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Digital Government as Implementation Means for Sustainable Development Goals

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ABSTRACT

One of the challenges for implementing Sustainable Development Goals (SDGs) is the measurement of indicators that represent progress towards such goals. Measuring such progress enables data-driven decision-making and management of SDG-relevant projects and strategies. The premise of this research is that measuring such indicators depends on measuring so-called means of implementation, i.e. activities that directly contribute to the achievement of SDGs. Building on this premise, this article studies how the measurement of digital government (DG) can contribute to the measurement of SDGs. In particular, how the indicators originating in three DG measurement instruments can inform the SDG indicators. The main finding is an alignment matrix, showing how the DG indicators contribute with varying level of specificity to the measurement of 10 SDG indicators.

KEYWORDS

2030 Agenda For Sustainable Development, Digital Government, Electronic Government, Networked Readiness Index, Sustainable Development Goals, Sustainable Development Indicators, UN E-Government Survey

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INTRODUCTION

The world development agenda is summarized in 17 goals that aim at protecting the planet, ensuring peace and prosperity, and fulfilling related targets by the year 2030. These goals – known as the 2030 Agenda for Sustainable Development or the Sustainable Development Goals (SDGs) – prioritize areas such as climate change, economic inequality, sustainable consumption, innovation, peace, and justice (United Nations Development Program, 2016), while simultaneously balancing three dimensions of sustainable development: social inclusion, economic development, and environmental sustainability.

The SDGs build on the process of the Millennium Development Goals (MDGs), a set of eight time-bound and quantified goals that led the worldwide efforts to meet the needs of the world's poorest between the years 2000 and 2015. Although the MDGs have been considered the most successful anti-poverty movement in history (United Nations, 2015a), they have been criticized on a number of accounts (UN System Task Team on the post-2015 UN Development Agenda, 2012).

One of them is that the efforts were mostly focused on the goals but not enough on the means for achieving them (Bhattacharya & Ali, 2014). Acknowledging this shortcoming, the SDGs point out that the Means of Implementation (MoI) are key to the realization of the SDGs and that they are equally important as the rest of the goals and targets. The agenda also dedicates one full goal (SDG#17) to the articulation of such means. The MoI are a mix of financial resources, technology development and transfer, capacity-building, inclusive and equitable globalization and trade, regional integration, as well as the SDG-enabling environment on the national level, particularly in developing countries (Technical Support Team of the Open Working Group on Sustainable Development Goals, 2014).

The MoI that are relevant to this research are the ones related to technology and, more specifically, to digital technologies, as well as data and statistics for monitoring and accountability. Innovation and technological advancements are needed to meet the aspirations of the SDGs. The challenge is to develop concrete and sustainable innovation and technology collaboration opportunities to enable countries at all levels of development to take advantage of available technologies. Strengthening the supply of data and statistical information is also necessary to monitor progress, conduct integrated policy analysis, and effectively implement the 2030 Agenda. Official statistics that adhere to the Fundamental Principles of Official Statistics (United Nations, 2014) and support the efficient production of high-quality SDG data are crucial for achieving such an ambitious agenda (United Nations Economic and Social Commission for Asia and the Pacific, 2017).

The concept of the MoI, however, is broader than just gathering resources; it also encompasses the institutional frameworks and governance issues required for achieving the SDGs. Governance is crucial for implementing the 2030 Agenda because it underlies all of the SDGs. Good public governance – the formal and informal arrangements that determine how public decisions are made and how public actions are carried out (OECD, 2011) is essential to achieving the SDGs (OECD, 2016).

Governments face a range of pressures including economic, political, environmental, and cultural demands. The utilization of technology, and in particular digital technologies, allows them to respond to such pressures more efficiently and in more transparent and accountable ways. Digital government (DG) refers to the use of digital technologies as an integral part of governments' modernization strategies to ultimately create public value (OECD, 2014). The role digital technologies play in government affairs has evolved as technological advancements and social demands have evolved, pushing governments to shift from a citizen-centric to a citizen-driven model, where the focus is on engaging institutional and non-institutional stakeholders in public value creation rather than focusing on the internal government coordination and collaboration (Ubaldi, 2013).

Janowski's DG evolution model (Janowski, 2015) describes the incremental stages of technology adoption in government, starting with digitization (or the use of technology in government) – the adoption of technology to represent information in digital formats; followed by transformation

(or electronic government) – the application of digital technology to improve internal processes, structures, and working practices in government organizations; followed by engagement (or electronic governance) – the improvement of the relationships between government and its constituencies; to contextualization (or policy-driven electronic governance) – technology-enabled government that enables territories, communities, and citizens to pursue development actions by themselves. Therefore, DG is more relevant to the SDGs as the adoption of digital technology by government institutions reaches the contextualization stage.

DG has become a development enabler, helping advance the delivery of basic and advanced services in various policy areas, such as education, health, employment, social welfare, and finances. It plays a critical role in making institutions more inclusive, transparent, and effective. It also enables countries, regions, cities, communities and other territorial and social units to pursue sustainable development objectives (United Nations Department of Economic and Social Affairs, 2016).

The core DG indicators along with methodologies to compile data for them were first identified in 2007 (United Nations Department of Economic and Social Affairs, 2016) and later extended in 2011 (United Nations Economic Commission for Africa, 2011). Even though DG is not explicitly mentioned in the 2030 Agenda, these indicators can contribute to the understanding of the DG impact on the SDGs. In this line, Hongbo Wu, the Under-Secretary-General for Economic and Social Affairs of UNDESA, expressed that, "In a world where Information and Communication Technologies (ICTs) are ever more present and economies and people are increasingly interconnected, governments and institutions have more opportunities than ever to connect with their communities. The expansion of e-government has great potential for the future sustainable development of the world" (UNDESA, 2016).

In this context, this article focuses on how existing DG measurements can contribute to the measurement of SDGs. To this end, the rest of this paper is organized as follows. Section 2 explores the literature in the field and positions this research in the context of existing and related work. Section 3 presents the key questions and objectives addressed by this research, as well as the adopted research methodology. Section 4 concentrates on the importance of measuring SDGs and the role of DG in enabling data-driven decision making towards them. Section 5 focuses on the processes for monitoring and reporting progress towards the achievement of the SDGs. The selection of the DG measurement instruments is explained and justified in Section 6. The results and findings of this research, including the definition of an instrument to measure the alignment among indicators are presented in Section 7. The validation of the results and policy recommendations are put forward in Section 8. Finally, Section 9 presents the conclusions and proposes a way forward for this research.

LITERATURE ANALYSIS

A review of the literature on the intersection of DG and sustainable development (SD) was undertaken to comprehend the existing work and discourses in this field. A frequency analysis based on the keywords search was performed on the Scopus database. Table 1 shows the results of the search, which coincide with the findings of (Estevez & Janowski, 2013). The initial set of research publications looking at the intersection between DG and SD dates back to the year 2000, and only less than 20 papers on this topic were published during the decade of 2000-2010. There is, however, a manifested interest in the field with the number of publications growing in the last five years.

In an editorial published in late 2016 backing the importance of DG for the implementation of the SDGs, Janowski pointed out that the literature concerning the connection between DG and the SDGs was still missing and advocated for more research focused of this area (Janowski, 2016). The research foundations for how to utilize DG in support of SD (EGOV4SD) were set in 2012 when two frameworks – one for conceptual research and another for research assessment in EGOV4SD – were proposed (Estevez & Janowski, 2013). Later, the same authors analyzed 10 case studies of existing DG initiatives with explicit SD objectives, finding significant differences between the EGOV4SD

Table 1. Results of literature search at the intersection of DG and SD

Keywords	#returned (#relevant)	Filters
"digital government" AND "sustainable development"	6 (3)	-
"electronic governance" AND "sustainable development"	142 (49)	-
"e-government" AND "sustainable development"	17 (13)	-

initiatives carried out by developed and developing countries (Estevez, Janowski, & Dzhusupova, 2013).

The literature review identified that most existing work concentrates on the relationships between DG and SDGs, or between technology and SDGs, but mostly at the targets' or goals' levels, not going more in-depth to the indicators' level. For instance, the WSIS-SDG Matrix (WSIS Forum, 2015) – the result of a mapping exercise that linked the World Summit on the Information Society (WSIS) Action Lines with the SDGs with the aim of strengthening the impact of ICTs on sustainable development – identified that the DG work led by WSIS can directly contribute to five SDG targets. The UN E-Government Survey (United Nations Department of Economic and Social Affairs, 2016) also contains a matrix linking the assessment parameters used in the survey to the goals and targets of the 2030 Agenda and identified 23 WSIS targets that can contribute to SDGs. The upcoming edition of the survey will, however, deepen the DG link to the SDGs by conducting analytical research related to specific SDGs.

The WSIS-SDG Matrix identified 71 SDG targets to which WSIS can be relevant (WSIS Forum, 2015). Similarly, the Partnership on Measuring ICT for Development identified 31 targets where ICT indicators and available datasets can contribute to SD. The aspiration-capacity gap for implementing SDGs with DG identified 19 technology-related targets scattered across the SDGs, where only four directly relate to digital technologies and the remaining 15 require digital technology as a tool to support other technological developments (Janowski, 2016). The ICT & SDGs report (Sachs et al., 2016) argues that ICT indicators account for seven SDG targets. Only looking at the SDGs from the level of the goals, the report (International Telecommunication Union, 2017) explains how utilizing advanced ICTs can contribute to achieving all SDGs.

Two main findings came up from the literature review. First, that there is no unique list of SDG targets to which DG or ICTs are directly related. This could be because there are different definitions of what makes DG or ICT relevant to SDG monitoring and because such definitions allow different interpretations. To address this challenge, this research defines and utilizes an instrument (a bi-dimensional alignment matrix, proposed in Section 7) to assess the relevance of the indicators based on clear criteria. The matrix focuses on the indicators' level and provides a mechanism for specifying the level of alignment, correlation, contribution and relevance among the indicators. The second finding is that the analysis is done at the targets' or goals' level, a higher level of abstraction than the indicators. Thus, there is a risk of inaccurate identification of the results. Some of the studies reviewed for this work utilized keywords to map targets (or goals) from different instruments and the results are legitimate at that level. However, when analyzed more deeply by considering the indicators underlying those targets, the results are different. For instance, target 7.a (clean energy research and technology) was identified as a technology-related target across the SDGs (Janowski, 2016); however, analyzing its indicators, the focus is not on digital technologies but on financial support for renewable energy production. Looking at the data at the indicators' level is the approach adopted in this research which, to the best of our knowledge, differentiates the analysis undertaken here from existing work.

RESEARCH DESIGN

The premise underlying this work is that existing measurement activities and instruments from different domains can contribute to the measurement of SDGs. Bearing in mind that several efforts and investments for measuring DG efforts have been made, and that valuable experience, lessons, and good practices have been gained over a long period of time in measuring DG performance, it can be expected that DG measurements can positively contribute to the measurement of SDGs.

To confirm this expectation, the following research questions will be investigated: Q1) how are the SDG indicators reported from the national to the international level? Q2) what existing DG indicators are relevant to measuring the SDG indicators? and Q3) what are the limitations and possible enhancements to the DG indicators to better inform the measurement of the SDGs?

To answer the first question, a detailed description of the ecosystem, including the actors, components, relationships, and processes for monitoring and reporting the SDG indicators was prepared based on the literature review. To answer the second question, a mapping exercise between the indicators of the DG measurement instruments and the indicators of the SDG Global Indicator Framework (GIF) was conducted. The mapping exercise consisted of: i) selecting a subset of the DG measurement instruments to analyze from all instruments available, ii) identifying and normalizing individual indicators considered by the selected instruments, iii) cross-tabulating the indicators identified in the previous step with the 232 unique indicators of the SDG GIF, iv) validating the indicators identified in the previous step by crossing the results with the targets identified in similar studies, and v) identifying the level of impact and alignment among the indicators based on the proposed alignment matrix. The last question was answered through the analysis of the obstacles, limitations, and barriers identified throughout this study. To overcome them and to foster the efforts for monitoring the progress towards SGDs, a list of recommendations and suggested corrective actions was formulated to improve existing instruments and practices.

MEASURING DEVELOPMENT

Peter Drucker, the well-known management thinker, is attributed to the idea that if something cannot be measured, it cannot be improved (The Drucker Institute, 2013). Measuring is a way of quantifying progress to be able to adjust decisions to achieve the desired outcomes. Only by measuring development, data-driven evidence-based decision making, which is critical for developing implementation strategies and allocating resources correctly, can be pursued.

The United Nations Economic Commission for Europe (UNECE) defines development as an increase in the well-being across members of a society between two points in time (UNECE, 2009). From this definition, measuring development is about measuring and comparing the evolution of well-being along time. Traditionally, development was measured by purely economic concepts of well-being, neglecting the environmental and social dimensions because, among other reasons, the social dimension has proven to be challenging to measure (Stevens, 2005).

While there are different approaches to measuring development, two of them have been the most widely used. One consists of selecting and enumerating a number of indicators; the other entails developing a reduced set of accessible and easily understood indicators (Stevens, 2005). However, indicators present two significant limitations as a means to measure development: they do not provide much insight into the interrelations among the various measures and they usually only consider quantitative data, excluding the qualitative analysis which could depict the development reality in more comprehensive ways (Veenhoven, 2002). Composite indicators – compilations of individual indicators – is one of the approaches followed due to their ability to integrate large amounts of information into easily understood formats and to help address the interrelations and trade-offs among indicators (Stevens, 2005). This approach can be useful for measuring SDGs, where the trade-offs between the social, economic, and environmental pillars must be balanced.

Sustainable Development Measurement

Extending the UNECE definition of development (UNECE, 2009), SD can be interpreted as increasing the well-being over a very long time while ensuring that fulfilling the current needs do not compromise the ability of future generations to meet their own needs (Brundtland, 1987). Measuring progress towards SD helps ensure the accountability of all stakeholders for achieving the SDGs. Nevertheless, the main challenge for measuring SD is understanding and considering the linkages and trade-offs across the environmental, economic, and social dimensions. The establishment of the SD indicators has been, for many countries and institutions, a key opportunity to move environmental issues higher up in the policy agenda alongside economic and social issues. Efforts to measure SD date back to the early 1970s, where the SD indicators were first discussed in the environmental economics literature (UNECE, 2009). Since then, many activities were conducted to advance and standardize the way SD is measured. Some remarkable milestones were the adoption of the Agenda 21 in 1992 when 183 countries agreed on the development of a novel set of indicators able to provide a solid basis for decision making at all levels to contribute to self-regulating sustainability of the integrated environment and development systems (United Nations, 1992). In that same year, the United Nations Commission on Sustainable Development was established to, among other tasks, monitor countries' efforts in developing and using SD indicators (UNECE, 2009).

During the 1990s, some countries developed their own SD indicator sets. In 2002, the World Summit on Sustainable Development held in South Africa received several of the SD strategies and related indicator sets prepared by countries for the summit. However, a major limitation of the nationally-based attempts to measuring SD is limited insights into trans-boundary effects or the impacts on global sustainability (Stevens, 2005).

During the 2000s, the Organization for Economic Co-operation and Development (OECD) worked on measuring SD focusing on the integrated economic, environmental and social frameworks that could be used for statistical development of the sustainability indicators (OECD, 2004). Eurostat also developed a set of SD indicators to support the European Union's Sustainable Development Strategy that was adopted in 2005 and updated and monitored regularly since then (European Commission, 2016).

Since the adoption of the 2030 Agenda in September 2015 (United Nations, 2015b), the GIF (United Nations, 2017a) – a set of 232 indicators to measure 169 STG targets – has become the globally accepted instrument to measure SD. SDG indicators are the backbone of monitoring progress towards SDGs at the local, national, regional, and global levels. While the National Statistical Offices (NSOs) have traditionally been responsible for the development of the SD indicators, their compilation and publication in many countries and international organizations is the responsibility of environment-related ministries or other bodies outside the statistical community. What is important is that, regardless of the agency responsible for producing the SD indicators, the underlying data should adhere to the fundamental principles of official statistics established by the United Nations (UN) as any other official statistical information (UNECE, 2009).

Digital Government Measurement

Measuring DG enables the formulation of policies and strategies for effective government. Reliable and relevant DG measurements are essential to assess whether decisions are being made correctly and whether they are leading the government development in the right direction. Furthermore, measurable improvements in the DG programs are sometimes considered a good investment since they make governments appear modern and transparent. The approach to measuring DG is typically based on individual indicators and composite indices developed by international organizations, academic institutions, and individual countries (United Nations Economic Commission for Africa, 2011). While globally-comparable indicators are needed for understanding the status of DG, such indicators must reflect locally-defined policy goals instead of trying to enforce a one-size-fits-all generic measurement approach.

The results of different measurement exercises show that the development of DG is at different stages in different countries and, in general, developed countries are relatively more advanced in their use of ICT for improving the functioning of the public sector and service delivery than developing countries (United Nations Economic Commission for Africa, 2014). The methodologies applied range from country-level surveys of government organizations to highly complex web-based surveys, and the scope of the studies include single countries, regions, and global measurement. Primary instruments to measure the status of DG are listed and briefly described below:

- **UN E-Government Survey** (United Nations Department of Economic and Social Affairs, 2001)**:** carried out by the Division for Public Administration and Development Management of the United Nations Department of Economic and Social Affairs (UNDESA), it covers all UN member states, making it the most comprehensive instrument. UNDESA has led the effort of conducting this survey since 2003. The latest edition focuses on e-government for SD and emphasizes the importance of ICT and e-government as tools to realize the SDGs (United Nations Department of Economic and Social Affairs, 2016).
- **Measuring the Information Society** (ITU, 2017)**:** published by the International Telecommunication Union (ITU) and reported since 2009, the report features critical ICT data and benchmarking tools to measure the information society, including the ICT Development Index (IDI). The IDI measures the progress in ICT development in 155 countries through a composite index of 11 indicators grouped in three clusters: access (ICT readiness), use (ICT intensity), and skills (ICT capability). The 2017 edition remarks that ICT applications in certain areas – including government – will contribute to accelerating the attainment of the SDGs (International Telecommunication Union, 2017).
- **Information Economy Report** (United Nations Conference on Trade and Development, 2005)**:** published annually by the United Nations Conference on Trade and Development (UNCTAD), it analyses current trends and major international policy issues regarding ICTs and their use for, and effect on, trade and development. The latest edition of the report focuses on digitalization, trade, and development, and highlights how harnessing the power of ICT can be one of the keys to success in the implementation of the 2030 Agenda (United Nations Conference on Trade and Development, 2017).
- **Partnership on Measuring ICT for Development** (International Telecommunication Union, 2010)**:** launched in 2004, it is an international, multi-stakeholder initiative seeking to improve the availability and quality of ICT data and indicators, particularly in developing countries. With a core set of indicators that can be compared on a global basis and assist developing countries in collecting data and tracking progress over time, the latest edition covered 68 countries with seven indicators (out of a total of 50) specific for measuring ICT in government (United Nations Economic and Social Council, 2016).
- **Networked Readiness Index** (World Economic Forum, 2016a)**:** prepared by the World Economic Forum (WEF) since 2001, it ranks how countries are doing in the digital world by measuring how well their economies are using ICTs to boost competitiveness and well-being. The latest index focuses on the role of innovation in the digital economy and compares the role of ICTs for 139 economies around the world to improve economically and socially (World Economic Forum, 2016b). One of the findings is that although most regions have registered a decline in the impact of ICT on government efficiency in the period 2012-2016, a recovery was starting by the end of that period.
- **Government at a Glance** (Organisation for Economic Co-operation and Development, 2017)**:** produced by OECD, the report compiles and compares data on the delivery of public services among 42 countries and across 10 policy domains through 58 indicators of good governance. A remark from the 2017 edition is that the use of DG services has tripled in OECD countries since

2006. OECD has collected government data since 1996, and this data empowers governments to understand their own practices better and provide different stakeholders with detailed comparisons useful to understand the international situation.

- **Digital Public Services in Europe (European Commission, 2017a):** a digital progress report prepared annually by the European Commission to analyze and report on the trends in ICT-enabled benefits for public services (including e-government studies). Based on the Digital Economy and Society Index – a composite index that summarizes relevant indicators on digital performance and digital competitiveness (European Commission, 2017b) – the 2017 edition considers 31 indicators grouped in five dimensions including connectivity, human capital, use of the Internet, integration of digital technology, and digital public services.
- **The Future of Government:** a series of reports prepared by experts and leading practitioners from some of the most advanced governments and international organizations, published by the WEF. The reports discuss how the strategies, structures, and practices of governments must change and how technologies can be leveraged to transform government capacity. The latest edition advocates for agile governance enhanced by new technologies to allow closer collaborations with citizens as value co-creators (World Economic Forum, 2017).
- **Waseda International Digital Government Ranking (Waseda University, 2005):** produced yearly by the Waseda University (Japan) since 2005, it is a ranking based on a group of indicators and sub-indicators to evaluate the overall DG development in a country. The most significant change in the 2017 edition in comparison with previous editions is the recognition of the transformation from e-government to DG since the latter is more comprehensive (Waseda University, 2017).

There are several other instruments for measuring aspects of DG at the international, regional, national, and local levels, but their analysis goes beyond the scope of this article.

Measuring the Impact of Digital Government on Sustainable Development

DG refers to the use of digital technologies to advance governance processes. Although DG is not explicitly mentioned in the 2030 Agenda for Sustainable Development it plays the role of MoI since both technology and governance are classified as non-financial MoI (Bhattacharya & Ali, 2014). While the former is a systemic MoI focused on providing access to information, communications, and other technologies to strengthen transformative and innovative processes, the latter focuses on improving national governance capabilities and institutions. Governance is central to any development effort and good governance is a necessary condition in achieving any form of development; therefore, governing the SD process is critical for achieving SDGs (Estevez & Janowski, 2013).

The relevance of the intersection between these two MoI (Estevez & Janowski, 2013) along with the lack of sufficient research on it (Janowski, 2016) has been made explicit. In the same line, the literature analysis conducted earlier in this paper shows that, although an interest in the field is increasing based on the growing number of publications in the last five years, further research is still needed. Consequently, this paper aims to contribute to this arena by studying how existing efforts in measuring DG could inform the measurement of SDGs in terms of monitoring and reporting progress towards SDG targets.

Since the MoI are key to realizing the 2030 Agenda and are of equal importance with other goals and targets (United Nations, 2015b), the relevance of DG across all SDGs, and in particular to SDG#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) and SDG#17 (strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development) is high.

Existing research advocates for relevant role that DG should play in the implementation of the 2030 Agenda and, subsequently, that national DG capabilities should be strengthened to embrace this role (Janowski, 2016). This research advocates for joining efforts of different DG measurement exercises to improve the measurement of SD.

MONITORING & REPORTING DEVELOPMENT

SDG indicators help countries monitor and report on their progress towards SDG goals and targets. The data underpinning the SDG indicators, primarily produced by the national statistical systems, needs to maximize international comparability and the time series consistency with the data produced at the international level. Data collection from the national to international level should be primarily based on existing reporting mechanisms to avoid duplication. Therefore, the national coordination is critical to producing data from national to international level since all international data should comply with international methodological standards and particularly with the Fundamental Principles of Official Statistics (United Nations, 2014) – a set of rules and basic standards guiding state-of-the-art high-quality statistical work, and the Principles Governing International Statistical Activities (United Nations Statistical Division, 2015) – good practice aiming to enhance the functioning of the international statistical system.

SDGs Monitoring and Reporting Ecosystem

The main actors in the ecosystem for monitoring and reporting progress on the SDGs are the United Nations Statistics Division (UNSD), the Inter-agency and Expert Group on SDG Indicators (IAEG-SDGs), the member states represented by their NSOs, and the UN agencies. The UNSD, a division under UNDESA, compiles and disseminates global statistical information, develops standards and norms for statistical activities, and supports countries' efforts to strengthen their national statistical systems (United Nations Statistics Division, 2018b). While its main mandate and focus are on the global indicators, it is also responsible for maintaining the global database of the SDG indicators and for producing the annual progress reports. The IAEG-SDGs is a body created by the UNSD to be responsible for the development and implementation of the GIF for the goals and targets of the 2030 Agenda (IAEG-SDGs, 2018). The group is composed of member states which on a rotating basis represent regions, certain UN agencies acting as observers, and the Chair of the United Nations Statistical Commission (UNSC). The UNSC is the highest body of the global statistical system. It brings together the Chief Statisticians from the member states and is the highest decision-making body for international statistical activities, especially for setting up statistical standards, and for the development of concepts and methods and their implementation at the national and international levels. The UNSC oversees the work of the UNSD (United Nations Statistics Division, 2018a).

Countries are the main entities responsible for the review and follow-up of the progress made in the process of implementing the SDGs. National ownership is essential to achieving sustainable development as they are able to take local realities, capacities, and levels of development into account (Food and Agriculture Organization of the United Nations, 2015). NSOs are members of the IAEG-SDGs, they are in dialogue with the UNSC and UN agencies on the monitoring and reporting of the global indicators. The role of UN agencies is to be custodians of the global indicators. Their responsibilities include collecting data from national sources, capacity building, providing storylines for the annual global SDG progress reports, providing and updating metadata, and working on further methodological development. Furthermore, custodian agencies are responsible for coordinating with other agencies and stakeholders interested in contributing to the indicators.

The Global Indicator Framework

The GIF was developed by the IAEG-SDGs. It comprises 232 unique indicators (United Nations, 2017a). These indicators are classified into four types: global, thematic, regional, and national. Global indicators comprise the minimum set of internationally-comparable indicators that countries are expected to report on at the global level; thematic indicators are a more comprehensive set of internationally-comparable indicators that countries may use to report on progress at the global level; regional indicators are specific indicators, common to countries within a specific region, which may also be developed to collectively monitor and report on progress; and the national indicators are intended for monitoring at the country level and include context-specific indicators essential for monitoring and regulating national development (United Nations Educational Scientific and Cultural Organization, 2016).

Intending to help identify indicators which require focused efforts, the GIF also classifies the SDG indicators in a 3-tier system, according to their level of methodological development and the availability of data at the global level (United Nations, 2017b). Indicators are considered to be in Tier I when they are conceptually clear, have internationally established methodologies and standards, and data are regularly produced; Tier II indicators are also conceptually clear, have internationally established methodologies and standards, but data are not regularly produced by countries; if internationally established methodologies or standards are not available but under development, the indicators are classified as Tier III. The classification changes as methodologies are developed and data availability increases. In the latest update dated December 2017, the tier classification contained 93 Tier I indicators, 66 Tier II indicators, and 68 Tier III indicators. In addition, there are five indicators that belong to multiple tiers (different components of the indicators are classified into different tiers).

SDGs Monitoring and Reporting Process

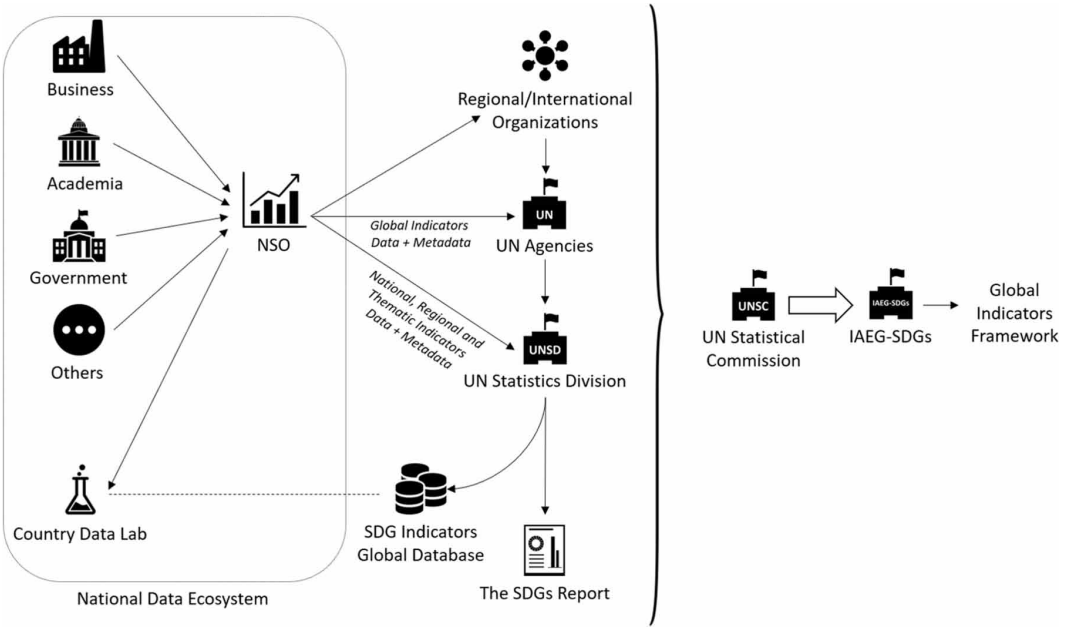
The national statistical systems – typically represented by the NSOs – collect data from the national data ecosystem, which includes organizations from the private sector, academia, and other government entities. Once data is consolidated at the national level, it is reported (along with the corresponding metadata) to the custodian agencies and other relevant regional and international organizations. National monitoring of the global indicators has the support for each indicator of a custodian UN agency that reports annually to the UNSD. Some indicators have, in addition to the custodian(s), the support from other partner agencies. For example, ITU and the UNESCO Institute for Statistics (UIS) are the custodians for the indicator 4.4.1 – the proportion of youth and adults with ICT skills, by type of skill – while OECD plays the role of a partner agency for this indicator. All these data populate the SDG Indicators Global Database maintained by the UNSD. National data is also stored in the country data labs. Coordinated by the UNSD, SDG Data Labs are responsible for capturing, managing, presenting, disseminating and offering ready access to all relevant human development data on one common database platform (United Nations Statistics Division, 2018a).

For thematic, national, and regional indicators, countries report directly to the UNSD. The UNSD interacts directly with the NSOs, sometimes through the Regional Economic and Social Commissions, and with the agencies directly involved in data collection and survey instruments. To illustrate the actors involved in the monitoring and reporting of the SDGs and to provide an understanding of the governance of the data for SDGs refer to Figure 1.

DIGITAL GOVERNMENT AND SUSTAINABLE DEVELOPMENT

The criteria for selecting the DG measurement instruments used in this research include the level of penetration (i.e. the number of countries from which data is collected), the relationship to DG, and the span of time over which the measures were taken. Based on these criteria, three instruments

Figure 1. The SDGs monitoring and reporting ecosystem



were selected: the UN E-Government Survey, the Networked Readiness Index (NRI), and the Waseda International Digital Government Ranking.

The UN E-Government Survey produces the E-Government Development Index (EGDI), a composite index with three dimensions to obtain a holistic view of DG at the country level. The three dimensions are: the Telecommunication Infrastructure Index (TII) which measures the adequacy of the telecommunication infrastructure; the Human Capital Index (HCI) which measures the ability of human resources to promote and use ICT; and the Online Service Index (OSI) which determines the availability of online services and content. Combined, EGDI includes 17 indicators and the latest edition (2016) covered 193 countries. ITU is the primary source of data for each indicator of the TII; UNESCO and the United Nations Development Programme (UNDP) collect the data for the HCI; and UNDESA supervises the data collection for the OSI, which is carried out by researchers and qualified graduate students and volunteers from universities in the field of public administration.

The NRI is a composite indicator comprising four main categories (sub-indices), 10 subcategories (pillars), and 53 individual indicators distributed across the different pillars, which are measured in 139 countries and economies. The data is obtained from ITU, UNESCO, the World Bank, and other UN agencies for 29 individual indicators, while the other 24 indicators are derived from the Executive Opinion Survey conducted by the World Economic Forum (WEF). Only the former 29 indicators are considered for this study since the 24 indicators relying on the opinion survey do not have factual data that can inform the SDGs.

The Waseda International Digital Government Ranking measures 10 main indicators and 35 sub-indicators in 65 countries and economies. The process is carried out through three steps: web search, a questionnaire administered to government officers and the last review by experts from the International Academy of CIO (International Academy of CIO, 2018). The respondents are government officers who work for a ministry that concerns DG and, to some extent, the respondents from academia who are knowledgeable about DG (Waseda University, 2017).

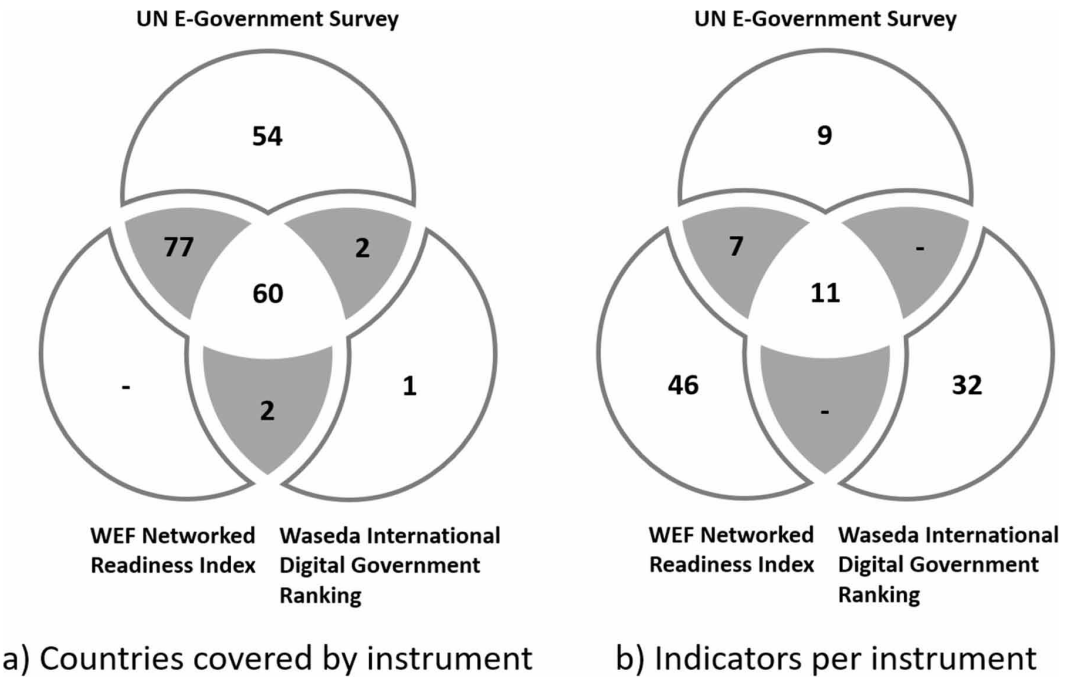
These instruments, despite having similar objectives, look at DG from different angles and with different levels of detail; therefore, when considered together as a larger instrument, they provide a

more holistic view of DG. Combined, the three instruments obtain data from all 193 UN member states and three economies, measure 95 unique indicators closely related to DG (105 individual indicators in total) and have been measuring DG for more than 10 years (since 2003, 2001 and 2005 respectively). These numbers, which support the selection of the instruments, are summarized in Figure 2.

RESULTS AND FINDINGS

From the mapping and subsequent validation of the indicators, the authors found out that 10 SDG indicators which determine 10 targets from seven different goals, can be informed by the three DG instruments selected. To determine alignment between the indicators, a two-dimensional alignment matrix was defined. The two dimensions are completeness and correlation, each of them assessed on a two-level scale. Completeness represents the degree to which one indicator has all necessary data to determine the other indicator. For the purpose of this article, completeness signifies the degree to which the DG indicators contain all necessary data required to determine the SDG indicators. The level of completeness is defined as partial or complete; if the data collected by the DG indicators only informs a subset of the data required by the SDG indicators, the level of completeness is considered partial. Similarly, if the level of disaggregation of the data collected by the DG indicators is lower than the level of disaggregation demanded by the SDG indicators, the completeness is considered partial. Correlation determines the relationship between the two sets of indicators' data for DG and for SDGs.If the DG indicators' data is weakly relevant to the measurement of the SDG indicators, the correlation is considered partial. Otherwise, the correlation is considered direct. A discussion on how the DG indicators can inform the SDG indicators is presented below, organized by the SDGs.

Figure 2. Countries and indicators covered by the three DG measurement instruments



Goal 1 – No Poverty

SDG#1.4.1 measures the proportion of the population living in households with access to basic services. The indicator is under the custody of UN-Habitat with UNICEF and WHO as partner agencies, and is currently classified as Tier III (United Nations, 2017b). Since access to the Internet is considered a new basic service necessary for all people (WSIS Forum, 2015), the "percentage of households with Internet access at home" reported by the NRI (with data from ITU) directly informs on Internet as a basic service at the household level. However, the NRI indicator only partially informs the SDG indicator since it does not offer data about all basic services but just about Internet access. Although the level of data disaggregation meets the SDGs demands, disaggregation by gender, economic level, geographical location, etc. would be useful to empower decision makers when developing strategies and allocating resources.

Goal 4 – Quality Education

SGD#4.3.1 measures the participation rate of the youth and adults in formal and non-formal education and training in the previous 12 months, by gender. The indicator is under the custody of the UIS, with OECD, Eurostat, and the International Labour Organization (ILO) as partner agencies, and is currently classified as Tier II (United Nations, 2017b). The indicators "Gross enrolment ratio" (the total number of students enrolled at the primary, secondary and tertiary level, regardless of age) of the EGDI-HCI, and "Secondary education enrolment rate" combined with the "Tertiary education enrollment rate" of the NRI can partially inform SDG#4.3.1 by providing information on formal education for both, young and adults. The indicator "Mean years of schooling" (average number of years of education completed by people from 25 years old) of the EGDI-HCI could complement the information about enrolment to provide a more holistic view of participation in formal education. The data for all these indicators are collected by the UIS, the custodian of SDG #4.3.1.

Goal 5 – Gender Equality

SDG#5.b.1 measures the proportion of individuals who own a mobile telephone, by gender. The indicator is under the custody of ITU and is currently classified as Tier I (United Nations, 2017b). The indicators "Mobile subscribers per 100 inhabitants" (number of subscriptions to mobile service in the last three months) of the EGDI-TII, along with the "Mobile telephone subscriptions per 100 population" (subscription to a public mobile telephone service that provides access to the telephone network using cellular technology) of the NRI offer mobile phone subscription data from 193 UN member states (137 measured by both of them). However, none of them disaggregates the data by gender (in their final reports) so they cannot completely help reduce gender inequalities.

Goal 7 – Affordable and Clean Energy

SDG#7.1.1 measures the proportion of the population with access to electricity. The indicator is under the custody of the World Bank. with UN-Energy as a partner agency, and is currently classified as Tier I (United Nations, 2017b). The indicator "Electricity production, kWh/capita" of the NRI could inform access to electricity by individuals but the way it is calculated – total electricity production divided by total population – does not represent the proportion of the population but an average of electricity available per person, which does not respect the premise of the 2030 Agenda of leaving no one behind.

Goal 8 – Decent Work and Economic Growth

SDG#8.6.1 measures the proportion of youth (aged 15–24 years) not in education, employment or training. The indicator is under the custody of the ILO and is currently classified as Tier I (United Nations, 2017b). The indicators "Gross enrolment ratio" (combined primary, secondary and tertiary gross enrolment ratio) of the EGDI-HCI, and "Secondary education gross enrollment rate" and

"Tertiary education gross enrollment rate" of the NRI (both prepared by UNESCO) could partially contribute to SDG#8.6.1. The information is partial because it only considers formal education (excluding employment and training) and because it does not consider age.

Goal 9 – Industry, Innovation and Infrastructure

SDG#9.c.1 measures the proportion of the population covered by a mobile network, by technology. The indicator is under the custody of ITU and is currently classified as Tier I (United Nations, 2017b). The indicator "Mobile network coverage rate" of the NRI, which measures the percentage of inhabitants who are within range of a mobile cellular signal, irrespective of whether or not they are subscribers is useful to evaluate this SDG indicator. The NRI collects this data from 137 UN member states and has a clear methodology that could be used for the remaining countries. There are five other indicators from the DG instruments with data about mobile usage, but they measure subscriptions, which are different from coverage.

Goal 16 – Peace, Justice and Strong Institutions

SDG#16.6.2 measures the proportion of the population satisfied with their last public service experience. The indicator is under the custody of UNDP and is currently classified as Tier III (United Nations, 2017b). The Government Online Service Index measured by UNDESA and reported by the NRI, which assesses the quality of government's delivery of online services to citizens, can partially and indirectly inform citizens' satisfaction with public services. Similarly, the E-Participation Index (E-PI), a supplementary index to the UN E-Government Survey reported under EGDI-TII, could also be used to partially and indirectly inform the level of satisfaction of the population with public services offered online by their governments.

SDG#16.10.2 measures the number of countries that adopt and implement constitutional, statutory and/or policy guarantees for public access to information. The indicator is under the custody of the UIS, with the World Bank and UNEP as partner agencies, and is currently classified as Tier II (United Nations, 2017b). The sub-indicator "Legal Framework" under the Open Government category of the Waseda International Digital Government Ranking could directly and completely inform, for 63 countries it surveys, about the presence of regulatory frameworks for access to information. The "Open Government Data" of the EGDI-OSI, despite analyzing open government data, does not focus on the legal frameworks for public access to information but on the availability of open data sets. Therefore, this indicator could indirectly and partially contribute to the measurement of SDG#16.10.2.

Goal 17 – Partnerships for the Goals

Two SDG indicators that measure the availability of technology for the SDGs can be informed by the DG indicators. Both indicators are under the custody of ITU and both are in Tier I (United Nations, 2017b). SDG#17.6.2 measures the fixed Internet broadband subscriptions per 100 inhabitants, by speed. The indicator "Fixed broadband subscriptions per 100 inhabitants" (fixed subscriptions to high-speed access to the public Internet at downstream speeds greater than or equal to 256 kbit/s) of the EGDI-TII, as well as "Fixed broadband Internet subscriptions per 100 population" of the NRI directly inform SDG#17.6.2.

#SDG17.8.1, which measures the proportion of individuals using the Internet, can be directly informed by the EGDI-TII indicator "Internet users per 100 inhabitants" (individuals who used the Internet from any location in the last three months), "Percentage of individuals using the Internet" (proportion of individuals who used the Internet in the last 12 months) compiled by the NRI, and "Internet Users" measured by the Waseda International Digital Government Ranking. Data about individuals using the Internet is available for 193 UN member states.

Table 2 summarizes how the data originating from the DG indicators can be used to measure the SDG indicators.

Out of the 10 SDG indicators identified, two are currently classified as Tier II (4.3.1 and 16.10.2), meaning that regularly produced data is missing for them, and the other two are classified as Tier III (1.4.1 and 16.6.2), meaning that both data and methodologies are still missing. For the latter, the ITU's Telecommunication Development Sector produces such data regularly, following well-defined methodologies and standards, which the NRI reports for 139 countries. Although the data does not cover all basic services, at least information on Internet access is available. Similarly, UNDESA collects and analyses data on online services that can serve as an input for the indicator 16.6.2. Although such data does not cover all public services, numbers on user experience and degree of satisfaction with online services is already being produced regularly, respecting international standards and methodologies. Figure 3 displays the results of the bi-dimensional alignment matrix utilized to determine the relevance and usefulness of the DG indicators to inform the SDG indicators.

From the three DG instruments analyzed, the WEF's Networked Readiness Index offers most data that contribute to the SDGs (nine indicators), followed by UN E-Government Survey (seven indicators) and the Waseda International Digital Government Ranking (two indicators).

Table 2. DG indicators informing SDG indicators

		SDG indicators									
DG indicators	**Source(s)**	**1.4.1**	**4.3.1**	**5.b.1**	**7.1.1**	**8.6.1**	**9.c.1**	**16.6.2**	**16.10.2**	**17.6.2**	**17.8.1**
Mobile subscribers	EGDI-TII, NRI			▲							
Internet users	EGDI-TII, NRI, Waseda										■
E-Participation Index	EDGI-OSI, E-PI							▲			
Fixed broadband subscriptions	EGDI-TII, NRI									■	
Gross enrolment ratio	EGDI-HCI, NRI		▲			▲					
Average years of schooling	EGDI-HCI, NRI		▲								
Open Government Data	EDGI-OSI, E-PI							■			
Tertiary education gross enrollment rate	EGDI-HCI, NRI		▲			▲					
Electricity production	NRI				▲						
Mobile network coverage	NRI						■				
Fixed broadband subscriptions	EGDI-TII, NRI									■	
Secondary education gross enrollment rate	EGDI-HCI, NRI		▲			▲					
Mobile phone subscriptions	EGDI-TII, NRI			▲							
Households w/ Internet access	NRI	◆									
Individuals using Internet	EGDI-TII, NRI, Waseda										■
Government Online Service Index	EDGI-OSI, E-PI							▲			
Internet Users	EGDI-TII, NRI, Waseda										■
Legal Framework	EDGI-OSI, Waseda								■		

Legend: ▲ weak-partially ● weak-totally ◆ strong-partially ■ strong-totally

Figure 3. Alignment matrix – SDG indicators informed by the DG indicators

Completeness	Correlation: Weak	Correlation: Strong
Partially	4.3.1, 5.b.1, 7.1.1, 8.6.1, 16.6.2	1.4.1
Totally		9.c.1, 16.10.2, 17.6.2, 17.8.1

DISCUSSION AND RECOMENDATIONS

Measuring SD requires large volumes of data to be produced and analyzed, posing a significant challenge for national statistical systems in both developing and developed countries. When the volumes of data and the speed at which such data is produced keep enlarging due to technology and its impact on social and economic behavior, monitoring SDG indicators demands quality-driven, disaggregated, accessible, timely, reliable and comparable data.

Several efforts for monitoring social indicators exist and should be used (Marcovecchio, Thinyane, Estevez, & Fillottrani, 2017), including the initiatives and investments made for monitoring the MDGs. However, in addition to measuring SD, other measurement instruments can contribute valuable data to tracking progress towards the SDGs. The analysis conducted in this paper uncovered that, while the DG data can contribute to measuring SD, there are some limitations and challenges to do this, as well as opportunities for improvement on how this can be done.

A recurrent limitation is the level of disaggregation of data. Following the premise of leaving no one behind, the SDGs request data to be as disaggregated as possible, not only by gender or age but also by income, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in different national contexts (United Nations, 2017a). For instance, for the indicator 4.4.1 different proportions of youth and adults are considered, but the data, as reported in the DG instruments, cannot be disaggregated.

The selected DG instruments cover the economic and social pillars of SD, considering also technological, legal, operational, and other aspects relatively well, but entirely ignore the environmental perspective. None of the 105 indicators measured by the selected instruments consider environment-related topics relevant to the SDGs, such as clean energy, renewable energy, energy efficiency, cleaner technologies, green policies, or any other carbon reduction resulting from DG service improvements.

Some DG indicators do not inform the SDG indicators per se, but inform on some aspects of the MoI, such as ICT readiness and preparedness, which are as important as the goals and targets for realizing the SDGs. Therefore, although they have not been highlighted in the findings of the mapping exercise, they also contribute to measuring progress towards SDGs.

While some DG indicators do not directly inform any SDG indicator, they do contribute to measuring key crosscutting aspects of the SDGs, like bridging the digital divide or fostering the capacity for innovation. Reducing the technological gap between regions, countries, communities, genders, and groups is crucial to accomplishing the leave no one behind principle, and the information carried by the indicator "Digital divide" of EGDI-OSI provides valuable data for fostering digital inclusion. Creating mechanisms through which technology and innovation can be shared and used for the common good was one of the requests of the UN Secretary-General's Independent Expert Advisory Group on a Data Revolution for Sustainable Development (Independent Expert Advisory Group on a Data Revolution for Sustainable Development, 2014), and the "Capacity for innovation" indicator (the extent to which companies in a country have the capacity to innovate) of the NRI can help identify gaps and create incentives to innovate.

The SDG and DG indicators both focus their data analysis on identifying macro phenomena, where Big Data approaches and innovations, for instance, play a key role in the monitoring and reporting processes. This can be also a risk that directly affects the leaving no one behind principle, which is core and foundational in the articulation of the SDGs. Complementary approaches that can enable and support community-level action, such as Small Data – an approach to data processing that focuses on the individual as the locus of data collection, analysis and utilization towards increasing its capabilities and freedom to achieve its objectives (Thinyane, 2017a) – should also be considered in order to obtain a more comprehensive understanding of the well-being of individuals, who are at the center of SD (Thinyane, 2017b).

One critique of the SDG indicators is that they only consider objective data, which only provides a biased view of the reality. One of the challenges of social reporting is to combine the strengths of objective and subjective indicators, and to make sense of the discrepancies between them (Veenhoven, 2002). DG instruments, on the contrary, complement the pure quantitative analysis with a qualitative one, which can provide a more complete understanding of the reality. For example, nearly half of the NRI indicators are derived from opinion surveys which help measure concepts that are qualitative in nature or for which internationally comparable statistics are not available for a sufficient number of countries. Although the indicators derived from opinion surveys were excluded from the analysis in this study, good practices like this could enhance the GIF and how SD is measured.

CONCLUSION

This paper advocates for pooling various measurement efforts for monitoring progress towards SDGs. In particular, it examines how the efforts and investments made in measuring DG can contribute to the measurement of the SDGs, and how the experience, lessons learned and good practices gained through several years of measuring e-government and DG can enhance the monitoring and reporting of the 2030 Agenda for Sustainable Development. This intention is justified with the analysis of how the indicators that are part of three DG measurement instruments can contribute to the measurement of the SDG indicators. The novelty of this study is that the analysis was performed at the indicators' instead of the goals' or targets' levels.

The main contributions of this paper are: a comprehensive description of the ecosystem and processes for the monitoring and reporting of the SDG indicators, a list of 18 DG indicators that can provide data and methodologies to the SDG indicators along with an alignment matrix to determine the correlation between the indicators, and a set of recommendations for improving the measurement of both the SDG and the DG indicators.

Future work includes expanding the set of indicators analyzed by considering a larger set of indicators originating from other DG measurement instruments.

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