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# Approach to the Technical Processes of Incorporating Sustainability Information—The Case of a Smart City and the Monitoring of the Sustainable Development Goals

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**Abstract:** Currently, the concern for achieving and fulfilling the Sustainable Development Goals (SDGs) is a constant in advanced societies. The scientific community and various organisations are working on obtaining an information system that will make it possible to offer the necessary value to this type of sustainability information. The article aims to incorporate criteria on the technology used in the reporting system, specifically in collecting the different types of data and generating other interfaces. The methods described here are carried out on a specific case study, a Smart City, showing the different types of data that exist and the possible interfaces that allow objective monitoring of the achievement of the SDGs. It is, therefore, a descriptive study of a process whose results are the establishment of criteria concerning the different data sources as well as the generation of a set of interfaces that motivate the monitoring that can be carried out in a specific city to observe its compliance and deviations from critical values, for example, environmental. The main conclusions of this research establish the importance of incorporating and sizing the technology needed to develop the criteria for monitoring the SDGs. There is a need for convergence between the correct, objective and universal provision of this type of sustainability information and the technology used for the collection and presentation of the data.

**Keywords:** sustainability information; SDGs; technological processes

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## 1. Introduction

Today, monitoring the different Sustainable Development Goals (SDG) is a growing concern involving states and individuals in their ambition to achieve sustainable and time-bound development [1–3]. Although already widely described in more recent literature, the SDGs were adopted by the United Nations in 2015 as a universal call to end poverty, protect the planet and ensure that by 2030 all people enjoy peace and prosperity [4,5]. Seventeen SDGs are integrated into the concept of Sustainable Development, as we can see in Figure 1 [6]. Each of the goals has specific targets that serve to monitor it; for example, in the case of SDG number 11, "Sustainable Cities and Communities", the specific targets for 2030 are (in summary) [7]:

- Ensure access for all people to adequate, safe and affordable housing, and essential services and to improve slums.
- Provide access to safe, affordable, accessible and sustainable transport systems for all and improve road safety.
- Increase inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable planning and management.
- Strengthen efforts to protect and safeguard the world's cultural and natural heritage.
- Significantly reduce the number of deaths caused by disasters, including water-related disasters.

- Reduce the negative per capita environmental impact of cities.
- Provide universal access to safe, inclusive and accessible green spaces and public spaces.
- Support positive economic, social and environmental linkages between urban, peri-urban and rural areas by strengthening national and regional development planning.
- Significantly increase the number of cities and human settlements that adopt and implement integrated policies and plans to promote inclusiveness, resource efficiency, climate change mitigation and adaptation, and disaster resilience.
- Provide support to least developed countries, including through financial and technical assistance, to enable them to construct sustainable and resilient buildings using local materials.


**Figure 1.** Sustainable Development Goals (United Nations).

Sustainability as a concept encompassing sustainable development emerged in 1987 with the publication of the Brundtland report [8]; this report was primarily concerned with the negative consequences of economic growth and globalisation and already, at that time, tried to begin to put solutions in place. In its eagerness to achieve social progress, environmental balance and economic growth, the United Nations drew up a roadmap called the 2030 Agenda, which focuses precisely on the promotion of sustainable development [9], understanding environmental sustainability [10], social sustainability [11] and economic sustainability [12], which are pillars of sustainability. The current context manifests the need for monitoring the SDGs due to the possibilities of expanding production and wealth.

Along with the growing and necessary concern for achieving sustainable development goals, there is a need to incorporate criteria for measuring the progress toward achieving these goals [13,14]. The basic process of supporting measurement to lead to subsequent comparability involves collecting information, mainly reports and statistics, which provides the broadest possible field of data on the issue in question [15]. Once the data are collected, they are then stored in certain systems according to the specific concern of the researcher or organisation, looking at each variable in relative terms to standardise and work with it in the same way. Therefore, the situation of the scientific community is marked by the problem of trying to measure the sustainability of the territory through comparative studies that facilitate decision-making to face the guidelines of the 2030 Agenda. (In 2000, leaders from 189 countries gathered at the United Nations to commit to the Millennium Declaration, a landmark document in which they pledged to achieve a set of eight measurable goals by 2015: the Millennium Development Goals (SDGs). In 2015, the SDGs were replaced by the action plan adopted by 193 UN member states—Transforming our World: The 2030 Agenda for Sustainable Development—which already set out the 17 SDGs and 169 associated targets) [16].

This article aims to delve into the technical phases of the development of data capture and subsequent incorporation into interfaces and storage systems, in line with the concern for the dissemination of the SDG principles to support the current recommendations of bodies such as the World Benchmarking Alliance, ACCA (Association of Chartered Certified Accountants), ICAS (Institute of Chartered Accountants of Scotland), Chartered Accountants (Australia—New Zealand) and IFAC (International Federation of Accountants) [17]. The aim is to shed light on essential aspects of dissemination, such as how straightforward the process must be or the connectivity of the information itself, and understanding the positive impact of the integration of the SDGs in organisations, specifically in the following areas:

- Business model.
- Consideration of risks and opportunities in the external environment.
- Strategy to create value and avoid harm.
- Risk management.
- Other key organizational processes.

It is essential to point out that the specific concern of this article focuses, as previously introduced, on knowing and understanding optimal systems for data capture and their arrangement in an interface [18,19]. As will be seen in the proposed case of a Smart City, it is essential to know, technically, the different types of data that exist in terms of their source, as well as the ability to work on their integration in the most appropriate systems for each case. With all of the above, the aim is to make progress in the provision of data through the automation of processes that serve to make the data available to the management of organisations or specific institutions so that they can carry out their sustainability reports in the most optimal way. This will undoubtedly result in the optimisation of the presentation of a company and organisation's sustainability report within the whole motivation of corporate social responsibility.

In a clear and determined way, the novelty of the incorporated research is given by the advancement in the integration of data in a system for monitoring compliance with the SDGs in a Smart City environment. As we have already introduced previously and as will be seen throughout the article, the current concern is working on measures to monitor compliance with the SDGs; however, in this article, we go a step further by incorporating technical aspects that are taken into account in the data capture processes and their subsequent incorporation into an interface. This issue must be worked on in parallel with scientific and accounting researchers that are concerned with incorporating the SDGs in their sustainability reports.

To develop the article, in the second section, we see the primary process of report integration in our case study, which is a Smart City. In section three, also referring to the Smart City case, we proceed to incorporate a vision of convergence with interfaces and recommendations. Finally, we set out the discussion and conclusions.

## 2. Basic Principles of the Data Integration System—The Case of a Smart City

Information, and more specifically the process of capturing it, is an element that arises precisely from the development of knowledge of raw data. The relationship between information and technology has always been a differentiating factor in any society, reaching its maximum exponent with the study of data transmission in any communication process. The use of information as a resource lies in its systematisation and access. The systematisation of information involves technological and organisational factors, as well as the nature of the information itself (in our case, it is linked to the monitoring and measurement of the achievement of the SDGs).

The technical aspects that define any information system include the following:

- To whom the information is directed → Executives and managers.
- Those who are indirectly nourished by the information → The environment.
- The support in the form of software and hardware.
- Methodologies and organisation.

What underlies all of the above is the linkage, through optimal process mapping, between information systems and technology, giving rise to what is known as information technology; this is the central issue on which this article works. By information technology, we mean processes that use a combination of means and methods of data collection, processing and transmission to obtain new, quality information about the state of an object, technique or phenomenon. The purpose of information technology is the production of information for people to analyse and make decisions based on this information to carry out a given action.

The main characteristics of information technologies are:

- User operation in data manipulation mode (no programming).
- Transversal information support at all stages of information transmission on an integrated database provides a unique way of entering, searching, displaying, updating and protecting information.
- Document processing.
- Solution of interactive tasks.
- Collective production of a document.
- Adaptive processing of the form and modes of presentation of information in the problem-solving process.

For the development of our work, we have taken as a reference a simulation of an average city in an environment that is certainly developed in such a way that it has adequate connections and transport, as well as modern and old infrastructures, and which requires the integration and fulfilment of the SDG objectives. The city does not necessarily have to be the capital of the nation or the region; our ambition is to make the study applicable to as many cities as possible in developed countries. The population of the city we take as a reference comprises people of all ages, both old and young. In the city that functions as a simulation, activities from all known sectors of the economy operate and have a place.

Focusing on our case study, Smart City, the technical processing method used in data capture is a process of heterogeneous nature due to the diverse sources from which these data can come [20]. This heterogeneity reflects the diversity of devices and protocols within the Internet of Things (IoT) technology paradigm. Their mere existence makes it challenging to standardise the data obtained and to standardise the data collection processes.

A typical data concentrator is needed that can act as an input buffer for the data by receiving data from various standardised sources and can offer the most generic solutions possible in the absence of specific developments. The functions of such a hub can be grouped into a platform and should have the following data collection options:

- Direct sources. This consists of taking data from existing sources that can be processed directly to then be added to the platform. This type of source must allow the import of standardised data sources such as files with standard formats or the import of data from a URL by making requests to it.
- Databases. Data management platforms should also allow the import of databases for cases where data are already structured and stored.
- Derived sources. This type allows transformations to be performed on data collected from direct sources.
- Connection with IoT devices or their gateways. The platform must also be able to collect data directly from IoT devices or the gateways responsible for managing them if they exist.

All these options are implemented by the Deep Intelligence Platform (deepint—Deepint.net) which is a platform hosting different forms of data ingestion. These ways of ingesting and transforming data include the following:

- Direct sources. CSV, JSON, XLSX, ODS or SQL file uploads. In addition, URL queries can be carried out in a personalised way, as this type of data capture allows the URL to be specified with security parameters and other types of processing to obtain the

data in the cleanest possible way. Another option it allows is the automatic periodic updating of this type of query.
- Databases. Regarding this type of data capture, deepint offers multiple options from relational databases such as SQLite, MySQL and Oracle and other non-relational databases such as MongoDB or InfluxDB.
- The ability to perform derived sources is used to filter unnecessary data for some actions, such as using partial data for graphs or using normalised data for Artificial Intelligence models.
- Finally, the direct connection with IoT devices can be made through publication/subscription. It can be used for the direct connection of the project stations to send data to the platform.

When all the data are collected, the sources have other characteristics that favour the standardisation of the data according to the available data report for Smart Cities of the relevant national or international institutions. Among this standardisation, objectives integrated into the platform, which can be seen in Figure 2, are:

- Definitions of the metadata and characteristics of the data, which allows them to be described to facilitate their reuse.
- Elaboration of taxonomies, which can be done through the title and description of the data source, making it fully configurable for the user.
- Unique identification of data, which is supported in the backend of the platform to avoid duplicates.
- Sustainable infrastructure for automated data publication. As previously mentioned, external data sources can be automatically updated regularly.

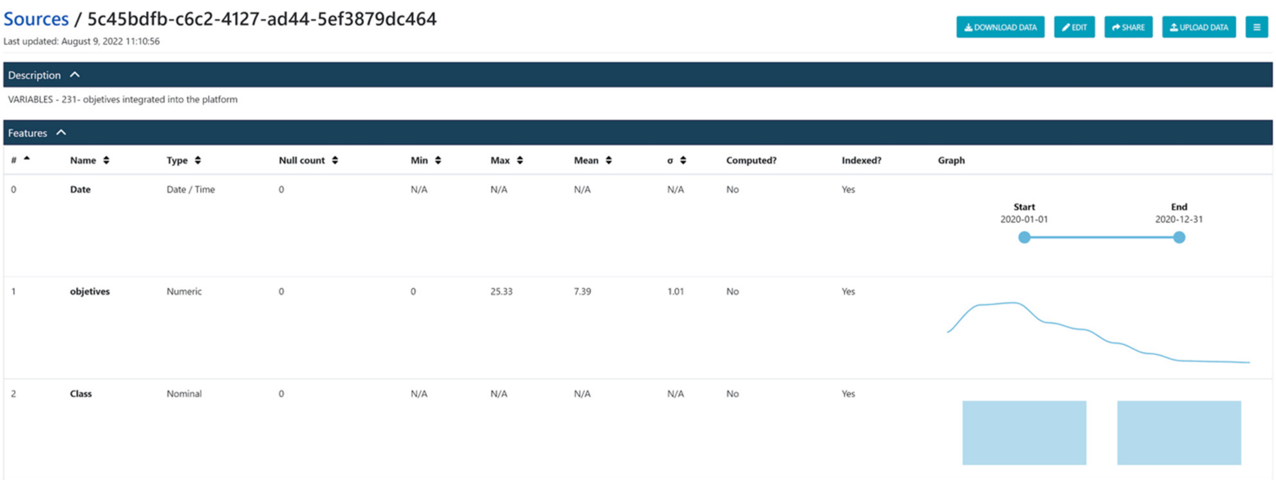


**Figure 2.** Objectives integrated into the platform.

It is essential to capture the importance and lessons learned from the principles of the data integration system outlined here, which allow for the proposal and incorporation of an appropriate methodology. The methodology in question essentially comprises the following main phases:

1. Data entry.
    - Style of information.
    - Volume.
    - Data retrieval.
    - Preferred indexing.
    - Data structure.
    - Response time/Available Resources.
2. Data capture.
    - Manual input for low volumes of data.

- Advanced Optical and intelligent recognition.
- Voice capture.

3. Data types.
4. Data cleaning.
5. Data integrity.
6. Data coding.
7. Data transformation.
8. Data translation.
9. Data summaries.
10. Data aggregation.
11. Data validation.
12. Data modelling.
13. Data analysis.
14. Statistical data analysis.
15. Data visualisation.
    - Complying with the central precepts of:
        - Understand the data you are trying to visualise, including their size and cardinality.
        - Determine what you are trying to visualise and what type of information you want to communicate.
        - Know the audience and understand how they process visual information.
        - Use a visual that conveys the information in the simplest and best way for your audience.
16. Data storage.
17. Data mining.
    - Main elements:
        - Extraction, transformation and loading of transaction data into the data warehousing system.
        - Storing and managing data in a multi-dimensional database system.
        - Providing access to data for analysts and information technology professionals.
        - Analyse data by application software.
        - Present the data in a useful format.
18. Data interpretation.

In a general way, each of the points outlined here are part of the methodology proposed and are sufficiently important to be taken into account in any technological process of data incorporation; they represent the basis. Specifically, this article focuses on the methodology points one to three and, in the following section (concerning the interface), on points 15 to 18 (it is these points of the methodology where the deepint.net tool plays a significant role).

All these characteristics are used by different projects to integrate the maximum amount of data possible, which provide indicators of the city's potential to be more sustainable, and it's present and future capacity to meet and continue to meet the Sustainable Development Goals (SDGs).

## 3. Optimisation of the User Interface

Today, cities and regions are the most significant data producers, and all major sectors can obtain information and benefit enormously from data analysis [21]. Thanks to computing advances, especially in artificial intelligence techniques, data can now be processed at high speeds that were unimaginable just a few years ago. As a result, significant investments have been made in information and computing, either by acquiring technologies to retrieve and process data or by investing in highly qualified profiles to carry out accurate research. As a result, platforms such as deepint [22] have emerged, designed to bridge the "gap" between the current need to create an intelligent field and the high fees usually required for tools and data scientists and were built for Smart City/region managers.

To build the visualisation interface associated with this research, deepint has been used as it facilitates all aspects of data storage and visualisation once collected and processed. Deepint has already been used in other cases related to Smart Cities, smart buildings and mass data management, as can be seen in a work developed by Juan Manuel Corchado and other authors in 2021 [23].

For the creation of the system related to the graphical interface of the system, the processed data (explained in previous sections) has been taken and stored in a persistence system, to be later accessed through external data sources by deepint. From these, a set of visualisations focused on usability have been created to later aggregate them into thematic dashboards with some SDGs, allowing the monitoring of indicators related to the achievement of these goals and helping to raise awareness of their importance and attainment.

Some of the thematic dashboards created for these ecosystems are presented below. The first dashboards relate to goal 11 on "Sustainable Cities and Communities". For this purpose, a dashboard has been created, visible in Figures 3 and 4, where the monitoring of air quality can be seen with several indicators, focusing mainly on $CO_2$ in the city where the user is located.

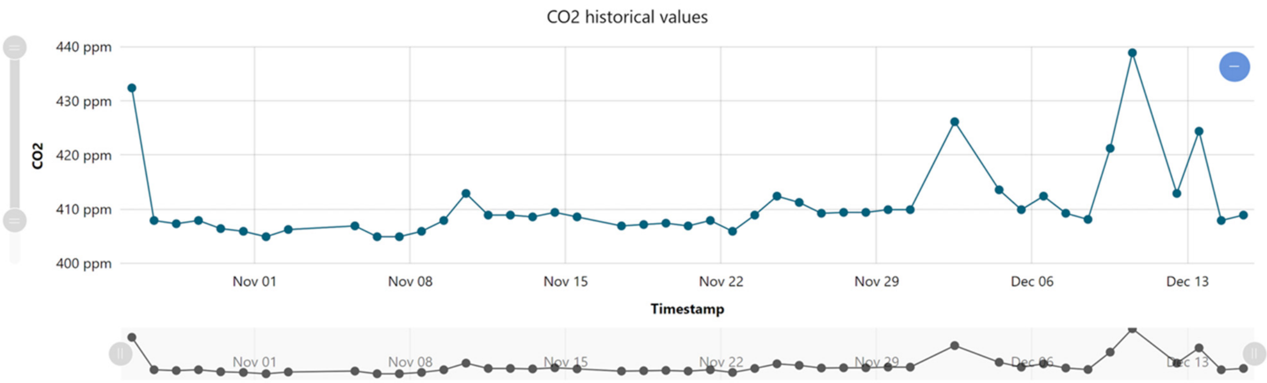


**Figure 3.** Real-time evolution of $CO_2$ levels in the area where the user is located.

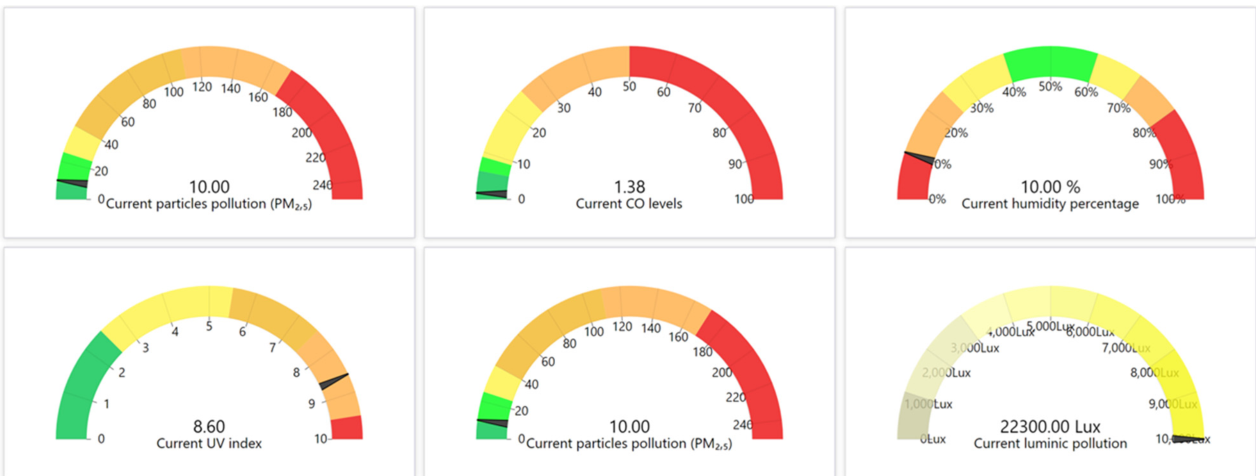


**Figure 4.** Current values of various air quality indicators in the area where the user is located.

The third dashboard (Figure 5) is oriented toward climate change objectives. For this purpose, it is possible to track changes in climate indicators by comparing to previous years in the region where the user is located. This is done to detect possible changes in these indicators that provide further information on rising temperatures and how these affect flora and fauna, both terrestrial and marine.

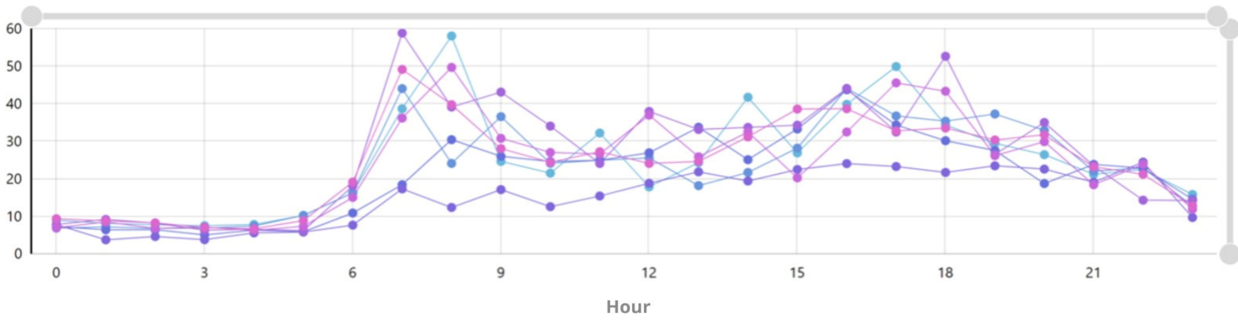


**Figure 5.** Comparison of several years (one per line) with the maximum temperatures reached for each of the weeks of the year in the same region. It is worth highlighting that the represented values consist of the mean of multiple sensor measurements (coming from various environments like private houses, buildings, streets, etc.) and is disposed in the Fahrenheit scale.

The fourth dashboard (Figure 6) is aimed at monitoring pandemics, for which information has been taken from the recent COVID19 pandemic. It consists of a SIRD model that allows the prediction of the evolution of the pandemic using a probabilistic mathematical model, adaptable to any future scenario with another disease that expands in a specific population.

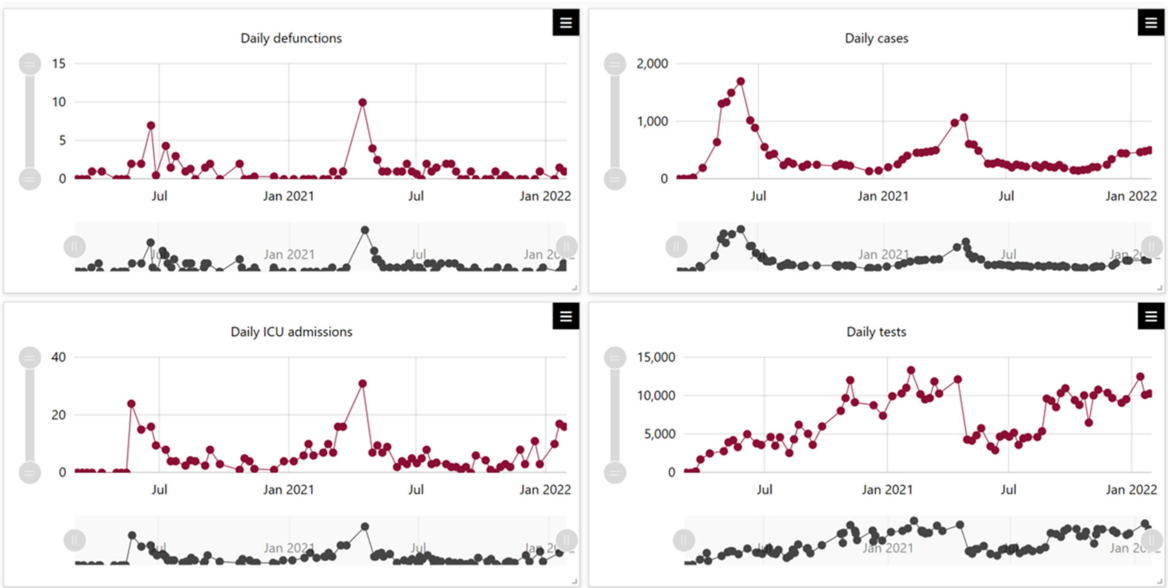


**Figure 6.** Example of indicators of COVID19 pandemic evolution.

Finally, as an example, Figures 7 and 8 show information on energy consumption and waste generation in the area where the user is located so that the user is informed about the situation in their area.

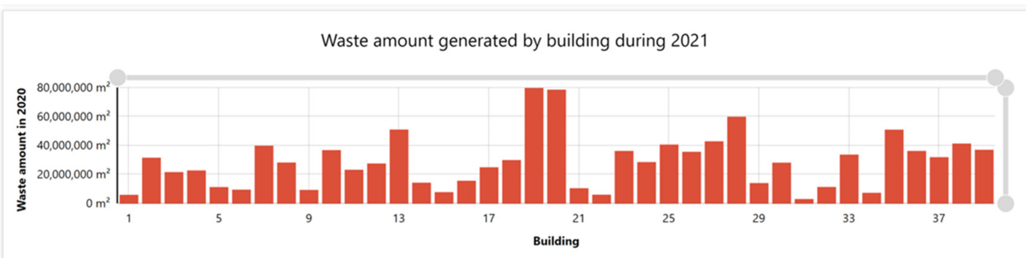


**Figure 7.** Indicators of sustainable consumption from waste generation during the year 2021.

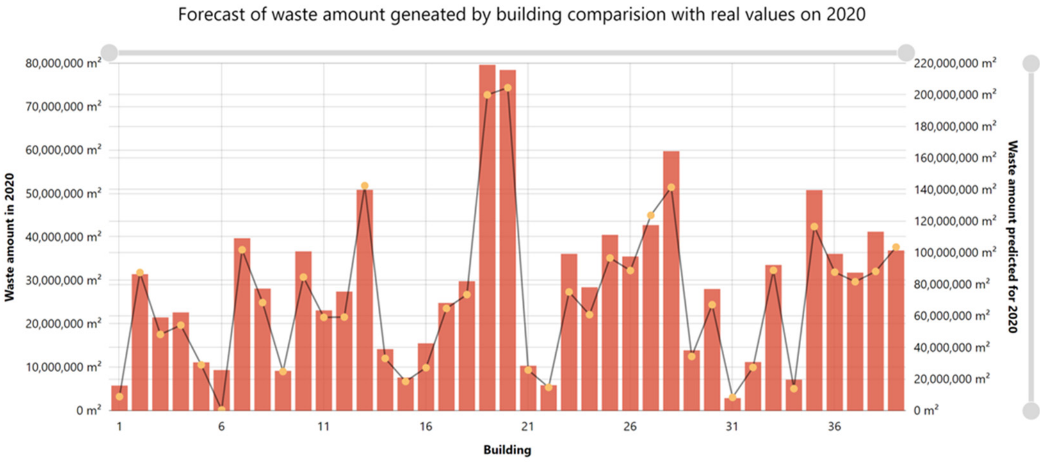


**Figure 8.** Comparison of responsible consumption based on waste generated in a city between 2020 and 2021.

## 4. Discussion

Throughout this work, we have incorporated and motivated the capacity of specific systems and techniques to automate the capture of different types and sources of data on a simulated Smart City. Their characteristics have been marked in the second section.

Our concern has been to incorporate optimisation criteria in terms of the different technologies used to group and present data to facilitate decision-making before incorporating and producing sustainability reports.

The technological processes incorporated in the study are based on the case of a Smart City that needs to be monitored by the authorities so that, in our case study, it can meet and report on the achievement of the SDGs focused on the 2030 Agenda.

There is a recent and growing concern about the measurement and comparability of the degree of achievement of SDGs by managers and directors of different institutions and organisations. Even more recent is the problem of how to technically optimise the engineering process in capturing and generating interfaces that facilitate user interaction [24,25].

The article incorporates the need to work on critical aspects of performance and reporting capabilities from a technological point of view without neglecting the organisational perspective. This is why work is carried out in a simulation environment on the incorporation of data and the generation of interfaces that enable the availability of robust reports that are capable of offering the appropriate importance and urgency in the face of possible deviations that may arise in the technical process of monitoring the development of a Smart City by the fulfilment of the SDGs.

The article has an important limitation of working on a simulation of a specific city. Furthermore, the simulation represents an average city in advanced countries, and this, although integrative, leaves out other types of cities.

The article, and expressly the technology incorporated within the quality of the urgency with which specific information must be presented, should in the future include the establishment of an alarm system that allows the authorities to work in real-time and prevent the deviations that may occur from becoming more significant.

Finally, although it is not a limitation of the study itself, a homogenising framework for presenting sustainability information in the field and monitoring sustainability is currently being developed. This could eventually change whether there is a need for a primary source.

In future work, the data sources listed here, the capture procedure and interface integration can be developed into a confirmed case of a city that could benefit from the automated monitoring and tracking of SDG compliance.

## 5. Conclusions

Throughout this article, we have taken a closer look at data capture systems and the development of a set of interfaces that can display objective and valuable information for those pursuing the achievement and convergence of the SDGs.

The different SDGs imply not only a mere agreement of the intentions of a set of nations but also that they must be involved in a firm and determined reporting system that can track the achievement of the targets and assess the deviations from those targets.

It is essential at this point to introduce the first conclusion concerning the current concern about the determination of a sufficiently uniform and objective system that allows for global monitoring of the achievement of the SDGs. In fact, in the scientific community, certain bodies and professionals at the international level are working continuously on a system for disseminating and reporting the SDGs by institutions and other organisations. Although there is also work currently being done on the processes of data collection, storage and presentation, the importance is not as great as for objective monitoring measures, which is entirely logical because it is understood that there must first be firm steps in progress concerning the indicators that make up the goals and, therefore, the targets. Even so, there can and should be parallel developments concerning possible data collection that have been corroborated by the international community regarding their relevance for incorporation as SDGs.

Once the evident importance of the value of progress in technical studies that result from optimisation and efficiency has been made, these studies must address the necessary differentiation of the data according to their sources, with some of them being considered critical and others with a periodicity and temporality that means they do not have to incorporate the specific data urgently or in real-time. Therefore, it is necessary in any SDG-monitoring activity to know the amount of data that we are faced with because the amount of direct sources, static databases, derived sources or connections with IoT systems, i.e., it is necessary not only for management and management planning but also for the technical planning of the required data capture systems and interfaces that work with them. The technologist must know how to pre-process CSV, JSON, XLSX, ODS or SQL files from direct sources, as well as, for example, whether static databases are based on SQLite or MySQL protocols.

A third conclusion, also of a technical nature, is the importance of the dimensioning of the interface in the process of displaying data via an interface. This system of interfaces can incorporate the necessary alert systems and automated reports that require a weekly, monthly, or quarterly periodicity, that is to say, that which is not marked with a temporality such as that of the annual. Working with the interface, in addition to showing the periodic reports that may finally be considered necessary, allows the manager to be permanently connected to the reality of monitoring and compliance with the criteria set for achieving the SDGs. This work will be the manager's day-to-day work, and they must clarify the layout of these graphs and figures so that they can discern, as objectively as possible, what is essential and what is urgent concerning the monitoring of the SDGs.

In conclusion, this research highlights the importance of incorporating the necessary technology in establishing the SDGs monitoring criteria. From a case study of a Smart City, we can conclude that there is essential convergence between the ideas of reporting about the information of what is happening in a city concerning its compliance with the SDGs and the technology used for reporting, meaning the process from collecting to displaying the data through an interface.

Finally, although not alluded to in the article, cybersecurity will be a precept that must be taken into account in terms of monitoring the technology that can be used to ensure that cyber-attacks do not attack the systems being used for reporting.

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