Geotechnologies and monitoring of Sustainable Development Goals by Supreme Audit Institutions

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ABSTRACT

One of the initiatives proposed by the United Nations (UN) so that Sustainable Development Goals (SDGs) can overcome challenges faced by Millennium Development Goals (MDGs) is the use of geospatial data and investments in training to use new technologies. In addition, International Standards of Supreme Audit Institutions (ISSAIs) acknowledge the importance of training its employees to meet new requirements. The proposal of concrete actions in this work aims at supporting the strategy of investing in geotechnologies so that Supreme Audit Institutions (SAIs) can monitor SDGs. This activity was accomplished by reviewing literature on United Nations and Intosai technical references that might contribute to the use of geotechnologies for SDG monitoring by SAIs.

Keywords: Sustainable Development Goals. Supreme Audit Institutions. Geotechnologies. Remote Sensing. Geographic Information System (GIS). *Global Positioning System* (GPS). Intosai. ISSAI. Audit International Standards. Technical Skills. Qualification. Diagnosis.

1. INTRODUCTION

The United Nations Organization (UN) 2030 Agenda for Sustainable Development poses a challenge on activities carried out by Supreme Audit Institutions (SAIs). Recent resolutions of the UN General Assembly emphasize the key role of SAIs and of the International Organization of Supreme Audit Institutions (INTOSAI) in meeting Sustainable Development Goals (SDGs) (UNITED NATIONS, 2016).

UN Resolution A66/209, dated 2011 (Id., 2011), points out that SAIs perform an important role in promoting the efficiency, accountability, effectiveness and transparency of public administration, fostering national development as to SDGs. In addition, Resolution A69/228, dated 2014 (Id., 2014a), strengthens explicitly the key role of SAIs in the 2030 Agenda.

The 23rd United Nations/Intosai Symposium report (Id., 2015d) on the role of SAIs regarding the 2030 Agenda emphasizes the importance of the intensive use of data analytics[1]. One of the initiatives proposed by the UN so that SDGs can overcome challenges faced by Millennium Development Goals (MDGs) is the use of geospatial data (Id., 2015c). In addition, the International Standards of Supreme Audit Institutions (ISSAIs) highlight the possible application of geotechnologies to several audit phases (INTERNATIONAL ORGANISATION OF SUPREME AUDIT INSTITUTIONS, 2013b).

However, in bibliographical information sources researched, there are no sources joining in a single system UN technical references on the use of geotechnologies for monitoring SDGs and Intosai technical references on the topic of geotechnologies.

For those reasons and in order to improve the use of new technologies applied to control, this paper aims at reviewing literature on United Nations and Intosai technical references that may contribute to the use of geotechnologies for SAI monitoring of SDGs.

2. GEOTECHNOLOGIES AS SUPPORT TOOLS FOR MONITORING SDGs

Geotechnologies optimize a universal and standardized approach for monitoring other relevant information, including economic, educational, environmental and health indicators. Geographic information allows data modelling and analysis, map creation and the detection and monitoring of its modifications along the time on a consistent and standardized basis (UNITED NATIONS, 2015a).

Souza (2016, p. 40) describes geotechnologies as "a set of technologies for collecting, processing, analyzing and making available georeferenced information". Some of them are the Global Navigation Satellite System (GNSS), Remote Sensing and Geographic Information Systems (GISs). GNSS enabled people to know accurately their location in Earth, and Global Positioning System (GPS) distinguishes from other systems of this type (SOUZA, 2016).

Souza (2016, p. 41) defines remote sensing "as the use of sensors to capture and record the distance, without direct contact, of power reflected or absorbed by the target surface". By using computer software, data generated by such technology can be stored, handled and analyzed. Unmanned aerial vehicles (UAV), small unmanned aircrafts, may monitor areas through air photographs and recordings (SOUZA, 2016).

Thus, GISs are "systems that computer process geographic information" (SOUZA, 2016, p. 41). Câmara (2015, p. 2) explains that "the main difference between a GIS and a traditional information system is its ability to store both descriptive attributes and geometries of different types of geographic information". GISs enable integration of data from various sources, making possible deeper analyses (SOUZA, 2016). It can be entered data from different sources in only one database, and that data can be combined by using analysis and manipulation algorithms (CÂMARA, 2005).

The document "The millennium development goals: report 2015" (UNITED NATIONS, 2015e) summarizes the progresses, challenges and lessons learned along fifteen years monitoring MDGs. When covering monitoring challenges, it can be said that large data gaps, poor data, outdated and non-disaggregated data are some of the main challenges. One of the initiatives proposed to overcome those challenges is the **use of geospatial data** (UNITED NATIONS, 2015e).

In report "A world that counts: mobilizing the data revolution for sustainable development" (INDEPENDENT EXPERT ADVISORY GROUP, 2015), UN calls signatory Member States to 2030 Agenda, Corporations and civil society to coordinate efforts to improve information availability, quality, update and disaggregation, in order to support implementation in all levels.

According to document "Assessing gaps in indicator availability and coverage" (CASSIDY, 2014), one major challenge to be faced is the low general coverage of indicators proposed. Almost one third of indicators lacks data in more than half of the countries (SHUANG et al., 2013) and, on average, only 46% of data were collected, posing an international challenge as for statistical data production (UNITED NATIONS, 2014e).

The report "Indicators and a monitoring framework for the sustainable development goals" (UNITED NATIONS, 2015c) highlights opportunities created by data revolution, via big data, geophysical and social data and new forms of data sharing. In addition, that report presents several examples of geotechnologies supporting SDGs, as shown in Exhibit 1 at the end of this paper.

Authors such as Jeffrey Sachs (2012) point out numerous differences between MDGs and SDGs, as detailed in Table 1.

In document "Data for development: an action plan to finance the data revolution for sustainable development" (OPEN DATA WATCH, 2015, p. 8, translation added), prepared by UN and by Open Data Watch, is it declared that

> The SDGs will depend on more geospatial and earth observations data than the MDGs. Satellite imagery is increasingly available for free at a moderate resolution, and at a cost for high-resolution sources. Satellite products have the potential to be utilized in monitoring more than 23 potential SDG indicators, ranging from measuring global air quality to crop and forest cover, to disaster impacts, and water resources. New satellite imagery is one example of emerging technology that offers significant opportunities for a global water monitoring platform.

There is no question that data collection poses a major challenge. As a consequence, it should be used new technologies and methods available, including those provided by big data and geographic information technologies (UNITED NATIONS, 2015a). Since there is more and more information available, the study of methods using databases has distinguished itself (FREITAS; DACORSO, 2014).

In view of comprehensiveness and complexity of 2030 Agenda, it is required several types of data with different cover levels (SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK, 2015). Thus, each type of data upholds and supports the other types.

For the purpose of monitoring SDGs, it is required data ecosystem fostering and composition. For that reason, UN specified the data typology in report "Data for development: A Needs Assessment for SDG Monitoring and Statistical Capacity Development" (SDSN, 2015), making clear what are primary data sources and setting key principles for selecting robust monitoring indicators.

Table 1:
Differences between Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs)

	MDG	SDG
Period	2000-2015	2016-2030
Intermediate control points (SACHS, 2012)	Absent	Present
Monitoring Depth (INTERNATIONAL ORGANISATION OF SUPREME AUDIT INSTITUTIONS, 2015)	8 goals, 20 targets	17 goals, 196 targets
Geographic scope (SACHS, 2012)	Developing countries	All signatory Member States
Monitoring Forms	Not defined previously	Agreed by governments; monitoring system development
Technology role (SACHS, 2012)	Secondary	Primary
Focus (UNITED NATIONS, 2014e)	Poverty Alleviation	Sustainable Development in a broad sense

Source: Authors' Making

Data typology refers to census data, vital records and vital statistics for births, household surveys, agricultural surveys, administrative data, economic statistics and environmental data, including geospatial data. The latter are critical to determine SDG environmental indicators, and to conduct a disaggregated analysis of their social and economic indicators (SDSN, 2015).

Out of primary sources of indicators proposed by such report (SDSN, 2015), 11% are related to environmental data, including geospatial data. Table 2 shows primary data sources for those indicators.

Another data ecology component refers to key principles for selecting global monitoring indicators, as proposed in report "Follow-up and Review of the SDGs: fulfilling our commitments" (UNITED NATIONS, 2015b). According to those principles, indicators need to be: limited in number and globally harmonized (for global monitoring indicators), simple, i.e. single-variable indicators with straightforward policy implications, high-frequency, allowing regular monitoring, preferably on an annual basis, consensus-based, in line with international standards and system-based information, constructed from well-established data sources, disaggregated to the greatest extent possible, universal, mainly outcome-focused, science-based and forward-looking, a good proxy for broader issues or conditions.

Tools and methodologies for data collection, analysis and communication are an integral part of data ecology. Those tools and methodologies are inherently connected with geospatial fields, including photogrammetry, cartography, geographic information systems (GISs) and geospatial analysis, remote sensing and geospatial intelligence.

Table 2:
Primary data sources for SDG indicators

Primary data sources	
Administrative data	33%
Household surveys	26%
International information	13%
Environmental data (agricultural surveys or geospatial data)	**11%**
Vital Records and vital statistics for births	8%
TBD	6%
Workforce surveys	2%
Other economic data	2%
Census	Cross-cutting
TOTAL	100%

Source: Sustainable Development Solutions Network (2015, translation and emphasis added)

In those fields, the following are particularly relevant to SDG monitoring by SAIs: cartography[2]; geographic information systems[3] and remote sensing[4]. Those fields are referred to hereunder as geotechnologies, i.e.: "the set of technologies to collecting, processing, analyzing and making available georeferenced information" (SOUZA, 2016, p. 40).

At event "Unleashing the power of 'Where' to make the world a better place: How geographic information contributes to achieving the SDGs" (UNITED NATIONS, 2015f), Lawrence Friedl, representing National Aeronautics and Space Administration (NASA), said that SDGs arrive at a prime convergence moment for seizing the power of spatial data. Geographic information is a key element in the complex context of implementation and monitoring of 2030 Agenda (Id., 2015a), being mentioned in target number 18 of SDG number 17, that seeks the strengthening of means of implementation and the revitalization of the global partnership for sustainable development as one of relevant data sources. The "target 17.18" seeks to enhance capacity building in developing countries by 2020, to increase significantly the availability of high-quality, timely and reliable data disaggregated, for instance, by geographic location (Id., 2015c).

By reviewing national indicators proposed by United Nations System in Brazil (UNITED NATIONS DEVELOPMENT PROGRAMME, 2015), it can be noticed that a significant amount of those indicators required geographic disaggregation. Most indicators proposed use some form of geographic disaggregation and, pursuant to report "Follow-up of 2030 Agenda for Sustainable Development", the data disaggregation present in the new agenda poses a challenge to be overcome.

3. INTOSAI TECHNICAL REFERENCES ON THE TOPIC OF GEOTECHNOLOGIES

Document "ISSAI 5130 – Sustainable development: the role of Supreme Audit Institutions" (INTERNATIONAL ORGANISATION OF SUPREME AUDIT INSTITUTIONS, 2004), covering new assignments arisen from SDGs, acknowledges that institutions need to question whether existing methodologies for conducting audits are appropriate for such context. It also affirms that, depending on particularities of each SAI,

experts may be included in the process, whether as hired employees or advisors.

"Auditing forests: guidance for Supreme Audit Institutions" ((INTERNATIONAL ORGANISATION OF SUPREME AUDIT INSTITUTIONS, 2010), prepared by Intosai Working Group on Environmental Audit (WGEA), describes how SAIs may use the technology of Geographic Information System (GIS). Covering methodological aspects, the document said that "Computer-based technologies can be exceptionally useful in audits. Two examples of those technologies include GPS and GIS" ((INTERNATIONAL ORGANISATION OF SUPREME AUDIT INSTITUTIONS, 2010, p. 9). Geographic information may be used for many purposes and in different audit phases. GIS may be used in planning phase and GPS may be used in execution phase as a support tool. Geographic information may be used for many purposes, including different planning phases, street network based applications, natural resource based applications, viewshed analysis, facilities management, and others (INTERNATIONAL ORGANISATION OF SUPREME AUDIT INSTITUTIONS, 2010).

According to document "Environmental data: resources and options for Supreme Audit Institutions" (INTERNATIONAL ORGANISATION OF SUPREME AUDIT INSTITUTIONS, 2013a), both audit governmental managers and SAIs will benefit from GIS use. Said document describes geospatial data on an independent basis, in a special section, because, in its author's view, data provide SAIs with unique considerations. Due to governmental budget restrictions, governmental managers feel pressured to show results, leading them to use environmental data on a larger scale to demonstrate that their programs met goals set. That type of change may influence how performance is measured and how governmental managers and SAIs evaluate those programs (INTERNATIONAL ORGANISATION OF SUPREME AUDIT INSTITUTIONS, 2013a).

Said document declares that spatial data sources may be exceptionally useful to SAIs when those are checking environmental issues with clear geographic aspects, such as environmental protection areas or polluted area location. Geospatial data is also useful to select samples from different sites, finding high risk areas and standards in data, what would not be possible without its spatial component. SAIs may also use spatial data to present its results, making them more tangible.

At last, in "Environmental Data: Resources and Options for Supreme Audit Institutions" (INTOSAI, 2013a), it is said that the use of data tied to geographic locations makes databases much more complex because of the need to record both what is happening and where, using geographic coordinates. The result is a greater demand on quality control. The challenge for SAIs of assessing the quality of the database is also greater. Finally, SAIs that are considering using spatial data sources need access to the tools and also have to invest in the development of technical skills required.

In report "The 7th survey on environmental auditing" (Id., 2012), WGEA presents the result of survey taken by over 112 SAIs. The survey asked SAIs to describe innovating work methodologies that they have been applying to environmental audits. Geospatial technology was the most voted item[5].

ISSAI 5540 (INTERNATIONAL ORGANISATION OF SUPREME AUDIT INSTITUTIONS, 2013b), that covers issues on the use of geospatial data in environmental disaster management audits, says that GISs and remote sensing may provide added value to all audit stages, as shown in Table 3[6]. According to the document, GISs may help in extensive and complex data analytics in many ways: present data spatially, filter data by spatial location, analyze spatial location, store and view data in tiers etc. GISs enable users to produce high quality maps in any scale, store large amounts of geographic information, view complex data and produce new data based on existing data.

ISSAI 5540 proposes a checklist for the use of geospatial data in audit, fully shown in Table 4.

Said ISSAI also says that the use of geospatial information and GIS in public sector has increased for many reasons. One of the main ones is the extent and complexity of information to be considered and assessed when making decisions. Numerous decisions require geospatial information and GISs support the assessment of that type of information. In the context of public policies, geospatial information has many

Table 3:
Geotechnology application to several audit phases pursuant to *ISSAI 5540*

AUDIT STAGE	GEOTECHNOLOGY APPLICATION
Evaluating relevant risks	GISs enable the analysis of comprehensive data or data tiers in a geographic context. Remote sensing may be used to check information in databases using field information
Planning audits	GISs and remote sensing may help to decide the audit focus at this point
Conducting audits	The team may use GPS devices and satellite-based maps to connect field audit data to geographic data. This field data can be assessed right after entering and combining data with maps
Assessing audit results	GISs enable the assessment of different geographic information tiers, allowing performance to be measured. In addition, the viewing of results through GISs allows to find geographic differences in governmental organizations performance
Disclosing results	Using GISs and remote sensing, audit results may be mapped and presented to support the main audit conclusions and recommendations and to make easier the disclosure of results. The viewing of audit results in maps makes the message clearer and stronger than a message only in writing

Source: Adapted from International Organisation of Supreme Audit Institutions (2013b, translation added)

Table 4:
Checklist for the use of geospatial data in audit

***Checklist*: use of geospatial data in audit**
What geospatial data is needed to answer the audit questions?
What accuracy is required of the geospatial data?
What is the required timeframe of the geospatial data?
What geospatial data is available?
From which sources can the required geospatial data been derived from and how reliable are they?
What is the quality of the available geospatial data?
What are the costs of the available geospatial data?
If the required geospatial data are not available, could they be gathered as part of the audit process and budge?
Do the auditors involved have the required knowledge to gather and analyse the required geospatial data or should external expertise be insourced?

Source: International Organisation of Supreme Audit Institutions (2013b, translation added)

purposes, such as goal setting, establishment of measures, monitoring and evaluation. In addition, geospatial information can be used in many public policy areas. Some examples are management of natural resources, environmental protection, economy, education, safety and health (INTERNATIONAL ORGANISATION OF SUPREME AUDIT INSTITUTIONS, 2013b).

4. FINAL CONSIDERATIONS

One of the initiatives proposed by UN so that SDGs can overcome challenges faced by Millennium Development Goals is the use of geospatial data (UNITED NATIONS, 2015e). In addition, ISSAI (INTERNATIONAL ORGANISATION OF SUPREME AUDIT INSTITUTIONS, 2004) International Standards acknowledge the importance of its employees' qualification to meet new requirements.

This paper aimed at reviewing literature on United Nations and Intosai technical references that may contribute to the use of geotechnologies for monitoring SDGs by Supreme Audit Institutions. We hope this systematization assists further studies to be developed in the scope of SAIs on this subject-matter.

NOTES

1 For instance, satellite imaging application or the use of remote sensing for control actions.

2 Science of designing, producing, disclosing and studying maps as tangible and digital objects.

3 Any system that captures, stores, manages and views location data.

4 Science of obtaining measurement information about an object or phenomenon through a sensor without making physical contact with the studied object/ phenomenon.

5 The use of external expertise had the same vote counting, sharing the first place as an innovating methodology, according to that survey.

6 It should be noticed similarities among audit steps and some functions described in DACUM Research Chart for Geospatial Analyst (*capture data, manage data, analyse data, produce deliverables*). Available at: <http://bit.ly/2gqLhvT>. Web: Jul 12. 2016.

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Exhibit 1:

Examples of geotechnology support to Sustainable Development Goals (United Nations, 2015)

SDG		INDICATOR		INDICATOR DESCRIPTION	DISAGGREGATION	SOURCE[1]
1	Eradicate poverty in all its forms everywhere	6	Losses from natural disasters by climate and non-climate-related events (in US$ and lives lost)	Measures human and economic losses in rural and urban areas due to natural disasters, disaggregated by climate and non-climate--related events	This indicator may be disaggregated spatially (including urban and rural segregation)	Non-geospatial sources
2	End hunger, achieve food security and improve nutrition, and promote sustainable agriculture	13	Gap in income of cultures	Tracks development gaps in the main cultures, i.e., current income against expected income in optimum conditions	Appropriate to spatial disaggregation, global to local scales	Geospatial data, including remote sensing and satellite
9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	58	Access to clear roads throughout the year (% access to roads within [x] km distance to road)	Access to clear roads throughout the year is critical to rural development processes, including access to inputs, markets, education and health services. This indicator tracks the share of population living within [x] km distance to clear roads throughout the year	This indicator may be disaggregated spatially	Geospatial data, including remote sensing and satellite
11	Make cities and human settlements inclusive, safe, resilient and sustainable	69	Mean urban air pollution in particulate matter (MP10 and MP2.5)	Follows up mean urban air pollution	Per city and state	Geospatial data, including remote sensing and satellite
12	Ensure sustainable consumption and production patterns	75	Aerosol Optical Depth	Measures total aerosols (e.g.: sea salt, dust and smoke particles) distributed within a column of air from Earth surface to the top of the atmosphere	This indicator may be reported with high level spatial disaggregation (including cities and neighborhoods)	Geospatial data, including remote sensing and satellite
15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	83	Annual change in forest area and land under cultivation (modified MDG Indicator)	Tracks the net change of forest area and the expansion of agriculture into natural ecosystems, as well as the loss of productive agricultural land to the growth of urban areas, industry, roads, and other uses	This indicator can be disaggregated spatially	Geospatial data, including remote sensing and satellite
		85	Annual change in desertification in land degradation (% or ha)	Components of land degradation include salinization, erosion, loss of soil nutrients, and sand dune encroachment	Geographic disaggregation by sub-region	Geospatial data, including remote sensing and satellite

Source: Adapted from United Nations (2015c, translation added)

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