CAPABILITY MATURITY MODELS TOWARDS IMPROVED QUALITY OF THE SUSTAINABLE DEVELOPMENT GOALS INDICATORS DATA

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ABSTRACT

Achieving the Sustainable Development Goals (SDGs) demands coping with the data revolution for sustainable development: the integration of new and traditional data to produce high-quality information that is detailed, timely, and relevant for multiple purposes and to a variety of users. The quality of this information, defined by its completeness, uniqueness, timeliness, validity, accuracy, and consistency, is crucial for appropriate decision making; which leads to improvements in advancing national development imperatives for reaching the goals and targets of the sustainable development agenda. In this paper, we posit that the more mature the organizations within the national data ecosystems are, the higher the quality of data that they produce. The paper motivates for the adoption and mainstreaming of organizational Capability Maturity Models within the SGDs activities. It also presents the preliminary formulation of a multidimensional prescriptive Capability Maturity Model to assess and improve the maturity of organizations within national data ecosystems and, therefore, the effective monitoring of the progress on the SDG targets through the production of better quality indicators data. Furthermore, the paper provides recommendation towards addressing the challenges within the increasingly data-driven domain of social indicators monitoring.

Keywords — Sustainable Development Goals, Capability Maturity Model, Data Revolution, Institutional Capacity

1. INTRODUCTION

In September 2015, leaders of 193 countries agreed on seventeen Global Goals for Sustainable Development which set off a world-wide call to protect the planet and ensure peace and prosperity for all people by the year 2030. These goals, known as the SDGs, define the global development agenda for the upcoming years and present challenging objectives that must balance the three pillars of sustainable development: social inclusion, economic development, and environmental sustainability. The SDGs build on the success of the Millennium Development Goals (MDGs), a set of time-bound and quantified targets agreed in September of 2000 during the UN Millennium Declaration [1]. In particular, SDGs prioritize areas not considered before such as climate change, economic inequality, innovation, sustainable consumption, peace, and justice [2]. The seventeen goals aim at reaching 169 targets, which will be monitored and evaluated through 230 indicators. The UN Statistical Commission [3] is the body within the UN system responsible for the development of a global indicator framework for monitoring the progress towards the achievement of the SDGs. The current measurement framework divides the 230 indicators into three tiers: Tier I comprising indicators for which statistical methodologies are agreed and global data are regularly available; Tier II comprising indicators with clear statistical methodologies, but little available data; and Tier III for indicators with no agreed standards or methodology, and no data. The latter represents 32% of the total number of indicators. On top of this, 15 indicators have yet to be assigned to a tier [4].

A crucial component of the SDGs agenda is the monitoring of progress towards the achievement of the targets, as well as the development of suitable technology tools and platforms to support the activities of the different stakeholders [5]. It is expected that the monitoring of the SDG indicators will demand further efforts to take advantage of the achievements of MDGs and to produce reliable and high-quality data that can cover the new subjects, while ensuring that 'nobody is left behind' [6]. However, there are deep-rooted capacity challenges for many countries in measuring progress on the proposed SDGs [7]. The capacity of key players in the data ecosystem, including governments, institutions, and individuals, also needs to be enhanced to be able to deliver and take advantage of this data. There is, therefore, a universal imperative to ensure that all countries have an effective national statistical system, capable of measuring and producing high-quality statistics in line with global standards and expectations [6].

High-quality data is critical for transforming the SDGs into useful tools for problem-solving and for proper decision-making. Without timely and reliable data, the design, tracking, and assessment of policies are almost impossible. For these reasons, data is one of the key elements of the accountability framework for the SDGs. High-quality data that can be transformed into information that reflects the progress, monitors the allocation of resources, informs policy making, and assesses the impacts of policy and programs, is fundamental for accountability and monitoring of the 2030 Agenda.

Notwithstanding the inherent complexity of the national data ecosystems, this research adopts an organization thinking approach to explore the potential interventions towards improving the capacity of organizations within the national data ecosystem to be more effective in producing high-quality data and therefore in monitoring the SDG indicators.

The rest of the paper is organized as follows. Section 2 discusses the unfolding data revolution especially in the context of social indicators monitoring for SDGs. Section 3 presents an extensive review of the current initiatives on improving the quality of statistical data. Section 4 motivates for the use of Capability Maturity Models (CMM) within the SDG indicators framework for improved quality of SDG indicators data. This is followed by a presentation of a preliminary multidimensional prescriptive CMM in Section 5. Sections 6 and 7 provide recommendations and a conclusion to the paper (respectively).

2. THE DATA REVOLUTION

The volume of data in the world is increasing exponentially. One estimate is that 90% of the data in the world has been created in the last two years [6]. The volume and types of data available nowadays have increased exponentially due to the evolution of technology and its impact on the social behavior. All players in the ecosystem, including governments, companies, academia, and civil society, need to adapt to this new reality and need to be prepared to continue adapting to a world that produces more and more data, generated at a faster speed, and coming from new sources. This new reality has been defined as the data revolution.

The concept of data revolution was coined in 2013 in the report of the High-Level Panel of Eminent Persons on the post-2015 Development Agenda [8] and it is defined as “an explosion in the volume of data, the speed in which data is produced, the number of producers of data, the dissemination of data, and the range of things on which there is data, coming from new technologies such as mobile phones and the Internet of Things, and from other sources, such as qualitative data, citizen-generated data and perception data” [6, p. 6].

Applying a data revolution perspective to SDGs involves the integration of new data (e.g. crowd-sourced data, citizen-generated data, etc.) with traditional data (e.g. census information) to produce high-quality information that is more detailed, timely and relevant for many purposes and users, especially to foster and monitor sustainable development [6]. Traditional statistics entities must therefore not only engage with new data sources but also with new technologies and data analysis tools. Supporting the evolution and modernization of the statistics production systems is also demanded by the large number of indicators for which novel and innovative data sources and methodologies are needed [5].

National Statistical Offices (NSOs), the traditional guardians of data for the public good remain central to the government efforts to harness the data revolution for sustainable development. To fill this role, however, they need to change more quickly than in the past. To be able to adapt to the constant changes, they need to abandon expensive and inefficient production processes, incorporate new data sources, and ensure that the data cycle matches the decision cycle. However, many NSOs lack sufficient capacity and funding, and remain vulnerable to political and interest group influence. Data quality should be protected and improved by strengthening NSOs, and ensuring they are functionally autonomous, independent of sector ministries and political influence. Their transparency and accountability must be improved, including their direct communication with the public they serve [6].

The data revolution, as any transformation, raises new risks. One of the main challenges for monitoring SDGs is to minimize the risks and maximize the opportunities that come from the data revolution for sustainable development. Among them, the enlargement of the data divide (i.e. the gap between those who have ready access data and information, and those who do not) is one of the riskiest. Inequalities in the access and use of information must be tackled to reduce the breach between information-rich and information-poor countries. A way of managing risks and exploring opportunities is by enhancing national capabilities in data science. National and international support and resources are needed, especially in developing countries, to achieve high-quality official statistics that are required for the data revolution to contribute to sustainable development.

Several efforts and important investments have been made for monitoring MDGs. Some of those efforts have been successful and have improved the way data for monitoring and accountability is used. Consequently, there is now a much better understanding of the realities of the world, including the ones of the people that need more help. However, and in spite of this significant progress, some big challenges still need to be tackled:

- Many people and groups are still ignored – some ethnicities, for instance, are being left further behind.
- There are data and knowledge gaps – new science, technology and innovation (among others) are needed to fill such gaps.
- There is not enough high-quality data – many countries cannot rely on their data because it is outdated, incomplete, or it simply does not represent the reality accurately.
- Lots of data that is unused or are unusable – many countries still have data that is of insufficient quality to be used to make informed decisions, for governments to be accountable or to fostering innovation.

These challenges limit governments' ability to act properly towards the achievement of the SDGs.

A key role of the UN and other international organizations is to set up principles and standards, and to lead the actions according to common norms. Mobilizing the data revolution for achieving sustainable development urgently requires actions such a raising awareness, improving capacity, setting standards, and building on existing initiatives in various domains, among others. In particular, initiatives built over previous foundations should consider the data production ecosystem to understand the multi-stakeholder engagement issues related to data sharing, ownership, risks, and responsibilities. Such initiatives are indispensable to enable data to play its essential role in the implementation of the development agenda.

The Independent Expert Advisory Group on a Data Revolution for Sustainable Development calls for "international and regional organizations to work with other stakeholders to set and enforce common standards for data collection, production, anonymization, sharing and use to ensure that new data flows are safely and ethically transformed into global public goods, and maintain a system of quality control and audit for all systems and all data producers and users" [6, p. 18]. Towards this aim, efforts must be made to support countries in empowering their statistical system to be resourced and independent in order to be able to respond to new realities of data, and to produce and use high-quality data in quantitative and qualitative ways.

3. STATISTICS DATA QUALITY INITIATIVES

The importance of the role of the national statistics entities in the production of official statistics for the monitoring and implementation of the development agenda, and the importance of high-quality statistics have been described in literature [9]. In order to serve sustainable and inclusive development, statistics should be obtained from high-quality, timely, easily accessible, reliable and disaggregated data. Data disaggregation, in particular, is key to achieve the principle of leaving no one behind [10].

From an extensive literature review, a wide set of initiatives aimed at improving the functioning and the results generated by the national statistics entities have been identified – including models, standards, frameworks, processes and programs, enterprise architectures, and readiness studies. Figure 1 shows some existing efforts grouped by categories.

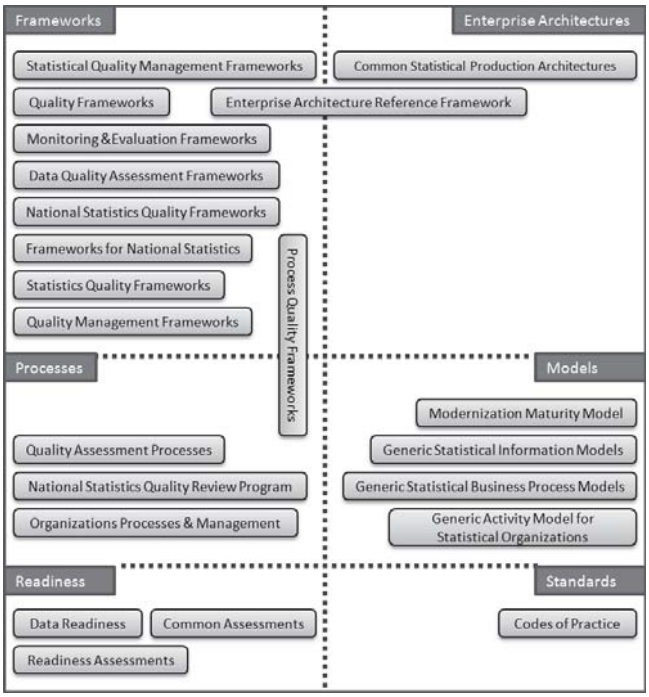

Fig. 1: Initiatives for improving quality in statistics generation

Among the **frameworks** for data or statistics, the following can be highlighted:

- *National Statistics Quality Framework* – based on the European Statistical System dimensions of quality (as laid out in the National Statistics Code of Practice Protocol on Quality Management), aims to improve the quality of data collected, compiled and disseminated through enhancing the organization's processes and management [11].
- *Frameworks for National Statistics* – define the status and governance framework for official statistics. For example, the one developed by the UK Statistics Authority [12] focuses on economy and society.
- *Statistics Quality Frameworks (SQF)* – set forth main quality principles and elements guiding the production of statistics. An example is The European Central Bank Statistics Quality Framework [13].
- *Monitoring and Evaluation Frameworks* – aim at identifying trends, measuring changes and capturing knowledge to improve programs' performance and increased transparency. For example, the SDG Fund Secretariat [14] has established a Monitoring and Evaluation framework with key indicators that allows to obtain a comprehensive overview of the contribution to sustainable development.

- *Process Quality Frameworks* – the framework for process quality in national statistical institutes [15] proposes a structured framework for the quality of the statistical processes used to produce official statistics.
- *Quality Management Frameworks* – for example, the one implemented in the Central Statistics Office in Ireland [16] is an extensive and long-term program of activities aiming at ensuring that statistical production meets the highest standards as regards quality and efficiency.
- *Quality Frameworks* – provide a systematic mechanism for ongoing identification and resolution of quality problems and increased transparency to the processes used to assure quality. An example is the Quality Framework and Guidelines for Economic Co-operation and Development (OECD) Statistical Activities, developed by the OECD in 2012 [17].
- *Data Quality Assessment Framework* – evaluates the data quality of statistics. For example, the International Monetary Fund created a data quality assessment framework [18] for comprehensive assessments of countries' data quality. It defines five dimensions and it covers institutional environments, statistical processes, and characteristics of the statistical products.
- *Statistical Quality Management Framework* – aims at setting out clearly and succinctly an organization's commitment to quality in respect of particular statistical outputs, and to describe the steps that it will take to meet its quality aims [19].

Enterprise Architectures (EA) are formal descriptions of the structure and function of organizational components, the relationships between such components as well as the principles and recommendations for their creation and development over time [20]. Some EA applications to official statistics include:

- *Enterprise Architecture Reference Frameworks (EARF)* – aim at helping countries (in particular, EU member states) with the production of statistics that respond more quickly and cost-effectively to new statistical business needs [21].
- *Common Statistical Production Architecture (CSPA)* – provides support for the whole span of statistical production process and gives a framework for collaborating and sharing effectively [22].

Koskimäki and Koskinen [23] discuss Statistical Enterprise Architectures as tools for modernizing the national statistical systems by identifying the gaps and overlaps between CSPA and EARF from the point of view of the National Statistics Institutes.

Readiness studies analyze the conditions in a country, city or sector to see if data initiatives are likely to be successful and, at the same time, they seek out suitable areas and identify challenges that may exist when implementing such policies [24]. Some readiness studies in the domain include:

- *Readiness Assessments* – are used to determine the existing environment and the preparedness for change. UNDP has developed a prototype tool – the Rapid Integrated Assessment (RIA) – to support countries in assessing their readiness for SDG implementation. RIA reviews the current national development plans and relevant sector strategies, and provides an indicative overview of the level of alignment with the SDG targets.
- *Common Assessments* – useful for assessing and promoting common approaches towards objectives involving multiple stakeholders. The Common Country Assessment (CCA) prepared by UNDP informs the design of UN policies and programs at the country level based on the review of context-specific data that correspond to the SDGs and targets of the 2030 Agenda [25]. The CCA assists in identifying links among goals and targets in order to effectively determine mutually reinforcing priorities and catalytic opportunities for implementation of the new agenda as a whole.
- *Data Readiness* – a tool to assess an organization's ability to produce and report data. In [26], a design-reality gap model is applied for the assessment of big-data-for-development readiness, barriers and risks. This kind of tools could similarly be applied to assess readiness for monitoring the progress towards the achievement of the SDGs.

Processes and **standards**. A statistical process is defined as the collection, processing, compilation and dissemination of statistics for the same area and with the same periodicity [27]. A statistical standard provides a comprehensive set of guidelines for surveys and administrative sources collecting information on a particular topic [28]. The following are some processes and standards for statistics:

- *Quality Assessment Process* – their purpose is to define the steps to process data in such a way that quality is preserved. The quality assessment process for Big Data developed by the OECD [29] presents a data quality assessment process which includes a dynamic feedback mechanism to adapt to the characteristics of big data, and define the tasks that should be conducted at early stages to improve quality.
- *Codes of Practice (CoP)* – the European Statistics Code of Practice aims to ensure that statistics produced are not only relevant, timely and accurate but also comply with principles of professional independence, impartiality and objectivity [15]. Similarly, the UK National Statistics Code of Practice sets out conditions and procedures which govern access to data, including access to data for research purposes, and appropriate actions for unauthorized data disclosure [30].

There are also **models** to represent information, activities, capabilities, business processes, and modernization of statistical organizations. Examples of such models are:

- *Generic Statistical Information Model (GSIM)* – a reference framework of internationally agreed definitions, attributes and relationships that describe the pieces of information that are used in the production of official statistics [31]. It describes the information objects and flow within the statistical business process.
- *Generic Statistical Business Process Model (GSBPM)* – describes and defines the set of business processes needed to produce official statistics [32]. It covers all the activities undertaken by producers of official statistics – at both national and international levels – which result in data outputs. It is designed to be independent of the data source, so it can be used for the description and quality assessment of processes based on surveys, censuses, administrative records, and other non-statistical or mixed sources.
- *Generic Activity Models for Statistical Organizations (GAMSO)* – describes and defines the activities that take place within a typical statistical organization. It extends and complements GSBPM by adding additional activities needed to support statistical production. It is useful to assess the readiness of organizations to implement different aspects of modernization.
- *Modernization Maturity Models (MMM)* – self-evaluation tools to assess the level of organizational maturity against a set of pre-defined criteria. The United Nations Economic Commission for Europe (UNECE) defined a MMM that considers multiple aspects of maturity and distinct dimensions in the context of modernization [33]. The model defines maturity levels allowing identifying the organizational maturity, which can be compared between organizations, and between statistical domains/business units within an organization.

4. IMPROVING THE QUALITY OF SDG INDICATORS DATA

While most of the existing work focuses on assessing and improving the quality of the information produced, we believe the way that such information is produced is equal or even more important. To be able to monitor progress, make governments accountable, and advance sustainable development, having strong institutions able to fulfill the rapidly changing demand for high-quality information is utterly important. It is also imperative for the improvement of the capability of the national data ecosystem that frameworks, models, and standards are formulated to support the adoption of best practices for improving the monitoring of SDGs.

The capability of national data ecosystems (focusing particularly on organizational capacity) can be improved through the formulation of a new multidimensional prescriptive CMM to assess and leverage the capacity of the entities responsible for reporting on the progress of the SDGs at the national level – typically, the NSOs – in collecting, analyzing, processing, and reporting data about the SDGs.

Maturity reflects a level of organizational development which can be used to determine the capability of organizations to perform certain activities. Maturity models are an important tool to assess the quality and effectiveness of processes. Evaluating maturity became popular with the introduction of the CMM for software defined by the Software Engineering Institute at Carnegie Mellon University [34]. Maturity models can be used to identify organizational strengths and weaknesses, and as tools for benchmarking information [35].

Prescriptive models surpass descriptive ones since they are good not only for assessing the here-and-now (also known as the “as-is” situation) but also to indicate the way to improve the level maturity by enabling organizations to develop a roadmap for improvement [36]. Organizations applying these types of models benefit from the ability to measure and assess their capabilities at a given point in time and to have guidelines on improvement measures.

Some of the statistics data quality initiatives (as discussed in Section 3) stand to make a contribution to improving the quality of the data produced by the NSOs. However, it remains that none of these initiatives are specifically aimed at improving the quality (defined by its completeness, uniqueness, timeliness, validity, accuracy, and consistency [37]) of the data generated for the monitoring of the SDGs, and at assessing the capability maturity of such entities and the processes they use to produce SDGs statistics. The closest initiative would be the MMM as it can be used to identify the maturity of statistical organizations and it helps them to modernize the way they produce official statistics. Nevertheless, the most critical difference with the model presented in this paper relies on the focus: while the CMM targets specifically the process that informs the progress towards the SDGs, the MMM focuses on the approach followed by statistical organizations to modernize the way they produce official statistics as a whole. The evolution of the model is also different; while the CMM is prescriptive, the MMM is descriptive. Defined as a "self-evaluation tool to assess the level of organizational maturity against a set of pre-defined criteria" [33, p. 1], the MMM is complemented by a roadmap where the guidelines to reach higher levels of organizational maturity are defined. The CCA by UNDP can also be a useful input to the CMM since it holds the potential for ensuring that the support provided by UN agencies as a whole in a country is coherent and complementary, drawing from each agency’s expertise, resources, and mandate. Other existing efforts, like GAMSO and CSPA, could also inform the CMM.

5. PRELIMINARY CAPABILITY MATURITY MODEL FOR SDG INDICATORS MONITORING

The initial/preliminary CMM explored in this research uses the activities (also called phases) defined by the GSBPM [32] and classifies maturity according to a five-point scale. The model is multidimensional, as each phase includes a number of dimensions. A simplified, high-level view of the model is shown in Figure 2.

Fig. 2: Capability Maturity Model

The diagram does not show (due to space limitations) the fact that each phase is composed, in turn, by a set of sub-processes. The sub-processes are crosscut by each dimension. For example, the Analyze phase consists of five sub-processes – 1) prepare draft outputs, 2) validate outputs, 3) interpret and explain outputs, 4) apply disclosure control, and 5) finalize outputs. The following dimensions are analyzed for each of the sub-processes: a) guidelines, processes and methodologies for preparing draft outputs; b) tools, platforms, and systems for preparing draft outputs; and c) research, experience, and information sharing for preparing draft outputs.

Figure 3 shows the levels of maturity: *Ad-hoc* (less mature), *Supported*, *Managed*, *Proficient* and *Optimizing* (more mature). Organizations in the *Ad-hoc* level are expected to deliver low-quality information because their processes are unclear; they rely primarily on manual practices and isolated efforts; and they have an inaccurate, partial, or incomplete representation of the ecosystem. Organizations in the *Supported* level have tools, platforms, and systems in place but have a poor representation of the ecosystem; the quality of data they produce is expected to be moderate. *Managed* organizations have guidelines, processes, and methodologies in place; have a good understanding of the ecosystem and the quality of information they produce is expected to be high and accurate. Organizations in the Managed level of maturity are trustworthy for decision making. Organizations are considered *Proficient* when they incorporate standards, best practices, and trends in their activities; have a complete and accurate view of the reality and the information produced is of high-quality. Proficient organizations are at a level of maturity that enables them to take advantage of data exchange and information sharing. The *Optimizing* level of maturity is reached when organizations adapt and react fast and easily to changes in the ecosystem. Such organizations offer the most accurate representation of the ecosystem and the information they offer has an impact on policy.

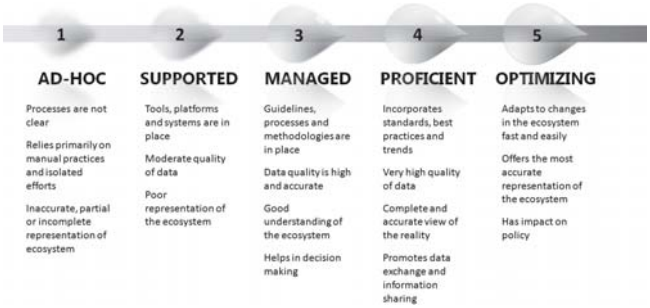

Fig. 3: Maturity Levels

Figure 4 illustrates the direct relationship between capability maturity and the expected quality of data. Hence, promoting capability maturity of the entities responsible for reporting the progress on the SDGs contributes to higher quality of information, and therefore, to better monitoring of the global development agenda.

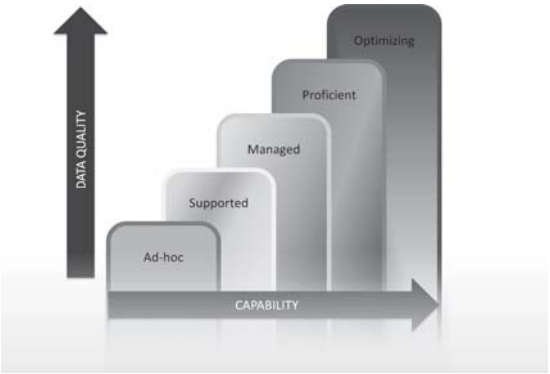

Fig. 4: Maturity and Data Quality

6. DISCUSSION AND RECOMENDATIONS

There is a clear need for reliable information within the international statistical community, and there have been a number of efforts to ensure quality and accuracy of data. However, the process is long and technology is changing rapidly, directly affecting the lives of human beings and in turn, the data they produce. Therefore, reliability must be safeguarded by robust and mature organizations which are independent of their employees, and the current and future administrations. To this end, national statistical systems must be empowered to quickly and easily adapt to the new reality of data.

International organizations play an important role in supporting countries in being able to produce reliable and efficient indicators, and in providing them with adequate tools for achieving so. For instance, UNECE is making great contributions with the development of GAMSO, GSBPM, GSIM, CSPA. There is space however, for other organizations to also make a contribution.

Every country, regardless of their advancement and level of development can benefit from the CMM. While developed countries tend to lead the way and have more resources for improvement and innovation, developing countries can benefit greatly from the efforts and experience gained from those leading the way. The achievement of the global development agenda is not a competition among countries and it depends on every member to be able to achieve its goals and targets. One of the beliefs and principles of the SDGs states that "The United Nations member states work together with a high level of cooperation to improve the circumstances of all people in the world, and place them at the core of future development" [38, p. 1].

The model proposed in this paper is targeted to the SDGs in particular, and to the social indicators for the public good in general. Practices and solutions taken from the private sector have to be analyzed and adapted carefully since their priorities and goals are different. As an example, while developmental indicators pay attention to inclusion (no one should be invisible) and respect for the privacy of individuals and their communities, the private sector solutions may have other priorities.

Other efforts for monitoring social indicators exist and can be taken advantage of. For instance, big investments have been made in improving data for monitoring and accountability for the MDGs. Similarly, UN member states have been reporting for over ten years on human rights in compliance with the Universal Periodic Reviews. All such efforts (and in particular, their results) have to be standardized and considered to develop the synergies that they can facilitate.

Data has to include everyone and has to be useful for everyone. The trend shows that businesses and governments are increasingly relying on big data and the associated analytics. While businesses use big data to inform business decisions and strategy, governments use big data to provide better service delivery and citizen engagement [39]. Initiatives on small data (in which data, instead of being aggregated is processed at the same unit as it was sampled [40]) are also important to make sure nobody is left out. The model proposed in this paper integrates both, the big and the small data approaches to promote inclusiveness.

7. CONCLUSIONS

This paper advocates the achievement of the sustainable development agenda through interventions towards improving the capabilities of the entities within the national data ecosystem responsible for monitoring its progress. By the adoption of an organization thinking approach, this research motivates for the adoption and mainstreaming of CMMs within the SDGs activities.

The main contributions of this paper are: a thorough definition and the problematization of a space where research and actions are urgently needed, the preliminary formulation of a multidimensional prescriptive CMM to assess and improve the maturity of organizations within national data ecosystems, and a set of recommendations towards addressing the challenges within the increasingly data-driven domain of social indicators monitoring. Furthermore, and aiming at reaching globally accepted standards, an extensive review that describes the landscape of the current initiatives on improving social statistics was also presented. This contribution can be helpful for informing statistics institutions of the domain of tools and platforms available. Gaps and overlaps were also identified, and the lack of integration among these efforts, leading to a poor utilization of current and previous investments, was highlighted.

Future work includes an in-depth review of case studies to identify best practices for the production of statistics for development, and further development of the CMM by integration the findings of this survey.

REFERENCES

[1] "UN Millennium Project | About the MDGs." [Online]. Available: http://www.unmillenniumproject.org/goals/. [Accessed: 31-Jan-2017].

[2] "Sustainable Development Goals | UNDP." [Online]. Available: http://www.undp.org/content/undp/en/home/sustainable-development-goals.html. [Accessed: 31-Jan-2017].

[3] "UNSD - United Nations Statistical Commission." [Online]. Available: http://unstats.un.org/unsd/statcom. [Accessed: 31-Jan-2017].

[4] J. Sachs, G. Schmidt-Traub, C. Kroll, D. Durand-Delacre, and K. Teksoz, "SDG Index & Dashboards, A Global Report," 2016.

[5] M. Thinyane, "Small Data for SDGs Community-Level Action and Indicators Monitoring." 2016.

[6] Independent Expert Advisory Group on a Data Revolution for Sustainable Development, "A World that Counts: Mobilising the Data Revolution for Sustainable Development," 2014.
[7] "Metrics & Indicators - Business for 2030." [Online]. Available: http://www.businessfor2030.org/metrics-indicators/. [Accessed: 31-Jan-2017].
[8] High-Level Panel of Eminent Persons on the Post-2015 Development Agenda, "A New Global Partnership: Eradicate Poverty and Transform Economies through Sustainable Development," 2013.
[9] United Nations, "Fundamental Principles of Official Statistics," 2014.
[10] Sustainable Development Solutions Network, "Leaving No One Behind : Disaggregating Indicators for the SDGs," 2015.
[11] H. Robinson and D. Obuwa, "Quality assurance of new methods in National Accounts," *Econ. Trends*, vol. April, no. 629, pp. 14–19, 2006.
[12] Office for National Statistics United Kingdom, "Framework for National Statistics," 2000.
[13] European Central Bank, "ECB Statistics Quality Framework (SQF)," 2008.
[14] "Monitoring and evaluation | Sustainable Development Goals Fund." [Online]. Available: http://www.sdgfund.org/monitoring-and-evaluation. [Accessed: 02-Mar-2017].
[15] G. Brancato, F. D'Assisi Barbalace, M. Signore, and G. Simeoni, "Introducing a framework for process quality in National Statistical Institutes," *Stat. J. IAOS*, vol. 33, no. 2, pp. 441–446, 2017.
[16] S. Portillo and K. Moore, "A systematic approach to quality: the development and implementation of a quality management framework in the Central Statistics Office, Ireland," in *European Conference on Quality in Official Statistics*, 2016, pp. 1–12.
[17] OECD, "Quality Framework and Guidelines for OECD Statistical Activities," 2012.
[18] International Monetary Fund Statistics Department, "IMF's Data Quality Assessment Framework," in *Conference on Data Quality for International Organizations*, 2010, pp. 1–11.
[19] S. M. Dahlgaard-Park, "Total Quality Management (TQM)," *SAGE Encycl. Qual. Serv. Econ.*, pp. 808–812, 2015.
[20] J. Dygaszewicz and B. Szafranski, "Introducing EA Framework in Statistics Poland," *Comput. Sci. Math. Model.*, vol. 3, pp. 23–32, 2016.
[21] Eurostat, "ESS EA Reference Framework," 2015.
[22] T. Lalor and A. Gregory, "Common Statistical Production Architecture," in *5th Annual European DDI User Conference*, 2015, pp. 1–50.
[23] T. Koskimäki and V. Koskinen, "Governmental and Statistical Enterprise Architectures as Tools for Modernizing the National Statistical System," in *European Conference on Quality in Official Statistics*, 2016, pp. 1–10.
[24] S. Elena, N. Aquilino, and A. Pichón Riviére, *Emerging Impacts in Open Data in in Argentina, Chile and Uruguay*. 2014, pp. 1–48.
[25] United Nations Development Group, "Common Country Assessment," 2002.
[26] L. F. Gómez and R. Heeks, "Measuring the Barriers to Big Data for Development: Design-Reality Gap Analysis in Colombia's Public Sector," 2016.
[27] Committee for the Coordination of Statistical Activities and Statistical Office of the European Communities, "Revised International Statistical Processes Assessment Checklist," 2009.
[28] Organisation for Economic Co-operation and Development, "OECD Glossary of Statistical Terms - Statistical standard Definition." [Online]. Available: http://stats.oecd.org/glossary/detail.asp?ID=4920. [Accessed: 26-Jun-2017].
[29] M. Giacalone and S. Scippacercola, "Big Data: Issues and an Overview in Some Strategic Sectors," *J. Appl. Quant. Methods*, vol. 11, no. 3, pp. 1–18, 2016.
[30] Office for National Statistics United Kingdom, "National Statistics Code of Practice: Statement of Principles," 2002.
[31] UNDESA Statistics Division, "Generic Statistical Information Model (GSIM): Statistical Classifications Model," 2015.
[32] UNECE Secretariat, "Generic Statistical Business Process Model: GSBPM," 2013.
[33] "Modernisation Maturity Model (MMM) - Roadmap for Implementing Modernstats Standards - UNECE Statistics Wikis." [Online]. Available: http://www1.unece.org/stat/platform/pages/viewpage.action?pageId=129172266. [Accessed: 28-Feb-2017].
[34] M. C. Paulk, B. Curtis, M. B. Chrissis, and C. V. Weber, "Capability Maturity Model for Software, Version 1.1," 1993.
[35] K. Jugdev and J. Thomas, "Project Management Maturity Models: The Silver Bullets of Competitive Advantage?," *Proj. Manag. J.*, vol. 33, no. 4, pp. 4–14, 2002.
[36] T. De Bruin, R. Freeze, U. Kaulkarni, and M. Rosemann, "Understanding the Main Phases of Developing a Maturity Assessment Model," in *Australasian Conference on Information Systems (ACIS)*, 2005, pp. 8–19.
[37] "Quality Assessment of Big Data with GIS," in *AGILE 2017*, 2017, pp. 1–6.
[38] "Sustainable Development Goals Beliefs and Principles | Agora Portal." [Online]. Available: https://www.agora-parl.org/resources/aoe/sustainable-development-goals-beliefs-and-principles. [Accessed: 05-Jun-2017].
[39] M. Thinyane, "Investigating an Architectural Framework for Small Data Platforms," in *17th European Conference on Digital Government*, 2017, pp. 220–227.
[40] M. Best, "Small Data and Sustainable Development," in *Int. Conf. on Communication/Culture and SDGs: Challenges for a new generation.*, 2015, pp. 1–6.