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"Strengthening the Capacities of Selected African Countries to Develop Geospatial Information Resources and Services in Support of the Implementation and Monitoring of the Sustainable Development Goals"

Manual on Standard Guiding Principles on a Global Statistical and Geospatial Framework for the Integration of Statistical and Geospatial Information in Africa

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Report 2.0

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The initial background document has been prepared by Amor Laaribi, UN Retiree and Former UN-GGIM Coordinator and; finalized with the support of Andre Nonguierma, Chief, Geospatial Information Management (GiMs) Section and Ayenika Godheart Mbiydzenyuy, Statistician at GiMs of UNECA

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Executive Summary

During the last four decades, population and housing censuses and other surveys have been primary sources of data for policy formulation, monitoring, evaluation and decision making for sectoral, national and regional development programmes in Africa. It is worthwhile, to mention that over the year's geospatial data have been equally been the backbone for policy formulation in areas including and not limited to: facilities management, environment and Natural Resources management, street network, planning and engineering, Land Information System, Global Navigation Satellite Systems (GNSS) etc. These geospatial and statistical systems are likely to remain the major sources of data decision making in the majority of African countries. The rapid evolution of geospatial data and science into Big Data has demonstrated the dynamism, variations in the size and spatial distribution of geospatial data and their related characteristics, play a central role within national data and statistics ecosystems for the foreseeable future. Since at least a decade, an increasing number of African countries have been building their geospatial information infrastructure which is becoming to be regarded as a fundamental asset of society, equal to its roads, communications networks, and other public utilities. It is now widely accepted that with the development of national spatial data infrastructures (NSDI), better geo-enable facilitates will be availability and increased access to geospatial data for governmental organizations, the private sector, universities and citizens in general will foster development in Africa.

In this context, building a statistical-geospatial infrastructure is increasingly recognized as an enabler for facilitating data exchange and improving the availability, quality of decision making and timeliness of country information in support of evidence-based decision making and sustainable development. Countries in the Africa region are indeed recommended to build, develop, and strengthen their geospatial information infrastructures in support of censuses and statistical activities, and recognize that the adoption of a geographic-based approach with full integration of statistical and geospatial information offers an opportunity for countries to proceed with the modernization of their national statistical systems and official statistics[1], national mapping systems and build their capacities to be able to cope with the 2030 Sustainable Development Agenda challenges.

It is against this mandate that the ECA aims to play a coordinating role in promoting the strategic use of geospatial and other innovative technologies in support of statistical systems, and to advocate for their adoption and implementation in accordance with UN recommendations, taking into account the national circumstances or landscapes in Africa. It should be indicated that the Sustainable Development Goal (SDG) indicators should be should be disaggregated, where

[1] Cf. In-depth review of developing geospatial information services based on official statistics, Note by the United Kingdom Office for National Statistics, CES, 2016, ECE/CES/2016/7.

relevant, by income, sex, age, race, ethnicity, migratory status, disability and geographic location, or other characteristics[2]. In this regard, ECA has commissioned this strategic document with operational guidelines that will inform on the establishment and implementation of national statistical geospatial frameworks (NSGF) and experiences and best practices in other parts of the world for the proper integration of statistical and geospatial information in African countries. A framework that defines the basic foundations for building a statistical-geospatial information infrastructure, and outlines some policy principles on how national statistical, planning and geospatial authorities have effective collaboration between them in the development of respective data infrastructures and systems.

2 General Assembly Resolution 68/261

1. Introduction

In most countries, including in the African region, the National Statistical Offices (NSO's), are in charge of, "collecting, processing, and disseminating data on a wide range of demographic, social, economic, and environmental topics", through population and housing censuses, surveys, registers and other administrative files providing the bulk of the official statistics for the country. Still, in some countries, these official statistics, constitute the major outputs of the national statistical system, which benefits limited users, principally government agencies and other few non-governmental bodies. Equally, there are other actors producing data and statistics but these sources are out of the official statistics usually not validated by governments. These have been efforts made for the National Statistics Systems (NSS's), to mainstream these actors into the officially acknowledge statistical production processes. These efforts to a larger extend fails to integrate geospatial information into the various statistical processes.

However, due to the data revolution with the emerging of innovative and enabling technology, data is increasingly available with lower cost from various sources, in better quality, and more easily accessible by different users. More specifically, with the proliferation of mobile technology and its electronic hand-held devices, with an easier access to satellite imagery and use of geospatial technologies, as well as the pervasive web-based and crowd-sourced tools, there is a shift from traditional paper-based census data collection methods to new technology and digital-based approaches. In response to these new developments, and in particular to the recent 2030 Agenda, NSOs are in need to build national statistical systems going beyond the traditional users, to being rather part of a larger "data ecosystem made up of multiple communities of data producers and users, including civil society, the private sector, academic and scientific communities, as well as regional, international and UN agencies, and specialized data producers"[3].

In this context, and within its framework and mandate to promote Africa's sustainable development, ECA is committed to assisting Member States to build their statistical capacities as well as to work with its development partners to strengthen the National Statistical Systems (NSS) through enhancing the National Strategies for the Development of Statistics (NSDS). ECA has been particularly leveraging the use of electronic devices as a new innovative and transformative tool in data collection aimed at assisting African Member States to produce and disseminate quality data for their environment and socio-economic development[4].

[3] See OECD, 2017: PART I, Chapter 3, The role of national statistical systems in the data revolution by Shaida Badiee, Johannes Jütting, Deirdre Appel, Thilo Klein and Eric Swanson*).

[4] See Use of Handheld Electronic Devices for Census Data Collection - United Nations Regional Workshop on the 2020 World Programme, Dar-es-Salam, Tanzania, 12 April 2017 (s12-01-UNECA). Available at:

Against this mandate, ECA is indeed working on "Strengthening the Capacities of Selected African Countries to Develop Geospatial Information Resources and Services in Support of the Implementation and Monitoring of the Sustainable Development Goals". In this regard, it has commissioned the "Development of Guidelines for the Integration of Statistical and Geospatial Information in Africa" on the recent methodological and technological developments that can help their NSOs strengthen, develop and modernize their statistical systems, and provide support for the implementation, measuring and monitoring of the Sustainable Development Goals (SDGs).

This document will be presented as a basis for discussion, with the view for consultation with Member States in the region and adopted as reference guidelines. It is composed of five main sections, dealing with the development of a National Statistical Geospatial Framework (NSGF) and a National Address Management Framework, the requirement for capacity building, the development of standards for Common Geographic Boundaries as well as standards and metadata standards for geospatially-enabled statistics, and geospatial statistical data accessibility and usability as well as related issues of protection, confidentiality and privacy. This guide is based on an inventory of NSSF and NSDI in Africa.

2. Developing a National Statistical Geospatial Framework (NSGF)

As stated earlier, this strategic document encompasses operational guidelines that inform on the establishment and implementation of a national statistical geospatial frameworks (NSGF) in African countries. This framework shall outline some policy principles that would guide national statistical offices, geospatial information authorities and possibly other national data-driven organizations to address challenges on the appropriate use of geospatially-enabled statistics, and on how they gain to have effective collaboration between them in the development of common data infrastructures and interoperable systems. A review of ongoing NSDI initiatives supported or assisted by ECA and its partners will be conducted. Equally a desk review of the NSDS process will be conducted by studying documents from countries where the statistical development strategies have been completed, are in the process or about to commence. In accordance with the terms of reference, the review aims to determine which approach should be adopted in integrating the two processes, namely the National Strategies for the Development of Statistics (NSDS) and the National Spatial Data Infrastructures (NSDI) in Africa.

https://unstats.un.org/unsd/demographic-social/.../2017/.../s12-01-UNECA.pptx

Why we need a national statistical spatial infrastructure?

In this era of data revolution, the 2030 Agenda and the 2020 Round of Censuses[5] are two major drivers behind increased demand, potential production and use of data, including geospatial information. It is well established that the census provides information on the demographic, social, and economic characteristics of the entire population, including at individual level, at a point in time, and thus constitutes a potentially viable data source to produce SDG indicators. Still, the 2030 Agenda demands in particular that Member States undertake new data acquisition and integration approaches to supply reliable, timely, accessible and usable, and disaggregated data that is essential to set priorities, make informed choices and implement better policies for sustainable development[6].

Moreover, with the increasing complexity of national and global challenges and issues, the need to understand the interrelationships across the economic, social and environmental dimensions is becoming crucial for sustainable development at all levels. In addition, to address the growing demand for information on small geographic areas to monitor the development goals and indicators at local and community levels, the 2030 Agenda 'calls out geospatial information and earth observations as key methods for tracking progress and informing people about these global development policies'[7]. The 2030 Agenda calls for the disaggregation of data by geography and the census cartography provides the platform for countries to map their geographies to granular levels that will enable the linking of not only census data but data from other sources.

The 'Where' dimension is being recognized central to the SDGs as geospatial data is absolutely imperative to understand the place, the location, the communities we are working with, the people that we are serving and the context about that place, allowing to identify where the root of the problem lies. And with other layers of information, it supports advanced analysis and visualizations through customized maps or 3D models, helping users in evaluating impacts, monitoring the progress to achieve the SDGs, and thus improving accountability and the relevance of the evidence on which decisions will be made.

In recognition of the importance of geospatial information, the UN recommended the necessity for countries to keep abreast with the technological advances made, since the previous Round of Censuses, especially in the area of Geographic Information Systems (GIS) and Global Positioning System (GPS), and that for the 2020 Round of Censuses the adoption of GIS should be a major

[5] https://unstats.un.org/unsd/demographic-social/census/censusdates/ [12 African countries already conducted a census from 2015-2018; 15 African countries have or planning to conduct a census in 2019; 25 African countries are planning their census between 2020-2024

[6] See UN-GGIM document on "National geospatial data and information systems - Note by the Secretariat" (E/C.20/2017/13/), available at: http://ggim.un.org/meetings/GGIM-committee/7th-Session/documents/E_C.20_2017_13-1708221E.pdf

[7] See more details in the Book: "GIS and the 2020 Census – Modernizing Official Statistics", Esri Press, 2019. Available as e-book and in print.

strategic decision[8]. Hence, the integration of geospatial and statistical information has become a significant way to unlock new insights that would never have been possible by looking at socio-economic or geospatial data in isolation.

Several governmental and private institutions have already recognized the geographic dimension of census and statistical data and its role in economic and social development. They are particularly realizing that the integration of geospatial data with statistics provides significant benefits for their countries, by opposition to the one dimensional traditional approaches, in terms of reduction of cost and time required, as well as accuracy and quality, to collect, process and communicate information, greatly increasing the return on investment in data collection and dissemination. In this regard, many national statistics offices are already transforming, or are planning to transform, their statistical infrastructure, offering an opportunity to embed geography into their national systems and processes. All this requires building capable national statistical systems and developing a mechanism, such as a statistical-spatial framework, to facilitate consistent production and integration approaches for geo-statistical information.

Developing a national statistical-spatial framework should take into account both the National Statistical Development Strategy (NSDS) and the National Spatial Data Infrastructure (NSDI) as well as other existing frameworks, in accordance with what is being developed at global level. Equally, most National Mapping Agencies in the continent are underfunded leading to underperformance in terms of having the needed capacity to link the two systems. In the following sections, we will provide a review of the ongoing NSDI initiatives supported or assisted by ECA and its partners, and conduct a desk review of the NSDS process by studying documents from countries where the statistical development strategies have been completed, are in the process or about to commence. We will also provide an overview on the Global Statistical Geospatial Framework developed by the United Nations. This reviews will help to draw some lessons from the best practices by countries, and particularly determine which approach should be adopted in integrating the two processes, namely the National Strategies for the Development of Statistics (NSDS) and the National Spatial Data Infrastructures (NSDI) in Africa.

[8] See UN Principles and Recommendations – Revision 3, 2017, United Nations Publications, New York. Available at: https://unstats.un.org/unsd/publication/seriesM/Series_M67Rev3en.pdf

National Spatial Data Infrastructure (NSDI)

Most studies and lessons drawn from country experiences show that collection and management of geospatial data does involve many stakeholders within a country, but with many relevant questions about their coordination, privacy, sharing, accuracy, reliability etc. Moreover, the development and maintenance of geospatial databases is often costly and time consuming. It is therefore necessary to minimize duplication of efforts and encourage the sharing and access to geospatial data. In this regard, Spatial Data Infrastructure (SDI) has emerged as a valuable solution.

Many definitions have been attributed to the term "Spatial Data Infrastructure" since two decades, and all of them revolve about technologies, standards, institutional arrangements and human resources that facilitate the availability of and access to geospatial data (The White House, Office of Management and Budget (2002) Circular No. A-16 Revised, August 19, 2002; SDI Cookbook supported by GSDI; Kuhn, W. 2005). Rajabifard (2002), Giuliani and Peduzzi (2011), and Giuliani et al. (2013) distinguish the following five main SDI components:

(i) Data (identification of data sets of critical national importance, with a basic reference framework of digital spatial data to act as a foundation for numerous other data collection activities);

(ii) People (human resources - training, professional development, cooperation, outreach);

(iii) Access network (networking technology - hardware, software, networks, databases, technical implementation plans);

(iv) Policies and Institutional Arrangements (institutional framework- governance, data privacy & security, data sharing, cost recovery); and

(v) Standards (technical standards to facilitate data collection, documentation, access, and transfer, and the means to search for, find, access and use spatial data).

The underpinning principle behind a National Spatial Data Infrastructure (NSDI) is the access to and sharing of data, which is becoming increasingly easier through the advances of technology and the development of electronic networks. Therefore, by making known and by sharing data, duplication of efforts for data collection can be avoided, forging ties with multiple stakeholders can be improved, and citizen and community engagement can be fostered. Indeed, building a National Spatial Data Infrastructure (NSDI) is being regarded as a fundamental part of the national infrastructure, as important as physical infrastructure assets such roads, communications networks, and other public utilities. It is now widely accepted that developing national spatial data

infrastructures will better facilitate the availability and access to spatial data for governmental organizations, the private sector, academia and citizens in general.

Many Governments all over the world are realizing the value of National Spatial Data Infrastructures (NSDI), making major investments to establish and develop them. In Africa, many NSDI initiatives[9] have been pioneered by a number of organizations and groups, including professional associations, the private sector and particularly by UN agencies[i]. For example, ECA has carried out various activities/initiatives in SDI/NSDI, such as the "Mapping Africa for Africa" initiative and its two projects about 'what geo-spatial data constitutes the fundamental geo-spatial datasets for Africa' and 'the catalogue of the available fundamental geo-spatial datasets in Africa – both in country and external data holdings'[10]. ECA has been steering the AFREF project, constituting the reference geodetic network for any geospatial information infrastructure at national and continental levels. It has conducted consultative meetings to bring African countries to agree on a set of fundamental data layers for an NSDI, and on an internationally agreed geo-standards that can be relevant for Africa. ECA has particularly put a lot of efforts to support African countries and strengthen their capacities with methodological work in preparing an implementation guide on SDI, and conducting a number of advocacy and capacity building workshops being organized regionally and nationally in the last decade. On the institutional level, ECA is a pioneer among the other UN Regional commissions in assuring the secretariat of UN-GGIM for Africa, providing support to African countries in building their geospatial information infrastructures and giving a voice to Africa in the international arena.

There are some good NSDI practices in the region, such as in South Africa or Nigeria. However, despite the efforts made by ECA for African countries, the implementation of formal NSDI is being carried out at a seemingly slow pace[11], and many gaps are underscored by some survey-based studies12, pointing out to the major factors that caused them: lack of national awareness of the value of geospatial information in national development planning and the importance of NSDI especially by policy/decision makers and senior management of government organizations; lack of financial resources mobilization; lack of capacity development; lack of policies, institutional

[9] See "SDI AFRICA: AN IMPLEMENTATION GUIDE". Available at: http://gsdiassociation.org/images/publications/cookbooks/SDI_Africa_Guide_full_text.pdf
[10] See "Status of GIS in Africa, By Dr. Derek Clarke https://www.geospatialworld.net/author/hastingsdun-org/).
[11] See "A Review of the Status of Spatial Data Infrastructure Implementation in Africa", by Prestige Makanga 1, Dr. Julian Smit, Research Article ─ SACJ, No. 45. July 2010. Available at: http://sacj.cs.uct.ac.za/index.php/sacj/article/viewFile/36/19
[12] "Spatial Data Infrastructures in Africa: A Gap Analysis", by Guigoz and al, Journal of Environmental Informatics 30(1) 53-62 (2017). http://www.iseis.org/jei

arrangements and legal frameworks for building NSDI, etc. The studies and surveys (See Table 3 on NSDI in annex) had also shown that the crucial finding is not about the lack of availability of data collected, but rather about the data available is either lacking metadata[13], inaccurate, unreliable, not maintained, or utterly out of date. Moreover, there is an imbalance in the availability of different datasets due mainly to the reasons of their collection which are mainly commercial. Indeed, there are existing datasets, such as main roads and railways, being collected with commercial value to trade, while others being very poorly represented[14].

Integrated Geospatial Information Framework

The Integrated Geospatial Information Framework is a United Nations endorsed Framework that was developed by the United Nations in collaboration the World Bank, the framework provides basis guidelines for lower to middle-income countries as a reference when developing and reinforcing their national and sub-national capacities in geospatial information management and the development of associated infrastructures. The vision is that governments are able to achieve sustainable social, economic and environmental development through the effective use of national and local geospatial information, systems and capabilities for evidence-based policy and decision-making. The vision statement is a future orientated and aspirational declaration of purpose and being. The Framework provides the strategic guidance that enables country specific action plans to be prepared and implemented in order to develop a viable geospatial information system. Direct benefits of the framework include encapsulating new and innovative approaches to national geospatial information management, implementing integrated evidence based decision-making solutions, and maximizing and leveraging national information systems that are tailored to individual country's situations and circumstances.

The Framework and its guidance build upon the existing body of work of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) and the World Bank, which was aimed at identifying gaps especially related to the establishment of viable geospatial information management practices in developing countries. The Framework is also a mechanism for articulating and demonstrating national leadership, cultivating champions and developing the capacity of leaders to take positive steps to achieve the vision for the effective use of geospatial information to measure, monitor and achieve sustainable social, economic and environmental development - leaving no one behind. In order to better link geography and statistics it is important to use the goals of the framework in the integration processes. These goals are: i) Effective Geospatial Information Management, ii) increased capacity, capability and knowledge transfer, iii) integrated Geospatial Information Systems and services, iv) economic return on investment, v) sustainable education and training programs, vi) international cooperation and

[13] Geospatial Data Infrastructure: The Problem of Developing Metadata for Geoinformation in Africa, Dr. Tsehaie Woldai, ITC.
[14] See "Status of GIS in Africa" By Dr. Derek Clarke https://www.geospatialworld.net/author/hastingsdun-org/

partnerships leveraged, vii) enhanced national engagement and communication and viii) enriched societal value and benefits[15].

National Statistical Development Strategy (NSDS)

To seize the opportunities presented by the data revolution, where innovative technologies have decreased the cost and increased the volume and speed of data collection and data dissemination, statistical offices gain not only to invest in these advanced technology and production processes to respond to the growing demand for actionable data, but also to establish partnerships with new actors from the private sector, academia, civil society, the media and other communities. To accomplish this, NSOs are recommended to revise their national statistical development strategies (NSDS), national statistical acts and adapt it to these data developments, thus modernizing their official statistics and having a national statistical system responding to all the user needs.

The Cape Town Global Action Plan for Sustainable Development Data, adopted by the United Nations Statistical Commission in March 2017, identifies national statistical systems and offices as the "necessary and appropriate leaders of this effort", providing a framework for planning and implementing statistical capacity to match the scope of the 2030 Agenda[16]. The UNSD director was even more explicit in stating that: "a transformation of national statistical systems to enable national statistical offices to play their new role as "chief data managers", coordinating and validating national information beyond official statistics and integrating geospatial information and big data[17].

A desk review of the NSDS process has been be conducted by studying documents about countries where the statistical development strategies have been completed, are in the process or about to commence. A summary of the information about the status of NSDS in African countries, gleaned from Paris 21 repository, is recorded in table 2 in annex.

What we can observe is that too many statistical offices are lagging behind to reset their national strategies and modernizing their national systems. This shows that these NSOs are not yet in a position to benefit from these opportunities offered by the data revolution, due mainly to the facts that they are either under-resourced, have limited capacity, and/or are unable to obtain the skilled

[15] Integrated Geospatial Information Framework, http://ggim.un.org/meetings/GGIM-committee/8th-Session/documents/Part%201-IGIF-Overarching-Strategic-Framework-24July2018.pdf

[16] (OECD, 2017: PART I, Chapter 3, The role of national statistical systems in the data revolution by Shaida Badiee, Johannes Jütting, Deirdre Appel, Thilo Klein and Eric Swanson*).

[17] See "In my view", by Stefan Schweinfest, UNSD Director.

staff or the equipment needed[18].

A golden opportunity for both communities

As stated by ECA[19], the nexus issues in linking geography and statistics are as follows: (i) Leadership - Establishment of effective national leadership; (ii) Cooperation – Institutional arrangements for operationalizing an integrated and coherent approach with other information infrastructures; (iii) Resources – Mobilization of resources needed to effectively produce development information; and (iv) Capabilities - Member States Capabilities to ensure geospatial data, products and services are ready available.

Since National statistical offices are generally not custodians of base maps and other mapping products which may be difficult to acquire but much needed for census mapping operations, they gain to collaborate with their country's national mapping agency to get them and avoid any duplication of efforts and resources. They also need to extend their involvement and active participation, in partnership with other national authorities, for the development of a national geographical information capacity, including the National Spatial Data Infrastructure (NSDI).

These Partnership and/or cooperation constitute a win-win situation for both the country's NSO and NMA. It is a golden opportunity to facilitate and boost the establishment of the NSDI on one hand, and to modernize the statistical system on another hand.

The Global Statistical Geospatial Framework

Linking geospatial data with socio-economic and other data, or integrating geospatial and statistical information, has been identified by the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) since its inception as one of the nine key priority issues to be addressed, as it is relevant to many national geospatial information authorities and international organizations engaged in geospatial information management, particularly with regard to linking information through geocoding[ii].

In recognition of this important need for taking into account the geographic dimension in statistics, the United Nations Statistical Commission (UNSC) and UN-GGIM have established in 2013 an Expert Group on the Integration of Statistical and Geospatial Information (UN EG-ISGI) tasked

[18] Idem.

[19] See UNECA Presentation at FOSS4G 2018 Conference Intergovernmental Geospatial: The African Opportunity 30 August 2018 – Dar-es-Salaam, URT. Available at: http://ggim.un.org/unwgic/presentations/1.1_Mr.-Andre-Nonguierma.pdf and http://ggim.un.org/meetings/2018-Addis_Ababa/documents/1.9.Andre_Nonguierma.pdf

with developing and advancing the implementation of a global statistical-geospatial framework as a standard for the integration of statistical and geospatial information, especially in the context of the 2030 Sustainable Development Agenda. This importance has also been recognized in 2017, when the 'Cape Town Global Action Plan for SD Data- SDG indicators' set its objective 3.4 "Integrate geospatial data into statistical production programmes at all levels", with the following "key actions: (i) Promote the integration of modern geospatial information management systems within mainstream statistical production programmes by highlighting synergies between the two systems; (ii) Promote the integration of geospatial and statistical metadata; (iii) Encourage the use and adoption of technologies that promote integration of geospatial and statistical information; and (vi) Support the implementation of the Global Statistical and Geospatial Framework, when it is adopted."

At the regional level, the integration of statistical and geospatial information is considered as a key priority area in Europe, Africa, the Americas and Arab region. For example, the 2014 report of the African Union 'Common African Position on the post-2105 development agenda'[20] noted that a key enabler for sustainable development to be effective, Africa must "invest in and strengthen national statistical capacities and geospatial information systems for the collection, analysis, production and dissemination of disaggregated data to measure and evaluate policy effectiveness; and promote a culture of evidence-based decision making". This has been confirmed when Africa adopted the African Data Consensus[21] - a roadmap to improving data standards and availability - in Addis Ababa, in March 2015. Moreover, under the leadership of UNECA, UN-GGIM: Africa has created a working group dedicated to the integration of geospatial and statistical information, and prepared the Africa Action Plan on Integration of Geospatial and Statistical Information[22]

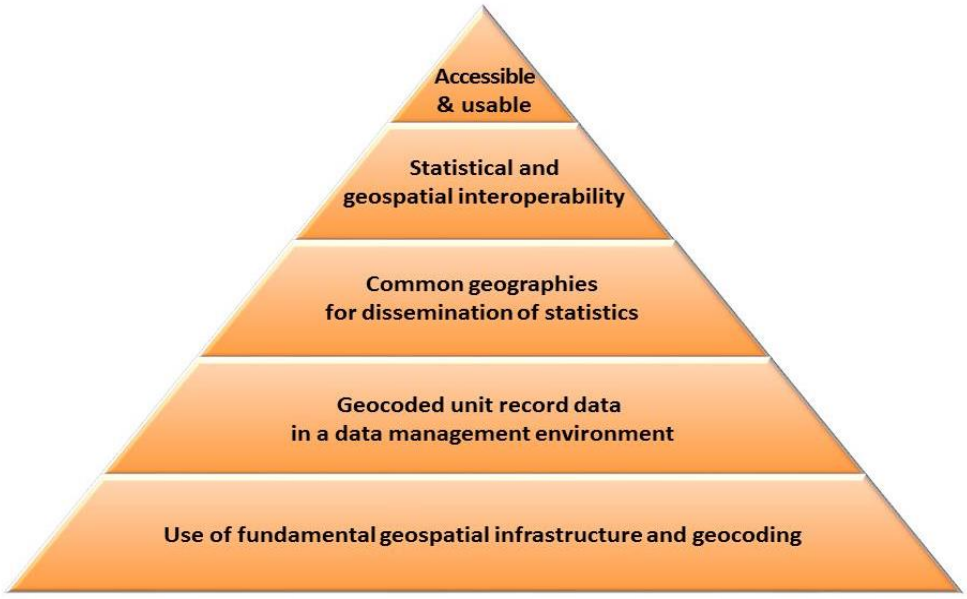
In this regard, the UN EG-ISGI has developed the Global Statistical Geospatial Framework that has evolved from Australia's Statistical Spatial Framework and refined, through a global consultation process, to be adopted by the UN Statistical Commission at its 48th Session in March 2017, and subsequently endorsed by UN-GGIM at its 7th Session in August 2017. (See an overview on what the GSGF looks like in the inbox below).

[20] http://www.africa.undp.org/content/dam/rba/docs/Reports/RBA-common-position.pdf
[21] https://www.uneca.org/sites/default/files/PageAttachments/final_adc_-_english.pdf
[22] See "The African Action Plan on integration of geospatial and statistical information". Available at: www.uneca.org/sites/default/files/PublicationFiles/un-ggim_- _geospatial_information_for_sustainable_development_i n_africa-20171115.pdf and www.uneca.org/sites/default/files/PublicationFiles/geospatial_information_for_sustainable_development_in_afri ca_fre-20171115.pdf

Overview of the Global Statistical Geospatial Framework (*)

The Global Statistical Geospatial Framework is a high-level framework that consists of five overarching principles that are considered essential for integrating geospatial and statistical information (see the orange layers in Figure 1 below).

Figure 1: Global Statistical Geospatial Framework



The Global Statistical Geospatial Framework Principles – Goals and Objectives

Each of the high-level principles in the Global Statistical Geospatial Framework are defined by a set of goals and objectives, and are supported by international, regional and applicable domestic standards and best practice. At its Sixth Session in 2016, UN-GGIM adopted the following five high-level principles:

Principle 1: **Use of fundamental geospatial infrastructure and geocoding**

This foundational principle is about the use of a fundamental geospatial infrastructure with the finest of geographic level possible. It refers to a common and consistent approach to establishing the location and a geocode for each unit in a dataset, such as a person, household, business, building or parcel/unit of land, in assigning accurate coordinates and/or a small geographic area or standard grid reference to each statistical unit. Another alternative approach to geocoding for recording location is to use direct capture of coordinates from field work (e.g. from Global Navigation Satellite Systems (GNSS) such as GPS) or indirect capture from maps. The fundamental geospatial infrastructure may vary from country to another, but the process of obtaining locations and geocodes should use relevant, fundamental geospatial data from the National Spatial Data Infrastructures (NSDI) or other nationally agreed sources.

Principle 2: **Geocoded unit record data in a data management environment**

This principle recommends that the linkage of a geocode for each statistical unit record should occur within a data management environment to ensure that all statistical data is consistently geospatially enabled and allow the flexible use of geocoded unit records in future analysis and visualisation (e.g. in aggregating data into a variety of larger geographic units, or taking future changes to geographies over time). This principle is underpinned by two important related aspects: geospatial enablement and flexibility is key (the finer the better), and statistical data management ensures confidentiality.

Principle 3: **Common geographies for dissemination of statistics**

This principle is about enabling comparisons across datasets from different sources, which requires to use a common set of geographies for the display, reporting and analysis of social, economic and environmental information. The underpinning element is the reference link that common geography can offer for data from disparate sources to be integrated, enabling aggregation and other spatial analysis, visualization and dissemination. While there is recognition of the importance of traditional statistical and administrative geographies, it also recommended that NSOs consider the benefits of grid-based statistical systems, as gridded data can be both a rich source of information and a consistent geography for disseminating and integrating information.

Principle 4: **Statistical and geospatial interoperability – Data, Standards and Processes**

This principle is about the benefits of greater interoperability between statistical and geospatial data and metadata standards, from cataloguing to data interchange. It is specifically about enhancing the efficiency of discovery, access and use of geospatially enabled statistics and geospatial data, by overcoming structural and syntactic barriers between data and metadata from different providers and communities. Both the statistical and geospatial data communities operate their own general data models and metadata capabilities with few common standards. However, there is a number of initiatives that have started internationally on how to better enhance interoperability between statistical and geospatial metadata standards, and within the statistical community there is a need to build geospatial processes and standards into statistical business processes in a more consistent manner. In consequence, the UN EG-ISGI has recognised that a top-down approach is required with a view to incorporating geospatial frameworks, standards and processes more explicitly into the Common Statistical Production Architecture and its components.

Principle 5: **Accessible and usable geospatially enabled statistics**

This principle is about the need to identify or, where required, develop policies, standards and guidelines that support the release, access, analysis and visualisation of geospatially enabled information. It specifically aims at ensuring that custodians release data in appropriate forms, with privacy and confidentiality protected, and users can discover, access, integrate, analyse and visualise statistical information seamlessly for geographies of interest. The final purpose of this principle is to allow data to be accessed, shared and used efficiently and ultimately support the modernisation agenda of NSOs and NMAs alike.

The UN EG-ISGI have identified a range of international and national standards, frameworks, infrastructure, and best practice that are relevant to the five principles. Their potential uses in support of these principles are outlined in Appendix 2 of the reference document (*). However, where standards, policies or datasets required to support the Framework do not currently exist, the Global Framework provides a clear mandate for their establishment. Collaboration between countries and within the Expert Group provides a mechanism to assist with the formation and establishment of these standards, policies or fundamental datasets – both within member states and internationally. A number of areas are still pursued by the Expert Group and will be brought to the UNSC and UN-GGIM for consideration when completed.

(*) Source: This text explaining the principles is mainly derived, with some adaptations, from the UN-GGIM reference document: http://ggim.un.org/meetings/GGIM-committee/8th-Session/documents/Global-Statistical-Geospatial-Framework-July-2018.pdf

Application of the Global Statistical Geospatial Framework in Africa

Principle 1: Use of fundamental geospatial infrastructure and geocoding

In Africa the use of fundamental geospatial infrastructure and geocoding have to cover every level of geographies with varying disaggregated statistical data, presented specifically at the sub national, national and international levels. Therefore, an institutional managerial body that governs and is responsible for the coordination of a geospatial data infrastructure and geocoding statistics is essential. The following list is fundamental for implementation:

1. The existence, availability and accessibility of official and non-official statistics from National Statistic Offices and other government agencies as well as NGO's, institutions, private sector, such as: sampling frames, use of statistical units, social statistics, economic statistics, demography, agricultural statistics, environmental statistics and censuses, etc. will be essential for the establishment of a viable geospatial infrastructure and geocoding that is linked to a geodatabase.
2. The existence, availability and accessibility of geospatial fundamental and thematic datasets from Geospatial Agencies (e.g. National Mapping and Cadastral Agencies (NMCAs): use of digital footprints of buildings,' use of administrative boundaries, addresses, transport/water networks, elevation data, satellite imageries and topographic data, etc. are critical for the development of a functioning geospatial infrastructure and geocoding that is linked to a statistical database.
3. The development and the sustainability of institutional within the geographic and statistical sphere in the continent for proper management, direction, supervision, monitoring, evaluation, functioning, cooperation and general acceptance, through partnership between NSO's and NMA's as well as other strategic partners is critical. This institution permeates the linkages between geography and statistics.
4. It is essential that formal working relationships between agencies are created especially the NMA's and NSO should work harmoniously towards the creation of working groups. The NMA's and NSO should work towards the establishment of a communication platform to discuss the issues of integrating geography and statistics.
5. The above efforts should culminate in an inter-institutional agreements that ease the promotion and usage of an integrated geospatial-statistical data. Within the framework of the agreement these institutions should define terms of use. The available, accessible data should be defined by an Open-Data Policy, preferably at a low-cost or free of charge. Equally, the sensitive nature of geospatial data requires that privacy and confidentiality issues are addressed by taking into recognition national and international laws. Moreover, policies, regulations, standards and guidelines supporting the utilization, access, analysis and visualization of geospatial and statistical integrated data should be well stipulated.
6. Implementation of Principle 1 achieves the following objectives:

a. It is essential that there is the development of a geospatial and statistical integration strategy that guides the linkages between geography and statistics.
b. It is important that experts from both the statistical and geographic communities join efforts in elaborating technical norms and regulatory agreements, related to the normalization of the geographical and statistical elements to be represented.
c. These experts should define the basic qualities and requirements of the necessary geospatial information, for geocoded statistical data.
d. Also, methodologies and procedures that standardize the generation and maintenance of data, both geographic and tabular should be examined and developed:
    i. Critical to this effort will be the use of geocoded address collection standards / consistent locations nationwide to effectively capture the physical location / address.
    ii. Equally, there should be an elaborated procedure for the validation of addresses / point of entry locations (for computer-based capture and internet) to improve their quality and the resulting geocoding and reduce the time spent in correction after the initial data capture.
    iii. Efforts should be made on adopting a common geocoding practices at the national level.
e. Equally, essential in the continent will be the development of methods to design and implement computer based tools to carry out the process of quality assuring geographic objects for incorporation into the data sets.
f. The NMA's and NSO should work harmoniously in order to establish an effective storage of data without the need for reprocessing for their integration.
g. The NMA's and NSO should work harmoniously in order to resolve data management systems issues (e.g. using data bases, services connecting data (Open Geospatial Consortium (OGC) standards: Table Joining Services (TJS)
h. The NMA's and NSO should work harmoniously in understanding, knowledge development and sharing in using map services to distribute results over world wide web (OGC standards: Web Mapping Services (WMS), Web Feature Services (WFS)

Principle 2: Geocoded unit record data in a data management environment

There should be a common understanding between the NMA's and NSO's on issues related to harmoniously developing geocoded unit records. It is worth noted that Principle 2 supports the process of linking or storing high-precision geographic references (i.e. geocodes – coordinates, small geographic area codes, or linked-data identifiers) to each microdata/statistical unit record. This is often referred to as geospatially enabling data, and must occur within a secure, standards-based data management environment. This process

applies the address coding infrastructure and fundamental data from Principle 1. Therefore there is the need to develop geocoded unit records standards that is accepted by both geographers and statisticians,

Therefore, the goal of Principle 2 is to allow every statistical unit records to be linked to a location, wherever it is possible to do so. It is critical that countries undertaking the 2020 round of censuses in the continent should cease this opportunity during census cartography to collect and link this data. This will afterwards enable integration of data from a wide variety of sources, such as other socio-economic statistical data, administrative data, and geospatial information about the built and natural environment. The incorporation of these data, using geospatial processing, can then deliver new, geospatially enabled statistical variables for analysis. Principle 2 also enables flexible application of any geographic content when preparing data for release and analysis. This includes supporting future aggregation of statistical data into new geographical units or adapting to changes to existing geographies over time.

Principle 2 includes the use of data-management tools, protocols, techniques, standards and good practices to facilitate the linking and management of geocodes within statistical datasets. This also serves to ensure that privacy and confidentiality requirements are correctly managed for the released data.

Implementation of Principle 2 achieves the following objectives:

- All stakeholders should make sure that all the statistical microdata is geospatially enabled for flexible use in analysis, visualization, dissemination and statistical data integration processes. The use of data-management tools, protocols, techniques, standards and good practices to facilitate the linking and management of geocodes within statistical datasets should be encouraged;
- Methods and procedures for the aggregation of data for larger geographies should be in place as this is simplified through storage of a unique identifier or code for a small area geography or standard grid cell for each unit record;
- The process should enable the adaptation to changes to existing geographies e.g. changing administrative boundaries that allows for the compilation of data for new geographies should be enabled;
- Data can be effectively managed, including the protection of privacy and confidentiality;
- Clear data maintenance and custodianship roles are defined; and,
- Geocoded information and metadata are consistent, interpretable and systematically maintained.

Implementation of Principle 2 achieves the following objectives:

i. Develop a geospatial and statistical integration strategy that includes Geocoded unit record data in a data management environment guides the developments of information as a whole.
j. Elaborate the technical norms and regulatory agreements, related to Geocoded unit record data of the geographical elements to be represented.
k. Define the basic qualities and requirements of the necessary geospatial information, for the geocoded statistical data.
l. Develop the methodologies and procedures that standardize the generation and maintenance of data, both geographic and tabular for Geocoded unit record data:
    i. Use address collection standards / consistent locations nationwide to effectively capture the physical location / address with geocodes.
    ii. Implement the validation of addresses / point of entry locations (for computer-based capture and internet) to improve their quality and the resulting geocoding and reduce the time spent in correction after the initial data capture.
    iii. Adopt common geocoding practices at the national level.
m. Design and implement computer based tools to carry out the process of quality assuring geographic objects for incorporation into the geocoded data sets.
n. Establish an effective storage of the geocoded data without the need for reprocessing for their integration.
o. Resolve data management systems issues (e.g. using data bases, services connecting data (Open Geospatial Consortium (OGC) standards: Table Joining Services (TJS)
p. Using map services to distribute results over world wide web (OGC standards: Web Mapping Services (WMS), Web Feature Services (WFS)

Principle 3: Common geographies for dissemination of statistics

Principle 3 applies geography as a tool for integrating data as an enabler for the measurement of the SDGs. It uses a common and agreed set of geographies for the display, storage, reporting, and analysis of social, economic and environmental comparisons across statistical datasets from different sources. Principle 3 establishes the fundamental importance of balancing existing statistical and administrative geographies with other geographic referencing systems, such as grids, as a basis for establishing common geographies across datasets.

The goal of Principle 3 is to support the provision of a common set of geographies that ensure the consistent geospatial aggregation and dissemination of statistical data, irrespective of whether they are in gridded or administrative boundaries. Data is uniformly allocated to smaller administrative segments or statistical units (such as quarters, sub-quarters, mesh blocks, sub blocks etc.) that are divided according to political, property or topological subdivisions, or consistently assigned to differently sized grid units (i.e. squares or pixels).

Furthermore, Principle 3 also allows for the translation and mapping of statistical information between gridded and administrative boundaries.

Implementation of Principle 3 achieves the following objectives:

- Data from different sources can be integrated using a common geography and evolving boundaries;
- The visualization, analysis and interpretation of statistical and geographic information is simplified;
- Metadata supports data aggregation, integration and use;
- Identification and application of aggregation and disaggregation methods will enhance data quality and the assessment, consistency and increased use of data; and,
- The conversion of data between geographies is supported, through standard conversion mechanisms (e.g. through correspondences).

Principle 4: Statistical and geospatial interoperability – Data, Standards and Processes

Principle 4 defines the preconditions for statistical and geospatial data to work as a data ecosystem, in which those involved interact with each other to exchange, produce and consume data. Interoperability between statistical and geospatial data and metadata standards, is needed to overcome structural, semantic and syntactic barriers between data and metadata from different communities and providers.

Furthermore, it is necessary to enhance the efficiency of discovery, access, and use of geospatially enabled data. Often, full interoperability of data first requires the removal of obstacles in country-level laws, policies, and organizations that hamper cooperation between stakeholders and create barriers between producers and end users.

Enhancing interoperability allows both the statistical and geospatial communities to continue to operate their own general data models, metadata capabilities and architectures, while efficiently and seamlessly accessing, integrating, and linking datasets across different systems and applications. Therefore, Principle 4 urges the use of internationally adopted standards and good practices from both communities to enable greater interoperability of statistical and geospatial data, standards, processes and organizations.

Implementation of Principle 4 achieves the following objectives:

- Greater efficiency and simplification in the creation, discovery, integration and use of geospatially enabled statistics and geospatial data;
- Ensures service-based or machine-readable access mechanisms (e.g. through APIs) are implemented to provide greater efficiency of access and use, and to allow adaptation and evolution of uses through time; and,
- Increases the potential application of a larger range of data and technologies.

Principle 5: Accessible and usable geospatially enabled statistics

Principle 5 highlights the need for data custodians to make geospatially enabled statistics accessible and usable according to agreed standards and good practices, so that data users can discover, access, integrate, analyses and visualize this information seamlessly for geographies of interest. It addresses the need to identify or, where required develop, policies, standards, good practices, and technologies that support these uses.

NSOs and NMA's need to be aware of a wide range of legislative and operational issues when releasing and analyzing information about people and businesses. As such, one important aspect of this Principle is to ensure that data can be accessed using safe mechanisms, which protect privacy and confidentiality, while also enabling the analysis of data to support data-driven, evidence-based decision-making. Other issues of relevance include: data quality in its different dimensions (particularly regarding reliability, timeliness, and relevance) and access to analysis, dissemination and visualization capabilities.

The goal of Principle 5 is to support the release of geospatially enabled statistical information in a usable and accessible form. It specifically promotes the use of standard web services and linked data methods to provide dynamic, machine-readable access to these data with the necessary assurances regarding the integrity of the data.

Implementation of Principle 5 achieves the following objectives:

- Data custodians can release data, with data privacy and confidentiality protected;
- Data users can discover and access geospatially enabled statistics;
- Data users can undertake analysis and visualization;
- Web services and linked data methods enable machine-to-machine access, as well as dynamic linkage of information; and,
- Data users can know the status of modifications / changes in the data provided by data custodians through data integrity checks[23].

[23] https://unstats.un.org/wiki/display/ISGI/Principle+5%3A+Accessible+and+usable+geospatially+enabled+statistics

Developing a National Statistical Geospatial Framework (NSGF)

As stated earlier, the development of the Global Statistical Geospatial Framework (GSGF) was expressed by countries for the sake of comparability globally, but also to be emulated at the national level. GSGF is indeed driven by overarching principles that are broad enough to allow countries adapt them to their nationally specific needs. In this regard, a country-oriented template has been prepared by the Australian Bureau of Statistics for each of the five principles, enabling countries to adapt this global framework to their national conditions and producing similar frameworks for their use nationally. The Template is being tested and validated through completion by the Expert Group. It is worth noting that already some countries all over the regions of the world, such as Australia, Egypt, Mexico, New Zealand, South Africa and Sweden, have produced similar frameworks for their use nationally (See table 1). Other members agreed to prepare country level frameworks in application of the five principles.

We have to delve into the requirements of the five guiding principles taking into account national contexts to provide support to African countries in their building and development of their NSGF[24]:

1. Building and developing a geospatial infrastructure
    - The Statistical-Geospatial Framework is about the use of a fundamental geospatial infrastructure and geocoding, and this presupposes in the first place the existing of a geospatial infrastructure at the finest geographic level, which is not the case in many African countries.
    - It is well known that a possible way to have a geospatial infrastructure at the finest geographical level for geocoding purposes is to establish a National Address Management Framework (NAMF), to be used to determine geographic positions based on an address, or even a National Dwelling Framework, based on a point-based capture of geographic coordinates at the dwellings/housing unit levels. Equally, the administrative limits of most countries are not validated at the lowest levels and often these boundaries change frequently making it difficult to compare statistical data over time. Many African countries are in need to build their national addressing systems. But a country like South Africa, Egypt, Malawi etc. are building their national dwelling frames, which offers experiences other African countries need to look at, while recognizing that the specific frameworks for coding addresses and dwellings can vary from country to country, and these would be important components for any national

[24] See "Spatially-enabled Statistics for Africa", International Workshop on Global Fundamental Geospatial Data Themes for Africa 25-27 April 2018 Addis Ababa, Ethiopia. Available at http://ggim.un.org/meetings/2018-Addis_Ababa/documents/1.9.Andre_Nonguierma.pdf

statistical-spatial framework.[25] In the 2020 round of the census countries such as Mali, Zambia etc. are using building footprints derived from satellite imagery for the carving out of enumeration areas, the validation or ground truthing of these building footprints have help developed an address system which will be eventually be used to link geography and statistics.

- The requirement here is to build and develop a national geospatial infrastructure which would cater to the needs of both geospatial and statistical communities. A national statistical-geospatial infrastructure in line with the National Spatial Data Infrastructure (NSDI), using for example the fundamental geospatial data and/or the national geodetic reference system.
- We have to be aware of the challenges to be addressed in building an NSDI, chief among them in many African countries are the lack of policies and legal frameworks, need for more institutional political leadership and support, and inadequate financial and human resources.

2. Geo-enabling statistical data
   - Geo-enabling statistical data is linked through the geocoding process of finding associated geographic coordinates from other geographic data for the statistical units such as street addresses or postal codes[26], direct capture by GNSS/GPS receivers of the coordinates (latitude and longitude) in the field or indirect capture of coordinates from existing maps. The geocodes, be it points, lines, polygons and raster images are linked or jointed with statistical data. The linked data should follow authoritative statistical procedures for data management.
   - It is worth noting that many National Statistical Offices in Africa are using enumeration geography (traditional administrative-based enumeration areas), but many other NSOs in the world are increasingly going further towards a point-based location of people and dwellings (establishing a dwelling frame) that increases the spatial relevance of statistical information. The point-based approach facilitates the convergence of information from multiple sources for a particular location and allows aggregation at any spatial unit and further spatial analysis.
   - African countries need to adopt a management approach to enable geospatially the basic statistical units to which characteristics of individual persons, households, enterprises and geographic features of interest can be attributed. This data management of storing geo-reference data together with the unit level records should take into account precautions and security measures to ensure that individual information is kept within the privacy and confidentiality spheres.

[25] See "Statistical and Spatial Frameworks. Standards and Data Infrastructure", 2013. Available at: https://www.unece.org/fileadmin/DAM/stats/documents/ece/ces/ge.40/2013/WP11.pdf

[26] "GIS and the 2020 Census: Modernizing Official Statistics", Esri Press, 2019. Available as e-book and in print.

3. Standard geographic boundaries
    - We need to have a Standard Geographic Frame which is consistent and stable over time. There is the traditional hierarchy of administrative boundaries (province, municipality, etc.) which provides the basis for consistent geographic areas, representing the smallest areas for which population information is available although most of these administrative levels needs to be validated and standardised by the relevant administrative authorities. It consists specifically in the creation of a list of all administrative and statistical reporting units in the country, with the relationships among all types of administrative and reporting unit boundaries being defined.
    - But, this traditional 'administrative method' which uses the enumeration area as a basis to report census data in accordance with a hierarchical system of administrative units, ranging from the local up to the country level, is more and more criticized as the administrative units are prone to changes. It is worthwhile to note that most censuses in Africa do not report census results at a granular or disaggregated geographic level especially when during the census cartographic process failed to capture or map the lowest administrative units.
    - Since some African countries are experiencing frequent changes with the administrative boundaries, a grid system would provide a solution for these recurrent issues of administrative boundaries. A grid system is indeed stable over time, and not affected by frequent administrative boundary changes.[27] It would also offer a cross-border studies, useful for instance to disseminate some environment or health statistical data, or global SDGs indicators. The grid system also fails to provide detailed demographic characteristics of the population by is useful to measure population densities. Efforts have to be made to link demographic characteristics of the data collected in censuses and surveys to interpolate and derive grids that reflect the demographic and other characteristics of the population.

It is particularly required for NSOs to take a standards-based approach and collaborate with the National Mapping Agency/National Geospatial Information Authority, as the custodians of base maps, to avoid that NSOs create their own data on administrative boundaries and topographic maps. Effective coordination among all the stakeholders should be done through a process of assessment, planning and implementation stages as this is vital to the proper functioning of geospatial-statistical enabled system. In order to improve coordination in the geospatial-statistical enabled process, it is important to define the stakeholders and the parties to the agreement. The first step is to identify them and analyze their mandates, roles and leverage points as contributors and end users to the geospatial-statistical enabled system. The analysis should include all the stakeholders and major actors, including Governmental bodies, non-Governmental entities, civil society organizations and donors. At the start of the process, it is crucial to establish common ground among

[27] Idem.

stakeholders on the critical importance of an effective coordination mechanism within the geospa tial-statistical enabled system, considering its inherent multi-disciplinary and multi-sector nature. Further, countries have to take stock of existing coordination/cooperation mechanisms, identify g aps and missing links in the value chain that may need improvement. The objective is to reach an agreement among all parties and stakeholders on the most sustainable and best functioning frame work that will enhance the geospatial-statistical enabled system in the country. This process may require tailoring and adjustment including proper human and financial resources allocated to sup port the geospatial-statistical enabled system.

The process of engaging stakeholders in identifying their unique and complementary roles as wel l as the collective results they are able to achieve through better coordination is key to the actual creation of the geospatial-statistical enabled system. It validates, step-by-step, all parties' joint co mmitment and accountability for the design, implementation and delivery of the elements of the geospatial-statistical enabled system and of the entire geospatial-statistical enabled system at the national level.

4. Metadata Interoperability
    - Developing, adopting and implementing technical standards and metadata is a ubiquitous process for African countries to enable interoperability and facilitate the integration and use of diverse sources of statistical and geospatial data and services in all sectors, and make statistical and geospatial information more relevant to a wider range of stakeholders. The geospatial information community is well advance in the development of meta data as compared to the statistical community and there is a lot of work to be done in harmonizing the two systems. For example, the tabulation plans used for censuses and surveys do not reflect table structures used in geospatial database. The data collected in most geospatial surveys do not tally with statistical processes of data collection and management.
    - It is particularly recommended for African countries to implement standards that meet their user needs, bearing in mind that these standards gain to be in line with the internationally-agreed geo-standards, like those developed by the international standard organizations ISO/TC211 and OGC[28]. They should also be aware of the standards under development such as the work on a statistical-geospatial metadata interoperability to integrate the statistical metadata standards SDMX and DDI[29] with ISO-19115.
    - Studies have shown that African Countries need to be involved in international Standard Organizations, and, thus, are encouraged to establish or develop their national standardization institutions, to provide a national policy on geospatial information,

[28] "A Guide to the Role of Standards in Geospatial Information Management", prepared cooperatively by the Open Geospatial Consortium (OGC); The International Organization for Standards (ISO) Technical Committee 211 Geographic information/Geomatics; and the International Hydrographic Organization (IHO). August 2015" – See: http://ggim.un.org/documents/Standards%20Guide%20for%20UNGGIM%20-%20Final.pdf

[29] Like SDMX, the Data Documentation Initiative (DDI) has become a well-established international metadata standard, designed to describe socioeconomic surveys, censuses, and other microdata collection activities.

which prescribes data standards to be developed or adopted and implemented.

5. Access and use
    - It is worth reiterating that the ultimate goal for developing a statistical-geospatial framework is to help make data easily accessible, and used by as many users as possible.
    - In this data-driven era, the benefits of linking socio-economic and geospatial information are increasingly acknowledged. This is reflected in the growing demand for statistical organizations to provide information on small geographic areas, right down to the geocode, needed at local and community levels.
    - There is also the recent rise of the 'Open Data' movement, recognized by the UN for tits support to the sustainable developments goals (SDGs). In this regard, the African Data Consensus recommended that "African governments should acknowledge open data provided by credentialed data communities as acceptable sources of country statistical information."[30]
    - Also, recognizing that the national statistical systems are concerned by this open data movement, the 2017 Cape Town Global Action Plan for Sustainable Development Data did "encourage national statistical offices to embrace the open data initiative and ensure stakeholders of the national statistical system as part of the process"[31]
    - However, since socio-economic, environmental and other geospatial data is provided by multiple sources in different formats, the quality of open data varies considerably in terms of coverage and consistency. National statistical and geospatial agencies are uniquely placed to ensure data quality, and their responsibility will continue to grow as the volume of additional crowdsourced and open data increase[32].
    - Governments are required to play a central role, not only to develop and implement policies, but also to take precautions and set security measures to mitigate the concerns about the misuse of any open data, particularly those infringing on individual privacy and confidentiality.

[30] Cf. "Africa Data Consensus" document – Addis Ababa, March 2015, available at: https://www.uneca.org/sites/default/files/PageAttachments/final_adc_-_english.pdf
[31] See Cape Town Global Action Plan for Sustainable Development Data. Available at https://unstats.un.org/sdgs/hlg/Cape_Town_Global_Action_Plan_for_Sustainable_Development_Data.pdf
[32] Cf. The Future Trends: The Five to Ten Years, Second edition, available at http://ggim.un.org/documents/UN-GGIM-Future-trends_Second%20edition.pdf

Table 1: Five principles as implemented in 5 different countries (*).

	Australia	Egypt	Mexico	New Zealand	South Africa
Principle 1: Use of fundamental geospatial infrastructure and geocoding	Foundation Spatial Data & NAMF – National Address Management Framework	Establishing a NSDI using a (nested) National Grid system with coordinate system MTM-WGS84 to be used to generate a unique geocoding system for each unit (e.g. building, household or business).	Topographic Chart, Geodetic Network, National Road Network, Catalogs: Geostatistical Areas, Roads, Localities, Natural Resources, Services	Statistical Location Register (SLR) aligned to national address management	Immediately after Census 1996, joint projects with the National Mapping Agency (NMA) to create a cadastral base map, to digitize enumeration areas. Continued collaboration to use fundamental geospatial data to demarcate enumeration areas for Census 2001
Principle 2: Geocoded unit record data in a data management environment	Statistical data management & Geocodes are location coordinate and ASGS Mesh Block	National Spatial Identifier is considered a new Geocoding System	Geostatistical Framework and Spatial Data Infrastructure	Geocode is a SLR compliant point coordinate or statistical mesh-block	Geocoding of dwellings, dot on map linked to a record on a list for Census 2011
Principle 3: Common geographies for dissemination of statistics	Australian Statistical Geography Standard - ASGS	The NSDI allows to unify the administrative geographic boundaries between all the Egyptian agencies. It is also used as a mechanism for data dissemination using the	Use of a single Geostatistical Framework allows to have a Data Infrastructure for the Statistical Information Subsystems (sociodemographic, economic and government)	SSGA-Statistical Standard for Geographic Areas	Dissemination for Census 1996 made use of administrative hierarchy, first place-name/ community data dissemination was achieved

		National grid merged with the geographic boundaries.			
Principle 4: Statistical and geospatial interoperability – Data, Standards and Processes	Use international statistical and geospatial metadata standards – further development required	The Military Survey Authority is building a base map applying the Spatial ID produced by CAPMAS to integrate with the census data. Also, general approval of the administrative boundaries of Egypt, updated during 2017-Census by CAPMAS to be the standard basemap of the administrative boundaries.	Online services that allow the exchange and use of information. Application of the Technical Stanford for the elaboration of Geographic Metadata	Developing the interoperability of statistical and spatial metadata	Use of International statistical and geospatial metadata standards (OGC/ISO)
Principle 5: Accessible and usable geospatially enabled statistics	Policies, standards and guidelines support the release, access, analysis and visualization of geo-statistics	Dissemination of 2017 Census data through the Egyptian Geoportal and Atlas, using the Grid System for different results.	Publication and free use of the platform of Digital Map of Mexico, free download of cartographic products	Policies, standards and guidelines, covering: geospatial confidentiality and privacy, data quality, analysis, dissemination and visualization.	Use of SuperCROSS[33] and map visualization

(*): Derived from Appendix 3 of the UN-GGIM background paper: http://ggim.un.org/meetings/GGIM-committee/8th-Session/documents/Global-Statistical-Geospatial-Framework-July-2018.pdf

3. Developing a National Address Management Framework

Addresses are one of the most traditional ways to locate people, buildings, landmarks, places and events. They are commonly used for postal and utility delivery, emergency responses, public, private and business services. Recognizing the benefits of standardized addresses to citizens,

[33] SuperCROSS is a programming free desktop tabulation software tool used by statisticians for aggregating and cross-tabulating data from surveys. It does not require programming expertise, but offers a Windows-based environment and a drag-and-drop graphical interface. It is a product of the SuperSTAR Suite licensed by Space Time Research, a software development firm located in Melbourne Australia who have worked with the Australian Bureau of Statistics since 1986. (Wikipedia)

Governments, the economy and the society at large[34], many countries have or are building their organized addressing infrastructures in terms of Address Reference Systems and National Address Databases. Indeed, an Address Reference System draws its importance from the fact that it forms a spatial reference system, along with coordinate reference systems, linear reference systems, and geographic names (gazetteer references), while it distinguishes itself as the only spatial reference system with visible features on the ground, such as street signs and building numbers.

While addresses are collected from multiple sources (post offices, municipalities, utilities, land administrations, private companies, etc.), their datasets are usually maintained by public authorities. However, while data may be created and maintained at local level, it gains to be compiled into a single national register, ideally an open national address database[35].

Point-based statistical/census data relating to individuals, housing units and other dwellings are often linked to addresses, which can be geocoded allowing such information to be matched to geographic coordinates. Until recently, these addresses for locating population are mainly postal addresses, but with the advancement of technologies, the use of new means of communication and identifiers, such as cell-phone numbers, e-mail and other Internet addresses, and/or satellite imagery, coupled with direct capture using global-positioning-system data, has become increasingly reliable alternative sources.

Some countries have their own standards while international organizations have developed address standards, such as ISO 19160-4:2017 defining international postal addresses. There is a process going on for some within the International Organization for Standardization (ISO) and OGC at bringing them together into a suite of international standards for addressing (Coetzee et al 2008, ISO/TC 211 2010). This is part of larger efforts by UN-GGIM and the International Standards organizations to promote the adoption and implementation by countries of the internationally agreed geospatial standards, including those relevant for the integration of statistical and geospatial information.

Despite these efforts, it has been reported that approximately 70% of the world is still confronted with addressing challenges, not having an accurate address, meaning that we don't know where people exactly live, and that these people are likely deprived from access to services, to banking loans or to a formal business, with no tax collection either – Everyone is losing: the individual and the community overall! In other words, the simple lack of an address is preventing the optimum

[34] Vivas and Lubenow (2009) describe the benefits of standardized addresses to the economy, society and governance.

[35] The Need for a National Address Database – Use Cases A Report Submitted by the National Geospatial Advisory Committee December 2014. Available at https://www.fgdc.gov/ngac/meetings/december-2014/ngac-national-address-database-use-case-paper-december-2014.pdf

delivery of goods, e-commerce, emergency services and other public, private, and government processes36. In Africa, apart from South Africa, Botswana and few others who are in the process of building their addressing systems, many African countries are lacking a formal addressing system, and are still dealing with incomplete, inaccurate or missing names, numbers of their streets and properties, in both urban and rural areas[37]. (UN ECA 2005).

African countries have the opportunity to use new geocodes as alternative to the postal Master Address List, traditionally used to find the population. Indeed, as stated earlier, satellite imagery, coupled with direct capture with GPS of the coordinates (latitude and longitude) of point-based features, could be used to locate, geocode, and define every structure in the country. Some countries are already embarking on capturing a latitude-longitude for every residential or commercial unit, building their geospatial infrastructure, known as the dwelling frame[38].

To effectively capture the physical address, we need a nationally consistent address collection standard, such as the South African National Standard for addresses which was published around 2009. The South African Standard covers address formats, aspects of data interoperability, address allocations and updating[39]. Considering a trade-off between people, the physical world and its digital representation when designing an addressing scheme, and drawing from their experience with the South African address standard (SANS 1883:2009), the ISO addressing ISO 19160, and other addressing initiatives, Coetzee and al.[40] proposed a relevant list of principles for the design of a national addressing scheme worth taking into account:

- "Define what objects are being addressed;
- Define the components that make up an address;
- Define how values are assigned to these components;
- Define how addresses are assigned to objects (including provision for possible future expansion);
- Define the purpose(s) for which the addresses are assigned;
- Define the intended precision of the addresses;
- State who is responsible for the assignment and maintenance of addresses by people (e.g. naming);
- State who is responsible for the assignment and maintenance of addresses in the physical world (e.g. signposts);

[36] file:///Users/amorlaaribi/Desktop/Fundamental%20Geospatial%20Data%20Themes-UN-GGIM.htm
[37] CODI-Geo/DISD, 2005. A functional addressing system for Africa: A discussion paper, background working document for the ad hoc expert group meeting on Geographic Data as a National Asset: Focus on Situs Addressing, April 2005, 46pp.
[38] See South Africa Dwelling Frame at: https://undataforum.org/WorldDataForum/wp-content/uploads/2017/01/TA2.03_Laldaparsad.SouthAfricaSLaldaparsad_UNWDF_Jan2017-ver1.2.pdf).
[39] See: "Towards good principles for the design of a national addressing scheme, 2011, Coetzee and al". Available at https://www.researchgate.net/publication/228827443_Towards_good_principles_for_the_design_of_a_national_addressing_scheme

[40] Idem.

- State who is responsible for the assignment and maintenance of addresses in the digital representation of addresses (e.g. data model, databases, etc.);
- State how its addresses are used together with other systems, such as land administration."

Since address data is received from various stakeholders and gain to be compiled into a national database, adopting common and practical methods of address data capture is considered as a key element of building a National Address Management Framework[41]. Indeed, a national address management framework, based on a point-based location of people and dwellings, has the advantage of increasing the spatial resolution and relevance of statistical information, particularly in crisis management as in the case of flooding and other natural disasters such as storms and fires. Indeed, the point-based data collection is the way forward for many other applications as it provides the most precise location-based information. And mobile technology offers the most appropriate tools to handle this approach (which it can be seen in more detail in this referenced book)[42]. Lastly, as stated earlier, since Government and business alike depend on addresses to provide essential services, efforts should be made to bring addresses into the NSDI. For example, URISA and the National States Geographic Information Council, known as NSGIC, have endorsed including addresses in the NSDI Framework Data as the 8th theme[43]. The address systems should provide the enabling environment for linking statistical information to the identified points, polygons and lines. The National Address Management Framework should provide possibilities of linking geography and statistics.

4. Requirement for Capacity Building

Using and sharing technologies to produce timely and reliable location-linked data and statistics requires increasing the capacities of national data producers and managers, chief among them the NSOs and geospatial agencies. It is recognized that harnessing the data revolution to achieve the ambitious SDGs depends greatly on how national statistical systems develop their capacities in monitoring systems, designing relevant indicators, and providing technical assistance about data collection and analysis. It is also recognized necessary to use geospatial data to support the implementation of the SDGs, for which it must be mentioned that building the required capacity is nowadays much more realistic since the technologies (GIS, GPS, satellite imagery, digital aerial photography, etc.) are a lot easier to use and integrate, and less costly than before.

More specifically, Sustainable Development Goal 17 stresses that there is a need to: "By 2020, enhance capacity-building support to developing countries, including for least developed countries

[41] See: http://ggim.un.org/meetings/GGIM-committee/8th-Session/documents/Global-Statistical-Geospatial-Framework-July-2018.pdf)
[42] See the book "GIS and the 2020 Census – Modernizing Official Statistics", 2019, Esri Press.
[43] "Bringing Addresses into the NSDI", Martha McCart Wells, 2014. Available at http://dels.nas.edu/resources/static-assets/besr/miscellaneous/MSC/2014/October/Bringing%20addresses%20into%20NSDI_Wells.pdf

and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts."[44] In other words, strengthening the institutional and human capacities and capabilities for implementing, monitoring and evaluating the SDGs is of utmost urgent need.

UNFPA strategy for the 2020 Round of Censuses, for example, "focuses on strengthening national capacities to generate, analyse, disseminate and utilize high quality, timely, relevant, and disaggregated geo-referenced census data to inform, implement, monitor, and evaluate sustainable development policies, plans and programmes for the public good".[45] The 2017 Cape Town Global Action Plan for Sustainable Development Data was explicit in stating that "National statistical systems (NSS) face the urgent need to adapt and develop in order to meet the widening, increasing and evolving needs of data users, including for the full implementation of the 2030 Agenda for Sustainable Development", recognizing that "capacity building is important for all countries, even more so for developing countries, particularly African countries, least developed countries, landlocked developing countries, small island developing States and middle-income countries and other countries in vulnerable situations."[46] This is in line with the 2030 Agenda which has explicitly called for enhancing capacity building to support national plans to implement the sustainable development goals.

In terms of data-driven programmes and activities to be carried out, the 2015 report by the Sustainable Development Solutions Network (SDSN, 2015) laid out a specific programme of data collection and capacity development that African countries can follow in building and developing their national statistical spatial framework. It identifies six major categories of activity that will be needed to produce data and statistics relevant for the core SDG indicators: 1) national survey programmes; 2) decennial censuses; 3) administrative data, including civil registration and vital statistics systems; 4) economic statistics; 5) geospatial infrastructure; and 6) environmental monitoring[47].

The beneficiaries of improved country capacity to build statistical-geospatial infrastructure and use of geospatially-enabled statistical data and information will be the broad spectrum of users, comprising the national governments, regional and international agencies, the development

[44] Reported in E/C.20/2017/13/Add.1: National geospatial data and information systems. Available at http://ggim.un.org/ggim_20171012/ggim_committee.html

[45] See "UNFPA Strategy for the 2020 Round of Population & Housing Censuses (2015-2024)", first published in March 2017 and revised in July 2019. Available at: https://www.unfpa.org/publications/unfpa-strategy-2020-round-population-housing-censuses-2015-2024

[46] Cf. "Cape Town Global Action Plan for Sustainable Development Data". Available at: https://unstats.un.org/sdgs/hlg/cape-town-global-action-plan/

[47] See Report at: http://unsdsn.org/wp-content/uploads/2015/05/150612-FINAL-SDSN-Indicator-Report1.pdf

research community and the public at large. In particular, integrating statistical information and geospatial information, strengthening and standardizing geospatial data exchange capabilities of member states will contribute to improve the availability and timeliness of country information.

5. Developing Standards for Geospatially-enabled Statistics, including for Common Geographic Boundaries, and Related Metadata Standards

As stated earlier, building a statistical-geospatial infrastructure enables data exchange capabilities and helps improve the availability and timeliness of country information. However, building a geospatial information infrastructure requires some building blocks, chief among them a set of standards allowing users to access and share data easily and in a meaningful way. Indeed, a fundamental component of the infrastructure is to adopt and implement common standards in accordance with the existing international standards, taking into account the national conditions. The benefits of developing, adopting and implementing technical geospatially-enabled standards and related common metadata standards have been recognized by both statistical and geospatial communities. It is particularly recognized that common standards and metadata enable interoperability and facilitate the integration and use of various statistical, geospatial and other data, coming from multiple sources in multiple formats.

UNECA has made multiple efforts to assist in this regard by facilitating the development of key geo-standards for the African continent, knowing that common standards are necessary to ease the effort of sharing data and understanding between organizations and between applications, and that many applications extend beyond national borders requiring the integration of datasets across national borders. It is worth mentioning some achievements: The metadata standard is one such standard, where an African profile has been developed, in consultation with many African countries.[48]

At national level, a number of African countries have indeed developed various data standards trying to meet their user needs, but these standards may not be aligned with each other[49] and not in line with the international standards mainly developed by ISO and OGC. There is a particular awareness that developing standards for common geographic boundaries (CGB), and using geographic boundaries and classifications with statistics, is of utmost importance in African countries who are experiencing constant changes in their administrative boundaries. This means that building, updating and sharing common administrative boundaries should be an essential component of any statistical geospatial framework. Geographic boundaries used by statisticians currently are mostly administrative boundaries, with some functional geographies and grid-based systems.

[48] Cf. UNECA research study:"Developing and Implementing Geo-standards in Africa", A. Laaribi, 2017.
[49] Idem.

In this regard, UNECA is actively involved in the Second Administrative Level Boundaries (SALB) project, a UN initiative launched in 2001 to provide the international community with a working platform for the collection, management, analysis, visualization and sharing of sub-national data down to the 2nd sub- national level, a very fundamental data for many applications (humanitarian assistance, censuses and statistical analysis, Environment, health, poverty mapping, etc.). The focus is on presenting the historic evolution of the administrative structure in terms of geography and names at the 1st sub-national level since January 1990 and at the 2nd sub-national level since January 2000.

As example of Common geographic boundaries at the national level, we can cite the Australian Statistical Geography Standard (ASGS) which is the common boundary set for analysis, display and reporting of socio-economic information within the Statistical Spatial Framework for Australia. The boundaries range in size from small geographic areas, such as a suburbs and groups of a few urban blocks, through to larger areas, such as a natural resource management areas and regions or cities. ASGS is set to ensure that socio-economic information is available for a consistent, hierarchical set of geographies. In addition, the core ASGS boundary hierarchies have been designed to include approximately equal population numbers within each area, enabling meaningful comparisons of the population and associated human activity between areas. The ASGS boundaries were also designed by the ABS to support flexible reporting[50].

With regards to metadata interoperability, the spatial and statistical communities operate different metadata capabilities. Approaches to ensure that these two metadata environments can work together effectively are being investigated. Existing metadata standards being investigated include: Statistical Data and Metadata Exchange (SDMX), Data Documentation Initiative (DDI), and the international geospatial metadata standard ISO19115. The OGC has developed a standard for linking geospatial data, such as census boundaries, with corresponding statistical data. It is important that any dataset that incorporates geo-referencing contains the relevant statistical and spatial metadata to be accessible, understood and useful across the statistical and spatial data-user communities[51].

An additional principle is about the benefits of greater interoperability between statistical and geospatial data and metadata standards, from cataloguing to data interchange. It is specifically about enhancing the efficiency of discovery, access and use of geospatially enabled statistics and geospatial data, by overcoming structural and syntactic barriers between data and metadata from

[50] See ABS Statistical Spatial Framework at https://www.abs.gov.au/websitedbs/D3310114.nsf/home/Statistical+Spatial+Framework
[51] See more details in the Book: "GIS and the 2020 Census – Modernizing Official Statistics", Esri Press, 2019. Available as e-book and in print.

different providers and communities. ISO metadata standards for geographic information are implemented in many geoportals and thus relevant here.

6. Geospatial Statistical Data Accessibility and usability, Protection of Confidentiality and Privacy of Geospatially-enabled Information.

As already noted, adopting and implementing common standards are the underpinning basic foundations for enabling interoperability, accessing and sharing of datasets. To enforce a basic principle stating that geospatial and statistical information should be collected once and shared by many, the NSO and NMAs/NGIAs should establish agreements and mechanisms for data sharing. For example, a One-Stop geospatial information portal makes government's geospatial information accessible to and shared by agencies and the user community. NSOs gain to use this one-stop portal to disseminate their census information and extend their outreach to a larger user community.

Earth observations and their support to digital mapping are increasingly recognized by NSOs as important additional sources of data for their statistical activities, improving official statistics on a wide range of topics spanning agriculture, the environment, business activity and transport. In addition, satellite imagery with mobile technology, including hand-held devices equipped with GPS, is increasingly used for data collection, providing more timely statistical outputs, and data at a more disaggregated level for informed decision making. Other cutting-edge technologies such as Cloud computing, geoportals, and new software tools have provided the means for easier accessing sharing of data and processes.

This section would not be complete if we did not mention the 'open data' movement, which is gaining popularity with the rise of the Internet and the need for the access and use of data citizens deem as of public domain. It has been especially put at the forefront by the ongoing data revolution.

Open Data is fundamentally defined by its free availability for everyone to use and republish without any restrictions or control. Indeed, most definitions of open data[52] include these basic features: Availability (machine-readable) and Access (preferably online); Re-use and Redistribution (open-licensed); and Universal Participation (everyone must be able to use, re-use and redistribute, free of charge or at minimal cost). In recognition of the importance of open data and its interoperability for the national statistical systems, UN Statistical Commission did

[52] Open Data: Digital data that is made available with the technical and legal characteristics necessary for it to be freely used, reused, and redistributed by anyone, anytime, anywhere. (Source: Open Data Charter).

"encourage national statistical offices to embrace the open data initiatives and ensure stakeholders of the national statistical system as part of the process".

There is also a general recognition that there are significant benefits related to the use of open data for the citizens and the society in general, in terms of economic benefits, governmental transparency and social accountability. However, Governments have expressed concerns with regards to data security and confidential issues, particularly with respect to census and statistical data at the individual level. In this regard, the United Nations Statistics Division recommended that "open data platforms can only achieve public support and success if proper precautions are taken to protect the privacy of individual persons, business and civil society organizations and we manage to ensure that data generated by administrative, civil and business registers could be made public by matching access with strict ethical and security protocols and secure technology platforms".

We cannot talk about Open Data without mentioning Big Data which is defined by volume, velocity and variety (some would add variability, value, visualization and veracity). In this regard, The United Nations Global Working Group on Big Data for Official Statistics has been 'working with Member States and their private sector partners to demonstrate the use of unconventional data sources to supplement official statistics', and 'that insights can be obtained by combining data from traditional sources – such as censuses, surveys or administrative data – with information from new, big data sources'[53].

Data privacy and security of statistical data dissemination has been a major concern for national statistical authorities, as one of the primary goal of confidentiality is to protect privacy by not allowing individual information to be identified, sometimes referred to as PII – personally identifiable information[54]. The concerns are even greater when the individual observation involves locational information and the use of sophisticated technology to access and disseminate it.

It is worth mentioning that GIS data is generally about geographic locations and features such as addresses, coordinates, rather than data about specific individuals, and that modern GIS platforms provide the capabilities to publish data openly and securely based on the needs of the organization. While there is a legitimate concern involving the disclosure of confidential information through

[53] "The role of national statistical systems in the data revolution". Available at: https://www.oecd-ilibrary.org/docserver/dcr-2017-8-en.pdf?expires=1542917837&id=id&accname=guest&checksum=E8C3F202464ED4360C50762C421F9BA4

[54] See more details in the Book: "GIS and the 2020 Census – Modernizing Official Statistics", Esri Press, 2019. Available as e-book and in print.

spatial display methods of aggregating spatial data can mitigate these concerns, but particularly disclosure methods that should be applied when the data is at the point/individual level[55].

7. Analysis of Geospatial- Statistical Linked Data

A strategy is usually required for the execution of the in-depth geospatial- statistical linked data. This should follow some approved methods after the tabulation plan has been adopted, and these methods may include:

Analyzing Spatial Patterns in the Data

Average Nearest Neighbor
Calculates a nearest neighbor index based on the average distance from each feature representing demographic data point (polygon, point, line) to its nearest neighboring feature.

High/Low Clustering
Measures the degree of clustering for either high values or low values using the Getis-Ord General G statistic.

Incremental Spatial Autocorrelation
Measures spatial autocorrelation for a series of distances and optionally creates a line graph of those distances and their corresponding z-scores. Z-scores reflect the intensity of spatial clustering of demographic spatial features, and statistically significant peak z-scores indicate distances where spatial processes promoting clustering are most pronounced. These peak distances are often appropriate values to use for tools with a Distance Band or Distance Radius parameter.

Multi-Distance Spatial Cluster Analysis (Ripley's k-function)
Determines whether demographic spatial features, or the values associated with features, exhibit statistically significant clustering or dispersion over a range of distances.

Spatial Autocorrelation
Measures spatial autocorrelation based on feature locations and attribute values using the Global Moran's I statistic.

Mapping Clustering in the Data

Cluster and Outlier Analysis
Given a set of weighted features, identifies statistically significant hot spots, cold spots, and spatial outliers using the Anselin Local Moran's I statistic.

Density-based Clustering
Finds clusters of point features (infrastructure data collected during the census) within surrounding noise based on their spatial distribution.

[55] Idem.

Hot Spot Analysis
Given a set of weighted features, identifies statistically significant hot spots and cold spots using the Getis-Ord Gi* statistic.

Multivariate Clustering
Finds natural clusters of features based solely on feature attribute values.

Optimized Hot Spot Analysis
Given incident points or weighted features (points or polygons), creates a map of statistically significant hot and cold spots using the Getis-Ord Gi* statistic. It evaluates the characteristics of the input feature class to produce optimal results.

Optimized Outlier Analysis
Given incident points or weighted features (points or polygons), creates a map of statistically significant hot spots, cold spots, and spatial outliers using the Anselin Local Moran's I statistic. It evaluates the characteristics of the input feature class to produce optimal results.

Similarity Search
Identifies which candidate features are most similar or most dissimilar to one or more input features based on feature attributes.

Spatially Constrained Multivariate Clustering
Finds spatially contiguous clusters of features based on a set of feature attribute values and optional cluster size limits.

Measuring Geographic Distributions in the Data

Central Feature
Identifies the most centrally located feature in a point, line, or polygon feature class.

Directional Distribution
Creates standard deviational ellipses or ellipsoids to summarize the spatial characteristics of geographic features: central tendency, dispersion, and directional trends.

Linear Directional Mean
Identifies the mean direction, length, and geographic centre for a set of lines.

Mean Centre
Identifies the geographic centre (or the centre of concentration) for a set of features.

Median Centre
Identifies the location that minimizes overall Euclidean distance to the features in a dataset.

Standard Distance

Measures the degree to which features are concentrated or dispersed around the geometric mean centre.

Modelling Spatial Relationships in the Data

Exploratory Regression
The Exploratory Regression tool evaluates all possible combinations of the input candidate explanatory variables, looking for the Ordinary Lease Square (OLS) models that best explain the dependent variable within the context of user-specified criteria.

Forest-based Classification and Regression
Creates models and generates predictions using an adaptation of Leo Breiman's random forest algorithm, which is a supervised machine learning method. Predictions can be performed for both categorical variables (classification) and continuous variables (regression). Explanatory variables can take the form of fields in the attribute table of the training features, raster datasets, and distance features used to calculate proximity values for use as additional variables. In addition to validation of model performance based on the training data, predictions can be made to either features or a prediction raster.

Generalized Linear Regression
Performs Generalized Linear Regression (GLR) to generate predictions or to model a dependent variable in terms of its relationship to a set of explanatory variables. This tool can be used to fit continuous (OLS), binary (logistic) and count (Poisson) models.

Generate Network Spatial Weights
Constructs a spatial weights matrix file (.swm) using a Network dataset, defining feature spatial relationships in terms of the underlying network structure.

Generate Spatial Weights Matrix
Constructs a spatial weights matrix (.swm) file to represent the spatial relationships among features in a dataset.

Geographically Weighted Regression
Performs Geographically Weighted Regression (GWR), a local form of linear regression used to model spatially varying relationships.

Ordinary Least Squares
Performs global Ordinary Least Squares (OLS) linear regression to generate predictions or to model a dependent variable in terms of its relationships to a set of explanatory variables

Modelling Space Time Pattern in the Data

Create Space Time Cube by Aggregating Points
Summarizes a set of points into a netCDF data structure by aggregating them into space-time bins. Within each bin, the points are counted and specified attributes are aggregated. For all bin locations, the trend for counts and summarized attributes are evaluated.

Create Space Time Cube from Defined Locations
Creates a netCDF data structure from panel data, station data, or other data where the locations are fixed and attributes change over time. For all locations, the trends for attributes are evaluated.

Emerging Hot Spot Analysis
Identifies trends in the clustering of point counts or attributes in a netCDF space-time cube. Categories include new, consecutive, intensifying, persistent, diminishing, sporadic, oscillating, and historical hot and cold spots.

Local Outlier Analysis
Identifies statistically significant clusters of high or low values as well as outliers that have values that are statistically different than their neighbors in space and time.

Time Series Clustering
Partitions a collection of time series, stored in a space-time cube, based on the similarity of time series characteristics. Time series can be clustered so they have similar values in time or similar behaviors or profiles across time (increase or decrease at the same points in time). The output of this tool is a 2D map displaying each location in the cube symbolized by cluster membership and messages. The output also includes charts containing information about the representative time series signature for each cluster.

8. Policy guidelines for the Development of a National Statistical-Geospatial Framework

A statistical-geospatial framework to support a national statistical system can be developed and maintained through country-specific policies to be formulated and related action plans to be prepared and implemented, in line with the five principles of the UN Global Statistical Geospatial Framework (GSGF). Such an approach has direct benefits as it allows for a country to identify and address the most fundamental issues to build a statistical-geospatial infrastructure that impact the integration of geospatial information with statistical information, leverage the interoperability of national information systems with a geographic dimension, forge ties and bring NSOs, NMAs/NGIAs and other organizations to cooperate and work together.

Policy/Action Plan 1

The purpose of the initial policy and related action plan would be to (i) build and develop a national geospatial infrastructure which would cater to the needs of both geospatial and statistical communities. A national statistical-geospatial infrastructure in line with the National Spatial Data Infrastructure (NSDI), using for example the fundamental geospatial data and/or the national geodetic reference system and (ii) identify the challenges to be addressed in building an NSDI, chief among them in many African countries are the lack of policies and legal frameworks, and inadequate financial and human resources, and the need for more institutional political leadership and support. For example, a possible way to have a geospatial infrastructure at the finest level for geocoding purposes is to establish a National Address Management Framework (NAMF), to be used to determine geographic positions based on an address. Another example is to establish a National Dwelling Framework, National Building Footprint Frame a point-based method to capture geographic coordinates, or and polygons of all dwellings/housing units. While the specific frameworks for coding addresses and dwellings can vary from country to country, these would be important components for any nation's statistical-spatial framework. This action plan could be prepared and implemented after conducting an inventory of the existing national frameworks, information systems, laws and policies, particularly those related to 'people and place - statistics, administrative, environment, Earth observations, etc."[56]; and after consultations with major stakeholders in the country, all this based on insights from surveys, such as the one provided in annex.

[56] See the UN-GGIM "Integrated Geospatial Information Framework- Part I", available at: http://ggim.un.org/meetings/GGIM-committee/8th-Session/documents/Part%201-IGIF-Overarching-Strategic-Framework-24July2018.pdf

Policy/Action Plan 2

The purpose of the second policy and related action plan would be to adopt a management approach to enable geospatially the basic statistical units to which characteristics of persons, households and geographic features of interest can be attributed. This data management of storing geo-reference data together with the unit level records should take into account the privacy and confidentiality issues. The goal is to build, use, update and share common geographies, including administrative boundaries, and related specifications and standards to ensure that all statistical data are consistently geospatially enabled. However, since many African countries are experiencing frequent changes with the administrative boundaries, a (nested) grid system would provide a solution for these thorny issues of administrative boundaries. A grid system would be also useful to disseminate for instance statistical data or SDGs indicators and would bypass the problems related to administrative units. In addition, a point or polygon-based data approach associated with addresses or buildings has the advantage to offer higher spatial resolution and a spatial aggregation at any spatial unit, including for gridded statistics. Geo-enabling statistical data in this case is carried out through the geocoding process of direct capture by GNSS/GPS receivers of the coordinates (latitude and longitude) in the field or indirect capture of coordinates from existing maps.

Policy/Action Plan 3

The third policy and related action plan would cope with a fundamental work that involves the NSO, the NGIA and other national organizations to develop common standards that would increase interoperability, sharing and understanding. It is particularly recommended to develop, adopt and implement standards that meet the user needs in the country, bearing in mind that these standards gain to be in line with the internationally-agreed geo-standards, like those developed by ISO/TC211 and OGC[57], or under development (e.g. the work on a statistical-geospatial metadata interoperability to integrate SDMX and DDI[58] with ISO-19115). For example, the NSO has to take a standards-based approach and collaborate with the National Mapping to avoid create their own data on administrative boundaries and topographic maps or other methods of linking geospatial and statistical data tables. Moreover, the plan should lead to the establishment or development of the national standardization institutions and legal and common frameworks, to provide a national policy on geospatial information, which prescribes data standards to be implemented. The goal for the country should be to put "legal, policy and institutional frameworks in place which allow effective and efficient interoperability of data and information across the different national

[57] "A Guide to the Role of Standards in Geospatial Information Management", prepared cooperatively by the Open Geospatial Consortium (OGC); The International Organization for Standards (ISO) Technical Committee 211 Geographic information/Geomatics; and the International Hydrographic Organization (IHO). August 2015" – See: http://ggim.un.org/documents/Standards%20Guide%20for%20UNGGIM%20-%20Final.pdf

[58] Like SDMX, the Data Documentation Initiative (DDI) has become a well-established international metadata standard, designed to describe socioeconomic surveys, censuses, and other microdata collection activities.

institutions which leverage geospatial information"[59].

Policy/Action Plan 4

The fourth policy and related action plan would be to implement a clear data policy as the ultimate goal for developing a statistical-geospatial framework is to make data easily accessible and used by as many users as possible. Governments are required to play a central role, not only to develop and implement policies, but also to mitigate the concerns about the misuse of open data, particularly those infringing on privacy and confidentiality. One method to prepare and apply such data policies would be to conduct government-wide geospatial information consultations and evaluations to identify any practices and the issues related to them. Such consultations would involve interviews of government officials, and major users from industry, academia and the NGO community as well as reviews of laws, regulations and a sample of data sharing agreements.

[59] See "National geospatial data and information systems" (E/C.20/2017/13/Add.1). Available at http://ggim.un.org/ggim_20171012/ggim_committee.html

9. Conclusions/Recommendations

In conclusion, these proposed recommendations are to be considered for adoption:

1. Countries in the African region are adopting innovative approaches to census taking and increasingly using emerging technologies, including GIS, GPS, and other geospatial tools, recognizing the advantages of their use at all stages of population and housing census process. The use of these technologies is recommended for all national censuses in the region in the 2020 round of censuses and in support of the SDGs; it is however of paramount importance to ensure these activities on a continuous and universal basis as they are crucial for many more applications other than censuses and official statistics.

2. It is advisable that African countries, like many other countries in the world, recognize geography as key to statistics, providing a structure for collecting, processing, storing, aggregating and disseminating data, and significantly improving the quality of official statistics. By embedding geography into their national systems and processes, many NSOs are already transforming their statistical infrastructure, with the view that such activities can contribute to the modernization of their statistics. In this regard, it is recommended that ECA continue to support African countries in building and developing their statistical-geospatial information infrastructures for the 2020 Round of Censuses and the 2030 Sustainable Development Agenda.

3. Many countries in the region are building or built their census geographic databases, recognizing that their development are fundamental for a full digital census geography programme. It's recommended to maintain these geographic databases as they offer a basis for spatial analysis which tend to become a core competency in any census office. It is also recommended to diversify the means for census data dissemination by using web-based mapping, cloud applications and services, and mobile technology to reach a wider audience for a better appreciation of census products and statistical work in general.

4. The desk review has shown countries' interest in adopting innovative approaches to census taking including the use of hand-held devices equipped with GPS for data collection and the Internet for dissemination. It is recommended to use mobile technology, GPS, satellite imagery, and UAV, as they are facilitating data collection at the individual level, provided we take into account the privacy/confidentiality issues. It is noted, however, that this requires strengthening of capacities and allocation of adequate resources, and that there is generally a lack of knowledge about successful experiences of other countries in the use of

these innovative approaches. It is recommended that study visits be carried out in order to enhance the sharing of national experiences and practices, and to get guidance on how to handle the use of mobile devices for data collection and other supporting software applications.

5. NSOs are often not custodians of base maps and other mapping products which may be difficult to acquire, but much needed for census cartographic operations. In this regard, NSOs are encouraged to collaborate with respective national mapping authorities, and extend their involvement and active participation, in partnership with other national authorities, in the development of a national geospatial information capacity, including the NSDI. However, building a national geospatial infrastructure in support of census activities requires technical as well as human capacities that may not be available in some countries in the region. Therefore, it is recommended to explore other mechanisms for empowering capacities through bilateral exchanges between countries, study visits, regional coordinated trainings and contact networks.

6. Coordination and institutional integration between the statistical and geospatial agencies within a country is vitally important. It is noticeable, however, that institutional coordination to support statistical and geospatial integration in some African countries is still underdeveloped, requiring a strong political commitment. In this regard, advocacy of the benefits of linking socio-economic data to a location and the value-added from their integration should be stressed to decision and policy makers, raising their awareness to the need of national institutions for adequate resources to achieve the integration.

7. Standardization and data interoperability are arguably one of today's central development challenges, since any progress in geospatial information management and sharing of authoritative geospatial data will depend on them. African countries are encouraged to develop a common regional framework of standards and tools, taking into account their specific conditions, but in line with the existing internationally-agreed standards[60].

8. The UN Expert Group on the Integration of Statistical and Geospatial Information has developed an overarching statistical-spatial framework which can significantly improve the quality of official statistics and Population Censuses, and support the sustainable development goals[61]. However, its implementation at the national level is still a challenge

[60] See http://gsdiassociation.org/images/publications/cookbooks/SDI_Cookbook_from_Wiki_2012_update.pdf

[61] Decision by the UN Statistical Commission at its 49th session in March 2018 to establish a federated system of national and global data hubs for the SDGs. 4 Arab countries are participating in this initiative conducted by UNSD and Esri.

in most of the countries in the region. Therefore, African countries are encouraged to develop their national statistical-geospatial framework in accordance with the guidelines and principles agreed upon internationally.

Some References:

1. **NSDI initiatives**

SDI Africa: An Implementation Guide :
http://gsdiassociation.org/images/publications/cookbooks/SDI_Africa_Guide_full_text.pdf

Spatial Data Infrastructures in Africa: A Gap Analysis - Journal of Environmental Informatics
http://www.jeionline.org/index.php?journal=mys&page=article&op=view&path%5B%5D=201500325

2. NSDS initiatives

https://paris21.org/NSDS-Documents

https://paris21.org/sites/default/files/inline-files/NSDS-Progress-Report-2018_0.pdf

Annexes:

Table 2: **National Strategies for the Development of Statistics (NSDS)**[62]

	Designation	Period	Comments
Angola	Plano Estatístico Nacional de Médio Prazo 2002-2006	2002-2006	In Portuguese
Benin	Stratégie Nationale de Développement de la Statistique Second National Strategy for the Development of Statistics (NSDS2)	Octobre 2009 2014-2016.	
Burkina Faso	Schéma Directeur de la Statistique 2011-2015	2011-2015	
Cameroon	Strategie Nationale de Développement de la Statistique (SNDS) au cours de la période 2009-2013 : résumé	2009-2013	
Cape Verde	Agenda Estatística Para O Desenvolvimento	2008-2012	In Portuguese
Central African Republic	Projet d'une Feuille de Route Pour l'Élaboration de la Stratégie Nationale De Développement de la Statistique (SNDS) de la RCA	NA	It's a road map for the preparation of a Strategy!
Chad	Stratégie Nationale de Développement de la Statistique (2001-2015)	2001-2015	
Comoros	Projet de Stratégie Nationale de Développement de la Statistique (SNDS)	2008-2012	
Congo, Republic	Programme Pluriannuel de Développement Statistique 2005-2009	2005-2009	
CÔTE D'IVOIRE	La Stratégie Nationale de Developpement de la Statistique 2009-2013 La Stratégie Nationale de Developpement de la Statistique 2012-2015	2009-2013 2012-2015	
Democratic Republic of Congo (DRC)	Feuille de route pour l'élaboration d'une Stratégie Nationale de Développement de la Statistique en République Démocratique du Congo	Prepared in November 2005	It's a road map for the preparation of a Strategy!
Djibouti	Stratégie Nationale de Développement de la Statistique 2009-2013 : résumé Rapport d' évaluation de la SNDS	2009-2013 2011-2015	

[62] See Paris21 Knowledge Base: https://paris21.org/knowledge-database?keyword=&type%5B%5D=NSDSs-Roadmaps&date-from=&date-to=&page=

Equatorial Guinea	Stratégie de développement de la statistique, 2003-2008	2003-2008	
Ethiopia	National Strategy for the Development of Statistics NSDS Final Evaluation	2009-2014 2009/10-2014/15	
Gambia	Master Plan for the Statistics System of The Gambia (2004) Strategic Plan for Development of Statistics in The Gambia: 2008 - 2011	2004 2008 - 2011	
Ghana	Ghana Statistics Development Plan NSDS	2009-2013 2017-2021	
Guinea	Stratégie Nationale de Développement de la Statistique (SDNS) 2009 – 2013: Résumé	2009 – 2013	
Kenya	Strategic plan for the National statistical system (2003-2007) Kenya National Bureau of Statistics Strategic Plan (2008-12)	2003-2007 2008-2012	
Liberia	Strategic Plan 2008-2013 -- National Statistical and Spatial System And Liberia's National Strategy for the Development of Statistics (NSDS) LIBERIA: Mid-Term Review Report on the NSDS (2011)	2008-2013 Prepared in 2008 2011	A rare National Statistical and Spatial System!!! Prepared by Liberia Institute of Statistics and Geo-Information Services (LISGIS)
Madagascar	Stratégie Nationale de Développement de la Statistique (SNDS)	Décembre 2007	
Malawi	National Statistical Office Strategic Plan National Statistical System Strategic Plan National Statistical System Strategic Plan 2008-2012 - A Summary National Statistical Office Strategic Plan 2012-2016	2007-2011 2008-2012 2008-2012 2012-2016	
Mali	Schéma Directeur de la Statistique Schema directeur de la statistique	2006 -2010 2015-2019	

Mauritania	Stratégie Nationale de Développement de la Statistique Stratégie Nationale de Développement de la Statistique (2007 – 2012) Document de synthèse	2007-2012 2007 – 2012	
Mauritius	Central Statistics Office Strategic Plan 2006 – 2008 National Strategy for the Development of Statistics in Mauritius (2007-2010)	2006 – 2008 2007-2010	
Morocco	Plan d'action à long terme de la Direction de la Statistique	2002	Prepared in October 2002
Namibia	Namibia Statistics Agency Strategic Plan 2012/13 to 2016/17 Namibia Statistics Agency Business Plan 2012/13 to 2016/17	2012/13 to 2016/17 2012/13 to 2016/17	
Niger	Stratégie Nationale de Développement de la Statistique (SNDS)	2008-2012	
Rwanda	National Institute of Statistics Strategic Plan National Strategy for the Development of Statistics	2007-2011 2009-2014	
Senegal	Stratégie Nationale de Développement de la Statistique	2008-2013	
Sierra Leone	A National Strategy for the Development of Statistics in Sierra Leone	2008-2012	
South Africa	Statistics South Africa - Strategic plan South Africa: Strategic Plan 2010/11 - 2014/15	2005/06 – 2009/10 2010/11 - 2014/15	
Swaziland	Strategic Plan for Central Statistical Office in Swaziland National Strategy for the Development of Statistics in Swaziland (2011-16) Consultation Version	2004/05 – 2008/09 2011-2016	

Tanzania	Tanzania Statistical Master Plan, 2008/09 - 2010/11 Tanzania Statistical Master Plan, 2009/10 - 2013/14 Tanzania Statistical Master Plan, 2009/10 - 2013/14 (advocacy)	2008/09 - 2010/11 2009/10 - 2013/14	Advocacy
Uganda	Plan for National Statistical Development	2006/7 – 2010/11	
Zambia	Zambia Strategic Plan	2003 – 2007	
Zimbabwe	National Strategy for the Development of Statistics (2011-15): NSDS Summary	2011-2015	

Table 3: African NSDIs

Country	Designation of the NSDI	Link
Egypt	Egyptian Spatial Data Infrastructure	http://www.arcgis.com/home/item.html?id=0807d0fa91954451b49f31302273c75b
Kenya	Establishment of National Spatial Data Infrastructure in Kenya	http://ggim.un.org/knowledgebase/KnowledgebaseArticle51510.aspx
Nigeria	NGDI	Nigeria has commenced the process of building a National Geospatial Data Infrastructure (NGDI), which incorporates a central apex database of National Geospatial data, and a network of fundamental datasets, (created, managed and updated by the respective custodians). The apex database is the custodian of the metadata, the information/data about the other available data. NGDI has digital network infrastructures to access and use these geospatial databases. http://www.ttics.com/ngdi/
South Africa	SASDI	South Africa - Spatial Data Infrastructure (SASDI): http://ggim.un.org/knowledgebase/KnowledgebaseArticle50415.aspx "South Africa has a Spatial Data Infrastructure Act since 2003 focusing on the establishment of the South African Spatial Data Infrastructure (SASDI). The Department of Rural Development and Land Reform (DRDLR) is mandated to administer the Act in collaboration with other stakeholders.

		The establishment of a Committee for Spatial Information is mandatory. Stats SA is a compulsory member. The Committee is functional with established Sub-Committees (Policy and Legislation, Education and Training, Standards, Systems, Marketing and Communication and Data). The Data Sub-Committee has so far drafted a list of base (fundamental) geospatial datasets for South Africa. The process to assign coordinating data custodians (bringing together common data themes to work together) and data custodians (in the different themes) has begun. As a start 10 base dataset themes are prioritized (administrative boundaries, imagery, transport, social statistics, land use, land cover, cadastral, hydrology, geodesy and conservation). The minimum list of Global Fundamental Geospatial Data Themes, as proposed by the UNGGIM Working Group on Fundamental Geospatial Data Themes, is being used for alignment."

[i] Mention the major ECA activities/initiatives in SDI/NSDI, such as the "Mapping Africa for Africa" initiative and its two projects about what geo-spatial data constitutes the fundamental geo-spatial datasets for Africa, and the catalogue of the available fundamental geo-spatial datasets in Africa – both in country and external data holdings. (See "Status of GIS in Africa, By Dr. Derek Clarke https://www.geospatialworld.net/author/hastingsdun-org/).

[ii] A situation that exemplifies the importance of the integration of census data with geographic data. Following a major natural disaster, some of the early questions asked include: which villages are affected? What is the size of their population? How many people were killed, injured and made homeless? What is the status of infrastructure, particularly roads and bridges, health centers, schools, water supply systems and government buildings, etc.? If digital maps of population distribution and housing characteristics could be easily linked with geographic information of the affected area by the disaster, it is possible to generate reliable estimates of the number of people affected, their needs in terms of medical aid, food and shelter, and particularly their location. For immediate disaster response, it is imperative to make sure that basic information is available beforehand and not to wait until after the disaster.