Nations, 2015).

Icon	SDG	Description	Icon	SDG	Description
	1	No poverty		10	Reduced inequalities
	2	Zero hunger		11	Sustainable cities and communities
	3	Good health and well-being		12	Responsible consumption and production
	4	Quality education		13	Climate action
	5	Gender equality		14	Life below water
	6	Clean water and sanitation		15	Life on land
	7	Affordable and clean energy		16	Peace, justice and strong institutions
	8	Decent work and economic growth		17	Partnerships for the goals
	9	Industry, innovation and infrastructure			

development. Considering the DLD standard values by number of inhabitants and not by type of settlement, the SDG monitoring framework can be used for any rural settlement to follow-up and evaluate the progress of the SDGs. However, stakeholders are recommended to interpret the results obtained, since there could be variations for the objective-acceptable-worse values. In the future, if all the countries can be compared, it will be seen if the data offered by Spain are adjusted to the average. But until then, it is represented as a theoretical average, used as a global reference value for the category of rural cluster (<5,000 inhabitants).

- By using official references, methodologies, tools and data, the SDG monitoring framework is rigorous and facilitates its replicability. These qualities contribute to the enrichment of the SDGs, being able to develop information exchange networks with the similarities and differences of each settlement and the way to proceed in each case.
- AUE includes standards for all municipalities:
  - >100,000 inhabitants
  - 50,000 to 100,000 inhabitants
  - 20,000 to 50,000 inhabitants
  - 5,000 to 20,000 inhabitants
  - all municipalities with more than 5,000 inhabitants
  - <5,000 inhabitants

Therefore, by changing the numerical values of the SDG monitoring framework, **other municipalities can be analysed.** In these cases, the framework would be useful for European settlements since characteristics and needs of cities are quite different worldwide.

- Identifying the standards of the DLD with colours to compare with the values of the first quartile, middle and third quartile distinguished according to the range of inhabitants, helps to better understand the progress towards the SDGs and obtain valid results as a comparing measure, in an intuitive and direct way.
- It is a global framework with multi-level governance, multi-goals, multi-scale, and social mix. Therefore, the various global sources of open descriptive data are cited, so that any stakeholder can apply the SDG monitoring framework in any rural settlement according to their particular case studies.

Future research on the implementation of the framework beyond the Spanish case is supported by the results obtained. Consequently, this paper offers a multitude of research advances: localising the monitoring framework taking into account additional indicators, proposing new standards for other realities based on the data obtained, studying adaptations to other scales of implementation, making monitoring and evaluation reports.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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Appendix A. Extended information about SDGs and SDG targets associated

SDGs with their icons and descriptions are presented below as FLG in Table 1.

The extended version of related SDG targets associated (Table 5) is presented below. The 10 targets in red are repeated, therefore, FLG are related not to 101 but to 91 of the 169 SDG targets, that is, a 54% synergy. Table A.2 comprises AUE trade-offs to explain the interlinkages between SDGs and DLD (Table 7) as well as to integrate FLG into the "5Ps"and the "3 pillars" (Figure 4).

[10] In appendix B, Table B.1 shows the extended SDG monitoring framework with the full 73 DLD, their formulas and sources.

Table 1
Decalogue of the First-Level Goals (MITMA, 2019b).

Icon	FLG	Description	Icon	FLG	Description
	1	Land planning and rational land use		6	Building social cohesion and equity
	2	Avoiding urban sprawl and revitalization of cities		7	Encouraging and promoting urban economy
	3	Preventing and reducing impacts of climate change. Strengthening resilience		8	Ensuring access to dwellings
	4	Sustainable resource management and promoting a circular economy		9	Leading and promoting digital innovation
	5	Fostering proximity and sustainable mobility		10	Improvement of intervention and governance instruments

Table A.2
Numbers of related SDG targets associated in FLG and SLG (MITMA and de, 2019a).

FLG	SLG	SDG targets	Total SDG targets in SLG	Total SDG targets in FLG
1	1.1	2.4, 11.a	2	15
	1.2	6.6, 11.4 14.1, 14.2, 14.5, 15.1, 15.2,15.3,15.4,15.a,15.b	11	
	1.3	15.5, 15.9	2	
2	2.1	1.4, 4.2, 4.a	3	4
	2.2	-	0	
	2.3	11.7	1	
	2.4	-	0	
	2.5	-		
	2.6	-	0	
3	3.1	11.b, 13.2, 13.3,	3	8
	3.2	3.9, 11.6	2	
	3.3	1.5, 11.5, 13.1	3	
4	4.1	7.1, 7.2, 7.3, 7.a, 7.b	5	16
	4.2	6.1, 6.2, 6.3, 6.4, 6.5, 6.b	6	
	4.3	12.2	1	
	4.4	12.2, 12.4, 12.5, 11.6	4	
5	5.1	3.6	1	3
	5.2	9.1, 11.2	2	
6	6.1	1.2, 1.3, 1.b, 10.2, 11.3	5	18
	6.2	4.2, 4.4, 4.5, 5.1, 5.2, 5.4, 5.5, 5.c, 10.2, 10.3, 10.4, 10.7, 11.3	13	
7	7.1	1.b, 2.c, 5.a, 8.1, 8.2, 8.3, 8.4, 8.6, 9.2, 9.3, 12.6	11	13
	7.2	8.9, 12.b	2	
8	8.1	11.1	1	1
	8.2	-	0	
9	9.1	9.5	1	2
	9.2	5.b	1	
10	10.1	16.b	1	21
	10.2	16.5, 16.6, 16.7, 16.8, 16.10, 17.9, 17.14, 17.16, 17.17, 17.18, 17.19	11	
	10.3	11.c, 12.7, 12.8	3	
	10.4	4.7, 16.5, 16.6, 16.7, 16.8, 16.10	6	
	30			101

Appendix B. Extended version of the SDG monitoring framework

The extended version of the SDG monitoring framework (Table 9) is presented below. Table B.1 incorporates the methodology and reference sources[11]. In addition, DLD without standard values[12] are included (Table 7) to have a complete monitoring framework and thus, obtain the full 73 DLD.

AUE identifies local entities as sources for certain DLD (MITMA, 2021). Specifically, for this SDG monitoring framework of fewer than 5, 000 inhabitants, rural settlements would be able to obtain the total DLD by applying each formula based on the fieldwork carried out by stakeholders (*local sources*). However, most DLD are available from open data consultation to support SDGs for local entities (*generic sources)*:

- The UN is the leading source with its own Global SDG Indicators Data Platform[13] that provides access to SDG indicator data for countries around the world. In addition, the UN offers a multitude of open data on various topics (crime, education, environment, finance, tourism, food, etc.) obtained from other open data repositories such as UNESCO, UNICEF, FAO (Food and Agriculture Organization of the United Nations), WHO (World Health Organization), IOM (International Organization for Migration), IMF (International Monetary Fund Organization) or the World Development Indicators[14] (WDI) by World Bank.
- SDSN is a complement to the official SDG indicators. The entire SDRs, datasets and any additional materials are available on its website [15] (Sachs et al., 2022).
- The Global Partnership for Sustainable Development Data[16] strengthens data-driven decision-making across a range of sectors, data communities, issues, and regions.
- In Europe, Eurostat provides information and data on the EU SDG indicators[17].

[11] For more information, consult the corresponding reference source.
[12] No. (-): DLD without standard value.
[13] Accessible at https://unstats.un.org/sdgs/dataportal.
[14] Accessible at https://datatopics.worldbank.org/sdgs/.
[15] Accessible at https://dashboards.sdgindex.org/.
[16] Accessible at https://www.data4sdgs.org/.
[17] Accessible at https://ec.europa.eu/eurostat/web/sdi.

Table B.1
SDG monitoring framework. Formulas, methodology and sources.

SDG	FLG	No.	DLD	Description	Formula, methodology	Unit	Sources
SDG1 SDG4	FLG2	**1**	6	Urban density	Inhabitants / (Consolidated Urban + Consolidated Development Areas)	Ha/inhab	Generic
		2	29	Dwelling stock	No. of dwellings built / (Total No. of inhabitants / 1000)	Dwellings/Ha	
		3	32	Variation in the number of households	(No. households 2021 - No. households 2011) / No. households 2011×100	%	
		-	13.a	Pedestrian streets length	Pedestrian streets length (m) / Total length (m) x100	%	Local
		-	13.b	Pedestrian streets area	Area of pedestrian streets (m^2) / Total area (m^2) x100	%	
		-	19.b	Supply of bus lines	Length of bus lines (km) / 1,000 inhabitants	No.	
		-	19.c	Supply of bus seats	Bus seats offered (No.) / 1,000 inhabitants	No.	
		-	19.e	Supply of railway networks	Length of railway networks (km) / Million inhabitants	No.	
		-	30	Type of dwellings	No. of multi-family dwellings / Total No. of dwellings x100	%	
SDG3	FLG5	**4**	22.a	Population ageing rate	No. of inhabitants over 65 years old / Total No. of inhabitants x100	%	Generic
		5	22.b	Population senescence rate	No. of inhabitants between 85 and over years old / No. of inhabitants between 65 and over x100	%	
		-	12.a	Green areas per inhabitant	Area of green and public recreation areas / No. of inhabitants	m^2/inhab	Local
		-	16.a	Silence quality during the day	No. of people exposed to more than 65 dB during the day / Total No. of inhabitants x100	%	Local
		-	16.b	Silence quality at night	No. of people exposed to more than 55 dB at night / Total No. of inhabitants x100	%	Local
		-	18.d	Age of vehicle fleet	Cars + Motorcycles domiciled after 2010 / Total fleet x100	%	Generic
		-	21	Cycling paths	Length of cycle paths (km) / 1,000 inhabitants	Km/inhab	Local
SDG8	FLG7	**6**	2.b	Cultivation area by municipality	Cultivation area (Ha) / Municipal area (Ha) x100	%	Generic
SDG2		**7**	3.a	Municipal area destined for agricultural and forestry holdings	Agricultural and forestry holdings area (Ha) / Municipal area (Ha) x100	%	
		8	3.b	Area destined to agricultural and forest holdings with respect to the urban land and urbanizable limit area	Agricultural and forestry holdings area (Ha) / ∑(urban land and urbanizable area) (Ha) x100	%	
		9	26.a	Workers in the agricultural sector	No. of affiliates social security in the agricultural sector / No. of affiliates x100	%	
		10	27.a	Establishments in the agricultural sector	No. of establishments dedicated to agriculture / Total No. of establishments x100	%	
		11	28.a	Percentage of total unemployed	No. of unemployed inhabitants / No. of inhabitants between 16 and 64 years old x100	%	
		12	28.b	Percentage of unemployed between 25 and 44 years	No. of unemployed inhabitants between 25 and 44 years old / Total No. of unemployed x100	%	
SDG9	FLG9	**13**	9	Urban compactness. Total built area per land area	∑Constructed area of cadastral plots of the municipality / (Consolidated Urban Land + Consolidated Development Areas)	m^2c/m^2f	Generic
		14	ST05	Percentage of land areas under development used for economic activities (industrial or tertiary)	Land area under development used for economic activities (m^2) / (Consolidated Urban Land + Consolidated Development Areas) x100	%	
		15	26.b	Workers in the industrial sector	No. of affiliates in the industrial sector / No. of affiliates x100	%	
		16	27.b	Establishments in the industrial sector	No. of establishments dedicated to industry / Total No. of establishments x100	%	
		-	11	Urban complexity	$\sum^{n}_{i=1} P_i \times \text{Log}_2 (P_i)$ • n is the number of different activity types. • P_i is the proportion of entities of a species or type of activity with respect to total No. of existing activities. • $\text{Log}_2(P_i)$ is the base 2 logarithm of the relative abundance of each species	Shannon-Wiener Index	Local
		-	19.a	Density of bus lines	Length of bus lines (km) / municipal area (km^2)	Km	
		-	19.d	Density of rail lines	Length of rail lines (km) / Area of municipality (km^2)	Km	
SDG10 SDG5	FLG6	**17**	23	Percentage of foreign population	No. of foreign inhabitants / Total inhabitants x100	%	Generic
		18	24.a	Total dependency rate	No. of inhabitants (between 0 and 14 years old + 65 and over years old) / No. of inhabitants between 15 and 64 years old x100	%	
		19	24.b	Child dependency rate	No. of inhabitants between 0 and 14 / No. of inhabitants between 15 and 64 years old x100	%	
		20	24.c	Elderly dependency rate	No. of inhabitants between 65 and over / No. of inhabitants between 15 and 64 years old x100	%	
		21	28.c	Female unemployment rate	No. of unemployed women / Total No. of unemployed x100	%	
		-	20	Accessibility to public transportation services	Inhabitants living near a public transport stop / Total No. of inhabitants x100	%	Local
		-	25	Percentage of people with access to social services	data compiled by local entities included in the Concerted Plan, the data of the territorial implementation	%	Generic
SDG11	FLG8	**22**	8	Dwelling density by urban land area	No. of dwellings / Area (Consolidated Urban Land + Consolidated Development Areas)	Dwellings/Ha	Generic
		23	10.a	Area of residential use per land area	∑Constructed area of cadastral parcels for residential use / Area (Consolidated Urban Land + Consolidated Development Areas)	m^2c/m^2f	
		24	10.b	Built area for residential use with respect to the total built area	∑Constructed area of cadastral parcels for residential use / ∑Constructed area of cadastral plots of the municipality	%	
		25	ST01	Projected dwelling density in development areas	No. of dwellings planned in development areas / Area of development areas	Dwellings/Ha	
		26	17.a	Transport infrastructure area		Ha	

(*continued on next page*)

Table B.1 (*continued*)

SDG	FLG	No.	DLD	Description	Formula, methodology	Unit	Sources
					Sum of the land surfaces, mainly as surface for airport, port, railway network, road network use, and the land surfaces of roads, car parks and pedestrian areas without vegetation.		
		27	17.b	Percentage of area of transport infrastructure to the municipal area	Area of transport infrastructure (Ha) / Municipality area (Ha) x100	%	
		28	35	Percentage of empty dwellings	No. of empty dwellings 2021 / No. of total dwellings 2021×100	%	
		-	31	Subsidized housing	No. of subsidized homes / Total No. of dwellings x100	%	Local
		-	36	Housing accessibility	Average house price / Average family income x100	No. of years needed	
SDG12 SDG6 SDG7	FLG4	**29**	14	Percentage of the building stock by municipality with a seniority prior to the year 2000	It is calculated from the information regarding the age of the building stock, based on data from the Cadastre and compared with the total building stock to obtain the percentage	%	Generic
		30	26.c	Workers in the construction sector	No. of affiliates in the construction sector / Total No. of affiliates x100	%	
SDG12	FLG4	**31**	26.d	Workers in the service sector	No. of affiliates in the service sector / Total No. of affiliates x100	%	
SDG6 SDG7		**32**	27.c	Establishments in the construction sector	No. of establishments dedicated to construction sector / Total No. of establishments x100	%	
		33	27.d	Establishments in the service sector	No. of establishments dedicated to service sector / Total No. of establishments x100	%	
		34	34	Percentage of secondary dwelling	No. of secondary dwellings 2021 / No. of total dwellings 2021×100	%	
		-	15	Water consumption	Water consumption / No. of inhabitants	L/inhab x day	Local
SDG13	FLG3	**35**	1	Population variation 2010–2020	(Population2020 - population2010) / Population2010×100	%	Generic
		36	18.a	Vehicles domiciled in the municipality per 1000 inhabitants	(Passenger cars + motorcycles) / (Total No. of inhabitants / 1,000)	Numbers	
		37	18.b	Percentage of passenger cars	No. of passenger cars domiciled in the municipality / Total No. of vehicles x100	%	
		38	18.c	Percentage of motorcycles	No. of motorcycles domiciled in the municipality / Total No. of vehicles x100	%	
		-	12.b	Density green areas	Surface of green and public recreation areas (m^2) / Surface urban area (m^2) x100	%	Local
SDG15	FLG1	**39**	2.a	Artificial coverage area by municipality	Artificial coverage area (Ha) / Municipality area (Ha) x100	%	Generic
SDG14		**40**	2.d	Forest and meadows area by municipality	Forest area and meadows area (Ha) / Municipal area (Ha) x100	%	
		41	5	Green zones area per 1000 inhabitants	Green zone areas (Ha) / (Inhabitants / 1,000)	Ha/inhab	
		42	7	Surface area of discontinuous mixed urban land over total mixed	Discontinuous mixed urban land (Ha) / ∑Total mixed urban land area (Ha) x100	%	
		43	ST04	Percentage of land areas under development for residential use with respect to the total urban land	Land areas under development for residential (m^2) / Area (Consolidated Urban Land + Consolidated Development Areas) (m^2) x100	%	
		44	33	Growth of the dwellings stock 2010-2021	(No. of dwellings 2021 - No. of dwellings 2011) / No. of dwellings 2011×100	%	
		45	ST06	Percentage of dwellings planned in development areas with respect to the existing dwellings stock	No. of dwellings planned in development areas / No. of total dwellings stock x100	%	
		46	ST07	Number of dwellings planned in the development areas	No. of dwellings planned in development areas / Total No. of inhabitants x100	Dwellings/Ha	
		-	2.c	Surface of Wetlands	Surface area covered by wetlands (ha) / Municipal area (Ha) x100	%	Generic
SDG16 SDG17	FLG 10	**47**	4	Municipal area of undeveloped land	(Non-developable + non-delimited developable land area) (m^2) / Municipal area (m^2) x100	%	Generic
		48	ST02	Percentage of development land areas with respect to the total urban land	Development land areas (m^2) / Area (Consolidated Urban Land + Consolidated Development Areas) (m^2) x100	%	
		49	ST03	Delimited developable land with respect to the total urban land	Delimited developable land (m^2) / Area (Consolidated Urban Land + Consolidated Development Areas) (m^2) x100	%	
		50	38	Date of the current urban planning figure in town	The proportion of plans prior to 2008 is calculated based on the population of the municipalities	Date	
		-	37	Current Urban Planning figure in the municipality	This data is offered based on information from the Urban Planning Database	Figure	Generic
		-	39	Urban Agenda, strategic planning and smart cities	Yes/No	Figure	Local

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