ESCWA Webinar on the Use of Contemporary Technologies for Sudan Population & Housing and Agriculture Censuses

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Use of Geospatial Information Technologies in support of the Census

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Outline

- Geospatial Information – 2020 Census Round: UN Recommendations
  - Census Geography: A Geospatial-based Continuous Process
- Use of Geospatial Information Technologies at all the stages of the Census
- Use of Mobile Technology/Handheld Devices
- Integration of CAPI with GIS
- Conclusions/Recommendations

Country Experiences:
Use of technology – Census Cartography

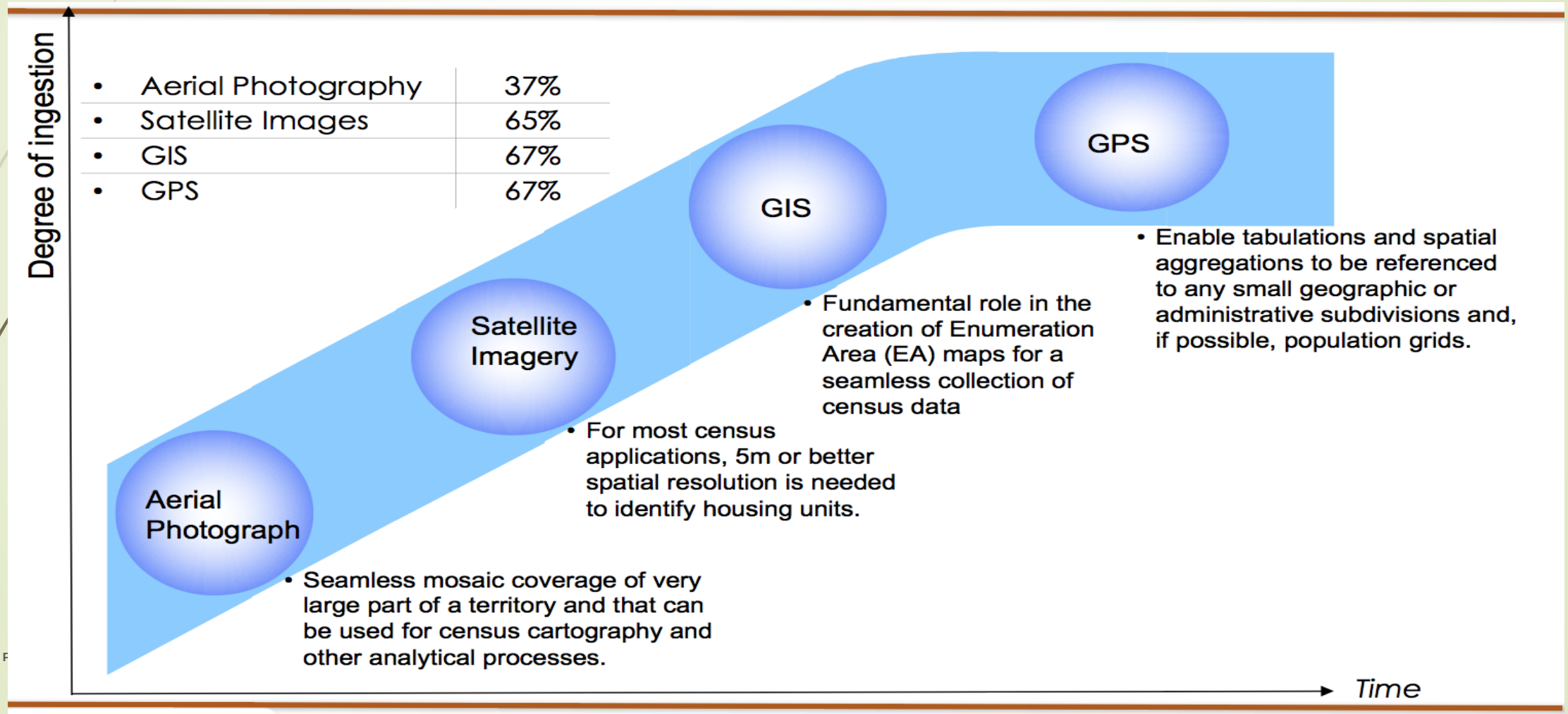
- **Census cartography** one of census domains that have benefited the most from technological innovations

- In 2010 Census Round:
  - 58% use digitized maps
  - **74% use GIS/GPS**
  - 25% aerial photography
  - 24% satellite imagery

- **Major Trends in Data Collection: Use of Mobile Technology - Handheld Devices**

Sources:
- Surveys conducted by UNSD to review experiences for 2010 Census Round and
- Presentations by countries at workshops/conferences

Mainstreaming Geospatial Information Technologies into Census processes *(Source: UNECA)*



Recommendations for the 2020 Round of Censuses

Principles and Recommendations for Population and Housing Censuses, Rev. 3 (adopted by UNSC at its 46th session, 3-6 March 2015)

- Recognizes availability of wide range of geospatial technological tools for use in census mapping
  - **enablers for NSOs** to collect more accurate and timely information about their populations

Recommendations for the 2020 Round of Censuses…

- Use and application of geospatial technologies are very beneficial to **improve quality** of census activities at all stages of census
  - Satellite images
  - Aerial photography
  - GPS
  - Georeferenced address registry
  - GIS for enumeration maps and for dissemination
- Adoption of GIS should be a **major strategic decision**
  - A census GIS database is an important infrastructure to manage, analyze and disseminate census data

Recommendations …

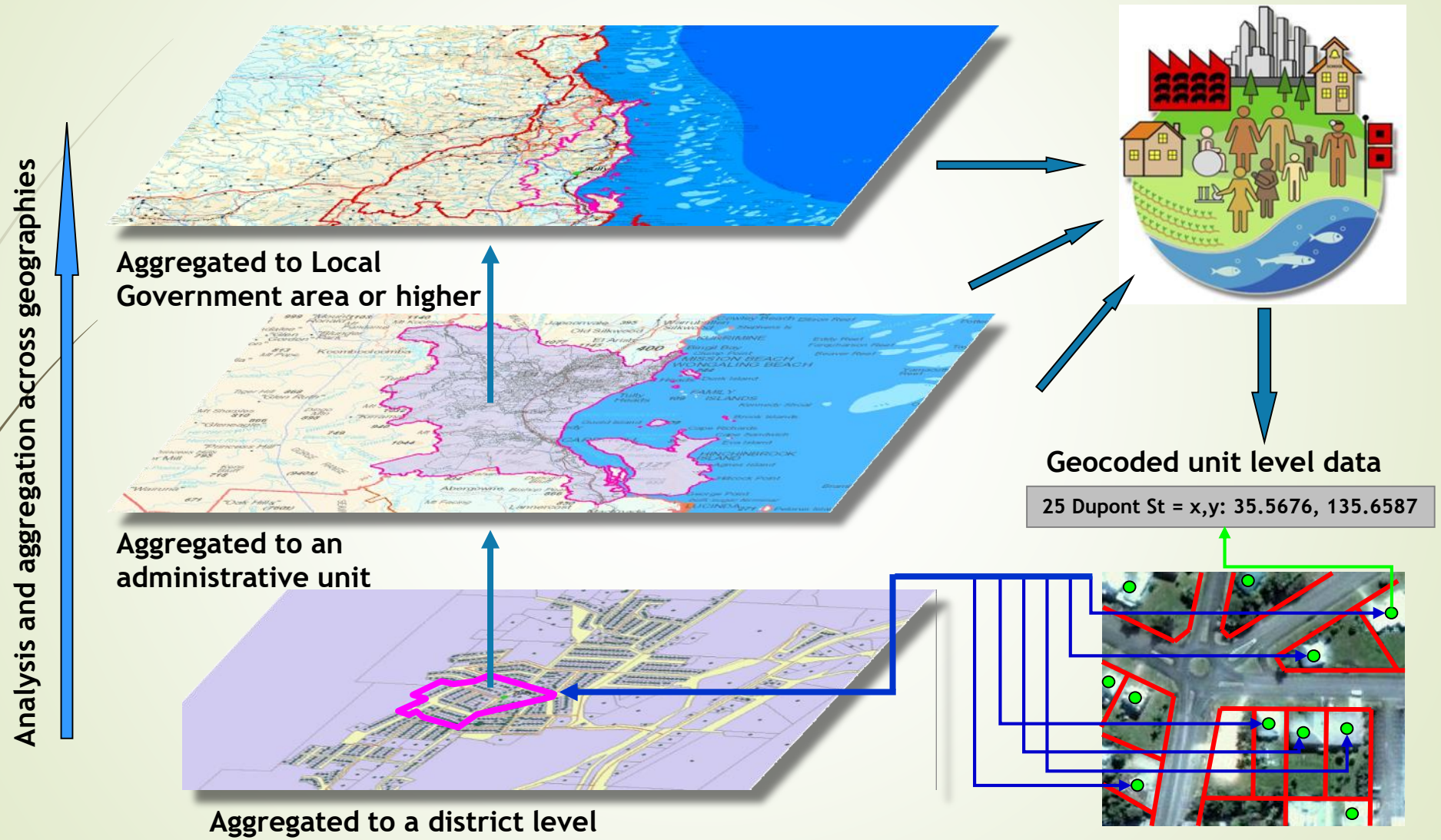
- Geospatial analysis must become a **core competency** in any census office
  - Statistical offices should develop GIS applications with population data and other geo-referenced data from other sources for more advanced forms of **spatial analysis**

- Realizing the advantages of direct digital data entry into a computer software application at the point of data collection through the use mobile technology for data collection and statistical production, the **United Nations has recommended its use in the 2020 Round of Censuses** in recognition of its importance and usefulness for many countries.

World Programme for the Census of Agriculture (WCA) 2020, covering agricultural censuses (2016 – 2025) Promoted by FAO - Guidelines

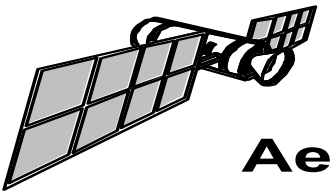
- **1.20** "Another feature of the WCA 2020 guidelines is an increased emphasis on the **use of information technology in data collection, processing and dissemination**. The increasing use of technology in census and surveys operations results in significant efficiencies and reduces the time lag between data collection and data analysis. **This includes the use of computer-assisted personal interviewing (CAPI)**, **internet-based** data collection methods and **geo-referencing**. Similarly, the use of interactive outputs and web-based data (tables, graphs, maps), as well as access to anonymized micro-data, has brought new opportunities for census dissemination. Novel and user-friendly dissemination tools support informed decision-making, unleash the analytical creativity of users and ensure greater sustainability of **agriculture statistics and their integration into the broader national statistical system**."

Geography at the Core of a Census



Geospatial Information Process

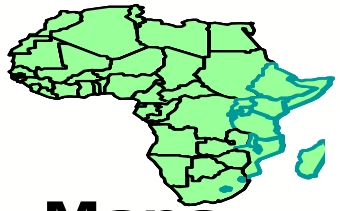
Geospatial Information Technologies



Aerial Photography/Drones

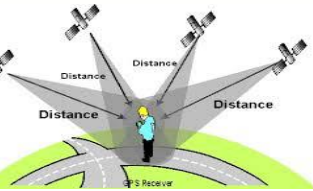
Satellite Imagery

Surveying.



Maps

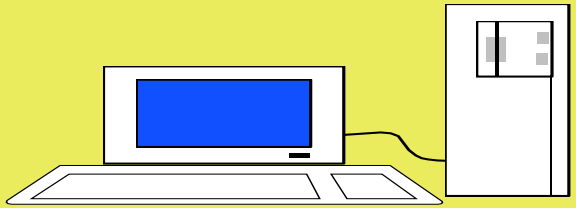
Census & Surveys



GPS

DB

GIS



Acquisition

Management

Dissemination

Use of GIS at all the stages of the Census

Pre-enumeration

- Delineation of EAs
- Geocoding
- Census Geographic Database
- Integration with CAPI
- Pilot GIS Mapping
- Other planning activities

Enumeration

- Mobile GIS for data collection
- Monitoring census activities
- Update Geographic Database

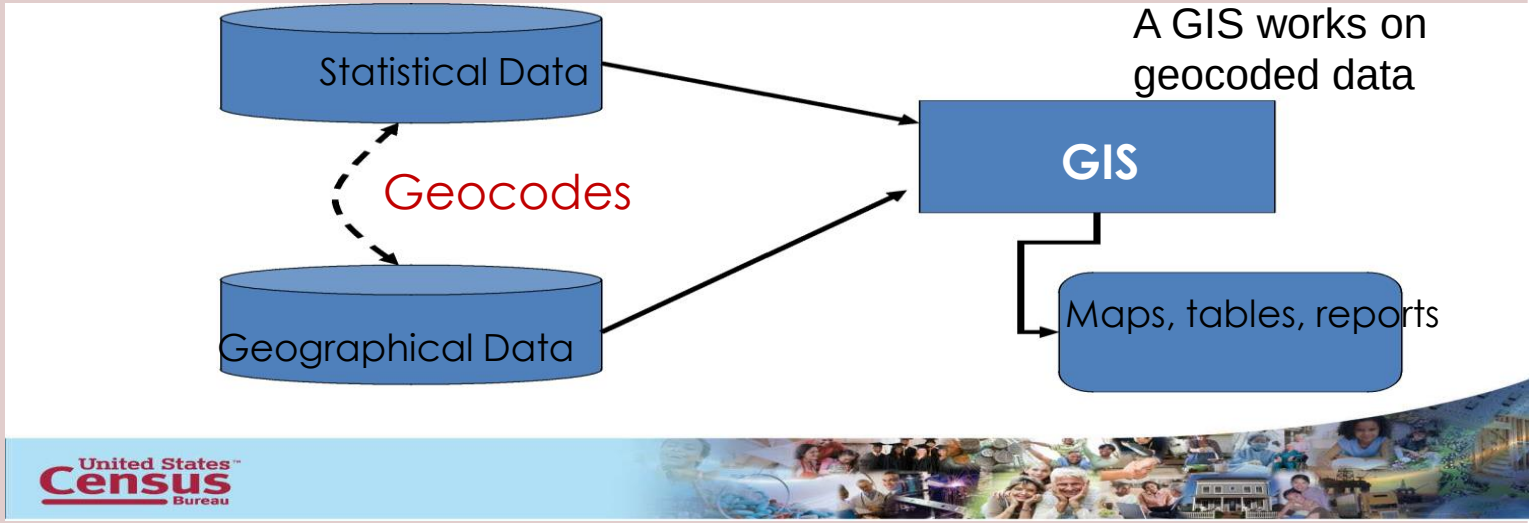
Post-enumeration

- Interactive Maps/Atlases/ GeoPortals
- Web Mapping/Story Maps/Smart Maps
- Web GIS
- Spatial Analysis
- Supporting Surveys and Sampling Frame

EAs

Administrative and Dissemination Areas

Phase	Activity	Procedures
I. Supporting and implementing geospatial activities for the pre-enumeration phase	**1. Delineation of EAs** The statistical unit for the agricultural census, **the agricultural holding**, remains the same as used in previous programmes.	**1.** The first step: **initial office demarcation or re-demarcation phase** which consists to demarcate new and re-demarcate existing EAs through on-screen digitizing, editing and GIS functionality superimposing the vector data such as administrative boundaries, roads, water bodies, place names, cadastral/parcel boundaries, and other point-based features (dwellings/buildings, schools, health facilities, landmarks, etc.) on top of **recent imagery** as a backdrop (Imagery at high resolution obtained within a year of census). **2. Field verification**: it entails the process by which the data and maps prepared and created in the office are verified, corrected and updated in the field. Based on criteria, we proceed to splits or merges **3**. The third step, following the field verification, consists of an **office work** to capture the verified data in the field, and thus create the final Enumeration Area/Supervisory Area maps to be used for the actual enumeration.

Phase	Activity	Procedures
… geospatial activities for the pre-enumeration phase	**2. Geocoding** (Attaching codes to the digitized features - geocoded features)	 • Geocoding is generally defined as the process of geospatially enabling statistical unit records so that they can be used in geospatial analysis. • More specifically, geocoding is the process of *linking* unreferenced *location information* (e.g. an address), that is associated with a *statistical unit*, to a *geocode* (i.e. a geospatially referenced object); alternatively, the geocode can be directly incorporated into the statistical unit record.

Phase	Activity	Procedures
… geospatial activities for the pre-enumeration phase	**3. Building or Updating the GIS/EA-based Census Geographic Database**	This is the process of building a geographic database which is the foundational core of any GIS. A **Census GIS database at the EA level** (or point-based level), as it is advised to build a comprehensive GIS-based census database that has at its foundation the smallest statistical unit for data collection, be it an enumeration area, a dwelling or housing unit, or an address. The census GIS database can be designed on an evolving basis. For example, beside the EAs, we capture the geographic location of the building, dwelling and/or household unit… for further spatial analysis. (Will elaborate on this)

Phase	Activity	Procedures
… geospatial activities for the pre-enumeration phase	**4. Integration of GIS with CAPI**	The integration of CAPI with GIS-based EA maps is the crux of the matters; it requires: • Selection or development by an IT team of a CAPI app; • Use of mobile GIS-based EA maps; • Use of Interactive GIS online or offline Maps uploaded in the office; • Admninistration of Tests before embarking on the actual use of the handheld devices in the census data collection; • Need for training prior to the deployment of mobile devices.

Phase	Activity	Procedures
… geospatial activities for the pre-enumeration phase	**5. Pilot GIS mapping exercise**	The Pilot GIS mapping exercise include the following steps: - In preparation of geospatial data for the Pilot, **pilot areas** need to be selected to represent the diversity of socio-economic and geographical conditions of the population in the country to observe the management and supervision of the field operation in real situations; - Preparation by the GIS team and provision of each pilot EA map at the EA/Building level with its related coding system and with the format required by the CAPI app; - Testing the integration of GIS with CAPI. The results of the Pilot GIS mapping exercise need to be carefully analyzed by the NSO to determine the potential modifications for the successful conduct of the actual Census, including the appropriate CAPI app to be selected and its integration with GIS.
	6. Other planning activities with GIS	Additional activities taking benefit of the Use of GIS: for optimizing the EAs in using spatial analysis, optimizing site placement of field offices, and asset distribution…

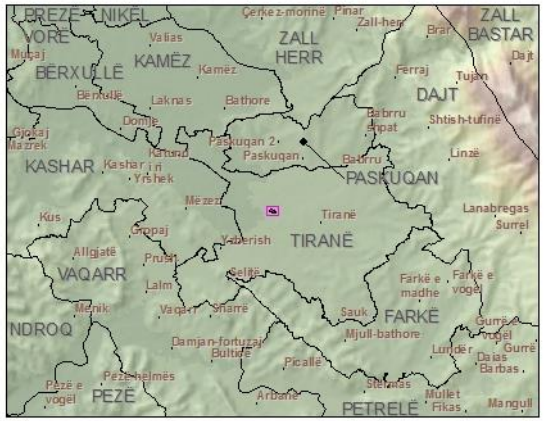
District Code	Mun./Com. Code	EA Code	Controller Code	Supervisor Code
34	14	0113	023	15

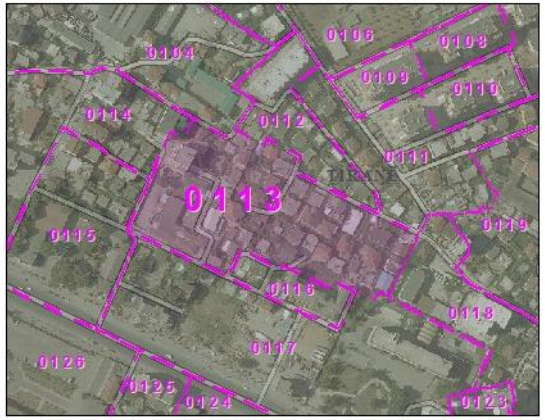
ENUMERATION AREA CENSUS MAP

Population and Housing Census 2011

INSTAT
Republika e Shqipërisë
Instituti i Statistikave

District:	TIRANË
Mun./Com.	TIRANË





2011 CENSUS-AL

BUILDING BOUNDARY

EA BOUNDARY

MUN./COM. BOUNDARY

ROAD

055 TOTAL NO OF BUILDINGS

Scale 1:990

Coordinate System: WGS 1984 UTM Zone 34N

0 215 430 Meters

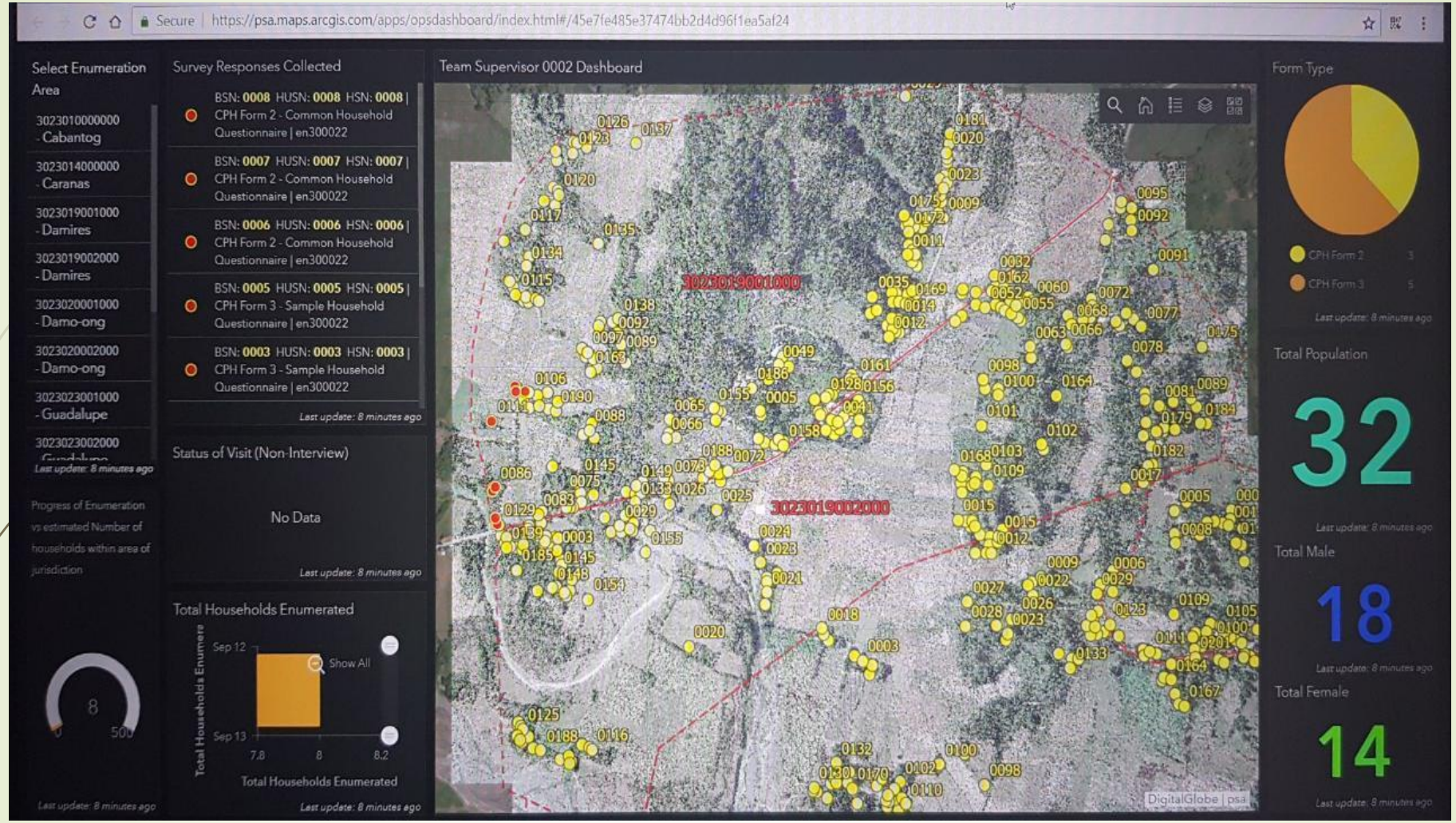
Phase	Activity	Procedures
II. Supporting and implementing data collection and helping monitoring Census activities for the enumeration phase	**1. Mobile GIS for field data collection**	This is about the use of handheld devices for the field data collection, where, in support of the CAPI enumeration process. - We upload the GIS-based Enumeration Area (EA) maps onto the device, and combine them with satellite or aerial images as backdrop. - This allows the enumerators to visualize the EA maps, helping them in their field orientation finding the correct housing units within their assigned enumeration areas. - Using the EA maps and the electronic questionnaires filled out by enumerators, along with GPS points collected on the device allows the NSO to verify the data collected, and whether the EAs were fully covered. - Ideally, once the data is transmitted to the NSO's central data center, the data including geocodes would be entered into the GIS census database, providing information about the progress of the census coverage - Software: For example, in the Open source side, there is Survey Solutions developed under the auspices of the World Bank, and in the commercial side, there are Esri's CAPI tools: **Survey123 for ArcGIS** and **Collector**.

Phase	Activity	Procedures
...Census activities for the enumeration phase	**2. Monitoring census activities**	Using GIS on mobile devices to support field operations management in streamlining and automating field operations: (i) Monitoring the workflow of timely information to and from the field allowing the census mangers to be informed of the progress of the data collection while providing enumerators with updates; (ii) Track the location of the enumerators; (iii) Optimizing the workload assignment as well as optimizing routes (in providing the enumerators where to go and the best route to take); and particularly monitoring the progress of census operations, including identifying trouble spots.

Supervisor Dashboard

لوحة القيادة

(source: Esri book)



Operational dashboards can be used to provide a view of geographic information that helps you monitor events or activities. Dashboards are designed to display multiple visualizations that work together on a single screen. From a dynamic dashboard, supervisors can view the activities and key performance indicators most vital to meeting objectives.

Phase	Activity	Procedures
…Census activities for the enumeration phase	**3. Updating EA maps/ Update Geographic Database**	• Using GIS/GPS and imagery during the field work of the enumeration phase for a final update of the EAs as there may still be some updates and corrections to the enumeration areas, that have to be brought to the master database. • Editing and Updates captured in this manner can be simply verified and then incorporated into the database in a much more streamlined fashion. • Updating the GIS census database would serve for post-enumeration and inter-census activities.

Phase	Activity	Procedures
III. Contributing to statistical analyses and dissemination for the post-enumeration phase	**1. Interactive Maps/Atlases/ GeoPortals**	GIS has been initially used for the dissemination of geographic products, mainly through maps. NSO can use it for: **1. Thematic maps and Interactive Atlases**: Thematic maps in an (electronic) interactive atlas can present census data and many indicators at all levels. (Geo-)Portals as they are a cost-effective mechanism for a diverse user base, 2. **Web Mapping/WebGIS/Story Maps/Smart Maps**: Web mapping is more than traditional mapping, as it is more a service by which users can choose and customize what the map will show. 3. **Web GIS** is indeed being done through Web mapping which is the process of using the maps delivered by geographic information systems in the Web, where the web map is both served and consumed. 4. **Spatial Analysis**: With the building of a geospatial census database at the EA level, GIS provides powerful tools to proceed with spatial analysis, 5. Geospatial information instrumental for other statistical activities, such as the creation of a geo-referenced national dwelling frame, business frame for use in an economic census, …these frames which are required for use as a basis for the **statistical sampling frame** for **inter-censal surveys** and **future censuses**.
	2. Web Mapping/Story Maps/Smart Maps	
	3. Web GIS	
	4. Spatial Analysis	
	5. Supporting Surveys and Sampling Frame	

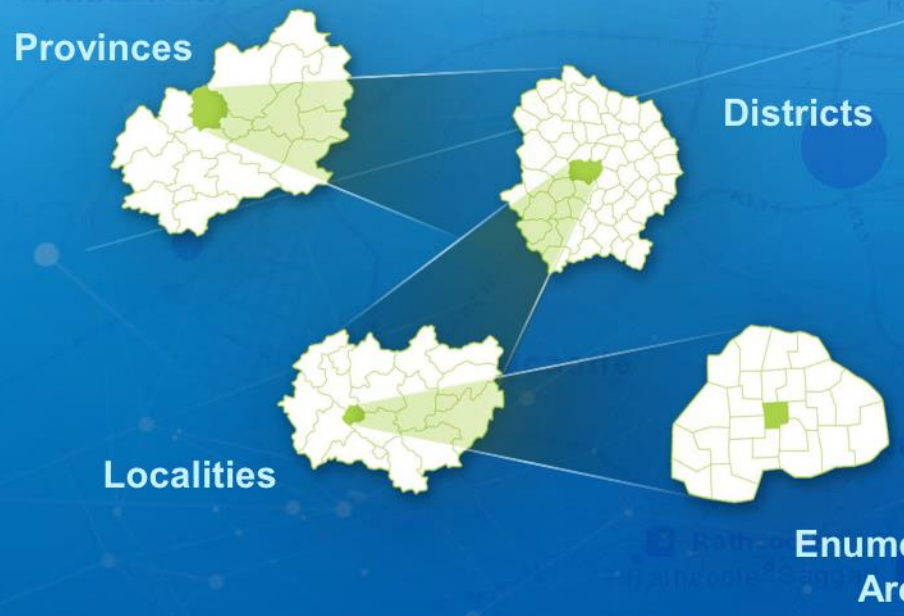
Establishing the Foundation – The Geodatabase

- Building a Geospatial Database at the level of data collection unit level.
- The basic elements of the census database would include the following:
  - Administrative or census units/enumeration areas
  - Entity type / Relations
  - Boundary database
  - Geographic attribute tables
  - Census data tables
  - "Agricultural censuses are mainly concerned with data on the basic organizational structure of agricultural holdings, such as size of holding, land tenure, land use, crop area, irrigation, livestock numbers, labour, use of machinery and other agricultural inputs."

Geography and Statistical Data Are Foundational

An Integrated Data Model is Essential

Nested Administrative Hierarchy



Boundaries

Key

EA Id	Area
1203501750071	42.3
1203501750072	34.8
1203501750073	26.9
1203501750074	51.2

Census Data

EA Id	Population	Male	Female
1203501750071	432	209	223
1203501750072	502	240	262
1203501750073	525	258	267
1203501750074	494	251	243

EA Id	Num HH	Avg HH size
1203501750071	89	4.9
1203501750072	98	5.1
1203501750073	102	5.1
1203501750074	85	5.8

Diagram and information taken from the “Handbook on the Geospatial Infrastructure in Support of Census Activities”, Department of Economic and Social Affairs, United Nations Statistics Division

An ArcGIS® Census Data Model

This diagram illustrates a geodatabase data model that can be leveraged by census organizations across the globe. A key feature of this design is the creation and maintenance of topologically nested polygon feature classes from line feature classes containing common boundaries. Census organizations can easily modify the design to reflect the nested feature classes that are pertinent to their country. Also, specific census demographic information can be readily added.

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Census Feature Dataset

- Province - Feature Class
- District - Feature Class
- Municipality - Feature Class
- Enumeration_Area - Feature Class
- GeoLocation - Feature Class
- Electoral_District - Feature Class
- Census_Topology - Topology

Stand-Alone Feature Classes

- Facility - Feature Class
- Landform - Feature Class
- Railroad - Feature Class
- Road - Feature Class
- Site - Feature Class
- Waterbody - Feature Class
- Waterline - Feature Class

Shape Type

- Polygon
- Point
- Line

Province - Feature Class

Shape Type Polygon **Alias Name** Province

Field	Alias	Type	Length	Nullable
GlobalID	Global ID	Global ID		false
ProvinceID	Province ID/Code	String	25	true
ProvinceName	Province Name	String	50	true

District - Feature Class

Shape Type Polygon **Alias Name** District

Field	Alias	Type	Length	Nullable
GlobalID	Global ID	Global ID		false
DistrictID	District ID/Code	String	25	true
DistrictName	District Name	String	50	true
ProvinceID	Province ID/Code	String	25	true

Municipality - Feature Class

Shape Type Polygon **Alias Name** Municipality

Field	Alias	Type	Length	Nullable
GlobalID	Global ID	Global ID		false
MunicipalityID	Municipality ID/ Code	String	25	true
MunicipalityName	Municipality Name	String	50	true
DistrictID	District ID/Code	String	25	true

Enumeration_Area - Feature Class

Shape Type Polygon **Alias Name** Enumeration Area

Field	Alias	Type	Length	Nullable
GlobalID	Global ID	Global ID		false
EnumerationAreaID	Enumeration Area ID/Code	String	25	true
EnumerationAreaName	Enumeration Area Name	String	50	true
MunicipalityID	Municipality ID/ Code	String	25	true

GeoLocation - Feature Class

Shape Type Point **Alias Name** GeoLocation

Field	Alias	Type	Length	Nullable
GlobalID	Global ID	Global ID		false
Latitude	Latitude	Double		true
Longitude	Longitude	Double		true
EnumerationAreaGlobalID	Enumeration Area Global ID	GUID		true

Electoral_District - Feature Class

Shape Type Polygon **Alias Name** Electoral District

Field	Alias	Type	Length	Nullable
GlobalID	Global ID	Global ID		false
ElectoralDistrictID	Electoral District ID/Code	String	25	true
ElectoralDistrict Name	Electoral District Name	String	50	true

The *Electoral_District* feature class is included in the feature dataset because electoral districts are often relevant in the context of a census. Although it is not part of the administrative division hierarchy that appears to the left, it does participate in the feature dataset's topology due to its spatial relationship with *District*.

Census_Topology - Topology

Feature Classes
Province
Municipality
GeoLocation
Enumeration_Area
Electoral_District
District

Origin Class	Rule	Destination Class
District	Must Not Overlap	District
Enumeration Area	Must Not Overlap	Enumeration Area
Municipality	Must Not Overlap	Municipality
Province	Must Not Overlap	Province
Enumeration Area	Must Be Covered By	Municipality
Municipality	Must Be Covered By	District
District	Must Be Covered By	Province
Enumeration Area	Must Cover Each Other	Municipality
Municipality	Must Cover Each Other	District
District	Must Cover Each Other	Province
GeoLocation	Must Be Properly Inside	Enumeration Area
Electoral District	Must Not Overlap	Electoral District
Electoral District	Must Be Covered By	District
Electoral District	Must Cover Each Other	District

Relationship Classes

Relationship Class	Cardinality	Origin Class	Origin Primary Key	Destination Class	Destination Foreign Key
ProvinceToDistrict	1 - M	Province	ProvinceID	District	ProvinceID
DistrictToMunicipality	1 - M	District	DistrictID	Municipality	DistrictID
MunicipalityTo EnumerationArea	1 - M	Municipality	Municipal-ityID	Enumeration-Area	MunicipalityID
EnumerationAreaTo GeoLocation	1 - M	Enumeration Area	GlobalID	GeoLocation	Enumeration-AreaGlobalID

Facility - Feature Class

Shape Type Point **Alias Name** Facility

Field	Alias	Type	Length	Default Value	Nullable
FacilityID	Facility ID/Code	String	25		true
FacilityName	Facility Name	String	50		true
FacilityDescription	Facility Description	String	250		true
FacilityCategory	Facility Category	Small Integer		1	true
FacilityType	Facility Type	Small Integer			true

Subtype Code	Subtype Name	Default Domain for FacilityType
1	Residential	ResidentialFacilityType
2	Commercial	CommercialFacilityType
3	Educational	EducationalFacilityType
4	Landmark	LandmarkFacilityType
5	Medical	MedicalFacilityType
6	Transportation	TransportationFacilityType

Site - Feature Class

Shape Type Polygon **Alias Name** Site Category

Field	Alias	Type	Length	Default Value	Nullable
SiteID	Site ID/Code	String	25		true
SiteName	Site Name	String	50		true
SiteDescription	Site Description	String	250		true
SiteCategory	Site Category	Small Integer		1	true
SiteType	Site Type	Small Integer			true

Subtype Code	Subtype Name	Default Domain for SiteType
1	Residential	ResidentialFacilityType
2	Commercial	CommercialFacilityType
3	Educational	EducationalFacilityType
4	Landmark	LandmarkFacilityType
5	Medical	MedicalFacilityType
6	Transportation	TransportationFacilityType

Landform - Feature Class

Shape Type Polygon **Alias Name** Landform

Field	Alias	Type	Length	Domain	Nullable
LandformName	Landform Name	String	50		true
LandformType	Landform Type	Small Integer		LandformType	true

Waterbody - Feature Class

Shape Type Polygon **Alias Name** Waterbody

Field	Alias	Type	Length	Domain	Nullable
WaterbodyID	Waterbody ID/ Code	String	25		true
WaterbodyName	Waterbody Name	String	50		true
WaterbodyType	Waterbody Type	Small Integer		WaterbodyType	true

Railroad - Feature Class

Shape Type Line **Alias Name** Railroad

Field	Alias	Type	Length	Domain	Nullable
RailroadID	Railroad ID/Code	String	25		true
RailroadName	Railroad Name	String	50		true
RailroadNumber	Railroad Number/Code	String	25		true
RailroadType	Railroad Type	Small Integer		RailroadType	true

Waterline - Feature Class

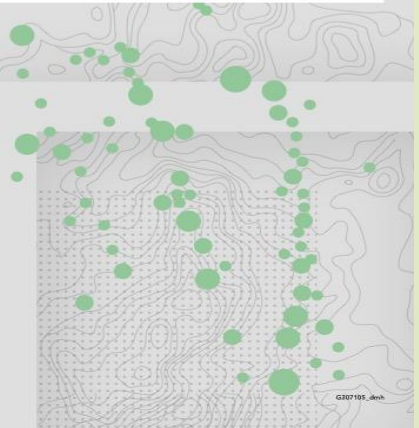
Shape Type Line **Alias Name** Waterline

Field	Alias	Type	Length	Domain	Nullable
WaterlineID	Waterline ID/Code	String	25		true
WaterlineName	Waterline Name	String	50		true
WaterlineType	Waterline Type	Small Integer		WaterlineType	true

Road - Feature Class

Shape Type Line **Alias Name** Road

Field	Alias	Type	Length	Domain	Nullable
RoadID	Road ID/Code	String	25		true
RoadName	Road Name	String	50		true
RoadNumber	Road Number/ Code	String	25		true
RoadClass	Road Class	Small Integer		RoadClass	true

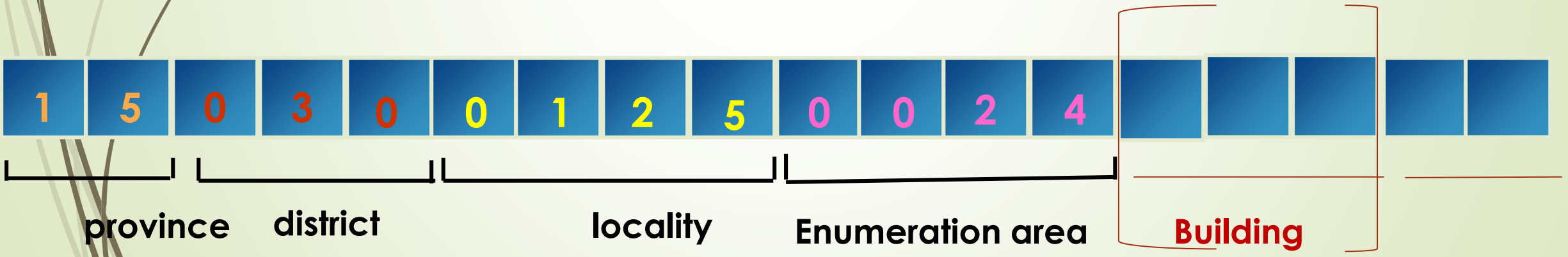


Coding Scheme -Sudan

لأغراض العمل الإلكتروني ولثبات ID فإن تنفيذ العمل لكل الطبقات لا بد أن يعتمد على ID جديدة اقليم/ولاية/محلية/ثم مدينة كبرى أو صغرى أو قرية يمكن أن تسمى منطقة ثم مربع أو حارة للحضر و قرية صغرى أو شمال-جنوب للريف ثم البلكات داخلها ثم المباني بكل بلك ثم الطوابق بالمباني ثم المساكن أو المنشآت بكل طابق ثم الأسر ثم الأفراد.

Example of a generic enumeration area coding scheme

- An EA code of **1503001250024** means that enumeration area number **24** is located in province **15**, district **30** and locality **125**.



Enumeration Area Census Map

1	0		0	6	0	1	0	3	7	8	0	6	6	0	1
Municipality Code (2)			Admin. Unit Code (4)				EA Code (4)				Building Code (3)			Entrance Number (2)	

0	2	3	1	3
Controller Code (3)			Supervisor Code (2)	

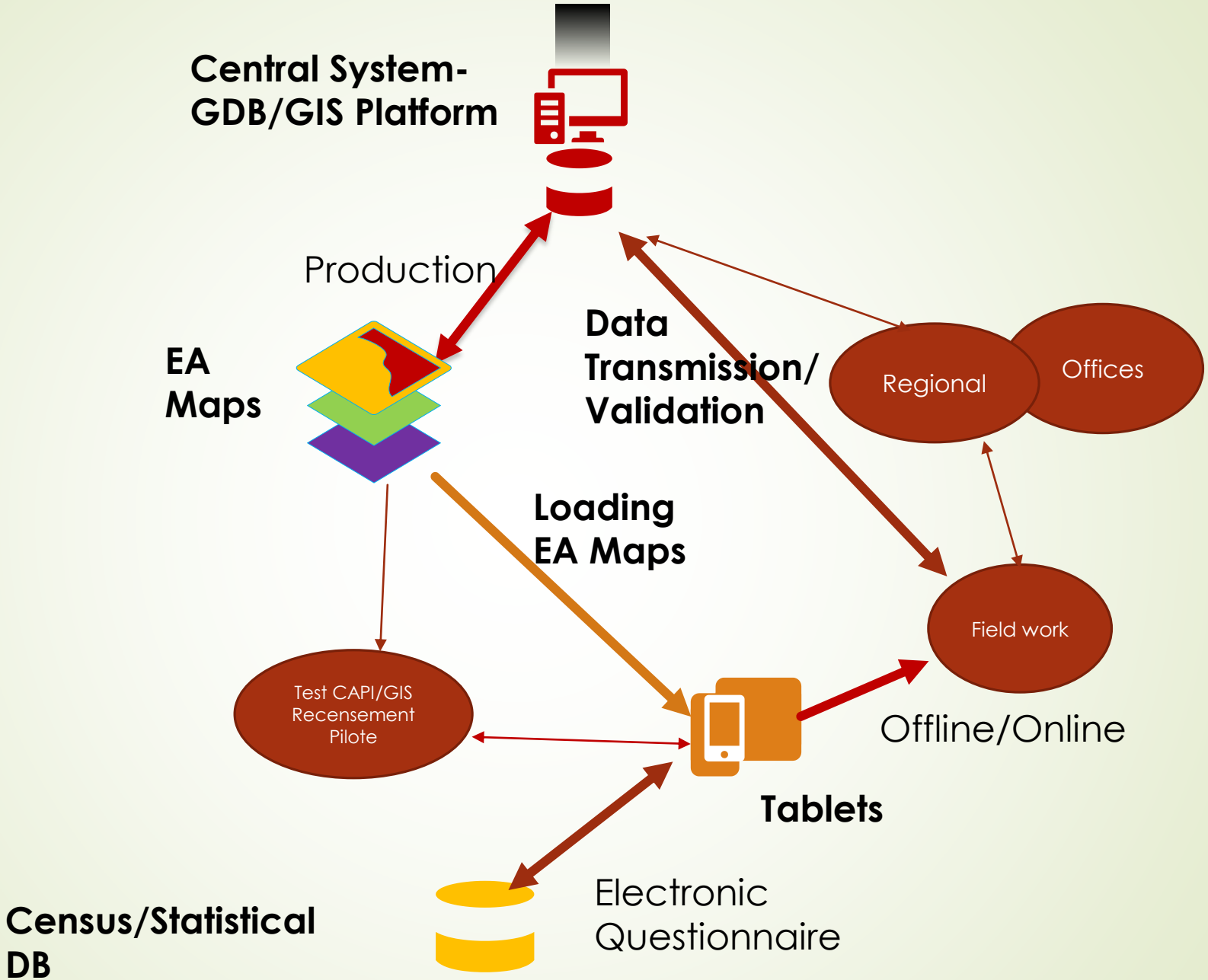
INSTAT
Republika e Shqipërisë
Instituti i Statistikave

Municipality: DURRËS
Admin Unit: DURRËS

N
W
E
S

Total Number of Buildings: 110

0 0.03 0.06 0.12 0.18 0.24
Kilometers


Central System-
GDB/GIS Platform
Production
EA
Maps
Data
Transmission/
Validation
Regional
Offices
Loading
EA Maps
Field work
Test CAPI/GIS
Recensement
Pilote
Offline/Online
Tablets
Electronic
Questionnaire
Census/Statistical
DB

Spatial Analysis: Query

- Select features by their attributes:
  - "find all districts with literacy rates < 60%"
- Select features by geographic relationships
  - "find all schools within this district"
- Combined attributes/geographic queries
  - "find all villages within 10km of a health facility that have high child mortality"

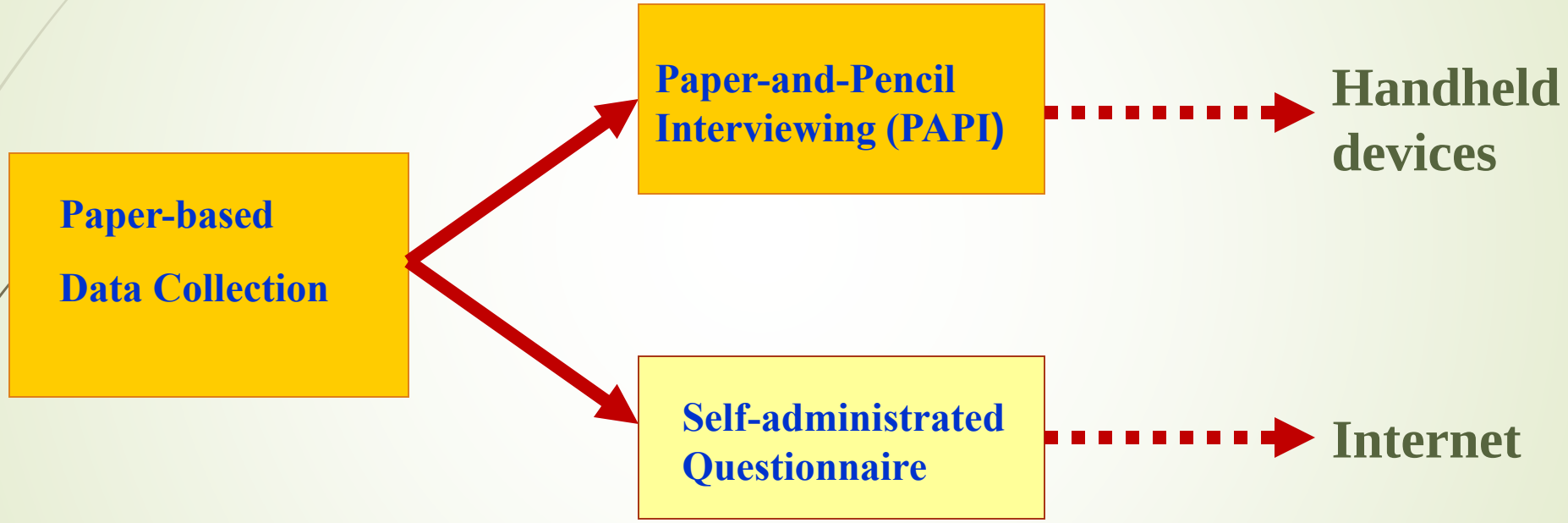
Query operations are based on the SQL (Structured Query Language) concept

Spatial Analysis Techniques

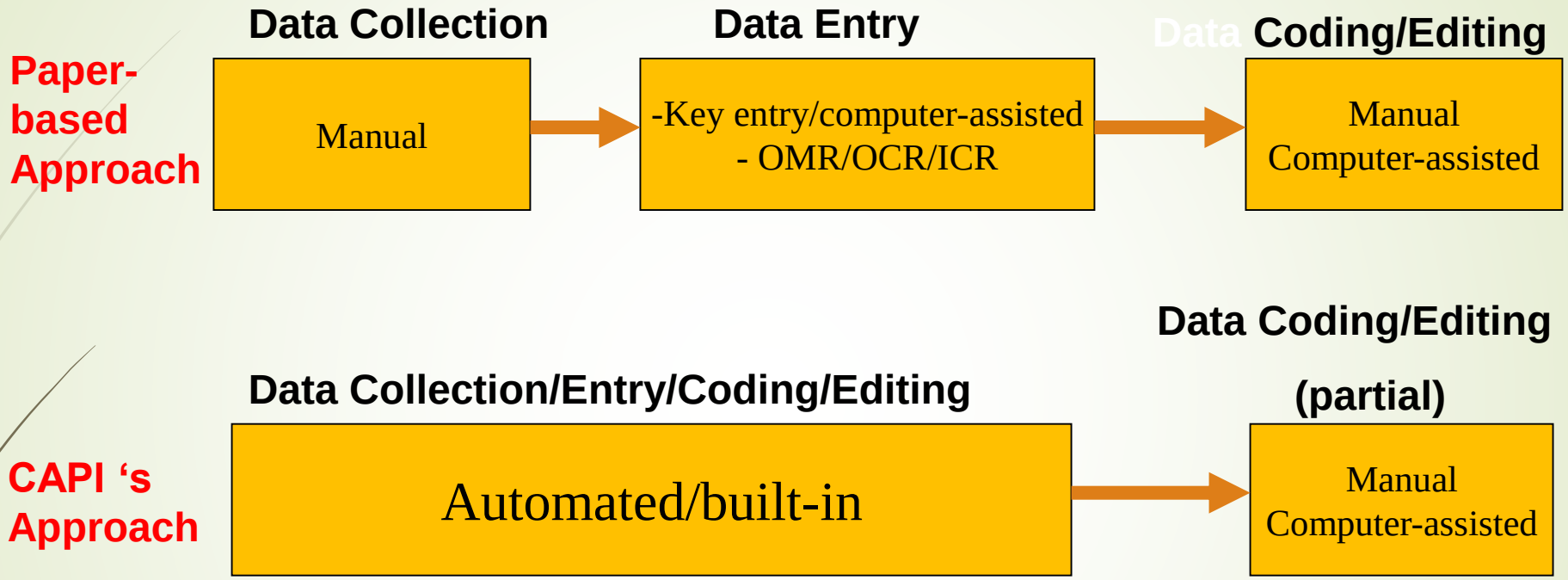
- Spatial Analysis Techniques include:
  - Queries
  - Distance measurements
  - Buffering
  - Linear interpolation
  - Point pattern analysis
  - Cartograms, etc.

- The main use of spatial analysis is for **census products and services**

Paper-based Data Collection



Paper-based Approach vs CAPI's Approach



Using handheld device would significantly automate the whole process of data collection by having a centralized Data Centre (and or a Regional Data Centre) where the data entered into the device would be collated automatically.

The Data Centre would also enable the supervisors of the census collection process to make real time checks into the data collected to ratify that the data collected is relevant and correct.

Need for CAPI: Computer Assisted Personal Interviewing

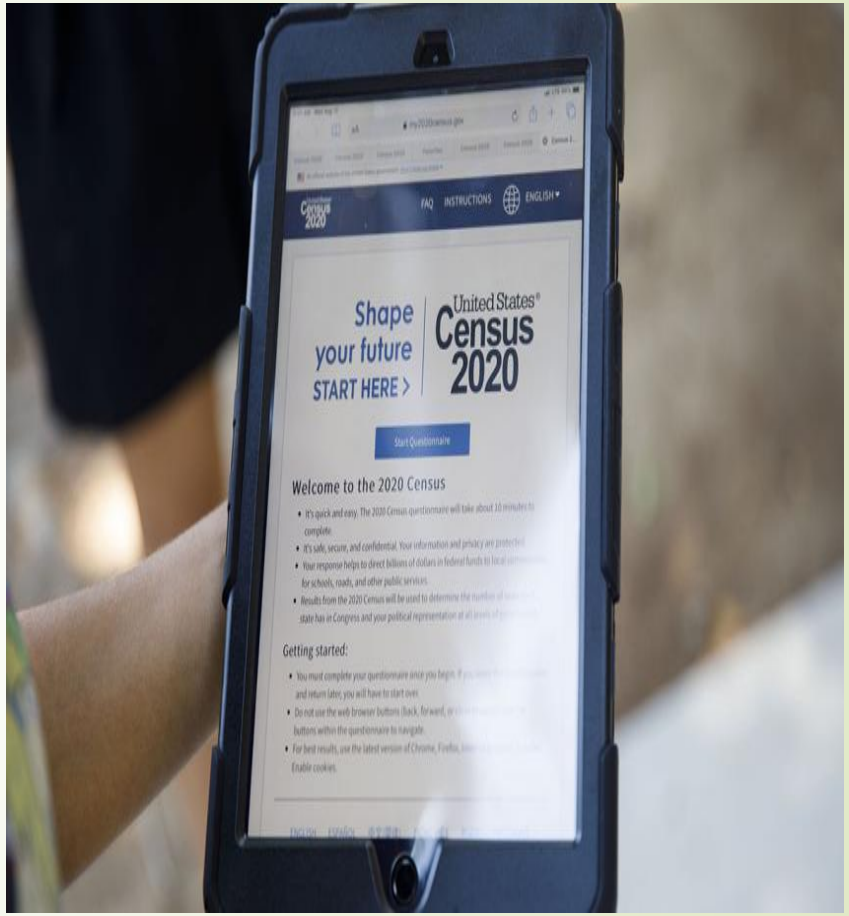
- Traditional paper-based methods of census data collection have proven to be tedious, time consuming, costly and often prone to errors.
- To overcome these problems, **Computer Assisted Personal Interviewing (CAPI)** methods are increasingly replacing pen-and-paper methods as a viable alternative for census data collection.
- "CAPI is the face-to-face interviewing mode in which a computer displays the questions onscreen, the interviewer reads then to the respondent, and enters the respondent's answers into the computer".

CAPI/Tablet: Way of Collecting (Census) Data

- Electronic questionnaire - Contents of the census form are stored onto the Tablet so that the questions appear sequentially on the screen
- Data are entered into a hand-held computer instead of onto a paper census form, allowing:
  - Immediate evaluation at the moment of data collection, allowing the correction of information at the moment of the interview;
  - The filling out of all the compulsory questions, avoiding the lack of answers due to forgetfulness or mistake by the enumerator;
  - Optimization of the filling out of data through automatic skips in the questionnaire, avoiding covering several items about which, sometimes, there would be no reply;
  - Optimize time used by the enumerator and the head of household.

Data Transmission

- Data are then electronically transmitted to an Central Data Center for further processing:
  - Offline or online depending upon the availability of connectivity options: WiFi, CDMA / GSM Radio
  - For example, if work is done in a remote area with no connectivity, the data would be stored in the device itself, but when we reach an area with connectivity the data would be automatically transferred to the Data Center
- Other characteristics:
  - Ease of use
  - Multi-lingual capability



Data security

- Data at rest-stored on the tablet PC storage media
  - Login password protection (OS and enumeration system)
  - Basic user privileges for census officers
    - Use of the enumeration software system
    - Data synchronization
  - File system level encryption of the local database files
  - Census officers do not have access to the decryption key
  - USB flash drives disabled
- Data in transit- during synchronization
  - From tablet PC to work branch
    - Wi-Fi 802.11n WPA2
    - IPsec/L2TP VPN using digital certificates
  - From work branch to HQ
    - Private network infrastructure
    - IPsec VPN tunneling

Examples of Rugged Tablet أجهزة لوحية

Dell Rugged Tablet

BAK Rugged device

- The suitable for census data collection would range from 7 to 10 inches, due to the optimized size and weight, brightness, and for being held with one hand, all this suitable for field work.

- And rugged tablets needed for the tough field environment, and to avoid breaking and dissuade theft.

Handheld devices with In-built GPS

- The device can be enabled with GPS/GNSS to:
  - Access to coordinates of the units visited during data collection;
  - Use of coordinates obtained during data collection to track the location of the place from where the data was entered which would allow the department to check cases of fraudulent data entry; and
  - Tracking could be undertaken to assist the enumerator in understanding their current location and also capture the geographical location of where the census data was captured.

Figure 15 - Satellite image on PDA screen.

Significant costs (Time and money)

- For implementation of both Tablet or hand-held GPS, the following needs to be considered
  - Purchase of hardware (Tablet ~ $100 Each)
  - Technical Training for enumerators
  - Cost of Pre/Post Census mapping exercise
  - Software development
  - Logistical costs
- Considering/Planning for the deployment of the massive number of devices

The integration of CAPI with GIS-based EA maps:

The integration requires:

- Selection or development by an IT team of a CAPI app;
- Preparation of mobile GIS-based EA maps;
- Uploading the EA maps on the handheld devices (mobile map packages to be used online or offline);
- Need for administrating tests with regard to the integration of electronic questionnaire, EAs maps, GPS, transmission of data functionalities, battery, etc., before embarking on the actual use of the handheld devices in the census data collection;
- Proceeding with a training prior to the deployment of mobile devices.

Software: Integration of CAPI App and GIS

- Integration of CAPI App and GIS
  - CAPI and GIS-based EA maps
  - Satellite imagery as backdrop
- Integration may need programming
- Examples:
  - Survey Solutions (World Bank)
  - Survey123 and Collector

Suvery123 for ArcGIS on a handheld device

Some Implementation/Organizational Aspects

- Need to Build Partnership with:
  - Application development partner

    (IT Cie with expertise in mobile forms and hosting data centers)
  - Device Manufacturer

    (To provide the devices as per specification)
  - Connectivity provider

    (To provide connectivity for the device so that the data can be transferred seamlessly to the data center)
  - Capacity building supporter

    (Training on using not only the forms and the entire process of data collection but also on the basics of the device and what to do for trouble shooting).

- **Nodal Agency**:
  - Operationalize the whole process

Lessons Learned-Good Practices

- Learn about some practices/experiences: the qualitative as well as quantitative benefits of handheld devices have been proven in field in many countries (Australia, Brazil, Canada, Malaysia, New Zealand, Oman, Jordan, Cape Verde, etc…)
- Various Options are available for selecting handheld devices
- Clear identification of objective is required for selecting best device
- Important to have extensive training prior to deployment
- Build a solid partnership: **Integrator**
- Post implementation support – technical as well as hardware support ensures project success

Internet Data Collection: Computer Aided Web Interview - CAWI

- CAWI on-line Internet questionnaire is not a simple replication of the paper form.
- Adjustments are likely to be made to accommodate the respondent with an easy to access user-friendly interface.
- CAWI data collection method relies on self-enumeration, and like other modes must ensure that every household and individual is counted once and only once.
- GIS functionality can be included in the web based form by way of a map presented to the user allowing them to indicate their place of residence. This information can be captured and stored along with the form providing the location component of the survey for validation against pre-assigned codes or other information.
- A key factor in managing data collection requires the provision of each respondent with a unique code.
- This code may be linked to a geographic location (e.g. the "Census-assigned unique address identifier" to be used at the 2020 US Census).

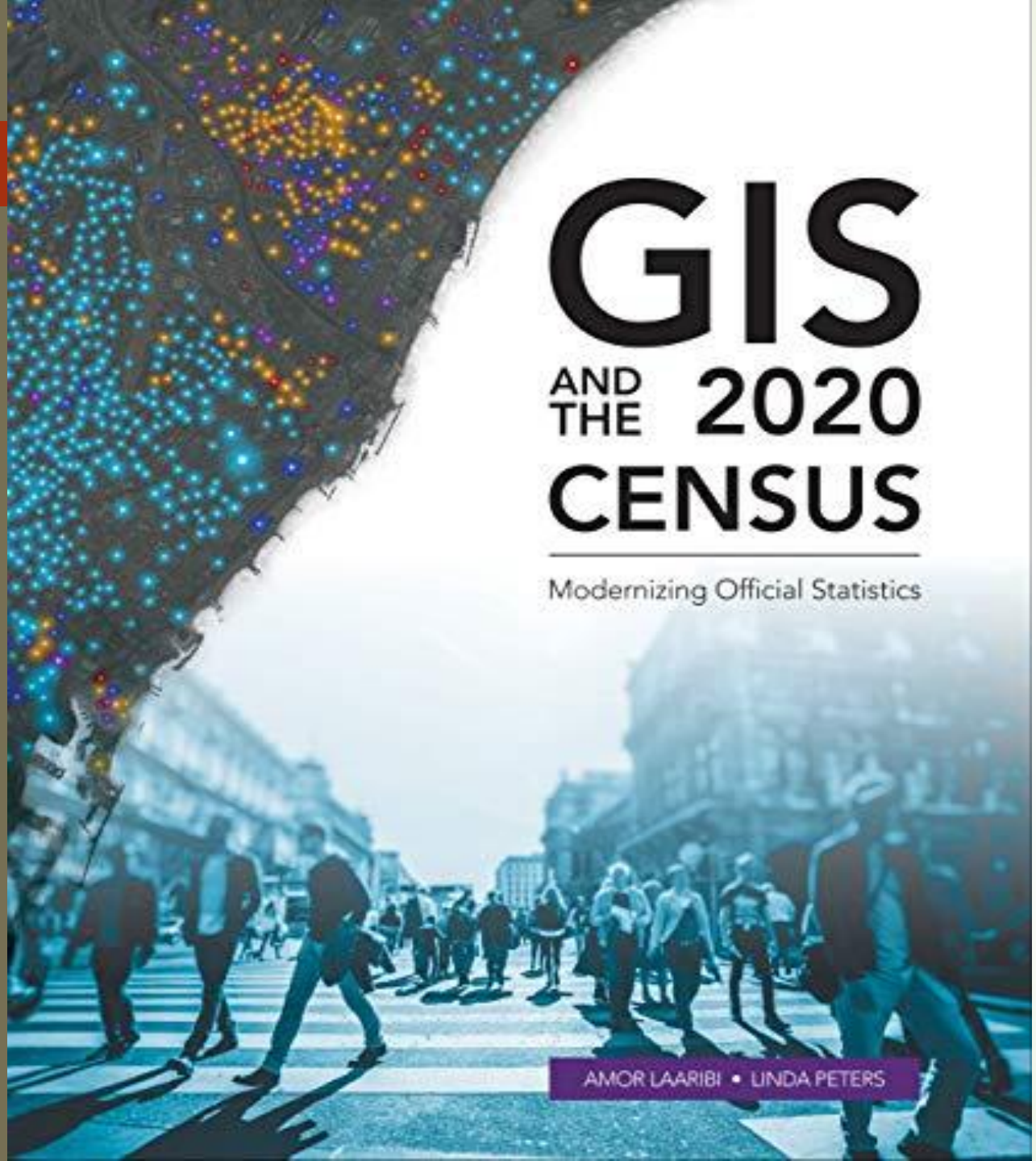
Source: GIS and the 2020 Census – Modernizing Official Statistics, 2019, Esri Press.

Recommendations/Conclusions

- Need for an inventory of the existing geospatial data/Infrastructure and identification of the needs
- Identification of the solution taking into account all the stages of the census
  - Mobile devices for data collection/dissemination is being recognized as an option worth considering in the next round of censuses: integration of CAPI + SIG
- The United Nations has recommended its use in the 2020 Round of Censuses in recognition of its importance and usefulness for many countries.
- As increasingly powerful hand-held devices are now an affordable and realistic option, the CAPI approach is being more commonly used.
- Still, there is necessity of **early planning** and through preparation for the adoption of mobile devices solution, including prototyping, use in small survey projects, and pilot exercises in order to validate all the stages and anticipate alternative solutions – a gradual approach.

Recommendations…

- As for any new technology-based approach, need to seek partnership/outsourcing
- Particular consideration for the "integration aspects" and training of enumerators
- Part of a multi-modal approach
- The use of hand-held devices equipped with GPS can especially contribute to the geocoding of schools, hospitals and other important reference elements, as a side benefit of the census operations.
- 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.
- Need for cooperation between NSOs and NMAs to develop a national geospatial infrastructure in support of statistical activities



A Reference Book: GIS and the 2020 Census – Modernizing Official Statistics

Why this book?

1. A personal reason: account of my journey almost 17-years working with two global communities, the geospatial and statistical communities, who share many in common. Just to give to look about how they represent their data in hand: statisticians use, not to say swear only by tables and matrices, while that same data can be represented by GIS people through maps!

2. The context was favorable to respond to the needs of countries: there are two major global drivers that push for the use of geospatial information and its integration with statistical information: **the 2030 SD Agenda** and the **2020 Round of Censuses**!

6. التحديات والفرص ومقترحات الحلول في مجال مخرجات تطبيقات جودة العمل الميداني ونظم تتبع تقدم العمل الميداني إلكترونياً

كان في الماضي تحدياً أما الآن بعد إنزال خريطة مجال كل مستخدم المضبوطة الرقمية كجزء من السودان فإن هنالك برنامج للتتبع داخل آخر إصدارة لتطبيق **CS Pro** تمكن من إنجاز العمل عليه، ولا داعي لتطبيق **CAPI** الذي يصلح في المسوحات وليس التعدادات لسرية بياناتها. فقط الحاجة لتدريب خاص لمجموعة من الشبكة في التقنية ومجموعة من مكتب نظم المعلومات الجغرافية.

شكرا جزيلا

THANK YOU !!

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