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Revising the Conference of European Statisticians Recommendations for Population and Housing Censuses for the 2030 round: Geospatial information and small area statistics for censuses

Developing the Recommendations on Geospatial information and small area statistics for censuses

Note by the Conference of European Statisticians Task Force on Geospatial information and small area statistics for censuses*,**

Summary

This document includes the draft chapter on Geospatial information and small area statistics for censuses, for the Conference of European Statisticians (CES) Recommendations for the 2030 round of population and housing censuses. This new chapter was not present in previous editions of the Recommendations, which instead contained short sections on geospatial information in the chapter on technology and in the sub-section on dissemination. A new stand-alone chapter has been drafted to reflect the heightened importance of the topic in censuses of many CES countries, and the clear need for expanded guidance. The main purpose of this document is to elicit comments and suggestions from national census experts on the proposed text, to ensure that it reflects the needs and priorities of national statistical offices.

* The Conference of European Statisticians Task Force on Geospatial information and small area statistics for censuses currently consists of the following members: Janusz Dygaszewicz (chair, Poland), Ingrid Kaminger (Austria), Florian Hennig (Germany), Kathleen Hanney (Ireland), Raffaele Ferrara (Italy), Gianluigi Salvucci (Italy), Mario Cruz (Mexico), Vilni Verner Holst Bloch (Norway), Anna Sławińska (Poland), Amelia Wardzińska-Sharif (Poland), Ana Santos (Portugal), Lucia Vanišová (Slovakia), Alejandra Silva (United Nations Economic Commission for Latin America and the Caribbean) and Seiffe Tadesse (United Nations Statistics Division).

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I. Introduction

1. Every ten years the Conference of European Statisticians (CES) issues Recommendations to guide countries in conducting their population and housing censuses. The Recommendations are developed by expert task forces overseen by the CES Steering Group on Population and Housing Censuses.

2. Previous editions of the Recommendations did not contain a stand-alone chapter on this topic. Geospatial information was covered briefly in the chapter on technology and in the sub-section on dissemination. Section II of this document therefore describes briefly the rationale and process followed for developing new content on this topic.

3. Section III presents the draft chapter on Geospatial information and small area statistics for the CES Recommendations for the 2030 round of population and housing censuses.

4. The main purpose of the document is to elicit comments and suggestions from national census experts on the proposed draft text, to ensure that it reflects the needs and priorities of national statistical offices and the latest methodological developments.

II. Developing new content on geospatial information and small area statistics for the 2030 Recommendations

5. The main objectives of the Task Force 11 (TF11) is to develop guidelines to improve and expand the use of Geographic Information System (GIS) to integrate census data with geospatial data. We see that spatial referencing plays an increasingly important role in statistical production, including censuses. Therefore the TF11 has prepared a proposal for a full new chapter containing recommendations on geospatial information in censuses.

6. The Task Force focused on reviewing aspects dedicated to the use of maps and GIS technology at all stages of the census. During the work, aspects mentioned in the global recommendations for the 2020 census round were taken into account, as well as responses to the CES-wide country questionnaire on the conduct of censuses in the 2020 round. In addition, other important documents and materials on the use of GIS and the integration of census data with geospatial data were taken into account. As a result of all this work, TF11 has prepared a separate new chapter on geospatial information and small area statistics for censuses, the geospatial components of census statistics, containing a set of guidelines proposed to be included in the CES 2030 recommendations. The chapter covers a range of topics: GIS as a tool in censuses, address-point approach, geocoding, common geographic areas or grids.

7. The task force welcomes all comments and suggestions from census experts on the proposed draft text, to ensure that it reflects the needs of national statistical offices, the latest technological and methodological developments, and the latest understandings of user needs.

III. Draft text for the chapter on Geospatial information and small area statistics for censuses, for the Recommendations for the 2030 round of population and housing censuses

A. Introduction

8. Geospatial and statistical data governance is crucial to avoid duplication of work and to enable sharing of data. Geospatial data plays a key role in revealing insights, patterns and trends, and thereby supports decision-making. Users of statistical and geospatial information do not want to worry about preparing the data before integrating and using it. It should be fit for purpose and ready-to-use, be available in harmonized formats, be easily accessible and

have the correct spatial and temporal resolutions to suit the analytical question or pending decision[1].

9. Activities to progress the greater integration of geospatial and statistical data have been going on for a decade. At the global level the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) Expert Group on the Integration of Statistical and Geospatial Information aims to raise awareness and promote the importance of integrated statistical and geospatial information to support decision-making and policy development across all political levels. Their work includes the development of the Global Statistical Geospatial Framework (GSGF)[2] which was adopted by the Committee of Experts at their ninth session as a bridge to facilitate the integration of a range of data from both the statistical and geospatial communities. The adoption of the GSGF is acknowledged as an important step towards more coordinated geospatial information practices and better integration of statistical and geospatial information at the global level. The focus of the GSGF is on comparability of statistical outputs, preferably at the level of smaller geographic areas, harmonized geospatial data sources, common methodologies, and interoperability of data and metadata to efficiently produce geospatially-enabled statistics.

10. The aim of the GSGF is to enable this integration, comparison, and sharing of data and integration of new sources of data at local, sub-national, national, regional, and global levels. Thereby, the GSGF supports informed, data-driven, and evidence-based decision-making within and between countries and thematic domains.

11. At their tenth session, the Committee of Experts also adopted the United Nations Integrated Geospatial Information Framework (UN-IGIF) to assist countries in the development and enhancement of their own geospatial information management processes.

12. The Global Forum for Geography and Statistics (GFGS) acts as a global network on geography and statistics to present, share and discuss new ideas and best practices relating to geospatial and statistical data. GFGS, in collaboration with UNECE and the European Free Trade Association (EFTA), currently run a series of coffee talks to present, share and discuss emerging ideas and good practices relating to geospatial and statistical information.

13. At the regional level UN-GGIM: Europe's Working Group on Data Integration focuses on the integration of geospatial data with other information including statistical data.

14. Eurostat undertakes activities relating to the Geographic Information System of the Commission (GISCO) which include coordinating Commission-wide geographic information activities, promoting the use of geospatial data within the European Statistical System, chairing a working group on the integration of statistical and geospatial information, and overseeing annual funding calls for project proposals relating to data integration.

15. The European Forum for Geography and Statistics (EFGS) has worked in collaboration with Eurostat on the GEOSTAT Projects, which focused on the development of common guidelines for grid-based and geospatial statistics for use by national statistical and geospatial organizations to promote the greater integration of statistical and geospatial data across the European Union. The GEOSTAT 4 project conceptualized and interpreted the Global Statistical Geospatial Framework within the European context, publishing GSGF Europe[3] in 2021. In the implementation of the GSGF in Europe, it is essential to understand how the GSGF principles are linked to the European operating environment including the structure and operation of the statistical geospatial communities and how the GSGF key elements are interpreted in Europe. Furthermore, the implementation of the GSGF is very much based on national capability building, cooperation, inspiration and the motivation of the statistical and geospatial communities for a common goal to monitor and align business processes – from intra-institutional silos to inter-institutional dataflows and services. It does not replace the descriptions and guidance provided at the global GSGF, but moves towards the framework's regional implementation.

[1] (Source: Eurostat).

[2] https://ggim.un.org/meetings/GGIM-committee/9th-Session/documents/The_GSGF.pdf.

[3] https://www.efgs.info/gsgf-europe-geostat-information-service/gsgf-europe/.

16. The UNECE High-Level Group for the Modernization of Official Statistics (HLG-MOS) works to advance the modernization of official statistics. Within their work the Guide to Data Integration for Official Statistics as well as a Geospatial View of the Generic Statistical Business Process Model (GeoGSBPM)[4] was published.

17. This chapter of the CES census Recommendations is the a result of a UNECE project in which it was decided to increase the emphasis placed on GIS data and related approaches, and geospatial information and small area statistics for censuses. This will further promote the data integration agenda.

18. While considering using GIS in censuses it should be recognized that the (potential) benefits and costs of GIS are as follow:

(a) Benefits:

(i) Closer linkage between maps for enumerators and map-based products for users;

(ii) Enriched dissemination of census data as they can be visualized in geographic areas for easy understanding by users;

(iii) The cost of intercensal updating of the base map will be lower with a digital base map, enabling, among other things, the construction and updating of sampling frames;

(iv) Producing duplicate maps may be less expensive with a GIS solution;

(v) GIS will have increased ability to undertake quality assurance of geographic boundaries;

(vi) The census agency will have a greater ability to perform spatial queries and advanced analysis under GIS;

(vii) The space needed to store input maps for digital purposes will be much reduced.

(b) Costs:

(i) GIS requires additional technical expertise;

(ii) GIS will require a higher level of computing infrastructure;

(iii) A clerical census system can proceed on the basis of basic maps. However, use of GIS in this task requires that a digital map base exists. If it is necessary to create the digital map base, significant lead times are required as well as significant funding. In both cases, more experienced technical staff are required;

(iv) In most cases, the preparation of maps or GIS will not be the core business of a statistical agency.

B. GIS technology and GIS for census needs

19. The introduction of x, y coordinates and address points in census data enables a shift from area assignment (census districts) to point assignment. The change of the assignment mode allows for more flexible grouping and presenting data collected by public statistics in statistical units smaller than the commune, i.e. in statistical regions, census enumeration areas or even in very small areas, such as a kilometre grid with a cell size of 1km^2. It also facilitates the creation of a spatially-oriented microdatabase, enabling the conduction of geo-statistical analyses on microdata (e.g. analysis in a user-defined area).

20. Census information at accurate and standard geographic levels is essential to facilitate comparative analysis and achieve better quality of geospatial statistical data production. In the context of a census, it is crucial to have georeferenced data at the level of x, y coordinates.

[4] GeoGSBPM - Generic Statistical Business Process Model - UNECE Statswiki.

21. The location of a given census unit should be specified by means of global positioning system (GPS) coordinates and descriptive attributes, especially taking into account the register identifiers of territorial units and address features (including the identifiers of administrative division units, locality identifiers and street identifiers).

22. For the purpose of conducting enumeration and disseminating results, the address point coordinates should be determined with an accuracy of several metres.

23. With the aim of facilitating the management of spatial data concerning the location of census units, the coordinate system adopted should be homogenous for the whole country or territory.

24. A geographic information system (GIS) can be seen as a system of hardware, software (commercial and/or open source) and procedures designed to support the capture, management, processing, analysis, modelling, and display of spatially-referenced data.

25. Careful planning should be undertaken to plan for a complete GIS that can solve complex census operational planning issues, providing solutions for managing operations, identifying, and resolving enumeration coverage problems, monitor field operations, enforcing quality controls, producing detailed georeferenced inventories, and supporting a variety of dissemination platforms, products, and formats.

26. GIS technology should be considered only at a level appropriate to the skills and resources available and should constitute an integral part of the overall work of the organization. Cooperative arrangements with a national mapping agency or other agencies should be pursued, particularly regarding the acquisition and maintenance of base map data, which usually is not the responsibility of the statistical organization. Therefore, as many administrative sources as possible should be reviewed for presence of spatially-referenced data and tested for the possibility of using it for statistical purposes. (The United Nations Integrated Geospatial Information Framework (UN-IGIF) provides a basis and guide for developing, integrating, strengthening, and maximizing geospatial information management and related resources supporting NSOs in seeing themselves in the national geospatial data production ecosystem.)

27. Given the great potential of geospatial information for censuses, statistical organizations should pursue the development or implementation of GIS and integration of geospatial information whenever possible, including for intercensal surveys. The integration of statistical and geospatial information must be an objective of NSOs, understanding themselves as important institutions that produce or consume geospatial information. Therefore, NSOs must pay attention to the five GSGF Principles for internal structuring.

28. In recent years, many countries have adopted GIS to facilitate census mapping in the production of enumeration maps and outreach products. As the cost is decreasing, geospatial technologies and inputs are being made available free of charge or openly, and the basic technology is now well established. This can be expected to continue to expand in future census rounds. It is likely that the census could help to increase the capacity of the statistical service (or the country as a whole). The adoption of GIS should therefore be seen as an important strategic decision, with impacts that go beyond the operation of the census, and many issues need to be considered.

29. The scope of geospatial and statistical data integration is very complex. The challenge is to understand how to achieve this integration in the most effective and consistent way. Developing a coherent and systematic approach for linking statistical and geospatial data requires considerable commitment and time.

30. The best way to achieve the consistent integration is having a common method of enabling statistical and administrative data to be geospatially referenced, preferably in connection with the GSGF, which enables comparisons within and between countries. The GSGF framework consists of five principles that are considered essential to integrate statistical and geospatial information. Moreover, GSGF is a high-level framework which facilitates consistent production and integration approaches for geo-statistical information. It is generic and permits application of the framework principles to the local circumstance of individual countries.

31. The creation of a geocoding infrastructure for statistics and its integration into the statistical production process does not demand a complete redesign of enterprise architectures and statistical production processes. Small and stepwise improvements are possible. However, integration of statistical and geospatial information is a cornerstone in the modernization of official statistics.

C. Address point approach/reference to an address point

32. Census information at accurate and standard/common geographic levels is essential to facilitate comparative analysis and achieve better quality of geospatial statistical data production. In the context of a census, first of all it is crucial to have georeferenced data at the level of x, y coordinates. The introduction of x, y coordinates and address points enables a shift from the previous system of spatial identification and from area assignment (census districts) to point assignment. The change of the assignment mode allows for more flexible grouping and permits presentation of data collected by public statistics in statistical units smaller than the lowest administrative level – commune, i.e. in statistical regions, census enumeration areas or even in very small areas, such as a kilometre grid with a cell size of 1 km^2. It also facilitates the creation of a spatially-oriented microdatabase, enabling the conduction of geo-statistical analyses on microdata (e.g. analysis in a user-defined area).

33. Wherever possible, data should be collected with reference to an address point; results can then be disseminated using any desired spatial divisions.

34. The address point approach refers to the strategy of geocoding census data using addresses to facilitate geocoding. Geocoding address data is usually done through specialized software or via an address register. In certain cases, manual geocoding of certain addresses, that have not been geocoded otherwise, must be added.

35. Geocoding of address points offers several advantages:

(a) Addresses are a common part of data that is used or collected for census purposes. Geocoding this data can therefore be done in existing workflows with minor adjustments. Connecting this address data to geographical coordinates broadens the analytic possibilities. Address points offer a high level of detail that presents analytical benefits. In addition, using the address point approach is robust against postal and administrative restructuring, and is therefore more suited to comparing data from different census rounds;

(b) If point-based geospatial data is collected in conjunction with each individual enumeration, then the dissemination unit can be easily conformed to different geographic layers. To put it another way, the availability of a precise coordinate for the location of each household can tie each individual enumeration response to a precise location where it was collected. Then there is a much greater flexibility in the eventual dissemination units, and those point locations can be aggregated and the data associated to any geography.

D. The importance of maps for census

36. Mapping has been an integral part of censuses for a long time and continues to be widely used irrespective of the type of census.

37. Over the years, census maps have played a critical role in all processes from preparation to dissemination of census results.

38. The census-mapping programme should be developed at a very early stage of census planning, considering the conditions and available resources of the country. Countries should evaluate available mapping options by considering the following factors:

(a) Available geographic resources;

(b) Requirements for new technologies and approaches;

(c) Available funds and the allocated time frame;

(d) Staff capacity needed for new approaches; and

(e) Requirements for developing an ongoing geographic system.

39. Evaluation of these factors will determine the best mix of technology and other approaches for each individual case.

40. Today maps play an important role, especially in the dissemination of census results, as they allow the main characteristics of the population and homes in the different territories to be represented. Users, both public and private entities, are increasingly interested in having a cartography that represents census statistics at a very detailed territorial level.

41. Another recommendable aspect would be to strengthen collaboration between National Statistical Offices (NSOs) and mapping organizations for the development of a common GIS as well having a geospatial framework. The development in these areas would produce numerous benefits, such as working on shared geographic areas, standardizing spatial concepts and codes, facilitating data integration, and improving the dissemination of census data at finer spatial levels.

E. Cooperation/collaboration on integrating census data with geospatial information

42. Integration of statistical and geospatial information describes the use of geospatial information for the production and dissemination of statistics. Integration can take place at any stage of the statistical production process, as described by the Generic Statistical Business Process Model (GSBPM). The integration includes geocoding of statistics, spatial analysis, and creating statistical maps. As part of the integration process the following steps may occur:

(a) Geocode statistical information at unit-record level;

(b) Processing and manipulation of statistical information using spatial analysis techniques with the purpose of selecting information or deriving new information with a focus on their spatial characteristics, e.g. buffering around spatial features;

(c) Supporting a more efficient and flexible statistical production process with geospatial information, e.g. for surveying and sampling, field operations;

(d) Combination of statistical end products with geospatial information in statistical maps;

(e) Improving the quality of existing statistical products adopting by spatial models, e.g. producing information on commuting patterns by calculating journey times based on detailed transport networks.

43. All statistical phenomena that can be associated to a location are in principle relevant for the integration of statistical and geospatial information. Location in this context means the location of the most individual observation at unit record level. In most cases the location will be a point with coordinates or a precise address. However, other spatial reference frameworks such as lines or polygons are relevant as well representing e.g. road segments or areas with a certain land cover[5].

44. Cooperation and collaboration on integration of census data and geospatial information can be a viable strategy to utilize the existing capabilities of other national actors. The opportunities and constraints of collaborating or cooperating with other actors depend heavily on the local statistical and administrative system. The roles and responsibilities of the involved actors therefore must be adapted to the local systems.

45. Regardless of the structure of the statistical geospatial framework, it is important to store data only once to reduce errors and enable synergies.

46. Both NSOs and national mapping and cadastral agencies play a crucial role in this data governance. The integration of statistical and geospatial data has been playing an increasingly important role and offers one of the most promising paths to provide reliable

[5] https://www.efgs.info/information-base/introduction/terminology/

and detailed information including census information about population and housing that can result in new insights.

F. Designing common geographies

47. A common set of geographies based on traditional statistical and administrative geographies should be used to display, report and analyse census information.

48. According to the GSGF, a common set of geographies ensures the consistent geospatial aggregation, comparability, and dissemination of statistical data. Data are uniformly allocated to smaller administrative segments or statistical units such as mesh blocks that are divided according to political, property, or topological subdivisions.

49. Aggregation and disaggregation methods enhance quality, assessment, consistency, comparability and use of data.

50. The common geographies should be based on authoritative data and also be included in the National Spatial Data Infrastructure (NSDI). The governance and management of common geographies include the agreed scale, reference dates, coding systems, resolution and accuracy of geographies. The framework of geographies also needs to be developed continuously in line with emerging user needs.

51. Documentation on the delineation methodologies for the dissemination geography and its lifecycle and changes is essential to ensure that the potentially complex concepts for understanding delineation methodologies used to maintain common dissemination geographies are understood and used by stakeholders.

G. Geocoding

52. Geocoding is the process of transforming a description of location or location information (such as an address, name of a place, or coordinates) to a location on the earth's surface. In other words, geocoding is a way to ensure data know where they are. It is also defined as translation of one form of location into another (ISO 19133:2005).

53. For the purposes of the GSGF, geocoding is generally defined as the process of geospatially enabling statistical unit records so that they can be used in geospatial analysis.

54. More specifically, geocoding is the process of linking unreferenced location information, often in the form of a text string (e.g. an address or address identifier), that is associated with a statistical unit, to a geocode. Alternatively, the geocode can be incorporated directly into the statistical unit record.

55. The condition for geocoding are high quality physical address, property or building identifiers, or other location descriptions, in order to assign accurate coordinates and/or a small geographic area to each statistical unit[6].

56. Geocoding refers to the process of linking geographical coordinates to address information. Geocoding is therefore the prerequisite to processing address information to make it usable in a geographic context. A basis for geocoding is an Address-, Building- and Dwellings-Register (ABDR). Through this register, the linkage of address information and geographical coordinates is made. It is therefore vital to maintain the ABDR. The address and buildings information must be maintained to reflect changes, for example the construction of new roads or buildings, postal or administrative restructuring or changes to existing buildings that alter the location. In addition, changes to the geographical information that is linked to each unit in the register, for example the correction of outdated geographical information, also must be included in the register.

57. A high-quality, comprehensive, updated and georeferenced address registry of each building and dwelling can give great support in planning and organizing a census. A georeferenced list of addresses can play a central role in many fieldwork operations and will

[6] Ibid.

provide the key to accurate delivery, collection and follow-up of questionnaires. The best way to associate each address with a location in physical space of a map is to specify its coordinates in a proper geographic reference system. With geographic coordinates addresses can be entered in available maps or into the GIS. If it is not possible to get coordinates it is recommended at least to geocode addresses. Geocoding is the process of finding associated geographic coordinates from other geographic data. For example, as geographic coordinates of an address, the coordinates of the centre point (centroid) of the enumeration areas to which the address belongs could be taken.

58. It is crucial to consider carefully how this linkage is performed and to ensure the geographic accuracy of the resulting data. The Address-Based Data Register (ABDR) often comprises multiple archives. Typically, buildings are sourced from administrative records in a geographic format. It is advisable to verify that the distance between a building and the coordinate used for its address is consistent with reality. There may be instances where an address has an estimated coordinate that is distant from the building it represents.

59. To increase acceptance and usability of the ABDR, it is necessary to include a common and stable identifier (ID) in the register that can be used by all statistics that use the ABDR. Through the ID, various parts of the census as well as other statistics can exchange information more easily, facilitating cooperation and easing the process of updating and sharing geospatial information.

60. To facilitate operations and enhance the usability of information, the Plus Code for the centroid coordinates of a building could be added to the ID. As is well known, a Plus Code is generated using an algorithm provided by Google. This is a completely free tool that allows for the immediate visualization of a geographic feature with an accuracy of three metres.

H. Supporting field work with maps and GIS tools

1. Planning for use of geospatial technology

61. Digital maps can be used at the census planning and preparation stage, during the pre-enumeration stage, and in the course of census conduct and management.

62. With a view to drawing up the census documentation on digital maps, as well as performing geo-statistical analyses and presenting output data on digital maps, a pre-enumeration assumption should be made that the adequate GIS tools, compatible with spatial microdatabases, will be used at the sampling frame creation stage of the census.

63. It is necessary to design the databases comprising the locations of census units. These locations should be obtained from the source materials currently available in NSOs (statistical maps) or from external sources (data of geodesy authorities/mapping agencies). In the event of compatibility/source quality problems, data correctness should be verified, and manual data supplementation should be performed where necessary.

2. Applying GIS and mapping to ensure coverage and facilitate census operations (pre-enumeration)

64. It is necessary to verify the correctness of data concerning census unit locations. Such verification may be performed on the basis of data coming from administrative sources – a referential register comprising address points.

65. If no such administrative sources are at hand, the correctness of data concerning census unit locations may be verified at the pre-enumeration stage, during which the enumerators' task is to verify and adjust (where necessary) the spatial location of individual census units, using handheld devices equipped with GPS.

66. Accurate data on census unit locations ensure efficient management of enumerators' work, in terms of assigning census questionnaires, monitoring enumerators' activities and monitoring the census completeness at each stage.

3. Accuracy requirements, standards, database design, geographic hierarchy, coding schema, etc.

67. It is crucial to obtain the locations of census units as x, y coordinates. The location of a given census unit should be specified by means of coordinates and descriptive attributes, especially taking into account the register identifiers of territorial units and address features, including the identifiers of administrative division units, locality identifiers and street identifiers.

68. For the purpose of conducting enumeration and disseminating results, the address point coordinates should be determined with an accuracy of several metres (no more than 7 metres).

69. With the aim of facilitating the management of spatial data concerning the location of census units, the coordinate system adopted should be homogenous for the whole country.

4. Production of digital Enumeration Areas (EA) maps for fieldwork and operations

70. Production of digital EA maps may be done by using data from National Spatial Data Infrastructures – authoritative geospatial data and services. The acquisition of census locations makes it possible to design the map services and dedicated applications to display maps by both enumerators and their supervisors. Below is a sample content of the digital map to be used by census supervisors. It can consist of the following layers:

(a) The administrative division boundaries;

(b) The statistical division boundaries;

(c) Cadastral data: cadastral parcel boundaries, building contours (depending on the completeness of acquired data);

(d) Road and street network;

(e) Address points (census unit locations along with x, y coordinates);

(f) Some topography elements such as bodies of water, railway lines, etc.

71. An orthophotomap and orthoimages obtained from very high spatial resolution satellite images may serve as the background for these layers.

5. Allocation of field workers to EAs

72. The map enables an interactive allocation of workload for field workers using the GIS technology. The visualization of census units against the division into EAs fosters the accurate determination of the workload to be performed in a given EA and its adequate division into enumerators.

73. The location of census units can then be verified during the pre-enumeration round. The pre-enumeration round could be aimed at verifying the existence of buildings and supplementing the list with missing address points. Additionally, during the pre-enumeration round enumerators have a chance to familiarize themselves with the area where they will later perform enumeration.

74. During the pre-enumeration round enumerators could not only confirm, remove or modify building data in respect of the address points assigned, but also inspect the entire census areas entrusted to them.

6. Use of GIS for logistics, planning and operations

75. GIS technology can be used to assign work to individual enumerators, as well as to monitor their activities and provide the necessary assistance. The tasks are assigned on the basis of the statistical division of the country. The GIS system can be used to entrust enumerators with the tasks located in the vicinity of their place of residence. However, it is a good practice to assign enumerators to census areas other than those containing or in the immediate vicinity of their direct places of residence.

76. Local leaders of the teams of enumerators should provide front-line support to enumerators. They should also be equipped with a desktop GIS tool which will allow them to monitor the fieldwork performed by enumerators.

7. Use of enumerators map application on hand-held devices during data collection

77. The map module could be used by enumerators to find their way to respondents. Due to the continuous access to the map and the possibility to determine their locations, enumerators will be able to effectively plan their work and visit units located close to one another on the same day.

78. With the aim of ensuring enumerators' safety, the mobile application on hand-held devices should be equipped with an alert function to notify the local leader or supervisor of any emergency situations and to provide support (emergency service, police) through an embedded GPS module.

8. Monitoring progress and management of field enumeration

79. The census progress and completeness could be also monitored on maps. Visualizing the census units on maps makes it possible to monitor the census completeness at any aggregation level (i.e. by census area, statistical region, local level or regional level), and to verify each census unit individually, in terms of the correctness of the conduct of the census.

80. While monitoring the census completeness, supervisors can monitor, on an ongoing basis, the workload of each enumerator and decide on reallocating tasks between individual enumerators, with the aim of ensuring a smooth course of census operations.

81. The GIS module also makes it possible to monitor enumerators' work in real time by displaying their routes and verifying whether the completed questionnaires are sent to the system from the locations where interviews have been conducted.

I. Grids

82. According to the result of the questionnaire regarding experiences from previous census round, most countries are now able to geocode census information at the level of individual geographic coordinates and subsequently obtain aggregate data at any spatial level and even at the 1km^2 grid level.

83. Providing grid-level census data is not only useful to better understand small territories, even regardless of administrative boundaries, and to study local dynamics, but it is necessary to enable policy actors to adopt intervention policies based on the specificities of local realities.

84. From the point of view of Common geographic classification (Principle 3 of the GSGF), the grid type geographies complement administrative and statistical geographies.

85. Gridded data can be both a rich source of information and a consistent geography for disseminating and integrating information. Recent global efforts have culminated in the development of a Discrete Global Grid Systems (DGGS) standard which has been developed under the auspices of the Open Geospatial Consortium (OGC). This system offers further options in the use of grids within the context of the principle of common geographies and in geospatially-enabled statistics.

86. To evaluate the comparability of census statistics between different areas, it is necessary for the data to be harmonized and for them to comply with international standards. It is therefore important to accompany statistics for the grid with quality metadata.

J. Data collection

87. Depending on the geographical frame and the technology used, geo-coding may need to be done at the same time as collection of the data by using inputs from GPS systems, putting a mark on a map, etc. What is also important is the management of the providers

involved in the current collection, ensuring that the relationship between the statistical organization and data providers remains positive, and recording and responding to comments, queries and complaints.

88. In addition to the traditional collection of data by enumerators and supplementing this data by geocoding, register data and even big data are increasingly used. Therefore, it is necessary to ensure the quality of address data, as they are crucial for the correct geocoding of individual data from alternative sources. We further treat geocoded data in the same way, regardless of its source. This applies especially to censuses using data from registers.

K. Census data dissemination through maps and maps portals

89. Statistical offices should understand GIS as an important tool for spatial analysis and dissemination of census data. Interactive maps, geoportals, and user-centred geography construction tools tend to be more direct and simple ways to interpret information than tabular data, especially for the lay public. NSOs provide vital information about current demographic conditions and future trends to policymakers in a range of sectors, such as health care, education, infrastructure planning, agriculture, and natural resource management; and the availability of spatially-referenced census databases is an essential prerequisite to facilitate the use of demographic data.

90. Maps make it easier to present, analyze and disseminate census results after enumeration. The cartographic presentation of census results provides a powerful means for visualizing the outcomes of a census. This supports the identification of local patterns of important demographic and social indicators. Maps are thus an integral part of policy analysis in the public and private sectors.

91. Dissemination of census results in the form of map outputs plays an increasingly important role in data dissemination. In this way, maps are effectively used to link statistical data with the geographic area to which they relate. The results of the statistics are thus easier to understand, and thus they are also applicable to the general public and not only to a narrow circle of experts.

92. As for thematic maps, the priority indicators for the census of population, houses and dwellings are the total number of population, houses and dwellings. Other important indicators are age, sex and/or gender, education, employment, types of census household, type of dwelling, form of house or dwelling ownership, number of rooms and others. Creating maps using the same set of indicators allows countries to compare their performance over time in a meaningful way. Maps are an invaluable aid when comparing results even at a lower than national level. New technologies provide great flexibility in building informative and visually appealing maps.

93. In addition to classic thematic maps, the creation of grids for the spatial representation of data is increasingly used in statistics. When creating grids, it is necessary to follow a uniform coordination system, which is necessary for the correct connection of geodatabases and the creation of correct map outputs.

94. Nowadays, many tools are available for implementing solutions that allow the user to visualize the boundaries of administrative and statistical geometries and map census indicators such as those identified above. These tools must have an intuitive interface and make it possible to navigate interactively on the map and obtain the census statistical value for each territorial unit (small area statistics).

95. Options for defining distribution criteria, changing the colour palette, or even statistical analysis tools for exporting data are increasingly sought after by users.

L. Small area statistics and small area data aggregation

96. In addition to the enumeration areas, census maps can define smaller geographical areas. In many countries, these areas are called small area statistics or census blocks. In situations where it is possible to count the number of housing units or people for each small

area, automatic or semi-automatic spatial aggregation processes are used to delineate the enumeration area.

97. The size of the enumeration areas can vary across the territory, depending on various factors, including the type of settlement in the territory (e.g., urban or rural). As a rule, there is no predefined value for small area statistics or census blocks. The definition of their geometry is usually based on territorial criteria and the definition of functional geographies that allow for convenient spatial analyses. However, concerns about the number of housing units or individuals these areas include must be taken into account, to avoid confidentiality problems when publishing results.

98. The possibility of using these small statistical areas to delineate functional geographies makes it easier to understand regional dynamics and define public policies.

99. For production of small area statistics, population and housing census data collected to the level of x, y coordinates will make a foundation for aggregation to the area that is the subject of statistical analysis of certain social, demographic and economic characteristics. Moreover, for many countries, the census data will also provide a unique source of solid information to develop sampling frames.

M. Confidentiality and disclosure control

100. The growing demand for detailed statistical data requires the use and promotion of Statistical Disclosure Control (SDC). The staff of NSOs should have a broad knowledge of various SDC methods and tools, be able to apply them to obtain sufficiently safe and useful data to be released. The knowledge of efficient ways of protecting the privacy of data stakeholders or customers is also important for many data custodians, who collect data to perform their activities and tasks. Users of statistical data (e.g. students, scientists, analysts, etc.) should also be aware of the benefits, drawbacks and expected effects of SDC methods.

101. Statistical disclosure control methods mean methods to reduce the risk of disclosing information on the statistical units (natural persons, households, economic operators and other entities referred to by the data), usually based on restricting the amount of, or modifying, the data released.

102. There are different SDC methods, depending on:

(a) The type of data released (microdata, tables, maps);

(b) The effect of the methods on the data released (data suppression, data perturbation).

103. Census and geospatial data used to create geospatially-enabled statistics should only be released publicly in a manner which complies with privacy and confidentiality legalisation, and prevailing community expectations. The ability to identify private and confidential information may be possible within data when collected and securely stored but should be confidentialized to an appropriate degree when disseminated.

104. Within the GSGF and its Principle 5 (Accessible and usable geospatially enabled statistics) it is emphasized that 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.

105. It is also worth becoming familiar with the SDC Handbook which is the compendium of information on SDC. This is a result of work of SDC experts working together in a project co-financed by Eurostat.

106. In addition to the development of the principles and tools of statistical disclosure control, it is also important to raise public awareness of why and how these methods are applied. In particular, the public should be educated about the use of SDC to protect privacy on the one hand and to maximize the amount of publicly available information, on the other. Educational efforts in this regard should obviously start with the NSO staff responsible for efficient data protection, and then this knowledge should be disseminated among data users

and taught to people who handle statistics and data managers in various institutions and economic entities.

N. Detection of changes in the territory as input to maintain an updated geostatistical framework

107. Cartography and maps in general are a support for carrying out the different stages of censuses and surveys. The maps ensure complete coverage of the territory, support data collection, supervision of the load assigned to field personnel, processing, analysis of results and dissemination of the results[7].

108. A permanently updated cartography allows the different stages of the development of a census to be carried out in a more efficient way, so it is essential to take advantage of technological advances that include the widespread availability of personal computers, handheld computers and personal digital assistants, GPS and GIS software, and low-cost aerial and satellite imagery to ensure cartographic updating that reflects changes in the territory as a continuous process[8].

109. The updating of the base cartography is the input for the definition of the common geographies of the statistical and geospatial framework, so the identification of the places where there is the greatest growth in the observation units, such as population, housing, and economic establishments, among others, requires substantial resources.

110. The final content of the base maps will result in better precision and completeness of the enumeration areas and, consequently, a more effective collection of information.

111. Some of the elements that must be updated in the cartography are: roads, the administrative division boundaries, reference elements such as (a) accurately named and presented roads and waterways; (b) administrative boundaries; and (c) landmark features, such as schools, place of worship, post offices, parks and large buildings based on blocks and localities[9].

IV. Conclusion

112. The draft recommendations on geospatial information and small area statistics for censuses for the 2030 round of population and housing censuses are presented for comments and discussion.

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[7] Principles and Recommendations for Population and Housing Censuses, Revision 3, p. 87 [reference to be updated when new revision is published].

[8] *Ibid*., pp 90–91.

[9] *Ibid.,* page 96. [reference to be updated when new revision is published].