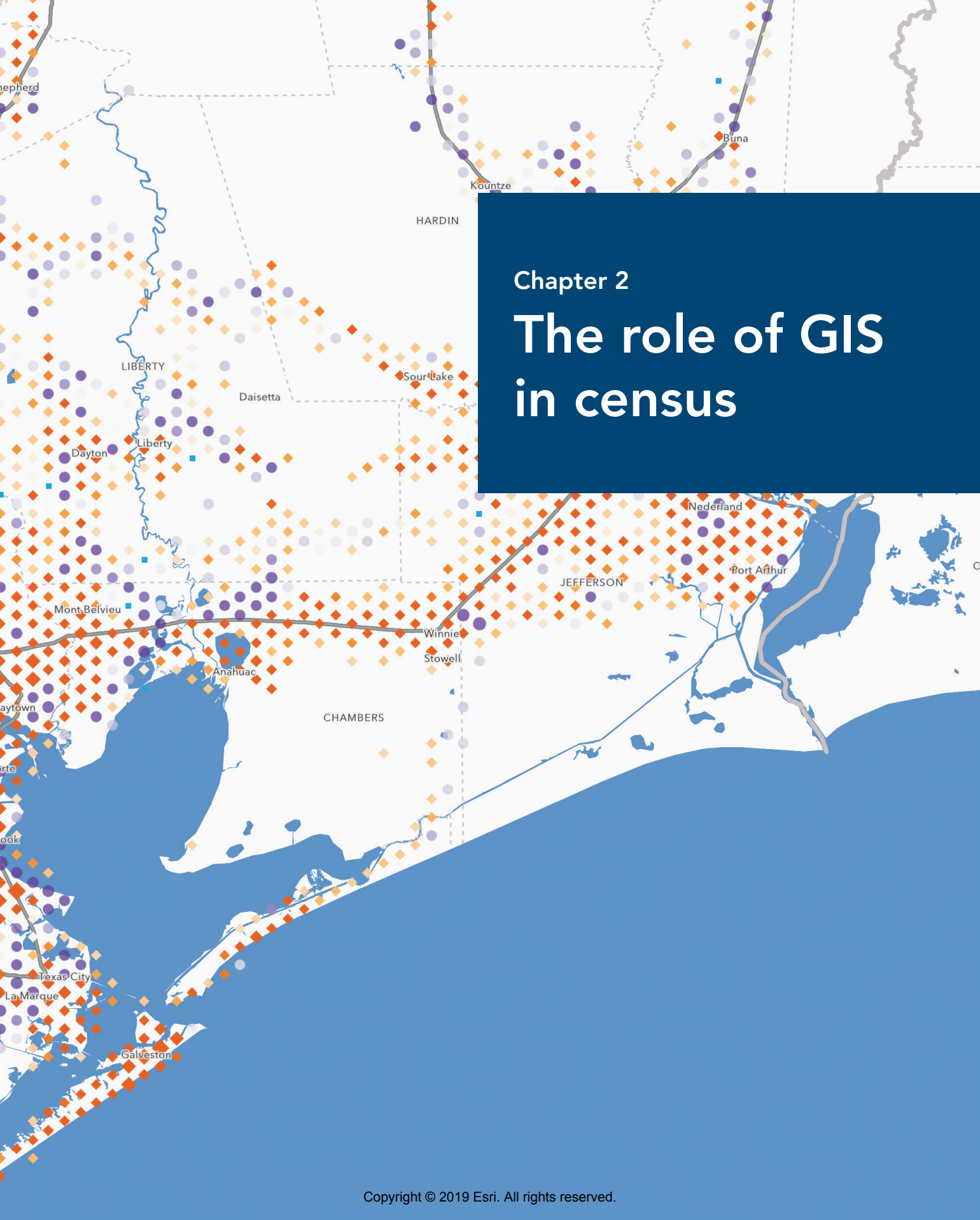

Chapter 2

The role of GIS in census

Planning the census process with GIS

Census geography program

In most countries in the world, a population and housing census is conducted periodically, at least once every ten years in accordance with the UN *Principles and Recommendations*.[1] A population and housing census is considered the greatest democratic operation because it is conducted at the individual or household level, providing information on the main characteristics of a country's entire population in terms of size, geographic distribution, and demographic, social, economic, housing, and living conditions.[2]

Mapping is generally recognized as one of the most crucial activities of a census, playing a critical role in providing the geographic basis used during the actual process of enumeration. Owing to recent technological developments in GIS and other geospatial technologies, the scope of census mapping has been extended to census data analysis and dissemination, with greater efficiency in data collection and enumeration. However, there are some challenges in opting for a full digital census-mapping approach; the use of these technologies has crucial impacts during mapping activities, data collection, processing, analysis, dissemination, evaluation, and archiving, and should therefore be taken into account at an early stage of census planning. Embarking on a GIS-based census should be planned and implemented in a consistent and timely manner.

GIS should be considered an integral part of the census process and carried out continually as a long-term strategy rather than a set of short-term stand-alone mapping and dissemination operations (figure 2.1).

A GIS-based census program aims to achieve the following objectives:

- Support the census planning process.
- Support fieldwork, field operations, and operations management.
- Improve the efficiency and accuracy of the data collected.
- Contribute to analysis.
- Contribute to the dissemination of the census data.
- Integrate statistical and geospatial information for data analysis and evidence-based decision-making and for future censuses and surveys.[3]

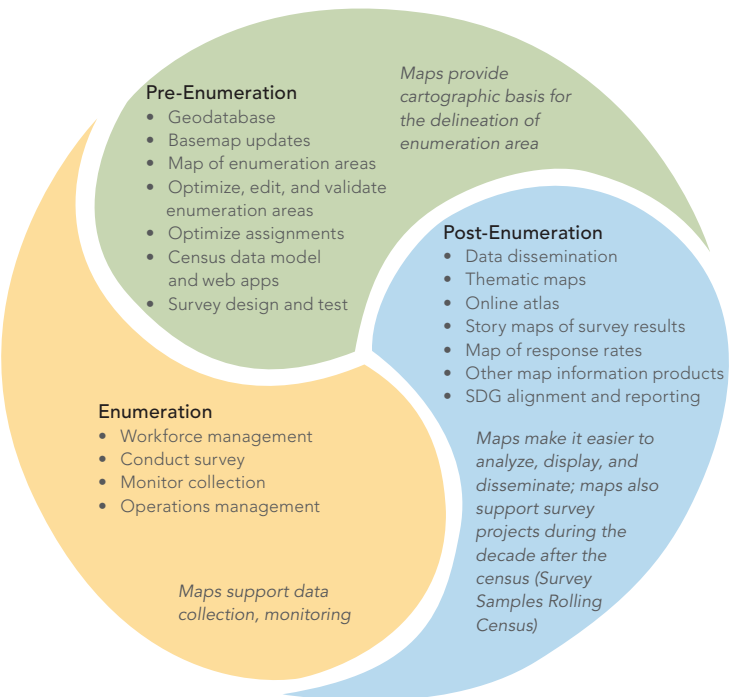

Figure 2.1. The evolving GIS role in census phases.

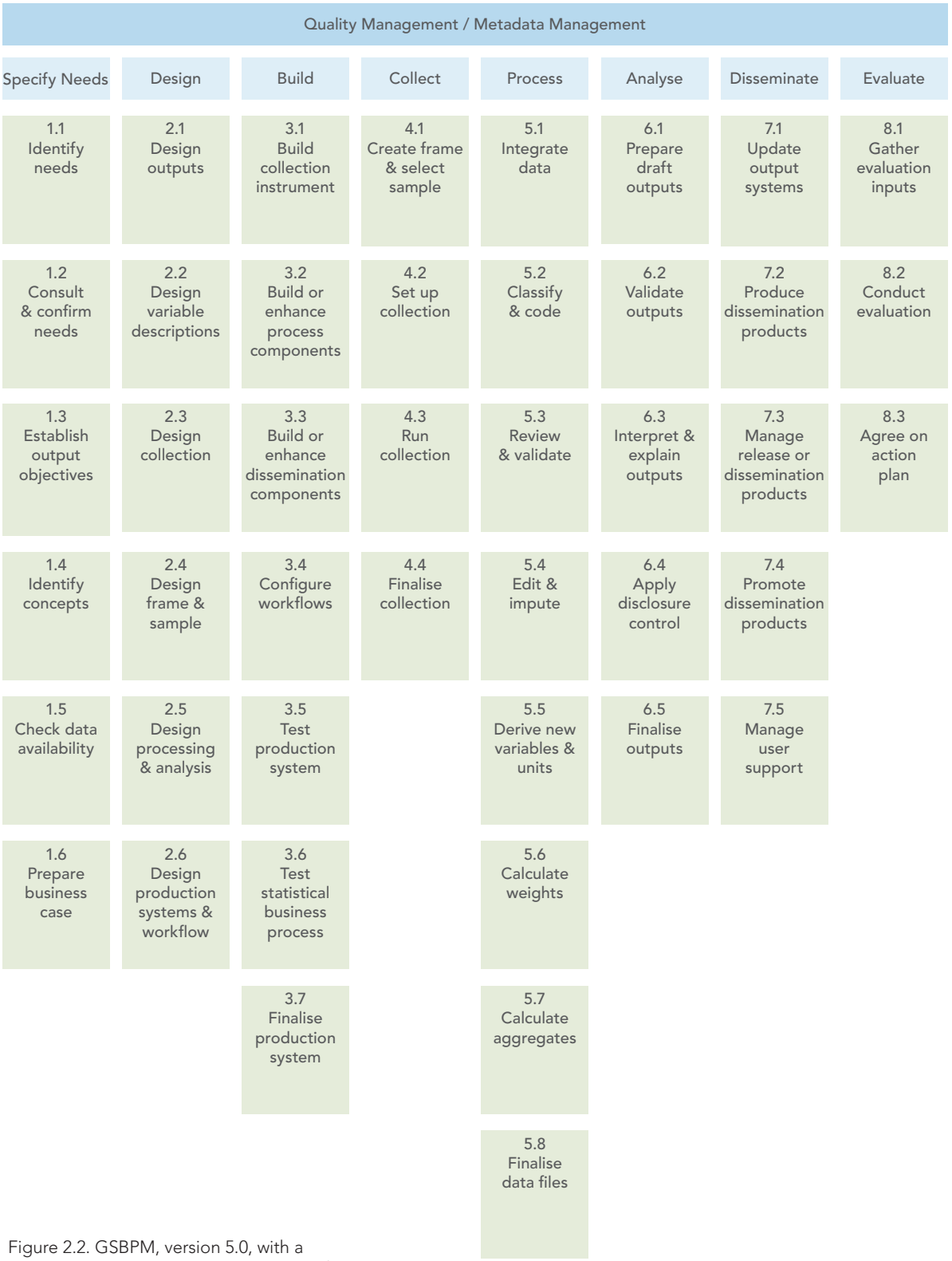

Figure 2.2. GSBPM, version 5.0, with a description of phases and subprocesses.[4]

Supporting the census planning process

GIS can be applied across the Generic Statistical Business Process Model (GSBPM), shown in figure 2.2. One of the primary objectives of a GIS-based census program is to support the census planning process.

The support includes maximizing coverage while avoiding coverage errors such as noninclusion or double inclusion of units that may result in undercounting or overcounting, respectively. It is important to define explicitly the census geography in terms of hierarchical subdivision of the whole territory into administrative, geographic, and statistical areas, including enumeration areas (EAs) and groups of EAs under the responsibility of supervisors. These geographies are used to estimate the staffing and materials needs and logistics requirements and define the operational zones (or census management areas) for the data collection.

As recommended by *Principles and Recommendations*, the GIS-based census program should be developed at an early stage of census planning to allow sufficient time to produce full national coverage maps (including map services and mobile map packages, which are covered in chapter 6) well before the census date and before the initiation of field-training exercises. Developing a timetable for the GIS and mapping activities is of paramount importance; it's a time-bound operation with the critical date being the date that all enumeration-related maps and map services must be made available to the census field enumeration. This requires the identification of the technical, operational, and institutional tasks to be carried out through the planning process. These tasks include the evaluation of available geographic and technological resources and the critical design issues that determine the nature of the census GIS, with a focus on its core geospatial database and the range of applications that it will support. Of importance is the inventory of existing data, maps, and other geographic data sources such as imagery. Data conversion and integration processes should also be understood—all of these depend on a well-designed environment and a well-planned operational strategy.[5]

The stages for planning geographic work for the census are shown in detail in figures 2.3a and 2.3b.

The planning stages are divided here into institutional issues, such as the user needs assessment, the determination of the GIS strategy, and the scope of census-mapping activities. The stages also include technical issues such as the explicit definition of census geography, the design of the geospatial database, and the development of clear protocols for data collection. These stages can be carried out more or less simultaneously using organizationally approved methodologies, and many of the choices depend also on the chosen data-integration strategy.[6]

These planning steps may seem difficult to follow or be considered costly by some NSOs. However, once a fundamental geospatial infrastructure is established and GIS is integrated into the statistical business process, the efficiencies gained and benefits realized far outweigh any initial costs. Each country needs to have guiding policies in place to tailor the technological options according to its needs and availability of resources. To justify the investments involved, the strategies of the pre-enumeration mapping program by many NSOs are designed to produce the geographical outputs suitable not only for the census enumeration but also for the operational requirements of data collection activities, dissemination activities, and other user applications such as demarcation of electoral boundaries, defining catchment areas of various public services, monitoring and reporting

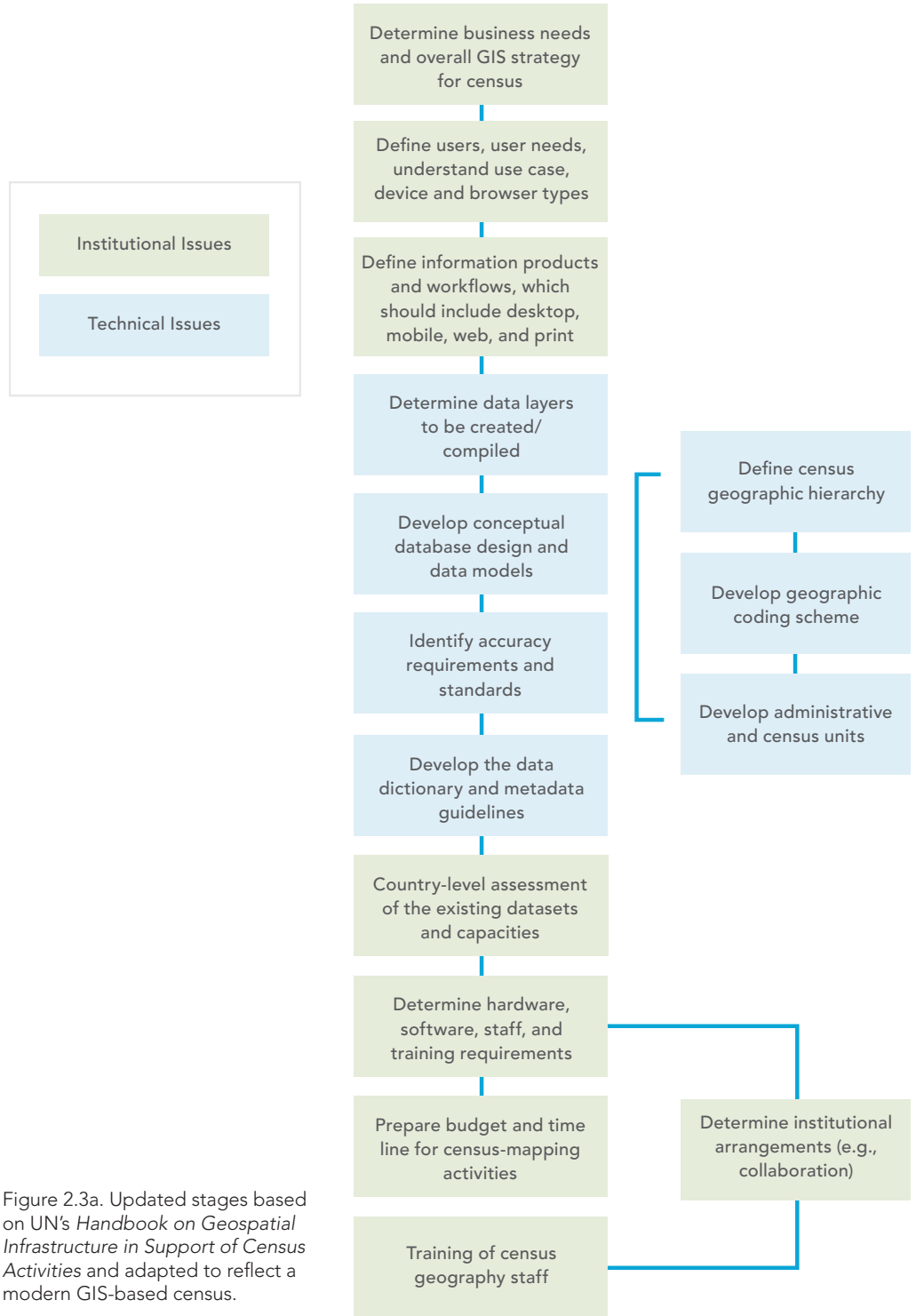

Figure 2.3a. Updated stages based on UN's *Handbook on Geospatial Infrastructure in Support of Census Activities* and adapted to reflect a modern GIS-based census.

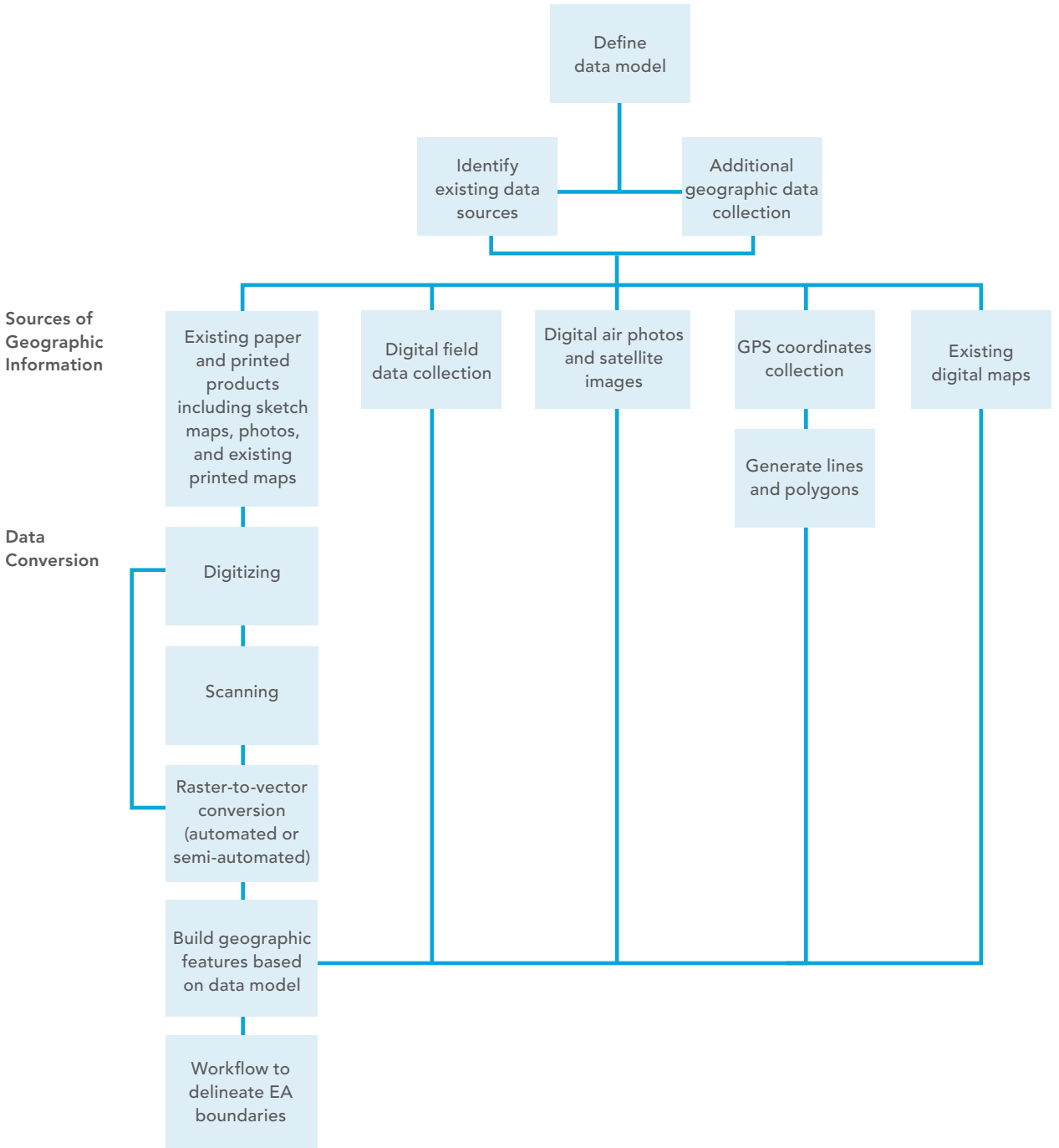

Figure 2.3b. Census planning stages—additional technical issues.

on the Sustainable Development Goals (SDGs), and more. To maximize return on investment in GIS, NSOs should actively participate with other national authorities, including the National Mapping Agencies (NMAs), in establishing a National Spatial Data Infrastructure (NSDI).

GIS planning considerations

The shift from limited census-mapping operations to an entirely GIS-based digital approach that spans across all stages of the census requires the implementation of an enterprise GIS. The planning and implementation of an enterprise GIS for the census should include a cost-benefit analysis to justify the long-term investment in building a GIS infrastructure. It should also require a comprehensive user-needs assessment; lessons learned from many GIS projects show that a GIS is successful when it provides outputs that meet well-defined user needs. The user-needs analysis should also assess the available technology in the market and allow the evaluation of different GIS software options to define the most suitable GIS capabilities for census purposes. More specifically, understanding the user needs requires understanding the appropriate hardware, software, and related integrated systems that will provide the specific digital products and services needed. Those products and services can range from interactive ad web-based mapping applications, map services, map packages, cloud computing, and mobile apps to spatial analysis and advanced analytics.

GIS-based planning considerations include the preparation of a detailed implementation plan that corresponds to the different operational phases of the census process. In line with the GSBPM and its equivalent for geospatial applications (see figure 2.4), such a plan should address issues related to

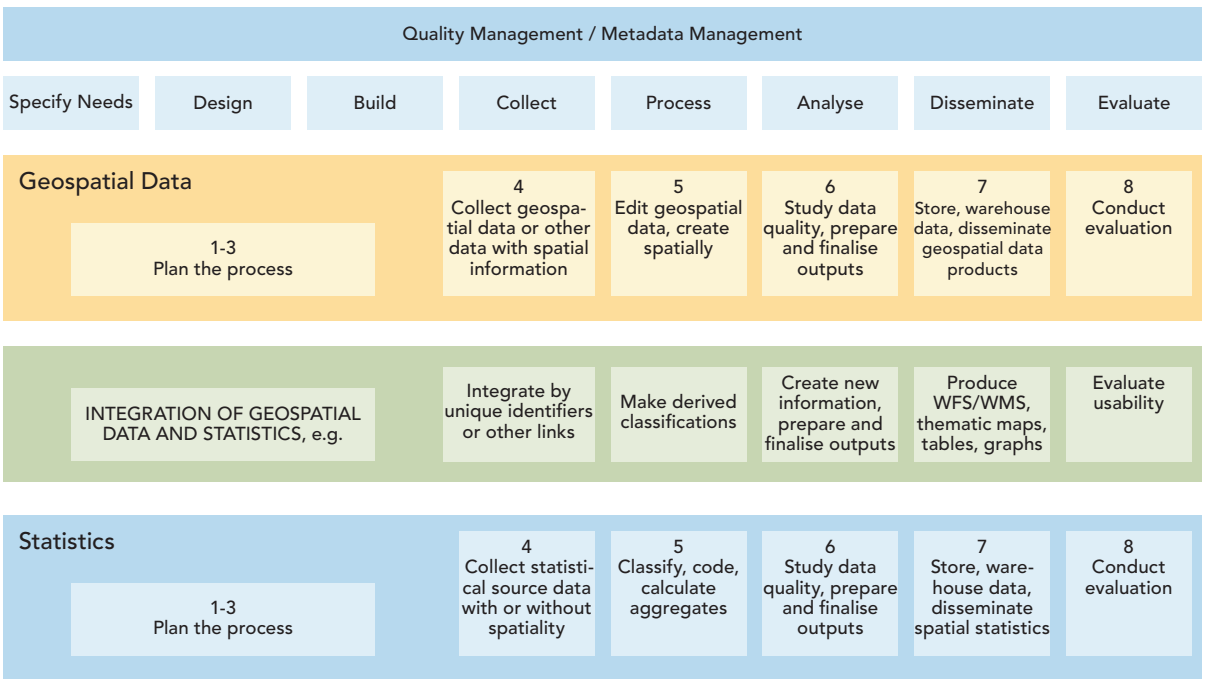

Figure 2.4. The GSBPM and its equivalent dimensions in the production of geospatial data. *Source: A Point-based Foundation for Statistics—Final Report from the GEOSTAT 2 Project.*

the design of the geospatial database, data conversion and integration, and all the other phases of geospatial data production.

Because GIS was not traditionally considered part of the core business of the NSO, awareness workshops about the benefits of GIS should be organized to win executive support for the program. Technical trainings and workshops about the use of GIS should be provided to the staff involved in the census and supporting functions. In addition, the plan should also involve workshops for the major data users about the potential of GIS and draw on institutional mechanisms to mobilize cooperation among all stakeholders to establish a GIS infrastructure at a national level.

GIS can be leveraged to support a wide variety of activities across the entire census process. Following are some examples of how GIS is being applied today in census preparation. These activities will create the foundation for all census work to follow:

- Creation or updates to geodatabase and basemaps.
- Creation or updates and validation of EAs.
  - Production of digital EA maps for fieldwork and operations.
  - Use of remote-sensed data in EA creation or update.
  - In-office address canvassing can be done using imagery where applicable and where quality data is available.
  - Where in-office validation is not possible, maps can be used in field verification or *in situ* validation.
  - Integrating fieldwork using remote-sensed data.
- Conducting GIS analysis to ensure complete and balanced coverage. Overlaying EA maps on a scaled national basemap to ensure the absence of omissions or duplications.
- Applying GIS analysis to facilitate efficient census operations.
  - Using GIS analysis to determine the most efficient placement of field offices.
  - GIS-based analysis to optimize allocation of field-workers to EAs based on various criteria such as language, distance, hours of work, and more.
- Creation of map services (the way maps are made available to the web).
- Creation of mobile map packages (the way maps are made available on a mobile device in an offline mode).

More details are provided in the following sections and subsequent chapters.

Needs assessment

It is generally recognized that a well-defined plan that involves various users with different data needs should be prepared at an early stage. Using geospatial information technology in all the stages of a census requires even more focus and the need to identify, understand, and plan how to address the specific GIS and mapping needs and expectations of the main user groups, as well as the census geographic products required.

The needs assessment plan should include strategies on the content to be discussed during the consultations with users, questions on the ways census products will be accessed (device type) and used as well as their presentation, and the kind of training that needs to be provided to users.

Conducting a comprehensive needs assessment with a business need–driven approach rather than a technology-driven approach helps to define

user needs. The assessment should also identify any available resources within the NSO (and in the country), such as maps suitable for the census operations, existing software packages and related equipment, qualified staff in GIS, and financial resources for the GIS-based census program. This identification will assist in reconciling user expectations with what is feasible given available resources, working backward from final products and services to requirements.[7]

The next section will elaborate on the needs assessment of the main user groups: (a) major users of census data, (b) persons and institutions participating in the census operations, and (c) the general public and civil society.

Major users of census data

A user-oriented census provides major data users—governmental departments, local administrations, the academic and research sector, and the private sector—with easy access and clear understanding of the statistics available, enabling them to benefit from census results. One of the major impacts of a GIS-based census is the extension of the community of users, interested in statistics with a geographic dimension. The assessment of needs in this case includes consultation on demographic and geographic content desired, geographic structures such as administrative hierarchies or geographic units needed for data collection or data aggregation, and geographic base products (maps, imagery, and other remotely sensed data) that support analysis and dissemination of census data. A consultation of the needs of these major users is necessary to determine the form and scope of data to be disseminated and to ultimately understand their expectations in terms of census geographic data products.

Persons and institutions participating in the census operations

Evaluating the needs for census-mapping activities is equally important for the persons (employees and contractors) and institutions participating in the census operations. To obtain an understanding of existing resources and requirement gaps, the NSO must carry out a survey of available human resources, hardware, and software, and must conduct an inventory of existing data (in digital format and on paper) and any requirements for data conversion. The NSO should also understand any ongoing or planned relevant GIS-oriented activities by other public and private entities. The purpose of this assessment is to avoid duplicating efforts, which is key to reducing the cost of census geographic operations and delivering census products on time.[8]

Conducting a comprehensive needs assessment to answer some of the critical questions shown in the following table will help the NSO consider which new technologies to adopt to modernize the census process.