The Applications of GIS in Census Data

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Introduction

- The applications of Geographic Information System (GIS) in the socioeconomic sciences are rapidly growing, especially for census data – a powerful tool for world development & poverty reduction.

- GIS = computer-based system that allows geographically referenced information to be captured, stored, edited, displayed, analyzed and printed.

- The South African National Department of Education introduced GIS in the curriculum for the first time in 2006.

- This is taking place as a phased approach for the last 3 years of secondary school.

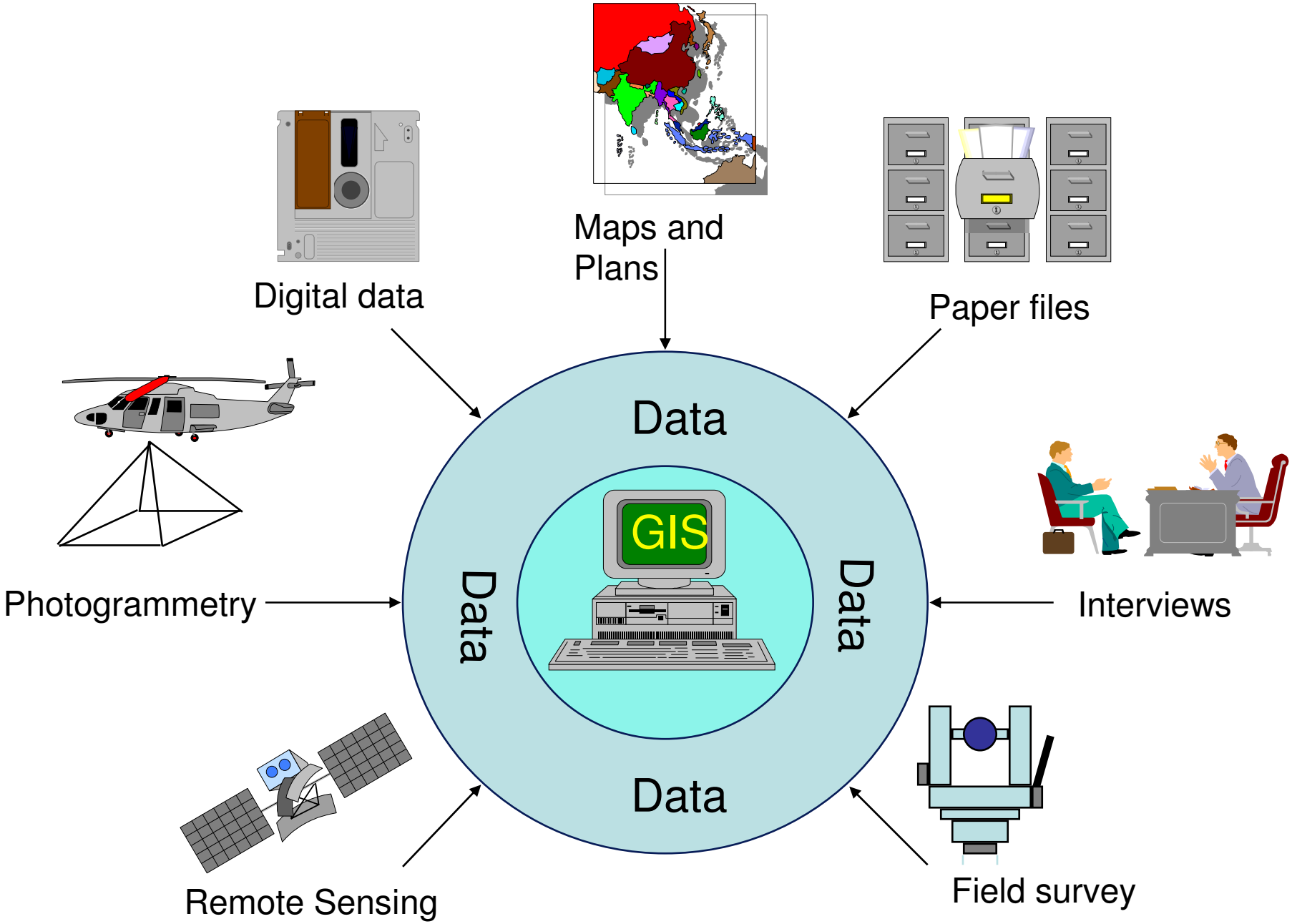

Fig. 1 GIS capable of merging data from diverse sources

Importance of Population Census

- A population census - process of counting number of people, and collecting, compiling, evaluating, analyzing as well as disseminating information about their demographic, social and economic characteristics.

- Census data:
  - are the foundation for a wide range of analyses required to improve the standard of living of people in any country in the world.
  - are primary sources of information needed for effective development, planning and monitoring of population.
  - provide a sampling frame for inter-censual surveys.

Census Geography

- Census geography - the division of the country into geographical zones for the purpose of census process.
- An enumeration area (EA)– the smallest geographical unit into which the country is divided for census data collection, of a size able to be enumerated by one census fieldworker (enumerator) in the allocated period.
- An Output Area (OA) - the smallest geographical unit for which census data are disseminated.
- However, most countries use the same EAs for both census data collection and dissemination of their census data, including South Africa prior 2001.

Census Geography Cont.

- There are some concerns regarding the use of the same geographical unit (EA) for both census data collection and dissemination. These include….
  - Similar population size
  - Confidentiality thresholds, requiring the data to be combined with those of a nearby EA.
  - The design of EAs before enumeration takes no account of social homogeneity.
  - Output shape

- Hence Stats SA decided not to release Census 2001 data at EA level

- Thus development of Small Area Level (SAL) in 2005 by Stats SA. The SAL mainly addressed the first two concerns.

- Therefore the investigation of different methods such as Automated Zone Design (AZD) in creation of census output areas is of high importance in South Africa.

Census GIS

- The applications of Geographic Information System (GIS) in the socioeconomic sciences are rapidly growing, especially for census data.

- GIS provides significant benefits to the census process in relation to reducing cost and time for pre-census activity.

- In addition, the heterogeneity and complexity of census datasets requires appropriate tools such as Satellite Remote Sensing (SRS) and GIS to handle it.

The Role of GIS Maps in the Census

- Generally, GIS mapping plays critical role in all three stages in the census process:
  - Pre-enumeration - Maps are important to ensure consistency and facilitate census operations such as EA demarcations.
  - During enumeration - Maps support data collection and help monitoring census activities.
  - Post-enumeration - Maps make it easier to present, analyze and disseminate census results.

Brief Global context of GIS Census

- Most developed countries as well as some developing countries were crucial in GIS applications in census in the past three decades i.e. USA, UK, Japan, France, Australia, Canada, China, South Africa, Uganda, Malawi, Israel, India, Nepal, and many others.

- E.g. Census Mapping System started during the years 1991-93 in Japan while the Israel 1995 census linked the census data to spatial elements as small as the buildings.

- The growth of GIS through the 1990's led to a dramatic increase in the use of digital geographic data.

Brief Global context of GIS Census Cont…

- In most African countries, the applications of GIS technologies in census are still new.

- Since 1997 National Statistical Offices (NSOs) in more than 15 African countries have benefited from GeoSpace in terms of census mapping solutions, technical support and training. i.e.
  - Providing census mapping solutions to the censuses of Namibia (2001); South Africa (2001); Tanzania (2002); Lesotho (2006) and Southern Sudan (2008).
  - Providing technical support and training to the NSOs of the following countries: Botswana, Ethiopia, Ghana, Kazakhstan, Malawi, Nigeria, Seychelles, Swaziland, The Gambia and Zambia.

SA GIS Census context

- GIS mapping of census data is a relatively new technology in South Africa.
- Prior to 1996, EA boundaries were hand-drawn, which is traditional demarcation (Laldaparsad, 2007).
- Census 1996 represented a transition from traditional demarcation and mapping methods towards an electronic spatial database.
- Up to Census 1996 administrative maps served as the basis for demarcation.
- Town planning maps were used for large new towns and developments.
- Aerial photographs were used to pinpoint new residential units.
- New developments were not reflected on these maps and map-based publications of census results were difficult to produce.
- HSRC took an initiative to address this situation and captured the EAs of Census 1991 digitally.

SA GIS Census context cont.

- For Census 2001, for the first time, GIS technology was utilized to demarcate EAs and for map production.
- About 80% of the 2001 EA demarcation was done in the office on a GIS using photography and digital topographical maps.
- For the other 10% field inspection was done.
- For 2011 Census, it is foreseen that the EA demarcation process would be less of a challenge than it was for the previous census
- GIS technology will be highly incorporated into the census processing as it has already been involved in the planning phase as well as on the pre-enumeration phase.
- This is shown by the use of Satellite Pour l'Observation de la Terre (SPOT) 5 2008 imagery in preparation of some EA boundaries/demarcation for 2011 Census
- Also by the creation of Dwelling Unit Frame for the whole country (Figures 3&4)
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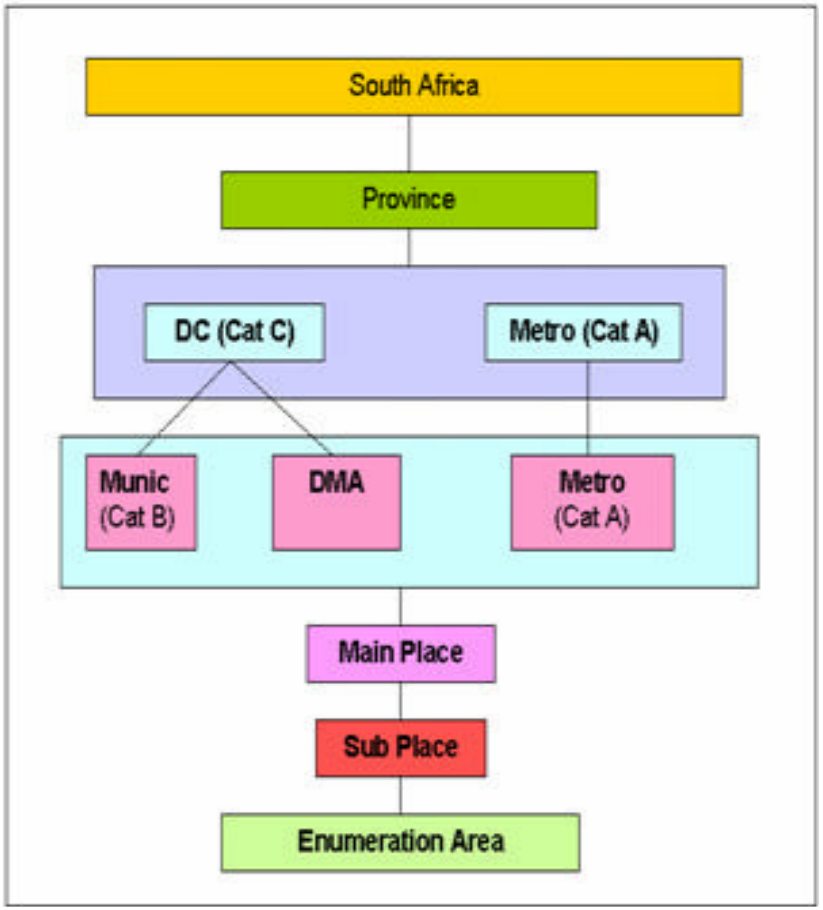

Geography Area Hierarchy Model

9 - Provinces

6 - Metropolitan Areas

47 - Distrcit Councils

231 – Local Municipalities

25 – District Management Areas

3109 – Main Places

21243 – Sub Places

80787 – Enumeration Areas

Other Geographies

17035 – Voting Districts

3754 – Wards

Fig. 2 South African Geography Area Hierarchy Model (Source: Dube, 2005).

Dweling Frame Project

Fig. 3 Digitized Dweling Units (Source: Laldaparsad, 2007)

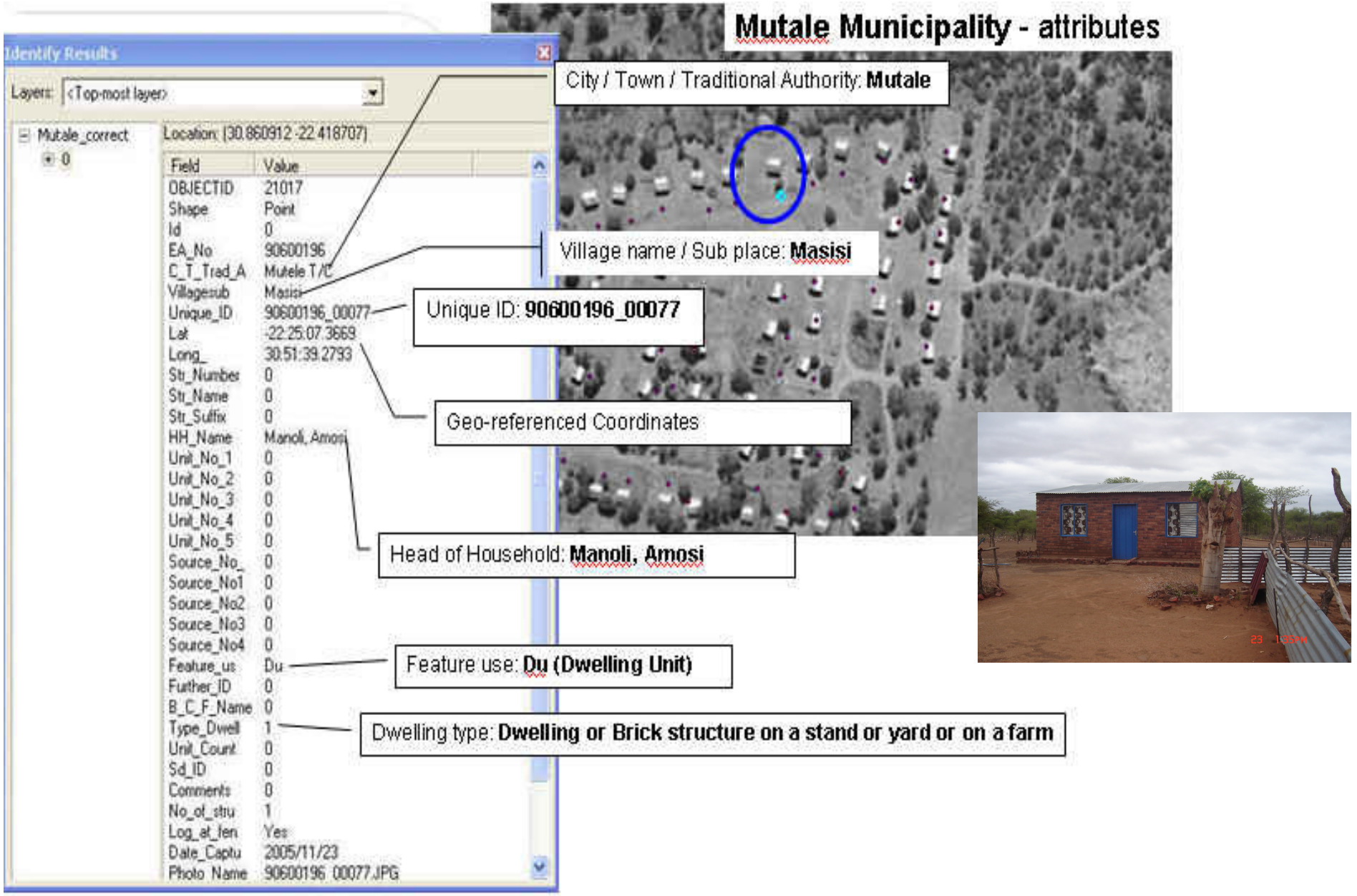

Fig. 4 Example of Dweling Unit with Information in ArcGIS (Source: Laldaparsad, 2007)

Challenges in GIS Applications in Census

- One of the main challenges of GIS applications on census data is the Modifiable Area Unit Problem (MAUP).

  - This is because census data are collected at an individual household level (higher resolution) but the data are disseminated at aggregated level (lower resolution), i.e. EAs

  - The MAUP is a defined as a problem arising from the imposition of artificial units of spatial reporting on continuous geographic phenomena which results in the generation of artificial spatial patterns (Openshaw, 1977, Heywood *et al.,* 2002).

  - The MAUP is often associated with Ecological Fallacy, which occurs when it is inferred that data for areas under study can be applied to the individuals within those areas (Heywood *et al.,* 2002).

  - Openshaw (1977) found that the optimal-zone design approach provided a general solution to the MAUP in the analysis of spatially aggregated data.

Challenges in GIS Applications in Census Cont.

- Another challenge of GIS applications on census analysis is that settlement status change with time and space (Fig. 5).

- Administrative boundaries or geographic frames keep on changing for every census, it is therefore hard to use GIS technology for trend analysis and comparison studies over time.

- Finally, the applications of GIS in census are said to be prohibitively expensive i.e. in developing countries.

- In contrast, the findings of Tanzania (2002) and Lesotho (2006) showed that Geo-Information Technology can reduce the cost of fieldwork for demarcating enumeration areas by up to 80% (Loots, 2005).

Fig. 5 Settlement status change, EA 17104316 Cape Town in 2000 and EA 17104316 Cape Town in 2002 (Source: Hakizimana, 2009).

Opportunities in GIS Applications in Census

- GIS technology is used in conjunction with high resolution satellite imageries (i.e SPOT 5) to confirm and define administrative boundaries in creating EAs.

- New technologies such GPS (Trimple TSC3 and Trimble Tablet PC) and Sumbandila Sat in South Africa.

- The UN is playing a crucial role in promoting the use of GIS on census processes in the 2010 round of censuses.

- In addition, the UN Statistics Division succeeded to ensure that the NSOs of forty developing countries were provided with no-cost versions of commercial GIS software Arc View 3.3 (UN, 2004).

Examples of GIS applications in census data

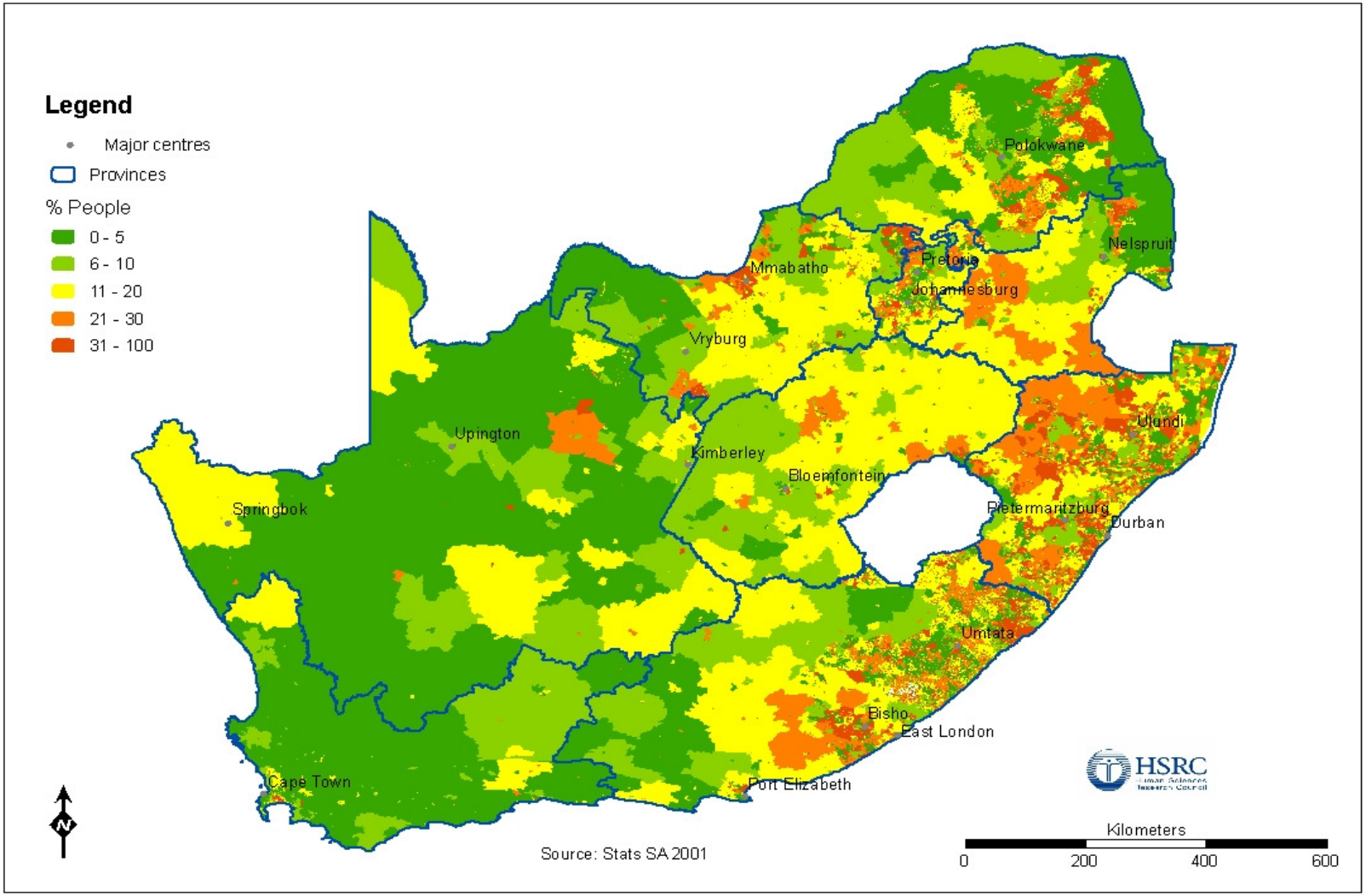

Fig. 6 Percentage unemployed people using 2001 census data at sub-place level

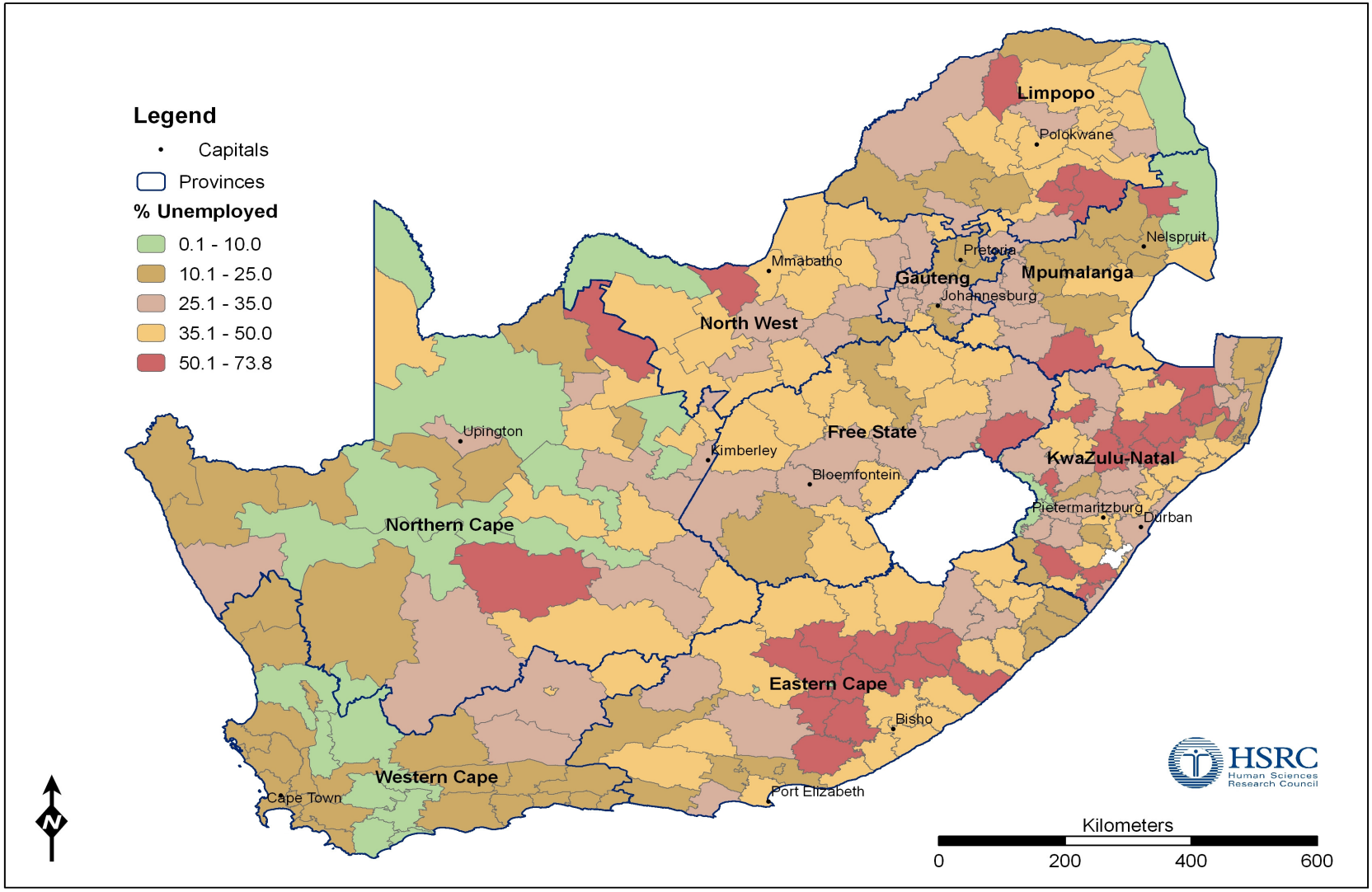

Fig. 7 Percentage unemployed people in using Community Survey 2007 at municipal level

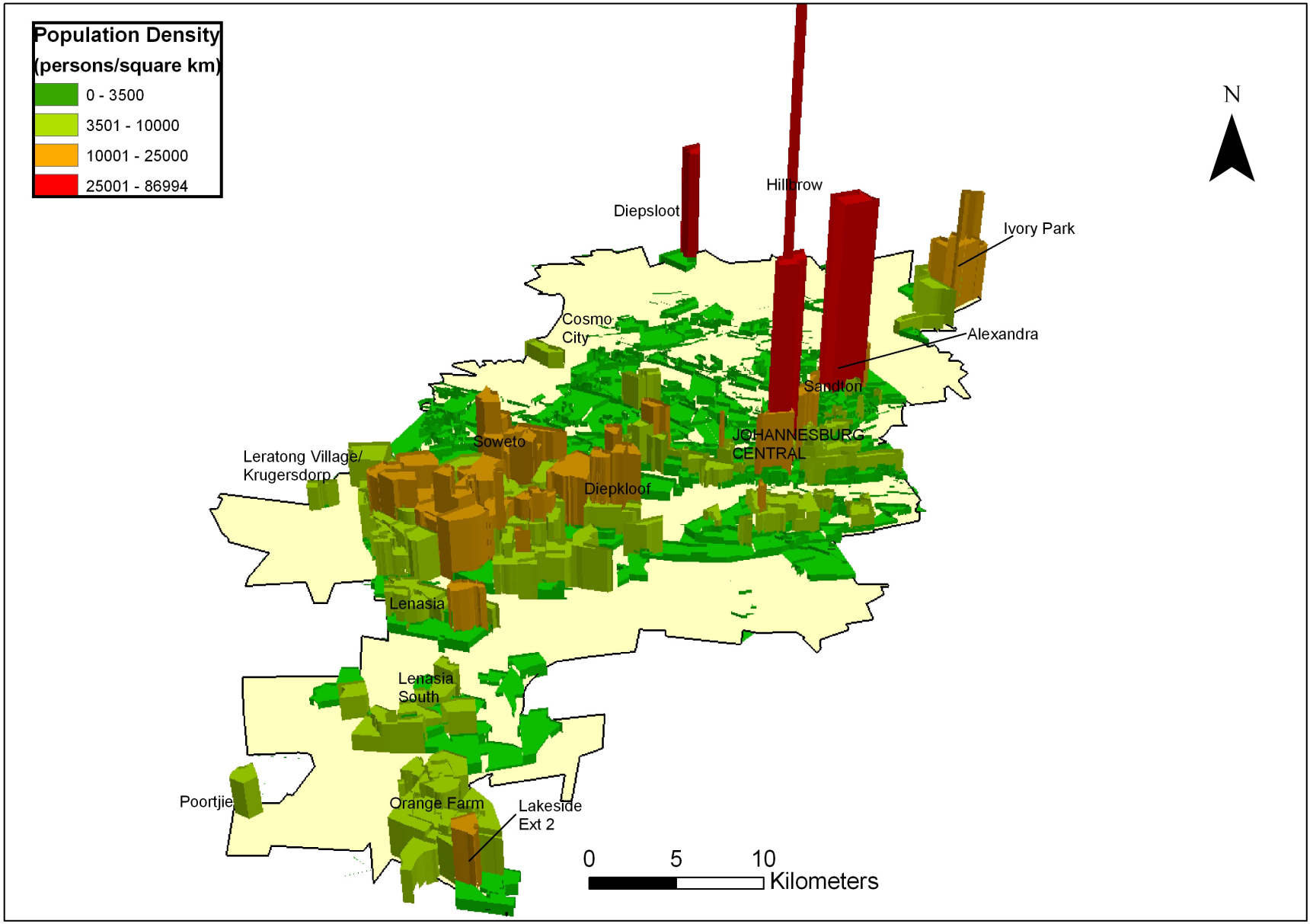

Fig. 8 3D map showing population density of City of Johannesburg metro at suburb level using HSRC 2006 population estimates derived from 2001 census data

Conclusion

- GIS is still a new technology in some countries, especially developing countries, and its growth seems to be promising.
- The role played by UN in promoting the use of GIS technology in census data is immeasurable.
- In South Africa, the role played by Stats SA in implementing the applications of GIS in census data is promising.
- There is a need for detailed research in applications of GIS as well as other GI technologies in census data in order to have fully informed polices and decision makings.

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Thank you

Siyabonga

Kea leboha