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Assessment of sustainable development objectives in Smart Labs: technology and sustainability at the service of society

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A B S T R A C T

Sustainable development is the working basis of engineering research and cities are becoming increasingly flexible, inclusive and intelligent. In this context, there is a need for environments that emulate real-life spaces in which cutting-edge technologies can be implemented for subsequent deployment in society. Smart Labs or Living Labs are spaces for innovation, research and experimentation that integrate systems, devices and methodologies focused on people and their environments. The technologies studied and developed in such labs can then be deployed in human spaces to provide intelligence, comfort, health and sustainability. Health and wellness, energy and environment, artificial intelligence, big data and digital rights are some of the disciplines being studied. At the same time, the UN 2030 Agenda provides a comprehensive framework to promote human well-being through the Sustainable Development Goals. In this work, an evaluation model of its indicators in smart environments is performed through a mixed review methodology. The objective of this work is the analysis and implementation of the SDGs in Smart Labs through a literature review and a case study of UJAmI, the smart laboratory of the University of Jaén. The results provide quantitative and qualitative data on the present and future of the smart devices implemented in the UJAmI lab, providing a roadmap for future developments.

1. Introduction

Intelligent systems, internet of things (IoT), advanced electrical engineering systems, smart grids (SGs) and sensors, among other technologies, are increasingly being deployed in society and the environments in which we live. The application of cutting-edge technologies in human environments is essential to improve quality of life, sustainability and progress towards a smarter humanity. As defined by the European Network of Living Labs (EnoLL) (2021), Living Labs (LLs) or Smart Labs (SLs) are open, user-centred innovation ecosystems that integrate research and innovation processes in real-life communities and environments. They are laboratories or spaces, generally located indoors, that simulate a home or a room and are fitted with various equipment, devices or smart systems. These are experimental laboratories that seek to facilitate and encourage open and collaborative innovation, simulating real-life environments where new technologies can be studied and subjected to experiments (Almirall and Wareham, 2011).

LLs operate as intermediaries between citizens, research organisations, companies, cities and regions for joint value creation, rapid prototyping or validation to scale up innovations and enterprises. While there are different types, they have common elements, one of the most important of which is to serve as a driver for community and societal progress through advanced technological implementations, delivering resilient, efficient and sustainable sensory, medical or urban experiences.

In 2015, the member states of the United Nations agreed to establish an Agenda involving actions aimed at reducing pollution and improving the health and quality of life of the world's population and promoting environmental sustainability (Assembly, 2015). The Agenda includes 17 Sustainable Development Goals (SDGs), along with 169 associated targets, and their fulfilment implies reviewing and evaluating any industrial, human, biological, social, economic or other type of action that affects our planet. The 2030 Agenda is evolving slowly and the SDGs are demanding but also necessary in order to progress towards a fairer world. The SDG targets must be measurable, assessable and applicable in all territories. They must be based on the three fundamental pillars for the development of the planet and our inhabited spaces: the economy, society and the environment (Griggs et al., 2013). The definition of sustainable development, as set out in the 1987 report of the United Nations World Commission on Environment and Development (the Brundtland Commission), should therefore be redefined as "development that meets the needs of the present while safeguarding the Earth's life support system, on which the well-being of present and future generations depends". The goal of the Brundtland Commission was to help guide the nations of the world toward the goal of sustainable

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development. The commission is also known as the World Commission on Environment and Development (WCED). The commission published its findings in the Brundtland Report in 1987 (Imperatives, 1987).

There are multiple research studies that reinforce the need for analysis and implementation of the SDGs in engineering, technology and industry, as detailed in the study conducted by Olawumi (Olawumi and Chan, 2018), which analysed the global trends and structure of sustainability research between 1991-2016 from a scientometric point of view. This research raises the need to carry out future concrete projects in the field of construction, design of facilities and applications in technology, for example in the field of IoT, to assess the sustainability of our smart environments (Nicolas et al., 2020). There is an urgent need to analyse the direct impact that technology will have on the population and our environments as a vector of change and a means to address climate change. In the work of Jeffrey D. Sachs et al. six SDG Transformations are investigated as modular pillars of SDG achievement: education, gender and inequality; health, well-being and demographics; energy decarbonisation and sustainable industry; sustainable food, land, water and oceans; sustainable cities and communities; and digital revolution for sustainable development. It is a very interesting work, in which we can see the implications of the circular economy on sustainability in a multidisciplinary field (Sachs et al., 2019).

David Attenborough's documentary A Life On Our Planet has been released recently (Fothergill and Scholey, 2020), in which Sir Attenborough proposes a series of urgent measures to guide our planet and secure the habitability of the different species that inhabit it, both animal and plant. Some fundamental measures include innovation in renewable energies and the use of advanced technology and intelligent systems to be able to control and improve changes in the environment, life in cities and inhabited environments, the sustainability of agriculture, forests and medical advances, among other suggestions.

The European Union Taxonomy for Sustainable Activities report was published in 2020 after months of work and analysis (EU Technical Expert Group on Sustainable Finance 2021). The EU taxonomy is a classification system that establishes a list of environmentally sustainable economic activities and is an important tool for increasing sustainable investment and implementing the European Green Pact. It provides appropriate definitions for companies, investors and policy makers on which economic activities can be considered environmentally sustainable and helps companies plan their transition to SDG-aligned activities.

Countries must require companies and institutions to comply with the SDGs and implement strategic tools and measures adapted to each industry or production sector. In this paper, we will review the stakeholders' responsibility to implement sustainable practices in relation to LLs, understood as living laboratories that run pilot tests for SDG compliance in construction, health care and industry. Some studies and publications, such as those by Topple (Topple et al., 2017), assess sustainable business practices through the lens of a corporate sustainability assessment framework, including the use of tools such as materiality analysis to identify and prioritise sustainability issues. The results of this exploratory study suggest that it is through the use of these international sustainability standards and guidelines (such as the Global Reporting Initiative standards) that greater consideration for and adoption of the SDGs can be achieved in businesses. Indeed, standards have a significant influence on sustainability issues and goals and on the achievement of the SDGs in human environments.

LLs are human-made environments that test IoT technologies and provide experiences based on technological transformation. These will be implemented in buildings, care homes, residences, etc. with the aim of improving health and sustainability. Health care and social institutions, as well as companies in the service and building sector, will be able to interact with these platforms to support intelligent living environments. The development of experimentation frameworks in these environments is scarce, but can be extrapolated to other similar research, such as that which is carried out in the classic residential building sector and by similarity with other living systems (Ahmad and Thaheem, 2017). Living laboratories and their contribution to the achievement of the SDGs is an unusual topic, though we have found some recent works, such as Compagnucci's (Compagnucci et al., 2021), in which a survey and evaluation of users is conducted and some SDGs are analysed, though not all. Likewise, in Mazutti's work (Mazutti et al., 2020), a survey and evaluation of users is conducted and some, but not all, of the SDGs are analysed, carrying out a study of LLs in academic, controlled environments and in which some very specific environmental parameters, such as air quality, are evaluated. Taylor (Taylor et al., 2017) explores the energy indicators for sustainable development, where again we highlight the specificity of the goals chosen instead of considering all the SDGs, as we intend to do in this paper. Chew (Chew et al., 2020) examines the implementation of 5G technology in smart building management, which is related to innovation and technological advances in LLs, for its subsequent launch into the real market. However, this analysis of the SDGs does not reflect an in-depth study of the market improvements or synergies that could be had for people's habitability in sustainable and efficient human environments.

The tools and analyses that can be carried out on the implementation of the SDGs in LLs can be transferred to the area of sustainable and efficient construction and to the field of inclusive design, taking account of the needs of the elderly and people with disabilities or simply to improve comfort and conveniencein inhabited environments. It is also the responsibility of academia, industry, society and political actors to incorporate environmental sustainability analysis in all systems, including purely experimental ones such as the one we develop in LLs (Mylonas et al., 2021). We have also found some works in which the analysis of the SDGs in intelligent systems includes the evaluation of one, two or three of these, considered as specific to a particular environment. However, there is no multidisciplinary and joint analysis of all the SDGs and their contributions to industry or to development. For example, if we perform a literature search in the Web of Science (WOS) database with the terms: title: (living lab or smart lab), refined by topic (IoT) we obtain 20 results, in none of which the term: "sustainable development goals" or its acronym "SDGs" appears in the title or abstract. This example shows us that the evaluation of SDGs is generally not considered important or necessary in LL research. Among these works is that of Knight (Knight et al., 2020), which details the research developed in a SL in a very interesting way. This article presents the use cases of an integrated SL and describes a prototype system, Talk2Lab, which was implemented in an experimental laser facility. Talk2Lab uses a combination of sensors to facilitate communication in the lab. This research discusses experimentation, future applications, smart systems and sensors, but does not touch upon SDG assessment. Chen's work (Chen et al., 2020), which analyses the study of gait to facilitate activities of daily living, is a very recent line of research and also does not comment on the need for the implementation of the SDGs, nor of sustainability in intelligent systems applications.

The case of Rodrigues (Rodrigues and Franco, 2018) is similar to those discussed above, in the study on the importance of LLs in urban entrepreneurship. However, despite talking about and analysing the importance of sustainability throughout the work, no reference is made to the SDGs, therefore neglecting to analyse one of the essential tools we have today to drive technological progress while protecting biodiversity and promoting efficient consumption.

The environmental impact in the value and supply chain indicated in the Greenhouse Gas (GHG) Impact Protocol will not be analysed in this document (AnonymousThe GHG Protocol for Project Accounting 2005), as these involve a very in-depth analysis of the equipment, systems and developments that will be made in LLs. It is not the objective of this work, although we will touch upon them and they provide a potential avenue for future research. The analysis of GHG emissions and their impact on the environment must be taken into account in the assessment of the SDGs in any discipline. For example, (Kesidou and Sovacool, 2019) provides research on the construction sector and the need to evaluate all processes in the supply and value chain of a building or facility design. In our work we will consider that a LL is an infrastructure with IoT equipment, smart systems, Smart Grids and devices that once evaluated should be installed in real building systems, smart buildings and human environments. The evaluation of the SDGs is not a trivial matter. It must be considered urgent so that the SDGs are effectively implemented in environments and territories all over the planet in order to have significant impact.

The purpose of this work is to make a clear and implementable evaluation protocol, in relation to the LLs or SLs that are being developed around the world in educational institutions, such as universities, research centres, etc., and in the business and construction sector. We want to obtain measurable values on all the SDGs and transfer them to our research in IoT, energy efficiency and technological sustainability, so that people using sensor technology and designing smart systems can know the impact they have on protecting the planet and improving environmental sustainability. Technology and device intelligence should make us wiser and more responsible. We will measure how to evaluate the devices used in a LL case study at the University of Jaén, which can be implemented in other non-academic environments. In section 1, we will put forward our introduction; in section 2, we will analyse the importance of the SDGs and their indicators for the evaluation of LLs, as research environments that can be incorporated into smart buildings or sustainable architecture and construction designs; in section 3 we will explain the methodology of our work, which will be through a multi-method approach; section 4 will analyse the SDGs assessment tool to be used in LL or SL environments in detail; section 5 will analyse a case study on UJAmI, the LL of the University of Jaén; and section 6 will conclude with a discussion on our work and our conclusions.

This work will focus on the analysis and implementation of the SDGs in LLs or SLs in order to contribute to the research on these tools, which are used to study and test the most advanced technological and engineering developments applied to smart environments. This analysis will lead us down several paths: the first one is the promotion of sustainability in human behaviour through technology and intelligent engineering designs; the second one is the reduction of energy consumption, which involves the implementation of systems and sensors under human control; and the third one is the power to bring systems tested and verified in LLs to activities of daily living, to intelligent buildings and advanced human environments that provide support in terms of health, mobility, accessibility and other areas.

2. The SDGs and their implementation and evaluation in the design of sustainable and efficient human facilities

The taxonomies and assessment tools for the SDGs are multiple but also complex, e.g. the European Union taxonomy (EU Technical Expert Group on Sustainable Finance 2021) is a classification system that establishes a list of environmentally sustainable economic activities. It is a facilitator to increase sustainable investment and to implement the European Green Pact, providing a tool for companies, investors and governments to design policies on environmentally sustainable economic activities. This system is an important step towards improving the implementation of IoT applications in all disciplines, especially in energy and health. There are also research and evaluation systems that provide relevant methodologies to implement and quantify the SDGs in different disciplines. For example, in (Giupponi and Gain, 2017) an integrated spatial assessment of the water, energy and food dimensions of the SDGs is carried out. This research proposes a set of indicators for the integrated assessment of water resources and a method that allows taking into account different decision-making attitudes of policy makers. In this case, only the indicators of SDGs 6, 7 and 2 are analysed (Assembly, 2015).

In other works, the evaluations focus on quantitative data analysis of territories, based on governmental statistics or those of related institutions. This is analysed in (Huan et al., 2019), where two countries, Kazakhstan and Kyrgyzstan, are compared and an economic, social and environmental analysis is made. A calculation table is used with the set of indicators analysed and filled in with the figures for each territory, thus obtaining conclusive graphs for the analysis. This type of quantitative methodology is very effective and valid for countries, communities or territories where there is easy access to statistical data (Benedek et al., 2021, Ruckert et al., 2017). In these studies, the aim is to construct an index based on quantitative macroeconomic and social data, providing an overview using a series of essential numerical indicators to understand the status of the SDGs in different communities, countries and regions. For example, the regions of a country are analysed individually and the SDG index is extracted for each goal, with standardised values ranging from 0 to 10, 10 representing the highest level of sustainable development, while 0 represents the lowest.

According to (Schmidt-Traub et al., 2017), SDG index analysis for countries should be set against clear metrics, so that each country can take stock of where it is, devise pathways to achieve the goals and track its progress. The UN Statistical Commission has recommended a first set of 230 global indicators to measure SDG achievement, but many of the suggested indicators lack comprehensive cross-country data and some even lack agreed statistical definitions. The SDG index is correlated with gross domestic product per capita, the most widely used indicator of economic progress; the Human Development Index (HDI), a composite measure of health, education and income outcomes; the Global Competitiveness Index, a common index of countries' economic competitiveness; the Environmental Performance Index (EPI), which comprises a broad range of environmental indicators; and the Global Peace Index, a broad measure of peace and conflict.

In another block of analysis we must review the documents, research and evaluations focused on business and industry. The results of the consultation "Contribution of Spanish companies to the 2030 Sustainable Development Strategy", promoted and coordinated by the Ministry of Social Rights, the 2030 Agenda and the Spanish Global Compact Network were presented in 2020 (AnonymousThe GHG Protocol for Project Accounting 2020). The indicators are structured in each European country according to a common strategy and it is the government statistical agencies that publish the data to be considered. For example, in Spain it will be the National Statistics Institute (INE) which will publish the data (AnonymousThe GHG Protocol for Project Accounting 2021). The 2030 Agenda for Sustainable Development consists of 17 goals and 169 targets. For its monitoring, 232 indicators were designed that can be measured with the statistical data collected. These indicators, which constitute a statistical operation included in the current Annual Program, are continuously updated and include information from both the Spanish INE and other official sources that will be incorporated progressively.

As a first highlight in this study, we point to the leadership shown by Spanish companies in implementing the Triple Bottom Line: Social, Environmental and Financial, representing a significant change in corporate culture and purpose. Companies consider it a benefit to implement the Sustainable Development Goals in their business strategies. 81% of the companies surveyed are aware of the SDGs, while 89% say that their activity can have an impact on the SDGs.

Institutional evaluation based on macro indicators is effective from the point of view of general analysis but lacks a more specific and clear vision in those sectors where there is no clear indicative data or where, due to professional or business secrecy, such data is not made public. This is a major drawback for conducting effective studies and research, as there are many unknowns and therefore a large informational "black hole", which leads to a failure to implement efficient SDG measures. For example, if we look at the graph in Fig. 1, we can determine that there has been a large increase in the construction of resilient infrastructure, promotion of inclusive and sustainable industrialisation and fostering of innovation, as stated in Goal 9, but if we analyse the data more closely, we can see that the manufacturing sector takes precedence over the service sector or others such as the health or energy sectors (AnonymousThe GHG Protocol for Project Accounting 2021).

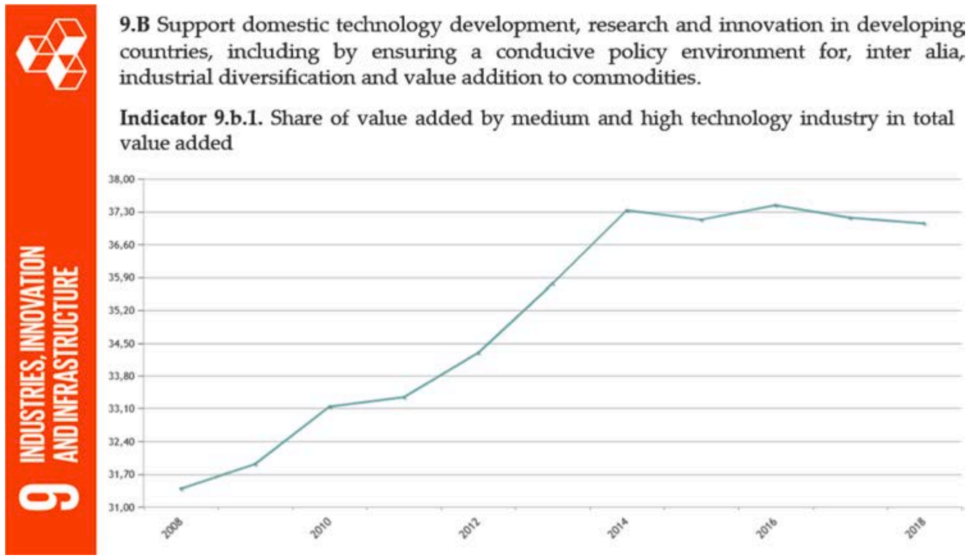

Fig. 1. Evaluation of SDG indicators for Spain. Objective 9. Indicator 9.b.1. Spanish National Statistics Institute (INE). (AnonymousThe GHG Protocol for Project Accounting 2021)

It is in the construction and building industry where we can find more synergies with our work, so it is here where we will focus our analysis. In (Jia et al., 2019), a review of IoT enabling technologies in the construction and smart building sector was carried out. The evaluation and implementation of SDG indicators will be key in this sector, as they can promote energy efficiency, social advancement for users, environmental protection and the improvement of health in general, so priority areas or sectors will be taken into account. Knowledge of IoT technologies is fundamental to our work, since we will perform a case study of a LL, which can be implemented in a real smart building, once it is validated. In (Alawneh et al., 2019), categories and indicators were identified to evaluate sustainable non-residential buildings through a methodology based on surveys and data collected from users and people who manage such buildings. In (Hewitt et al., 2019), a quantitative survey and user/expert panel discussions were conducted to evaluate and reconceptualise the existing sustainable development assessment tool used by Health Service England, called the Good Corporate Citizenship Assessment Tool (Sustainable Development Assessment Tool (Sustainable Development Assessment Tool (SDAT) 2021) 2021). This evaluation is based on surveys of people responsible for the health services in England and draws conclusions on different issues in the self-assessment, some of them requiring improvements to formal issues by revising questionnaires, question formulation, etc. It is interesting to note that in many of the works that evaluate the implementation of SDGs in the industrial or business sector, "greenwashing" is mentioned, i.e. business strategies aimed at visualising sustainability and social impact as a marketing campaign and not as a reality involving useful and real business strategy development (Silva, 2021, Johnsson et al., 2020). For an SDG assessment to provide a basis for informed decisions regarding real change towards sustainable and equitable corporate practices, it must identify and include concrete measures, include relevant value chains and consider both the short and long-term effects of strategic decisions. An SDG assessment plan is not enough; it must be implemented, verified and an active management model must be implemented with verifiable results. In (Akuraju et al., 2020), an exploratory urban-scale study of SDG 11 is conducted and concludes by noting the complexity of the task of quantifying the sustainability of cities.

Some tools for SDG assessment and their analysis and implementation in industries, countries, territories or other scenarios are shown in Table 1.

A review of various tools for analysis, evaluation and implementation of the SDGs is shown in Table 1. They have been selected based on their temporal impact, innovation, results and importance. Some tools are endorsed by the UN, others by academic institutions, others by financial institutions and some are related to research projects.

3. Methodology

To achieve the objective of this work, a mixed methodology has been used, integrating: a) a systematic literature review to investigate, analyse and compare different research on the verification and assessment of SDGs and their implementation in human activities, including SDG assessment tools, b) a detailed analysis of the tools located in order to obtain an adequate taxonomy for SDG assessment in LLs and c) a case study of the LL of the University of Jaén.

The systematic literature review was designed with the objective of locating already existing SDG analysis models and assessment methodologies that are being implemented in other disciplines, such as industry, in territories, etc. and that can be tested in LL laboratories. The analysed tools have been retrieved on the basis of certain criteria, taking into account that they can be extrapolated to assessment of LLs. These criteria are: time range, keywords, databases, institutional websites and suitability for research. Table 2 shows the academic databases analysed and the access link to the same, while Table 3 shows the criteria for the exclusion and selection of literature.

Table 3 shows the results obtained according to the search strategies and exclusion filters used. In the filtering of fields of study or areas of work, we have selected only the areas that will provide useful systems and analysis tools for our research; we have discarded the rest. The most prominent areas and where most of the references are found are three: green sustainable science technology, environmental sciences and environmental studies, as can be seen in Table 4.

As can be seen in Table 3, the number of bibliographic sources from academic databases to be analysed is 47; in addition to these sources, other references from the institutional and business spheres have been selected in Table 1. In Table 4, the main areas of the sources analysed and filtered in the reference databases have been selected. It can be seen that the field of engineering covers almost 13% of the works, a percentage that is perhaps somewhat low, since engineering is key to the construction and analysis of LLs and thus to finding solutions to many environmental impact issues we face today.

The databases used for the bibliometric analysis of scientific literature provide significant coverage; the same keywords were used in all searches. The keyword search of the academic bibliometric databases

Table 1
SDG assessment tools.

Tool	Description	Reference
SDG Compass	Guidance for companies on management strategy to meet the SDGs.	(Compass, 2021)
SDSN Northern Europe	United Nations Sustainable Development Solutions Network (SDSN) Northern Europe. Offers high quality education for sustainable development and provides advice and solutions for societal transformation towards sustainability.	(SDGI Impact Assessment Tool. Available online 2021)
IRIS +	Analysis and assessment tool using taxonomies for measuring environmental impact.	(Available online, 2021)
UNDP	The United Nations Development Programme (UNDP) is a United Nations agency that helps assess and implement the SDGs.	(United NationsDevelopment Programme (UNDP) 2021)
KTH's Toolbox	KTH's Toolbox for Learning for Sustainable Development offers tips and examples for the integration of sustainable development into teaching.	(United NationsDevelopment Programme (UNDP) 2021)
Local 2030	Local 2030: localizing the SDGs, an online platform. Stakeholders and partners share tools, experiences, new solutions and guides to support SDG localization.	(Local 2030 2021)
SDG Toolkit	SDG Toolkit is part of a European project to involve European NGOs at national and European level in the SDGs, containing materials, tools, reports and databases from EU territories.	(SDG's Toolkit 2021)
SDG Helpdesk	SDG Helpdesk provides access to models, methodologies and guidance to support policy makers in the implementation of the SDGs.	(SDG Helpdesk 2021)
EU taxonomy	The EU taxonomy is a classification system that has established a list of environmentally sustainable economic activities. The EU taxonomy is an important enabler to scale up sustainable investment and to implement the European Green Deal.	(EU Technical Expert Group on Sustainable Finance 2021)

Table 2
Consulted databases.

Source	URL
IEEE Xplore (accessed on 15 June 2021).	http://ieeexplore.ieee.org
Web Of Science (WOS) (accessed on 18 June 2021).	https://clarivate.com/webofsciencegroup
Scopus (accessed on 20 June 2021).	http://www.scopus.com

yielded 47 unique academic publications, which were reviewed for relevance using selection criteria that included explicit references to SDG assessment. Studies that were not relevant to the analysis were excluded.

The tools selected for the assessment of the SDGs and that we will take as reference for the assessment of the University of Jaén LL case study have been indicated in Table 1 and are: SDG Compass, which guides companies on management strategy for the achievement of the SDGs (Compass, 2021); SDSN Northern Europe, which is a United Nations Sustainable Development Solutions Network offering high quality education for sustainable development and providing advice and solutions for societal transformation (SDGI Impact Assessment Tool. Available online 2021); IRIS +, is an analysis and evaluation tool using taxonomies to measure environmental impact (Available online, 2021); UNDP is the United Nations Development Programme, which helps to assess and implement the SDGs (United NationsDevelopment Programme (United NationsDevelopment Programme (UNDP) 2021) 2021); KTH's Toolbox for Learning for Sustainable Development offers tips and examples for the integration of sustainable development into teaching (United NationsDevelopment Programme (United NationsDevelopment Programme (UNDP) 2021) 2021); Local 2030, localizing the SDGs, is an online platform where stakeholders and partners share tools, experiences, new solutions and guides to support SDG localisation (Local 2030 2021); SDG Toolkit is part of a European project to involve NGOs at the national and European level in the SDGs, containing materials, tools, reports and databases from EU territories (SDG's Toolkit 2021); SDG Helpdesk provides access to models, methodologies and guidance to support policy makers in the implementation of the SDGs (SDG Helpdesk 2021); and finally, the EU taxonomy tool is a classification system that has established a list of environmentally sustainable economic activities, an important enabler to scale up sustainable investment and to implement the European Green Deal (EU Technical Expert Group on Sustainable Finance 2021).

The case study that we will analyse in this work is the Intelligent Laboratory of the University of Jaén, called UJAmI SmartLab, which is an innovative space within the University of Jaén that plays a key role in the implementation of new ground-breaking solutions in e-healthcare based on ambient intelligence. This SL features a fully furnished apartment that is organised into the following spaces: an entrance hall, a living room, a kitchen and a bedroom with an integrated bathroom. There are more than 130 smart devices deployed in this apartment to analyse the behaviour of its inhabitants. Multiple sensors are distributed throughout the UJAmI SmartLab in order to gather data from human-environment interactions. Furthermore, the SmartLab includes actuators to fulfil the needs of users. A common middleware based on openHAB is responsible for managing the data in a unified way that simplifies

Table 3
Methodological search strategy and filters.

Search for Keywords	Results
Searched for: Title: ("Sustainable development goals" or "sustainable development objectives")	2076
Filters applied	
Refine Results: ("Assessment")	164
Refine results by Category	120
Source Selection	47

Table 4
Results for the most relevant research areas.

Research Areas	Number of sources*	%
Environmental sciences ecology	28	59.6%
Other topics in science technology	18	38.2%
Engineering	6	12.8%
Business economics	5	10.6%
Energy fuels	5	10.6%
Construction building technology	3	6.3%
Public administration	3	6.3%
Development studies	2	4.3%
Imaging science photographic technology	2	4.2%
Public environmental occupational health	2	4.2%
Remote sensing	2	4.2%
Other topics in social sciences	2	4.2%
Computer science	1	2.1%
Entomology	1	2.1%
Health care sciences services	1	2.1%

*Some areas have multiple sources

the intelligent processing of information (Espinilla et al., 2018).

An analysis tool incorporating variables, devices, environments or other evaluation vectors to obtain a quantitative and qualitative score will be obtained. This tool will allow us to ascertain the SDG compliance of the research and design environments that are included in the LL. Each of the 17 SDGs and their main indicators, which are directly related to the evaluated environment, will be analysed. It should be noted that there are different models and types of LLs or SLs, but all follow a similar structure and design architecture. This generally includes the existence of a group of connected devices which perform specific functions focused on an ultimate goal, generally aimed at the improvement of health, mobility, work or some other aspect of human technology. These devices, their design, installation and effectiveness must respect the principles of ethics, energy efficiency and competitiveness for their subsequent implementation in society.

SDGs are evaluated in relation to LLs in order to achieve the reduction of carbon footprints, the improvement of environmental sustainability and the provision of intelligence through IoT and efficient electrical devices. These devices add value to an increasingly technological society, without losing the focus on health, comfort and quality of life of people in general and the protection of the environments in which we live.

Finally, the results of the analysis, including the negative aspects found, will allow us to offer proposals for improvement and innovation. Evaluation tools must be flexible and offer solutions that are adaptable to different LL models. It is interesting to note how the SDGs interact and relate to each other (Nilsson et al., 2016). For example, SDG 3, which provides indicators promoting health and well-being, cannot be achieved if SDG 6, which assesses the right of access to water and sanitation, is not met (Assembly, 2015). This shows that these goals are interconnected and should therefore be assessed together.

The analysis and implementation of the SDGs in the SmartLab that will contribute to the research, study and testing of the most advanced technological and engineering developments applied to smart environments will lead us down several paths: the first one is the promotion of sustainability in human behaviour through technology and intelligent engineering designs; the second is the reduction of energy consumption, which involves the implementation of systems and sensors under human control; and the third consists in bringing systems tested and verified in the SmartLab to activities of daily living, intelligent buildings and advanced human environments that provide support in health, mobility, accessibility, etc.

This work addresses the following research questions:

RQ1.: What SDG assessment tools exist and what are the parameters and analysis vectors of these tools?

RQ2: Are SDG assessments being conducted in LLs, and do these assessments provide quantitative or qualitative analyses, or both?

RQ3: What assessment can be conducted at the LL of the University of Jaén, UJAmI, that would allow us to make a real assessment of the SDGs in this case study?

4. Architecture and analysis of the Living Lab of the University of Jaén: UJAmI

The University of Jaén (UJA) is an institution committed to quality research and continuous improvement of teaching. Among its objectives is the transfer of knowledge and its impact on the economic and social environment, helping to improve people's living conditions (University of Jaen. Available online 2021). The Shanghai ranking positions UJA among the best in the world in Food Sciences and Technologies, Atmospheric Sciences and Computer Sciences. The 2021 edition of this ranking places the University of Jaén among the 300 top institutions in the world in scientific disciplines, maintaining a relevant position in the field of Computer Science (University of Jaen. Available online 2021).

In this context, the Center for Advanced Studies in Information and Communication Technologies (CEATIC) (University of Jaen. Available online 2021) of the UJA is part of the strategy to support research and teaching excellence as well as promoting knowledge transfer. It is a non-profit centre which brings together research groups, resources and instrumental means that enable the advancement of knowledge, development and innovation in the field of information and communication technologies through education, scientific research and excellence in technological development.

Currently, there are several research groups within CEATIC, bringing together numerous national and international projects of great prestige. The main lines of research are: Human Language Technologies, Intelligent Systems Based on Fuzzy Decision Analysis, Wireless Network Sensors, Big Data and Deep Learning and IoT Applications to Intelligent Systems, led by the Research Group Advances in Intelligent Systems and Applications under the ASIA acronym and code TIC-25 (University of Jaen. Available online 2021).

Within CEATIC, there is an intelligent laboratory based on Ambient Intelligence (AmI) called UJAmI. The SL proposal is focused on AmI (Gams et al., 2019), which is an information technology paradigm aiming to empower people's capabilities through digital environments. The goal of the UJAmI is the design of an apartment similar to a real one, which is adaptive and responsive to human needs, habits, gestures and emotions based on assistive technology in the home (Espinilla et al., 2018).

The laboratory is equipped with more than 130 sensors of more than 30 different types, enabling precise study and monitoring of the inhabitants. It is located in the Campus of Las Lagunillas of the UJA in the city of Jaén and has a usable area of 25 square meters. It is divided into three rooms: kitchen, living room and bedroom. Each of these rooms is equipped with certain sensors and devices controlled and monitored from a remote control and management system (Fig. 2).

Table 5 lists the sensors, devices and systems currently installed in the LL. The types of devices and their main functions are summarised in this table. The UJAmI is a changing environment, which is constantly being renewed, its equipment and applications being innovated and updated according to the latest advances in sensors and intelligent systems.

We have reviewed the contents, elements, intelligent devices, sensors, hardware and software systems installed in the UJAmI lab of the University of Jaén and note the diversity of environments and configurations that can be implemented in a limited space (Montalvá Colomer et al., 2014, Fagerberg et al., 2010). The existing literature on LLs or SLs indicates the importance of these laboratories for energy sustainability and climate pollution abatement (Voytenko et al., 2016, Evans and Karvonen, 2013, Baccarne et al., 2014, Silver and Marvin, 2016, Lupión et al., 2021). As such, the evaluated devices, after testing, can be brought to real life in a city, a care home, a residential building or any inhabited environment. Further deployment has the potential to bring about big advances towards the achievement of the SDGs.

In the following section we want to address the problem of assessing the SDG indicators, goals and targets in a LL laboratory. Thus, we will determine which are the main objectives to be assessed, quantify them and obtain a first estimation of a percentage representing the smart laboratory's SDG compliance. There are multiple tools, as we have seen in the previous sections, specifically in section 2, to evaluate and determine the importance of the SDGs and their contributions to intelligent systems applications and IoT in human environments. The aim is to evaluate whether they meet the daily needs of the people living in these environments, including but not limited to the elderly, the disabled or those with special needs, but also anyone who, for any reason, requires and can make use of advanced technological systems, such as sensors, Smart Grids or intelligent systems, to improve their quality of life (Sharda et al., 2021).

5. Evaluation of the SDGs at UJA's Living Lab

The UN SDG global indicator framework includes 244 indicators across its 17 goals and 169 targets. Nine of these indicators are repeated in two or more different goals, resulting in 232 unique indicators

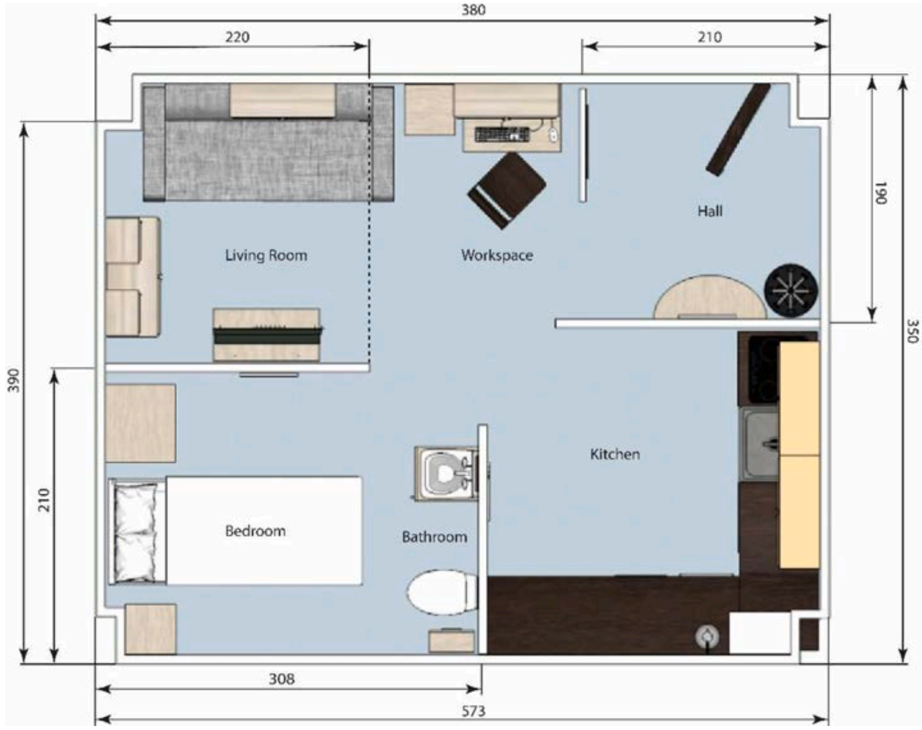

Fig. 2. Floor plan of the UJAmI laboratory.

(University of Jaen. Available online 2017, Indicators, 2021).

The case study evaluated here tries to frame the importance of the SDG in all developments, facilities and architectural and engineering designs in general and specifically that of the UJAmI laboratory of the University of Jaén. As detailed in the previous section, it is a laboratory that simulates an apartment, where smart devices, IoT systems, security, advanced elements for the control, supervision and monitoring of its inhabitants have been installed. Great importance has been given to choosing simple, intuitive, experimental and at the same time innovative and low-cost devices. Its ultimate goal is to serve as a pilot test for commercial and generic use in any real apartment, block of apartments or even other living facilities, such as nursing homes, centres for people with disabilities, centres for minors or any facility where people live.

The ultimate goal of this analysis is to obtain a quantitative and qualitative SDG assessment of a human living environment designed with intelligent systems. Such an environment should comply with the Paris Agreement, which states that SDG analysis should help to improve a facility, a territory or development to aid with climate change, sustainability and energy efficiency. One of the pillars of this analysis is the improvement of people's health through the use of advanced technologies and energy efficiency and savings, through devices that consume very little energy and, if possible, from renewable sources (Ahvenniemi et al., 2017).

A living laboratory (LL) is a platform for technological drive and transfer that can be analysed in an academic and controlled environment. It is equipped with tools for observation and improvement of the installed devices. An SDG evaluation in this field could be a taxonomy for the future design of sustainable and efficient apartments or living quarters, using the most advanced technology.

There can be several approaches to such an analysis. In this paper, we have taken a comprehensive approach through an SDG evaluation system where the main objectives and targets that can be applied to the evaluation of a LL can lead, for example, to a health objective (Korman et al., 2016, Kim et al., 2020). This, in turn, leads to improving sustainability, fulfilling dissemination and academic objectives by providing knowledge for the community of technology education professionals (Mazutti et al., 2020, Bronson et al., 2021), providing useful knowledge to drive energy and sustainability policy (Giles-Corti et al., 2020) or, from a purely technological perspective, advancing experimentation with innovative technologies (Kapur, 2019, Tundis et al., 2019).

Most sources and works on sustainable assessment in buildings focus on the analysis of one or several goals. In this work we have adopted a broader vision for comprehensive sustainability assessment based on the 2030 Agenda in which all SDGs and 232 indicators have been taken into account. Although some of the goals, such as SDG 14, cannot be assessed in this work, it has been included with the aim of quantifying and obtaining a final assessment for the analysis of the UJAmI lab. Table 8 (supplementary material), shows an analysis of the devices currently installed in UJAmI according to the established objectives and indicators, as well as suggesting possible improvements that can be implemented in the future. An evaluation has been carried out that offers us, on the one hand, a quantification and total percentage of the SDG indicators currently evaluated and, on the other hand, proposals for improvement. It also shows the systems and devices grouped by categories of sensors, including those that currently exist and others that may be installed in the coming years.

As detailed in (Mora-Sánchez et al., 2021), smart cities and smart laboratories are spaces in which the work carried out transcends the building or enclosed environment. These integrated and sustainable spaces will form their own eco-systems interconnected with the exterior and with other business, social, health and recreational platforms, allowing us to understand the concept of apartment or building from a more evolved perspective. This is why we decided to analyse all SDG objectives in this work.

Each of the SDGs is broken down into a set of targets and indicators. Table 6 analyses Goal 9: Build resilient infrastructure, promote sustainable industrialisation and foster innovation. Likewise, a review of all the SDGs and their targets and indicators has been carried out in relation to their alignment with the UJAmI smart lab. This work has been reflected in Table 8, which can be found as supplementary material to this manuscript, as well as on the associated web page. This table is available at the following URL: http://asia.ujaen.es/evaluation-sdgs-ujami.

A summary of all the indicators analysed and their value is also

Table 5
UJAmI Sensors and Devices.

Device	Group	Basic Functions
Environmental Sensors	Aqara Flood Sensor	Flood control and sending signals to other devices and actuators.
	Environmental sensor	Reports humidity, temperature and atmospheric pressure values. Can send signals to actuators or other devices.
	Aqara Vibration Sensor	Detects vibration in items, devices, etc. and sends signals to actuators or other systems in the environment.
	Motion and light sensor	Detects motion and lighting. Sends signals to other devices and actuators.
	Opening and closing sensor	Access control to rooms, opening and closing of appliances, furniture, others.
	SensFloor	Intelligent floor equipped with sensors. Detects movement, position, etc.
	SensFloor Sensor Mat Low-Resolution	Intelligent carpet to detect various scenarios.
	Samsung Smart Things	Control and monitoring of devices and systems.
	Arrival Sensor Samsung	Information and control of access and exit of people/animals.
	Mother (Hub)	Management and interconnection system of multiple intelligent devices.
	CO_2 and gas detector	Control and management of gases, CO_2. Interaction with alarm systems.
	Everspring	Motion sensor
	NFC tags	Passive devices that transmit information to other assets.
	Smart thermostat Nest	Energy control and efficiency.
Actuators	Philips HUE lamp	Control and management of lighting, color, intensity, ambience, etc.
	TP-Link lamp	Lighting and color control and management.
	Raspberry Pi	Computer control and management of devices.
	Schlage electronic lock	Control of access to environments. Interaction with other devices.
	Harmony Ultimate Hub	Control of multimedia devices and smart things inside and outside the laboratory.
	LG Watch Urbane	Smart watch that can connect applications, make phone calls and other functions.
	ConBee II	Bridge device that connects other elements, sensors and systems.
Indoor Location	Estimote Beacons	Beacon that emits signals to other actuators or intelligent systems.
	Estimote Stickers	Stickers are the world's smallest beacons. They have built-in sensors and can inform nearby phones not only about proximity, but also interactions with real-world objects.
	Estimote Mirror	A video beacon, which means that it broadcasts its presence over Bluetooth to all nearby devices, such as smartphones.
Vision Cameras	D-Link 5020L IP Camera	Video surveillance camera, with cloud storage function, which transmits image and sound in real time to any device connected to the Internet.
	D-Link Security Camera	Motion detection, image and video recording. Connection with alarms and other devices.
Multimedia	Samsung Smart TV 6400	Smart TV that integrates multiple multimedia services, internet access, connection to other devices, alarms and many other functions.
	SONOS ONE speaker	Intelligent sound system. Communication with other devices.
	X Box ONE Kinect	Peripheral for accessing game consoles and other devices, equipped with sensors, cameras and microphones.
Health Devices	Polar Smart Watch M600	Smart bracelet for health control and management, time information, environmental information, etc. Interacts with other devices and systems.
	HAPifork Smart Fork	Health control through food.
	Body+ Scale	Control and management of health, muscle mass, weight, hydration, etc.
Brain Interfaces	BrainLink Macrotellect	Smart headphones that detect brainwaves.
	Emotiv Insight	Emotion detection system and human-machine interaction.
Human Computer Interfaces	Amazon Echo	Sound assistant. Interaction with other devices.
	Leap Motion	Help and control system, through virtual reality.
	Graphic tablet	Help and control device, information management, etc.
Robots	BQ Zowi	Small interactive robot for entertainment.
	Bioloid Robotics	Educational robot kit which helps you learn the basics of structures and principles of robot joints.
	Robot Pepper	Personal assistant for help, management and control. Interaction with other devices and systems.
Software	Home Assistant Python	Intelligent management and control software.

included in Table 7 in the discussion section.

6. Discussion

In this work we have conducted an in-depth study on the importance of the analysis and evaluation of SDGs in smart laboratories (SLs), in which numerous systems, devices and sensors from all fields and disciplines are designed, deployed and tested. In this work, the SL evaluated was the UJAmI lab of the University of Jaén. In the scope of this work, we first conducted a study on the main SDG assessment tools used in business, institutional, academic or residential environments. These tools were extracted from a systematic literature review carried out with academic and institutional databases (Table 1). Numerous tools exist, but taxonomies and structured protocols are lacking in many fields of study, such as smart laboratories. We have not found any tool or model for this case.

By performing a multiple analysis methodology, as outlined in section 3, we have been able to check existing research, apply the knowledge found to our case study, and verify and implement our research questions.

UJAmI is a living laboratory that is in a continuous process of innovation, improvement and testing. In Section 4 we detail its architecture, design and a list of all the devices, sensors, systems, software and equipment installed in it. In addition, we have performed an evaluation of all these systems in order to perform a high-quality systematic, quantitative and qualitative analysis.

The final objective is to carry out an evaluation of the SDG objectives and indicators, and to conclude by establishing the number of indicators that can be analysed in the UJAmI lab at present and those that require future improvements. Tables 6, 7 and 8 show this analysis of the laboratory.

Finally, in section 5, we have performed an in-depth analysis of each SDG and indicator and their importance in the implementation of

Table 6
Evaluation and implementation of Objective 9 at the UJAmI Smart Lab 1

Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development (Indicators, 2021).	Evaluation of SDGs in the Living Lab UJAmI@Installed Devices and Systems 2				
	Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.				
Goals and targets	Indicators	Existing	Future	Installed Systems	Future Systems
9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all@	9.1.1 Proportion of the rural population who live within 2 km of an all-season road	0	0		
	9.1.2 Passenger and freight volumes, by mode of transport	0	0		
9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries@	9.2.1 Manufacturing value added as a proportion of GDP and per capita	0	1		Smart Grids Manager@Advanced environmental monitoring@Economic and environmental sustainability@Intelligent administrative management
	9.2.2 Manufacturing employment as a proportion of total employment	0	1		
9.3 Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets@	9.3.1 Proportion of small-scale industries in total industry value added	0	1		
	9.3.2 Proportion of small-scale industries with a loan or line of credit	0	1		
9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	9.4.1 CO2 emission per unit of value added	0	1		Smart Grids Manager@Advanced environmental monitoring@Intelligent administrative management
9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending@	9.5.1 Research and development expenditure as a proportion of GDP	1	1	Software	Intelligent administrative management
	9.5.2 Researchers (in full-time equivalent) per million inhabitants	0	1		
9.a Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States	9.a.1 Total official international support (official development assistance plus other official flows) to infrastructure	1	1		Advanced environmental monitoring@Circular economy control@Economic and environmental sustainability@Intelligent control and management of social funds@Intelligent administrative management
9.b Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities	9.b.1 Proportion of medium and high-tech industry value added in total value added	1	1		
9.c Significantly increase access to information and communications technology and strive to provide universal and affordable access to the	9.c.1 Proportion of population covered by a mobile network, by technology	1	1		Intelligent administrative management

(continued on next page)

Table 6 (*continued*)

Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development (Indicators, 2021).	Evaluation of SDGs in the Living Lab UJAmI@Installed Devices and Systems 2			
Internet in least developed countries by 2020				
		Current	Future	
Indicators evaluated. SDG 9		4	10	
%			33.3%	83.3%

1 Table 6 is a part of Table 8, supplementary material, which is available at the URL: http://asia.ujaen.es/evaluation-sdgs-ujami
2 The score given for each indicator is 0 or 1, depending on whether or not the indicator can be evaluated in the UJAmI lab. Current and future systems have been evaluated, taking into account existing and potential future sensors and devices, which are proposed as improvements for the smart lab.

Table 7
Summary of the evaluation of SDG indicators in UJAmI.

SDG	Number and of Indicators Evaluated in UJAmI				
	Current	%	Future	%	
1	End poverty in all its forms everywhere	1	7.7%	5	38.5%
2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture	1	7.1%	1	7.1%
3	Ensure healthy lives and promote well-being for all at all ages	5	17.9%	9	32.1%
4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	1	8.3%	12	100%
5	Achieve gender equality and empower all women and girls	1	7.1%	4	28.6%
6	Ensure availability and sustainable management of water and sanitation for all	5	45.5%	8	72.7%
7	Ensure access to affordable, reliable, sustainable and modern energy for all	0	0%	6	100%
8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	0	0.0%	4	25.0%
9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	4	33.3%	10	83.3%
10	Reduce inequality within and among countries	0	0.0%	5	35.7%
11	Make cities and human settlements inclusive, safe, resilient and sustainable	1	7.1%	9	64.3%
12	Ensure sustainable consumption and production patterns	2	15.4%	8	61.5%
13	Take urgent action to combat climate change and its impacts	2	25.0%	5	62.5%
14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development	0	0.0%	0	0.0%
15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	5	35.7%	10	71.4%
16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	2	8.3%	8	33.3%
17	Strengthen the means of implementation and revitalize the global partnership for sustainable development	6	25.0%	7	29.2%
	Total	36	15.5%	111	47.8%

existing smart systems at UJAmI. In addition, we have incorporated an analysis of future improvements and systems that are intended to be implemented in the laboratory in the coming years.

Among the categories analysed in this work, several can be considered essential for people's health. They correspond to the SDG indicators that take into account public health, digital health, autonomous energy systems associated with the maintenance and care of healthcare equipment, and the educational and training systems needed to train healthcare personnel in any part of the world. Industry, infrastructure, Smart Communities, Smart Human Cities and, in general, digitalisation in all areas, which inevitably entails the implementation of IoT systems, will substantially improve people's health.

Other studies and resources, such as the sustainable management tool developed by the English National Health Service (Hewitt et al., 2019), have obtained interesting results, aligning the SDGs with modules and cross-cutting sections to health. This approach guided our work. We have also analyzed other sources, such as Silva's study on business contributions to sustainability implementation (Silva, 2021). In our research, in addition to the quantification of the impact of the objectives in the UjamI laboratory, the method and parameters for the verification of environmental regulations can be transferred to other teaching or industrial laboratories. There is still much analysis to be done in this area, in addition to the development of a protocol and taxonomies of its own.

Table 7 details the conclusions drawn from the data analysis set out in Table 8 (supplementary material). Table 7 indicates the figures corresponding to the SDG compliance results obtained in the evaluation of each objective and the overall outcome. For a better understanding of Table 7, please refer to Table 8. It reflects a full analysis of the data extracted from the assessment of the SDGs at UJAmI, showing that the UJAmI lab is equipped with devices, sensors and energy systems that have the capacity to impact the SDGs, their targets and indicators, directly or indirectly.

We note here that our statistics indicate compliance with 36 SDG indicators assessed, which represents 15.5% of the total indicators, according to the Global Indicator Framework for SDGs and the Agenda 2030 targets.

7. Conclusion

Intelligent systems, sensors, Smart Grids, energy efficiency systems, ubiquitous tracking and monitoring, data control and environmental management and monitoring are some of the many technological applications that can be deployed in our environments and that we increasingly find in our homes, workplaces or public spaces. Experimental laboratories, such as SLs or smart labs, are essential for testing, researching and implementing technologies that can be transferred to society in compliance with quality and efficiency standards. In this work we have conducted an analysis to study the evaluation tools of the SDGs, specifically applied to the case study of the UJAmI smart lab of the University of Jaén.

A multiple methodology has been used based on a systematic review, an analysis of the tools obtained and a case study. The main objective has been met and the research questions posed have been answered. More and more innovative and original systems are being developed which are adaptable to any situation and territory, as we have verified in the literature review. In addition, it can be demonstrated that IoT applications benefit public health and sustainability according to the SDG indicators. At the beginning of this work, we posed the following research questions:

RQ1.: What SDG assessment tools exist and what are the parameters and analysis vectors of these tools?

RQ2: Are SDG assessments being conducted in LLs, and do these assessments provide quantitative or qualitative analyses, or both?

RQ3: What assessment can be conducted at the LL of the University of Jaén, UJAmI, that would allow us to make a real assessment of the SDGs in this case study?

We have answered RQ1 and RQ2 in sections 1, 2 and 3 of the paper and question RQ3 in sections 4 and 5.

The results obtained indicate that compliance with the SDG indicators in the UJAmI lab is currently at 15.5%, which could reach 47.8% with the proposed measures to be implemented in the future. This will be achieved by installing new systems and improving existing ones.

In the research conducted we can highlight the following aspects: a) in the proposed analysis we have detected a set of SDG assessment tools for residential, institutional and educational environments that can help to resolve issues and conflicts that may arise when certifying the quality and veracity of the smart systems installed in the UJAmI, in line with the commitment to meet the SDGs; b) to improve the innovation and development of smart systems, sensors and devices that can contribute to sustainable development in terms of the environment, society, the economy and health, it is necessary to follow the standards proposed by the SDGs and their indicators; c) it is necessary to implement research and systems in living laboratories, such as UJAmI, to meet the regulatory quality standards demanded by an increasingly technological and connected society, without forgetting environmental protection, health and energy efficiency; d) the data obtained from the multiple applications implemented will allow greater control of the population's safety, improving societies in all territories, which will lead to improvements in institutional management and governance; e) security will be important and, therefore, must be taken into account for the management of smart systems and applications aimed at improving public health and efficiency; f) the SDGs must be a vehicle for the development of the intelligence of cities, homes, environments, etc., offering their goals and objectives as a framework for the design, installation and management of the technology to be implemented.

Declaration of Competing Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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Supplementary materials

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