Perspectives on geospatial information science education: an example of urban planners in Southern Africa

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ABSTRACT
Since the introduction of geographic information systems (GIS) in the 1960s, it has evolved tremendously to an extent that it permeates our daily lives. Initially, GIS usage started in the developed countries and now increasingly filtered to developing countries. The town planning profession was one of the early adopters of GIS. Geospatial information is a useful source of data that is needed in urban planning. In these days of the New Urban Agenda 2030, smart cities are even more required from planners in using geospatial information to face urban challenges such as sustainable urban development and climate change. Although GIS has promised a lot for urban planning, it has not reached its full potential. Moreover, many studies have focused on developed countries with limited studies on geospatial information application in municipalities and GIS education from a perspective of developing countries. In this study, a survey on the usage of geospatial information science (GSIS) in two cities, namely Bulawayo in Zimbabwe and Ekurhuleni in South Africa, was conducted, and an overview of the state of GIS curricula in planning schools is discussed. The results indicate that considerable progress has been made in the application of geospatial information in municipal planning; however, there are impediments limiting the full utilization of geospatial information in local municipalities. These impediments include: inadequate GIS curricula in planning schools, lack of resources, and lack of political will. These challenges manifest differently in well-resourced municipalities and those with limited resources. The study proposes planning-relevant GIS curricula to improve the level of GIS use in planning practice.

1. Introduction
Geographic information systems (GIS) and geospatial information science (GSIS) has grown and matured over the last decade (Malczewski 2006; Malczewski and Rinner 2015; Yuan 2017). Advances in remote sensing, information communication technology (ICT), big data, geolocation-based services, and geotagged social media have propelled GSIS into an influential field (Goodchild 2009, 2014; Li et al. 2013; Tao 2013). Likewise, GSIS has played an important role in urban and regional planning. Bodies or associations such as Computers In Urban Planning and Management (CUPM) have showcased progress made in the use of GSIS and technologies in advancing the field of urban and regional planning (Geertman et al. 2015).

Geospatial information in urban planning has increasingly been applied in municipalities, land use planning, infrastructure planning and improvement of service delivery (Yeh 1999; Kohsaka 2000). Although GSIS has advanced, there is a mismatch between research on GSIS, and its application in urban municipalities. Several scholars have investigated the reasons behind the limited use, and challenges of applying GIS in municipalities (Yeh 1999; Göçmen and Ventura 2010). These challenges include: lack of data, inadequate funding, inadequate training in GIS among planners and organizational contexts. Despite these challenges, GIS use in municipalities provides benefits such as improved efficiency, resource management, communication, and informed decision-making.

GSIS has also gained tremendous importance in urban and regional planning as a result of the emergence of smart cities (Caragliu, Del Bo, and Nijkamp 2011; Gruen 2013; Tao 2013). Smart cities should take advantage of ICT to facilitate better decision-making (Ching and Ferreira Jr 2015; March 2016). In an era of smart cities, big data, web mapping, geolocation-based services, volunteered geographic information (VGI), and the Internet of Things have all provided valuable data to inform urban planning (Batty et al. 2012; Neirotti et al. 2014; Zanella et al. 2014; Hashem et al. 2016). All this has opened up new possibilities to guide and inform urban planning (Geertman et al. 2015; Abella, Ortiz-de-Urbina-Criado, and De-Pablos-Heredero 2017). It is important to note that smart cities are not only about

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the use of ICT in urban and regional planning, but they also are about planning that promotes relearning, adaptation, collaboration, participation, and planning for the future (Ching and Ferreira Jr 2015). The smart city theory has necessitated a rethink in planning education to go beyond teaching GIS in urban planning, so urban planning can relate and harness other ICT to facilitate better decision-making which makes cities a better place to live in. Cities particularly in the developed world have thus began smart city initiatives using ICT and geospatial information to inform urban planning tasks (Yin et al. 2015).

As a result of the advances in GSIS, planners have utilized and developed planning support system (PSS) (Brail 2008). PSS is defined as geo-information-based tools that support planners in planning-related undertakings, such as information handling, communication and analysis in planning processes (Vonk and Geertman 2008). Timmermans (2008) noted that many PSS have been developed but not used. Contemporary PSS are often “toy” enterprises, developed as standalone projects, and presented at conferences with little practical relevance for use in municipalities (Timmermans 2008). Studies, particularly from a developed world perspective and by authors in developed countries, have endeavored to explain the reasons behind the limited use of GIS and PSS in municipalities (Geertman 2008; Vonk and Geertman 2008; Pelzer 2016; Te Brömmelstroet 2016). Some of the reasons include: mismatch between supply and demand of PSS (Vonk and Geertman 2008), lack of knowledge on real-life applications of PSS (Te Brömmelstroet 2016), mismatch between tools and users (Klosterman 1995, 2008), complexity of the PSS and lack of funding to develop the PSS (Batty 2007; Brail 2008; Geertman 2008; Moore 2008; Forgie 2011; Pelzer 2016; Te Brömmelstroet 2016). A major reason for the limited use of PSS is that they are too complex, difficult to implement, and do not cater for situations with little or no data, such as the cases in most developing countries (Klosterman 1995; Musakwa and van Niekerk 2013). In developing countries, particularly Africa, there are few PSS been developed.

The developed PSS includes: a system for monitoring urban functionalities (SMURF) (Repetti, Soutter, and Musy 2005), a relational indicator set model for urban functionalities (SMURF) (Repetti, Soutter, and Musy 2005), a system for monitoring land use planning developed to monitor and control land use development in African cities (Repetti and Desthieux 2006), a PSS for growth potential modeling in the Western Cape Province in South Africa (van Niekerk et al. 2016) and a few others developed by the Council for Scientific and Industrial Research (CSIR) in South Africa (CSIR 2017). CSIR has developed PSS, such as geospatial analysis platform (GAP), to visualize the spatial spread of economic activity in South Africa, the national spatial development perspective and the housing atlas (CSIR 2017). Nevertheless, these tools have hardly been applied in local municipalities. Likewise, the Department of Rural Development and Land Reform in South Africa have developed some PSS, but their application in local municipalities has been limited or non-existent (Musakwa, Tshesane, and Kangethe 2017). A major reason for the limited use of PSS in Africa is the limited resources and inadequate GIS training in planning schools.

There is an urgent need to make GIS education relevant in urban and regional planning (Montagu 2001; Chatterji and Soni 2016). Montagu (2001) noted that the current GIS instruction is not very relevant for urban planning. GIS technologies should be ultimately integrated into the traditional and substantive areas of urban planning, such as land use planning (Drummond 1995). More recently, (Dawkins 2016) noted that planners in America value generalist planning knowledge over technical skills, such as GIS, hence, there is need to reconsider how GIS is taught in planning schools (Pettit and Pullar 2009). The education planners received in planning schools affects how they apply geospatial information in municipalities. In developing countries, there is often a deficiency of GIS training in planning schools (Machakaire 2015). Moreover, in some cases, geospatial information is first introduced in government agencies by donors, before it has reached planning schools (Yeh 1999) and GIS is often taught by a GIS specialist without expertise in urban planning. There are also limited studies that have focused on GSIS education in planning schools in developing countries. Accordingly, the purpose of this study is to identify the perspectives and challenges on the use of geospatial information in municipalities. Second, this paper looks at GIS education in urban and regional planning schools from a developing country perspective and how it affects GIS usage in planning practice. The remainder of the paper is structured as follows: the next section presents the research methodology followed by the results and discussions, and lastly, the conclusions from the paper are presented.

2. Research methodology

A questionnaire-based survey was sent to 20 planners in the Ekurhuleni Metropolitan Department. The questionnaire contained both open ended and closed questions. The questionnaire contained questions relating to GIS usage in municipalities and questions relating to barriers on GIS use in urban planning which was adopted from Göçmen and Ventura (2010). Similarly, open-ended questions were also administered to GIS experts in the GIS department in Bulawayo municipality, Zimbabwe. Only three GIS experts were selected, because the study sought to obtain a deeper issue on GIS use in municipalities in Zimbabwe, and within the Bulawayo municipality only three GIS experts are employed (The source of information is through personal communication with a Planner in the City of Bulawayo). The themes that the
questionnaire focused on relate to GIS software, GIS data, and general information technology, GIS functionality, funding for GIS, and GIS education (Table 1).

Table 1 describes the themes and description of the questions asked to the respondents. To supplement the survey data, extensive secondary data were also consulted: reports from South African Council of Planners (SACPLAN), Zimbabwe Institute of Regional Urban Planning (ZIRUP) documents, websites of planning schools in Zimbabwe and South Africa, and journal articles.

The analysis was carried out using Microsoft Excel for the descriptive statistics for the closed questions. For the qualitative open-ended questions, NVIVO software was utilized to determine the common themes and patterns from the questions. The query builder functionality (text search, word count, and word count) of NVIVO was utilized for better understanding of the responses to the open-ended questions. Likewise, the secondary data texts were also subjected to qualitative analysis in NVIVO software.

### 3. Results and discussion

#### 3.1. Use of ICT in urban planning

The use of ICT has revolutionized urban planning particularly in this era of smart cities (Tao 2013; Geertman et al. 2015). The participants in Ekurhuleni indicated that 25% were very interested and 50% interested in the use of ICT in urban planning, whereas 25% showed little or no interest in how ICT is used in urban planning. Similarly, the majority of respondents in Ekurhuleni (75%) are comfortable with the use of ICT in urban planning. Likewise, professionals in Bulawayo all acknowledge the importance of ICT in urban planning, but they point out that other service delivery problems and lack of resource problems inhibits use of ICT in Bulawayo and other smaller cities. This is an encouraging sign because the planners need to engage with ubiquitous information and ICT to make decisions on land use, transportation and other aspects in a demanding era where decisions need to be backed by sound information. Given the increased use of ICT in urban planning, perhaps planning curricula in South Africa and Zimbabwe should introduce ICT-focused courses to enable planners to tackle ubiquitous information, big data and advances in ICT. Currently, the planning education (defined by the SACPLAN) vaguely lists the use of ICT as a generic competency (SACPLAN 2014). Likewise, ZIRUP does not list ICT as a key skill in the application to become a member. There is an imperative need to redefine ICT competency among urban planners in Southern Africa and make it a core competency. The 2017 status of Department of Urban Studies and Planning, Massachusetts Institute of Technology (MIT), is a good example that goes beyond educating planners in GIS and planning-related software to the examination of the “ripple effects of computing, communications, and digital spatial information on current planning practices and on the meaning and value of the communities and planning institutions” (MIT Department of Urban Studies and Planning 2017).

#### 3.2. GIS education in urban and regional planning

Regarding education, the majority of respondents in Ekurhuleni (65%) indicated that they had some formal training in GIS, whereas 35% had no formal GIS training. This is consistent with the competencies defined by SACPLAN that planners should be competent in GIS and spatial analysis. Nevertheless, SACPLAN does not clearly specify what GIS skills planners should possess; nonetheless, it just broadly states that planners should be component in GIS (SACPLAN 2014). In contrast, The South African Geomatics Council clearly states GIS professionals should possess what specific GIS skills, for example, mapping, spatial statistics (du Plessis and van Niekerk 2014). This shows that it is necessary to redefine and be more specific in defining GIS curricula in urban planning schools in South Africa. In sharp contrast, in Bulawayo the key informants indicated that GIS training is mostly on the job training with few possessing professional or academic qualifications. However, the personnel in charge of the GIS all had academic and professional qualifications. In Bulawayo and many cities in Zimbabwe, GIS usage is being developed by donor organizations that set up GIS departments and train staff (Australian Embassy 2015). Similarly, the city of Harare, Zimbabwe, has also partnered with Munich and Durban to roll out GIS in the city (The Herald Zimbabwe 2016).

The lack of a functional GIS in cities in Zimbabwe, such as Bulawayo and Harare, often leads to loss of revenue, haphazard planning, poor record keeping, and diminishing of the planning ability (Machakaire 2015). Therefore, there is an exigent need to transform urban planning practices in Zimbabwe using GSIS and technologies. Furthermore, the respondents argued what GIS taught in urban planning schools in Zimbabwe was theoretical and less practical which ill-prepares planners.
to conduct GIS related work in local municipalities. Similarly, ZIRUP does not list GIS as a key competency or skill required to a member of ZIRUP. Therefore, there is need for ZIRUP to lobby planning schools to promote GIS education (both theory and practical), as well as listing it as a key competency in their application for membership. Consequently, as Montagu (2001) posited, there is an exigent necessity to develop new GIS pedagogy to ensure what GIS taught is relevant to urban planning, particularly in developing countries where the context is different from developed countries. GIS instruction in planning schools should enable students to simultaneously comprehend the substantive underpinnings of urban planning while comprehending the substantive underpinnings of GIS to investigate planning problems (Montagu 2001). This means that planners should be taught basic to advanced GIS skills that will enable them to attain spatial analysis skills for facing common developing country problems such as informality, spatial fragmentation, urban agriculture, poor land use management systems, disaster management, communal resource, and land management.

In South Africa, universities, such as the University of Cape Town, the University of Pretoria, the University of the Witwatersrand, and the University of Venda, do not teach GIS as a standalone course in some of their planning bachelors and honours programs. These universities fuse teaching on geospatial information in courses such as planning techniques (Table 2). This partly explains the limited knowledge in GSIS among planners in South Africa. Other universities, such as the University of Johannesburg and Durban University of Technology, have a one-year or semester course in GIS in their planning programs. Other universities, for example, the University of Zimbabwe, have a GIS course where planning students enroll for a GIS course in the geography or surveying department. Universities, such as North West University and Great Zimbabwe, go a step further by teaching planning students GIS and remote sensing techniques. This equips planners with broader GSIS skills that are required in an era of smart cities and the New Urban Agenda. Nevertheless, SACPLAN and ZIRUP are also silent on whether GIS should be taught as a stand-alone course in planning schools, fused with urban planning courses, such as planning techniques or research methods, or whether planning students should enrol for a GIS course in another department. This creates inconsistencies. LeGates (2006) argues that the most satisfactory way to teach GIS in urban planning schools is that a competent faculty member teaches it as a stand-alone course with substantive material related to urban planning (LeGates 2006). Similarly, the course material including textbooks that focus on applied GIS skills in urban planning (Maantay, Ziegler, and Pickles 2006; Pamuk 2006; Netzband, Stefanov, and Redman 2007; Scholten and Stillwell 2013) as well as those that focus on the state of the art and recent developments in GIS and GSIS (Longley et al. 2005, 2015) may be used to enrich GIS curricula in planning schools (LeGates 2006). Furthermore, utilizing the course material that focus on geospatial applications in urban planning problems of the developing world equip planners with the requisite skills to work in local and national governments.

In Bulawayo municipality, the professionals complained about the nature of the fast evolving field of GSIS. With the emergence of new versions of GIS software, big data, Internet of Things, VGI, planners who are not tech-savvy feel overwhelmed and are often left behind. It is essential for local authorities to support their employees to attend short courses that enable planners to keep their geospatial skills relevant and up-to-date. In both South Africa and Zimbabwe, there is no shortage

### Table 2. Sample GIS teaching approaches in planning schools in South Africa and Zimbabwe.

| University                  | Program                                | Duration (year) | Comment on GIS teaching                                      |
|-----------------------------|----------------------------------------|-----------------|--------------------------------------------------------------|
| University of Cape Town     | Bachelor of urban and regional planning degree | 1               | GIS fused into courses such as planning techniques and computers in planning |
| University of Venda         | Bachelor of Science (BSc) Honours (BSc Hons) in urban and regional planning | 4               | No mention of courses on GIS and geospatial information on the website |
| University of the Witwatersrand | BSc urban and regional planning | 1               | A course on CAD and GIS taught in the second year in the department |
| University of Pretoria      | Bachelor’s degree in town and regional planning | 3               | No mention of courses on GIS and/or geospatial information on the website. There is a course on spatial concepts |
| University of Johannesburg | Bachelor of technology in town and regional planning | 1               | One year course on GIS taught within the department |
| Durban University of Technology | Bachelor of technology in town and regional planning | 3               | Course on GIS taught within the department |
| University of Zimbabwe      | Bachelor degree of the built environment in urban and regional planning | 1               | One year course on GIS taught within the department |
| Great Zimbabwe University   | BSc Hons degree in urban planning and development | 4               | A GIS and remote sensing course is offered as a core module in year one within the department |
| North West University       | BSc urban and regional planning        | 4               | A GIS and remote sensing course is offered as a core module in year one within the school |

Source: Departmental and university websites; author’s experience at the University of Zimbabwe and the University of Johannesburg.
of GIS courses (Scientific and Industrial Research and Development Centre 2017; University of Johannesburg 2017; University of South Africa 2017). Most of these short courses are not suited to the substantive nature of urban and regional planning. It then becomes crucial to integrate GSIS with thematic focus areas of urban planning such as (land use management, transportation, and poverty) into GIS curricula.

Another crucial aspect in Bulawayo is the disconnection or knowledge gap in GIS knowledge and application, since it is mostly the “younger generation” with GIS skills, yet they are not in positions of power and have no influence to advance GIS usage in municipalities. The “older” generation with power and influence often stifle GIS use due to inadequate appreciation of the benefits of GIS. As a result, the training opportunities on geospatial science by donor organizations in Zimbabwe are often attended and hijacked by people in power, yet they are not tech-savvy and not in a position to train other staff left behind. The staff in Bulawayo also felt immense pressure as only three staff served in the GIS department in the City of Bulawayo with a population of 653,337 people in 2012 as reported by the Zimbabwe National Statistics Agency (ZIMstat 2012), covering an area of 465 km². This mismatch has negatively affected GIS performance and rollout of GIS within the municipality. Besides, the GIS department is housed within the sewer and water section within Engineering Services Department. As a result, there is lack of coordination with the town planning section, which further hampers use of GIS in land use management. Machakaire (2015) also noted that those in power in Harare City lack an appreciation of a GIS and computer applications in urban planning and this has negatively affected the development of GIS in municipalities.

3.3. Challenges on GIS implementation

Concerning the barriers and challenges of GIS use in urban planning, financial resources are cited as a major stumbling barrier in GIS adoption and usage in Ekurhuleni with 37% agreed, while 21% strongly agreed. In Bulawayo, there was consensus among the key informants that the limited financial capability is an immense impediment in purchasing GIS software, servers, and other GIS infrastructure required in setting up a GIS department. Due to the high cost of proprietary software, such as ArcGIS for Bulawayo, there is need to explore the use of open-source software to enable smaller and less resourced municipalities to establish functional GIS units. The other problem is attributed to the poor Internet connections. These findings are similar in most developing countries, because setting up GIS hardware; software and supporting infrastructure, such as servers, are often very expensive (van Genderen 1992; Klosterman 1995; Kohsaka 2000). In South Africa, the situation is worse in smaller local municipalities than that in metropolitans. The government, especially for the metropolitans, can sometimes overcome the financial difficulty to obtain the benefits of GIS adoption. As a result, most metropolitans are upgrading their GIS departments to contain online- or web-GIS and even upgrading spatial data to include light detection and ranging (LiDAR) data that is readily available to the public. This is in stark contrast to the smaller municipalities with limited funding to adopt GIS (Tengbeh and Martin 2008).

Pertaining GIS functionality in municipalities, the respondents in Ekurhuleni indicated that GIS is mostly used for mundane and simple tasks such as mapping, data capturing, information retrieval and visualization (Figure 1).

There is the minimal usage of GIS in advanced spatial analysis such as model building and GIS-multi-criteria decision analysis (GIS-MCDA) that is critical in facilitating decision-making. In Bulawayo and in most urban areas in Zimbabwe, GIS use is still in its infancy and is mostly for data capturing. A plausible reason to minimal use of sophisticated GIS tasks in Ekurhuleni and Bulawayo could be lack of education and training indicated earlier on and also that GIS professionals are underutilized in municipalities, and GIS

Figure 1. Percentage of GIS usage according to tasks in Ekurhuleni municipality.
professionals are often intimidated to explain to their political bosses the benefits of GIS. It is also common in South Africa that most of the sophisticated GIS tasks are outsourced through a tendering process to consulting companies. This further inhibits growth of advanced GIS usage in municipalities. Ultimately, the skills are not transferred to employees within the municipalities. In Ekurhuleni, the continued focus on mundane GIS task can often lead to demotivation among GIS staff. Despite the lack of advanced GIS use, the mundane tasks such as creating zoning maps and visualizations are key components in improving service delivery to residents.

Concerning data availability, professionals in Ekurhuleni responded that they have sufficient data in their GIS departments to service clients such as zoning maps and there is general consensus that GIS data is accurate and up-to-date (Figure 2).

However, the data are available because Ekurhuleni is a metropolitan city and relatively well resourced. In remote areas or smaller cities and towns in Southern Africa and elsewhere, lack of data is still a problem. For example, in Bulawayo, Zimbabwe, the GIS department is still in its infancy and the key informants noted that they still struggle with putting cadastral data, land use and zoning data in place. This lack of basic GIS data inhibits planners’ ability to carry out their land use management duties properly. Similarly, Machakaire (2015) noted that the absence of any significant GIS data in cities, such as Harare, he therefore wonders how sustainable land use management is possible without basic GIS data, such as cadastral data. Therefore, many cities in Africa are left behind and this puts serious questions in whether such cities will be able to implement and achieve the New Urban Agenda 2030 in particular Sustainable Development Goal 11, which is proposed by UN Secretariat on Global Geospatial Information Management (UN-GGIM). The sustainable development goals seek to “make cities inclusive, safe, resilient and sustainable” (UN 2016). This statement summarizes and covers most big urban buzzwords of the past two decades, such as climate change and sustainable urban development (Caprotti et al. 2017). Sustainable Development Goal 11 is profoundly based on indicators and urban data that are missing in cities of the developing world without GIS data. Cities in Southern Africa and the developing world need to put in GIS data collection systems if Sustainable Development Goal 11 is to be realized.

4. Conclusions

The beginning point of the study was to identify the perspectives and challenges on the use of GIS in municipalities. Secondly, the paper sought to give an overview of GIS education in urban and regional planning schools from a developing country perspective and how this status affects planning practice. Planners in Southern Africa and the developing world acknowledge that ICT is crucial in equipping planners to face today’s urban challenges and demands from the New Urban Agenda 2030 and the need for smart cities. In light of this, there is perhaps a need to change curricula in planning schools so that planners can be more tech-savvy. Like ICT, the world of GSIS is a fast evolving field and the high rate of urbanization in developing countries also brings unique problems. This also calls for a rethink of how GIS is taught in planning schools. GIS curricula ought to be relevant to urban planning so that planners are equipped with geospatial skills to face third world challenges such as informal settlements and rapid urbanization as well as global problems such as climate change. GIS education among planners should be considered a lifelong process given the changing nature of GSIS.

With the New Urban Agenda 2030, there is an urgent need to transform urban planning practices in municipalities of the developing countries. Metropolitan municipalities, such as Ekurhuleni in South Africa, are well resourced and are more advanced in their use of GSIS in municipal planning. Smaller municipalities in South Africa and municipalities (big or small) in Zimbabwe have severely limited GIS functionality. The lack of resources, (financial, lack of data, lack of skills, and lack of GIS) and poor management are some of the reasons behind the limited GIS usage in such municipalities. These challenges need to be addressed if the New Urban Agenda 2030 goals are to be realized. Planners alone cannot address these challenges, and the political will is also needed to overcome them.

GSIS will continue to play an important role in planning education and municipal planning. More studies that focus on exploring the challenges faced by municipalities in applying geospatial information, GIS education in planning schools, and how GIS education affects planning practice are required in developing countries.

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**References**

Abella, A., M. Ortiz-de-Urbina-Criado, and C. De-Pablos-Hereder. 2017. "A Model for the Analysis of Data-driven Innovation and Value Generation in Smart Cities’ Ecosystems." Cities 64: 47–53. doi: 10.1016/j.cities.2017.01.011.

Australian Embassy. 2015. “Geographic Information Systems (GIS) in Zimbabwe.” http://zimbabwe.embassy.gov.au/hare/hare-news_GISarticle.html.

Batty, M. 2007. “Planning Support Systems: Progress, Predictions and Speculations on the Shape of Things to Come.” Planning Support Systems for Urban and Regional Analysis (Seminar). Lincoln Institute of Land Policy, Cambridge, MA, September 27–28.

Batty, M., K. W. Axhausen, F. Giannotti, A. Pozdnoukhov, A. Bazzani, M. Wachowicz, G. Ouzounis, and Y. Portugali. 2012. “Smart Cities of the Future.” The European Physical Journal Special Topics 214 (1): 481–518. doi: 10.1140/epjst/e2012-01703-3.

Brail, R. K. 2008. Planning Support Systems for Cities and Regions. Hollis, NH: Puritan Press.

Caprotti, F., R. Cowley, A. Datta, V. C. Broto, E. Gao, L. Georgeson, C. Herrick, N. Odendaal, and S. Joss. 2017. “The New Urban Agenda: Key Opportunities and Challenges for Policy and Practice.” Urban Research & Practice (Online Publishing). doi: 10.1080/17535069.2016.1275618.

Caragliu, A., C. Del Bo, and P. Nijkamp. 2011. “Smart Cities in Europe.” Journal of Urban Technology 18 (2): 65–82. doi: 10.1080/10603732.2011.601117.

Chatterji, T., and A. Soni. 2016. Urban and Regional Planning Education: Learning for India: Positioning Urban Governance in Planning Pedagogy. Singapore: Springer.

Ching, T.-Y., and J. Ferreira Jr. 2015. Planning Support Systems and Smart Cities: Smart Cities: Concepts, Perceptions and Lessons for Planners. New York: Springer.

CSIR (Council for Scientific and Industrial Research). 2017. “Geospatial Analysis Platform.” https://gap.csir.co.za/gap/about-gap-1.

Dawkins, C. J. 2016. “Preparing Planners: The Role of Graduate Planning Education.” Journal of Planning Education and Research 36 (4): 414–426. doi: 10.1177/0739456X15627193.

Drummond, W. J. 1995. “Extending the Revolution: Teaching Land Use Planning in a GIS Environment.” Journal of Planning Education and Research 14 (4): 280–291. doi: 10.1177/0739456X9501400405.

Forgie, V. 2011. “Making Planning Support Systems Matter: Improving the Use of Planning Support Systems for Integrated Land Use and Transport Strategy-making.” Environmental Modelling & Software 26 (12): 1772–1773. doi: 10.1016/j.envsoft.2011.06.002.

Geertman, S. 2008. Planning Support Systems for Cities and Regions: Planning Support Systems: A Planner’s Perspective. Cambridge, MA: Lincoln Institute of Land Policy.

Geertman, S., J. Ferreira, R. Goodspeed, and J. Stillwell. 2015. Planning Support Systems and Smart Cities. New York: Springer.

van Genderen, J. L. 1992. Guidelines for Education and Training in Environmental Information Systems in Sub-Saharan Africa: Some Key Issues. Washington, DC: The World Bank.

Göçmen, Z. A., and S. J. Ventura. 2010. “Barriers to GIS Use in Planning.” Journal of the American Planning Association 76 (2): 172–183. doi: 10.1080/01944360903585060.

Goodchild, M. F. 2009. International Encyclopedia of Human Geography: GIScience and Systems. Oxford: Elsevier.

Goodchild, M. F. 2014. “Two Decades on: Critical GIScience since 1993.” Canadian Geographer 59 (1): 3–11. doi: 10.1111/cag.12117.

Gruen, A. 2013. “Smart Cities: The Need for Spatial Intelligence.” Geo-spatial Information Science 16 (1): 3–6. doi: 10.1007/s12361-013-9188-0.

Hashem, I. A. T., V. Chang, N. B. Anuar, K. Adewolea, I. Yaqooba, A. Gania, E. Ahmeda, and H. Chiromac. 2016. “The Role of Big Data in Smart City.” International Journal of Information Management 36 (5): 748–758. doi: 10.1016/j.ijinfomgt.2016.05.002.

Klosterman, R. E. 1995. “The Appropriateness of Geographic Information Systems for Regional Planning in the Developing World.” Computers, Environment and Urban Systems 19 (1): 1–13.

Klosterman, R. E. 2008. Planning Support Systems for Cities and Regions: A New Tool for a New Planning: The What If? Cambridge, MA: Lincoln Institute of Land Policy.

Kohsaka, H. 2000. “Applications of GIS to Urban Planning and Management: Problems Facing Japanese Local Governments.” GeoJournal 52 (3): 271–280. doi: 10.1023/a:1014228426254.

LeGates, R. 2006. “GIS in U.S. Urban Studies and Planning Education.” CalGIS Annual Meeting, Santa Barbara, CA, April 4–7.

Li, D., J. Shan, Z. Shao, X. Zhou, and Y. Yao. 2013. “Geomatics for Smart Cities – Concept, Key Techniques,and Applications.” Geo-spatial Information Science 16 (1): 13–24. doi: 10.1080/10095020.2013.772803.

Longley, P. A., M. F. Goodchild, D. J. Maguire, and D. W. Rhind. 2005. Geographic Information Systems and Science. New York: John Wiley & Sons.

Longley, P. A., M. F. Goodchild, D. J. Maguire, and D. W. Rhind. 2015. Geographic Information Science and Systems. New York: John Wiley & Sons.

Maantay, J., J. Ziegler, and J. Pickles. 2006. Guidelines for Education and Training in Environmental Information Systems in Sub-Saharan Africa: Some Key Issues. Washington, DC: The World Bank.

Maantay, J., J. Ziegler, and J. Pickles. 2006. Guidelines for Education and Training in Environmental Information Systems in Sub-Saharan Africa: Some Key Issues. Washington, DC: The World Bank.

Malczewski, J. 2006. “GIS-based Multicriteria Decision Making.” Geo-spatial Information Science 9 (1): 66–75. doi: 10.1080/13658810600661508.
Malczewski, J., and C. Rinner. 2015. *Multicriteria Decision Analysis in Geographic Information Science*. New York: Springer Berlin Heidelberg.

March, H. 2016. “The Smart City and Other ICT-led Techno-imaginaries: Any Room for Dialogue with Degrowth?” *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2016.09.154.

MIT Department of Urban Studies and Planning. 2017. “Overview.” https://dusp.mit.edu/uis/program/overview.

Montagut, A. S. 2001. “Repackaging the Revolution.” *Journal of Planning Education and Research* 21 (2): 184–195. doi: 10.1177/0739456X0102100206.

Moore, T. 2008. *Planning Support Systems for Cities and Regions: Planning Support Systems: What are Practicing Planners Looking for? Cambridge, MA: Lincoln Institute of Land Policy.

Musakwa, W., and A. van Niekerk. 2013. “Implications of Land Use Change for the Sustainability of Urban Areas: A Case Study of Stellenbosch, South Africa.” *Cities* 32: 143–156. doi: 10.1016/j.cities.2013.01.004.

Musakwa, W., R. M. Tshesane, and M. Kangethe. 2017. “The Strategically Located Land Index Support System for Human Settlements Land Reform in South Africa.” *Cities* 60: 91–101. doi: 10.1016/j.cities.2016.08.007.

Neirotti, P., A. De Marco, A. C. Cagliano, G. Mangano, and F. Scorrano. 2014. “Current Trends in Smart City Initiatives: Some Stylised Facts.” *Cities* 38: 25–36. doi: 10.1016/j.cities.2013.12.010.

Netzband, M., W. L. Stefanov, and C. Redman. 2007. *Applied Remote Sensing for Urban Planning, Governance and Sustainability*. Berlin Heidelberg: Springer-Verlag.

van Niekerk, A., D. du Plessis, I. Boonzaaier, M. Spocter, S. Ferreira, L. Loots, and R. Donaldson. 2016. “Development of a Multi-criteria Spatial Planning Support System for Growth Potential Modelling in the Western Cape, South Africa.” *Land Use Policy* 50: 179–193. doi: 10.1016/j.landusepol.2015.09.014.

Pamuk, A. 2006. *Mapping Global Cities: GIS Methods in Urban Analysis*. Redlands, CA: ESRI Press.

Pelzer, P. 2016. “Usefulness of Planning Support Systems: A Conceptual Framework and an Empirical Illustration.” *Transportation Research Part A: Policy and Practice*. doi: 10.1016/j.tra.2016.06.019.

Pettit, C. J., and D. Pullar. 2009. “An Online Course Introducing GIS to Urban and Regional Planners.” *Applied Spatial Analysis and Policy* 2 (1): 1–21. doi: 10.1007/s12061-008-9014-4.

du Plessis, H., and A. van Niekerk. 2014. “A New GiSc Framework and Competency Set for Curricula Development at South African Universities.” *South African Journal of Geomatics* 3 (1): 1–12.

Repetti, A. M., and G. Desthieux. 2006. “A Relational Indicators Model for Urban Land-use Planning and Management: Methodological Approach and Application in Two Case Studies.” *Landscape and Urban Planning* 77 (1-2): 196–215. doi: 10.1016/j.landurbplan.2005.02.006.

Repetti, A., M. Soutter, and A. Musy. 2005. “Introducing SMURF: A Software System for Monitoring Urban Functionalities.” *Computers, Environment and Urban Systems* 30 (5): 687–707.

SACPLAN (South African Council for Planners). 2014. “Consolidated Report on Competencies and Standards.” http://www.sacplan.org.za/documents/Consolidated%20Report%20SACPLAN%20Final%20Draft.pdf.

Scientific and Industrial Research and Development Centre. 2017. “Training Courses.” http://www.sirdc.ac.zw.

Scholten, H. J., and J. Stillwell. 2013. *Geographical Information Systems for Urban and Regional Planning*. Dordrecht: Springer.

Tao, W. 2013. “Interdisciplinary Urban GIS for Smart Cities: Advancements and Opportunities.” *Geo-spatial Information Science* 16 (1): 25–34. doi: 10.1007/1095020.2013.774108.

Te Brömmelstroet, M. 2016. “Towards a Pragmatic Research Agenda for the PSS Domain.” *Transportation Research Part A: Policy and Practice*. doi: 10.1016/j.tra.2016.05.011.

Tengbeh, S. M., and S. M. Martin. 2008. “How to Successfully Implement GIS in Local Government.” http://www.ee.co.za/article/how-to-successfully-implement-gis-in-local-government.html.

The Herald Zimbabwe. 2016. “80K Properties Not on City Database.” http://www.herald.co.zw/80-k-properties-not-on-city-database/.

Timmermans, H. 2008. *Planning Support Systems for Cities and Regions: Disseminating Spatial Decision Support Systems in Urban Planning*. Cambridge, MA: Lincoln Institute of Land Policy.

UN (United Nations). 2016. “The New Urban Agenda: Key Commitments.” http://www.un.org/sustainabledevelopment/blog/2016/10/newurbanagenda/.

University of Johannesburg. 2017. “Certificate in GIS.” https://www.uj.ac.za/faculties/science/geography/Pages/Certificate-GIS.aspx.

University of South Africa. 2017. “Short Learning Programmes.” http://brochure.unisa.ac.za/slp/showprev.aspx?d=1_5_744_92&f=p_75515.

Vonk, G., and S. Geertman. 2008. “Improving the Adoption and Use of Planning Support Systems in Practice.” *Applied Spatial Analysis and Policy* 1 (3): 153–173. doi: 10.1007/s10098-008-9011-7.

Yeh, A. G.-O. 1999. *Urban Planning and GIS*. New York: John Wiley.

Yin, C., Z. Xiong, H. Chen, J. Wang, D. Cooper, and B. David. 2015. “A Literature Survey on Smart Cities.” *Science China Information Sciences* 58 (10): 1–18. doi: 10.1007/s11432-015-5397-4.

Yuan, M. 2017. “30 Years of IJGIS: The Changing Landscape of Geographical Information Science and the Road Ahead.” *International Journal of Geographical Information Science* 31 (3): 425–434. doi: 10.1080/13658816.2016.1236928.

Zanella, A., N. Bui, A. Castellani, L. Vangelista, and M. Zorzi. 2014. “Internet of Things for Smart Cities.” *IEEE Internet of Things Journal* 1 (1): 22–32. doi: 10.1109/jiot.2014.2306328.

ZIMstat. 2012. “Census 2012 Provincial Report Buluwayo.” http://www.zimstat.co.zw/sites/default/files/img/publications/Census/CensusResults2012/Buluwayo.pdf.