Exploring the potential suitability of an SDI model in context of the National Spatial Data Infrastructure (NSDI) of Namibia

Kisco M Sinvula[1], Serena Coetzee[1], Antony K Cooper[1,2] and Martin Hipondoka[3]
[1]Centre for Geoinformation Science, University of Pretoria, 0002, Pretoria, South Africa
[2]Built Environment, CSIR, PO Box 395, Pretoria, 0001, South Africa
[3]Department of Geography, History and Environmental Studies, University of Namibia, Private Bag 13301, Windhoek, Namibia

Abstract

During the 1990s Namibia marked the introduction and acceptance of desktop Geographical Information System (GIS) technology into various sectors at national, regional and local community levels [22-25]. This technology quickly disseminated across many disciplines, and desktop GIS has now been established as an important component of research, strategic planning and evidence based decision making in the public and private sectors. Numerous spatial datasets and information have been produced over the past decades due to the broad acceptance of GIS technology and its functionality [22-25]. Individuals and organizations have created most of the datasets with limited compliance to structured documentation systems and standards, and this has posed major challenges in the Namibian geospatial community as search and retrieval system infrastructures do not exist [22-24].

A diagnosis of spatial data infrastructures (SDIs) model suitability for the National Spatial Data Infrastructure of Namibia (NSDI) and Health Informatics is outlined in this paper. The understanding of the sub-systems of a functioning SDI is pivotal in support of geospatial data management and sharing practices across the national geo-spatial community of Namibia [7&5]. This paper assesses the suitability of an SDI model in context of the National Spatial Data Infrastructure of Namibia and it's relation to spatial health datasets in Namibia. The NSDI policy of Namibia, NSDI Standards Schedule of Namibia and Statistics Act of Namibia are the only existing blueprint that make provisions for a discipline based heterogeneous SDI using GIS in many sectors of Namibia, including academia, and health informatics [22,23&24]. This paper presents a diagnosis of SDI model suitability for effective implementation of the NSDI of Namibia.

Keywords

spatial data infrastructure, SDI models, health informatics, NSDI of Namibia

Introduction

Availability of current and accurate discipline based spatially referenced datasets at national, regional and local levels in Namibia was identified as one of the key components of the National Development Plan Three (NDP3) in aiding strategic planning and evidence based spatial decision making [23]. The application of geospatial technology to Namibia's heterogeneous sectors has enabled it to identify critical areas needing a targeted approach for effective and sustainable implementation of spatial data and information management. This trend has risen to prominence in the past decades through the recognition that planning and decision making practices and resource allocation require various sets of data and information that are spatially and strategically centralized and maintained in a national geo-portal system [30]. The growing demand for information management, spatial data sharing and geomatics across different disciplines and organisations has resulted in the development and implementation of *spatial data infrastructures (SDIs)*, together with the theory and concepts behind them across the world[1,2,12,17-20]. An SDI is an evolving concept that seeks to facilitate and coordinate the exchange and sharing of spatial data and services among stakeholders at different levels of governments and geospatial community in general [6&7]. Many countries across the world developed and implemented SDIs applicable to their environments and usability. For example, the Brazilian SDI corresponds to the American National Spatial Data Infrastructure (ANSDI), the European INSPIRE, and, more recently, the United Nations Spatial Data Infrastructure (UNSDI) [33]. With this in mind, Namibia embarked on a national SDI initiative with the goal for better management and usage of spatial datasets and information for planning and decision making purposes [22, 23&24].

The fundamental question is which SDI model is suitable for implementing an effective National Spatial Data Infrastructure of Namibia in context of generic geospatial datasets, standards and formats enshrined in the NSDI policy and standards schedule [22&23]? Many countries in Africa have started developing their SDIs, but to what extent have SDIs contributed to social and technical aspirations of governments and geospatial communities in ensuring that geospatial information is effectively used in planning and decision-making processes [14]? This paper adopted a desktop-based secondary literature review approach and an exploratory and situation analysis methodology by making use of online literature and case studies in order to fully understand, assess and investigate the intricacies of spatial data infrastructures and SDI models.

This paper is organised into the following sections, (i) the background and objectives, (ii) Namibian NSDI stakeholders and needs, (iii) SDI conceptual models, (iv) Namibian NSDI as RM-ODP Model, (v) Health informatics through Namibian NSDI Lens and (vi) Conclusion. The background and objectives section provides the legislative framework and purpose of this research project. The second section presents a brief discussion on NSDI stakeholders and needs. Sections three and four present SDI models and an analysis of RM-ODP viewpoints in the context of the NSDI of Namibia. Section five discusses the linkage and commonalities that exists between NSDI and Health Informatics in Namibia. The sixth section presents conclusions that articulate directions for future work on similar subject matter.

Background and objectives

The National Spatial Data Infrastructure (NSDI) of Namibia was crafted to set out a framework that integrates technology, policies, criteria, standards and people essential for promoting the collection, processing, integration, storing, distribution, sharing and improved access and utilisation of geospatial data, information and services at all levels of government, non-governmental organizations, the private sector, and academic institutions [22,23&24]. The Namibia NSDI provides the foundational structure for facilitating spatial data capture through cooperation between government bodies and other stakeholders; effective management and maintenance of geospatial data; promoting geospatial data sharing in spatial planning, decision making and socio-economic development; elimination of geospatial data capturing duplication; and geospatial data copy right protection practices among data producers and users [23].

The Statistics Act of the Republic of Namibia [22] was promulgated in 2011 to provide a legal framework towards the successful implementation of the NSDI of Namibia. With due respect to the accomplished work on NSDI policy [23] and standards schedule [24], it is the author's view that, a lack of motivation in driving the implementation of NSDI and generic geospatial data infrastructure challenges and pitfalls are being experienced by the geospatial community in Namibia such as:

- Data not disaggregated below regional level;
- Gaps in regional and urban data;
- Lack of standardized spatial data collection, sharing strategies and workflows across national, regional and local government level;
- Spatial monitoring systems largely non-existent;
- Reliability and accuracy of produced spatial data;
- Traditional issues associated with institutions;
- Data are produced, stored and distributed independently by different organizations, each according to its own mandate;
- General lack of stakeholder awareness strategies and spatial literacies;
- Nonexistent NSDI geoportal and data discovery technologies.

Namibian NSDI stakeholders and needs

The NSDI of Namibia was crafted by many stakeholders, individuals, academics and organisations involved in the production and use of spatial data in Namibia [23&24]. Section forty seven (47) of the Statistics Act [22] led to the establishment of the NSDI of Namibia and its frameworks of technologies, data, policies, institutional arrangements, and people with the aim of maximizing spatial data usage, sharing, availability, understanding, and services for Namibia's quest for policy support and evidence based decision making at national, regional and local levels of government and society at large [23].

Various line ministries of the Government of the Republic of Namibia, private sector, academia and non-governmental organizations (NGOs) are the main producers of spatial data. Their activities regarding spatial data involve data collection, processing, integration, storage, exchange, access and dissemination [23]. Spatial data and services are mainly used by government institutions (i.e. ministries and state owned enterprises), utility companies, public services, commercial and professional users, academic and research institutions, NGOs, international organizations, the donor community and private individuals. In line with [7] argument, The NSDI of Namibia is formed as a mechanism for providing ready access to spatial data to as many users as possible, at a national, regional, local level. The NSDI of Namibia standards for appropriate use, capture and distribution of spatial data at national, regional and local levels was issued by the Statistician General of the National Statistical Agency (NSA) in accordance with the Statistics Act [22] after consultations with the Committee for Spatial Data [24]. The objective of the NSDI standards is "to provide an institutional and operational legal framework in relation to the capture, management, maintenance, integration, distribution and use of spatial data within the territorial boundaries of Namibia" [24]. According to the NSDI standards, standardization is of paramount importance in ensuring consistent access and sharing of spatial data amongst all producers and users [24].

Meanwhile, the purpose of the NSDI Policy of Namibia [23] "is to set out a policy for the collection, processing, integrating, storing, distribution, and improved access and utilisation of spatial data and services in public, private and civil society organisations in Namibia". The Statistics Act [22] outlines the following NSDI objectives:

- Facilitate the capture of spatial data through cooperation between government bodies and other organs of state
- Promote effective management and maintenance of spatial data
- Promote the use and sharing of spatial data in support of spatial planning, socio-economic development and related activities
- Create an environment which facilitates coordination and cooperation among stakeholders regarding access to spatial data
- Eliminate duplication in the capturing of spatial data
- Facilitate the protection of copyright of the state in works relating to spatial data.

The NSDI policy and standards of the Republic of Namibia have been developed under a strong partnership framework that recognized and leveraged the improved utilisation of SDI in policy development, decision making and research at all levels of government and community at large. In line with [7], who emphasized the need for providing a clearinghouse for spatial datasets that conforms to set standards, metadata and frameworks; the NSDI standards schedule sets out the clearinghouse standards for metadata and spatial data in accordance with international standards. The NSDI of Namibia is defined by NSA (2011) as an umbrella of SDI policies, standards, and procedures where interactions between technologies and organizations foster the efficient use, management and production of geospatial data.

The NSDI policy [23], the NSDI standards [24] and the Statistics Act [22] constitutes the framework for the establishment of a Namibia NSDI model, involving four components: the institutional framework (NSA), technical standards, fundamental datasets, and clearing house networks.

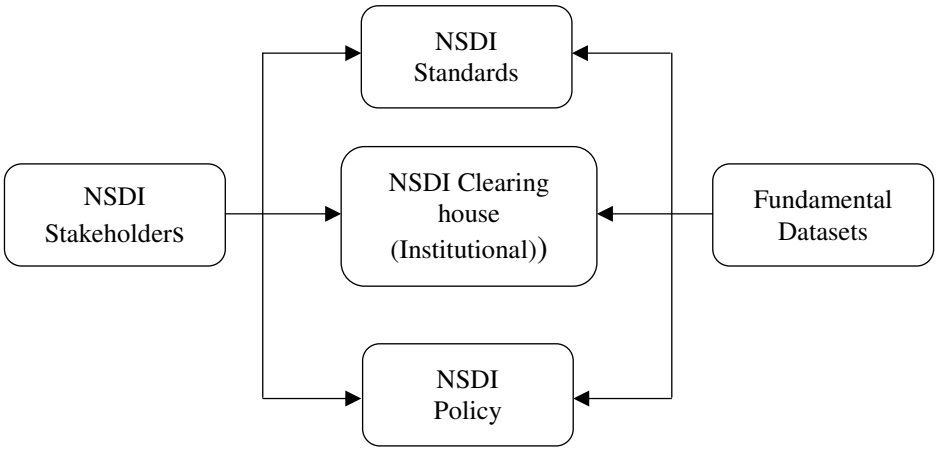

Fig. 1: NSDI and its components (Source: Rajabifard and Williamson [28])

The most immediate needs of the Namibian NSDI through NSA are the notable amount of required resources (time, money, expertise, commitment) as prerequisites in ensuring the successful and effective implementation. The Namibia Statistical Agency is still a new organization that became operational at the beginning of this year (2012), with a facet of organizational challenges. The Government of Namibia and the global financial climate makes it potentially more challenging to invest in new infrastructures, however the successful implementation of the NSDI relies heavily on availability of financial resources from national, regional and international donor organizations. The NSA work needed to leverage resources from national and international organizations is of paramount importance in ensuring that all the NSDI components, initiatives and deployments are successfully coordinated and implemented in order for the stakeholders to reap the benefits. Underpinning the NSDI organizational needs are the key issues related to awareness, education, and training, even though many organizations are aware, only a few people within these institution are actively participating, and engaged. According to the Namibian NSDI policy statement, the Government of Namibia shall develop appropriate capacity to establish the NSDI and ensure its effectiveness and maintenance of an infrastructure that will deliver added value to spatial data in conformity with international standards and best practices [23].

SDI conceptual models

[15] documented different reference models applicable to SDI namely i) the architecture reference model used by the International Organization for Standardization' (ISO) Technical Committee for Geographic Information/Geomatics, ISO/TC 211 (ISO 19101, 2002), ii) the OpenGIS Reference Model (ORM) (OGC, 2003) iii) the Geospatial Interoperability Reference Model (GIRM) and iv) Reference Model of Open Distributed Processing (RM-ODP) (ISO/IEC 10746, 1995). The RM-ODP, used as the base in the majority of reference SDI models, defines a framework comprising five viewpoints: enterprise, information, computation, engineering and technology. [15] and [16] concluded that RM-ODP permits the description of complex distributed systems given a framework of different levels of abstraction. The *Architectural reference model* is characterised by the reference model, overview, conceptual schema language, terminology, conformance and testing, imagery and gridded data, and imagery and gridded data components (ISO/TC 211, 2009). According to Fadaie (2000), the Architectural reference model describes the environment, within which the standardization of geographic information takes place, the fundamental principles that apply and the architectural framework for standardization.

The OpenGIS Reference Model describes an architecture framework for the Open Geospatial Consortium and the interoperable solutions and applications for geospatial services, data, and applications. Percivall (2003) describes ORM as architecture used for sharing geographic data and functionality over the Internet, thus leading the standardization process on data formats, methods and interface specifications. Meanwhile, the Geospatial Interoperability Reference Model is a reference model that supports the development and interoperability of systems that provides data and services. Whereas, the Reference Model of Open Distributed Processing (RM-ODP) describes a framework for ODP standards that creates an infrastructure within which support for distribution, interworking and portability are integrated. [29&31] stated that five viewpoints of the RM-ODP framework satisfy an audience with interest in a particular set of aspects of the SDI system.

Namibian NSDI as RM-ODP model

The importance of the Namibian NSDI in supporting decision-making and spatial data management, capturing and distribution has been cited as critical in important Namibian National Development Plans (III and IV), Statistics Act, NSDI Standards and NSDI policy and as well as Vision 2030. [4] stated that, non-technical enterprise based viewpoints of complex distributed systems such as SDIs are accommodated in the RM-ODP. In the *enterprise viewpoint*, emphasis is placed on the general purpose, scope and policies of an SDI system. [15] argued that the *enterprise viewpoint* consists of four different elements, i.e. the purpose, scope and policies for an SDI. Hence, the NSDI of Namibia was established in consideration of the four elements of RM-ODP *enterprise viewpoints* [22, 23&24].

The *information viewpoint* is more concerned with the data and information handled by the system [17]. This viewpoint describes the systems requirements regarding information management structure and content type of the supporting data. The *computation viewpoint* is more concerned with the interactions of core concepts of services, interfaces and operations (and the relationships amongst these concepts) of the system. The NSDI of Namibia is still in its infant state and does yet not conform to the computational viewpoints technical specifications. The *engineering viewpoint* describes the mechanisms and functions required to support distributed interaction between the services and data within the system. This viewpoint is primarily concerned with the interaction between distinct SDI services and data. Communication, computing systems, software processes, and the clustering of computational functions are the chief cornerstones of the engineering viewpoint at physical nodes of a communications network [9].The *technology viewpoint*, is concerned with the choice of technology of the system and distribution. Information processing, functionality and presentation are clearly defined under the technology viewpoint.

NSDI of Namibia as an enterprise viewpoint of RM-ODP model

The NSDI of Namibia is large, open, distributed, standards and policy-based spatial information systems intending to facilitate and promote the use of national, regional and local spatial data and spatial services electronically. In a publication titled An RM-ODP Enterprise View for Spatial Data Infrastructure, [4] states that "RM-ODP allows specifying an Open Distributed Processing (ODP) system in terms of different, but interrelated viewpoint specifications". An enterprise viewpoint on an SDI system is aimed at addressing distinctive sets of system concerns directly as required by utilizing appropriate language.

The suitability of SDI models for the Namibian NSDI was based on established tenets of an enterprise viewpoint of the RM-ODP in consideration of Part VX of the Namibia Statistics Act (2011) that made provision for the establishment of the National Spatial Data Infrastructure (NSDI) of Namibia, its objectives, the committee for Spatial Data and its functions. The NSDI policy , NDSI Standards and Statistical Act of Namibia corresponds with the enterprise viewpoint of the Reference Model of Open Distributed Processing (RM-ODP) in terms of purpose, standards and policies for an SDI system that facilitates the capture, management, maintenance, integration, distribution and use of spatial data [4,22-24].

The NSDI policy of Namibia as a RM-ODP outlines sets of rules related to the purposes of the national spatial data infrastructure in facilitating the capture, management, maintenance, integration, distribution and use of spatial data [23]. For example, the NSDI standards objectives is to regulate the process of coordinating the NSDI within Government, the advisory committee for the Agency in all aspects relating to spatial data and administration of the NSDI by the Statistician-General . The Namibian NSDI policy and standards [23&24] states precisely which standards are accepted in terms of spatial data technical framework and as well as institutional arrangements regarding the NSDI of Namibia.

All relevant standards and policies related to NSDI of Namibia spatial information, terms and conditions of purchase, capture, collection, production or dissemination of geospatial data are clearly outlined in the NSDI policy and standards schedule of Namibia [23]. The NSDI standard schedule and policy provides guidance and requisites for the type and quality of data required to be purchased, captured, collected or produced. The enterprise viewpoint of the NSDI policy and standards of Namibia describes a model for policy analysis and spatial data processes [23&24].

Health informatics through NSDI of Namibia Lens

The National Health Information System (NHIS) and the Management Information Systems (MIS) in the Ministry of Health and Social Services (MoHSS) is charged with the responsibility of providing a comprehensive source of data on a large number of health related indicators [32]. According to [32], the NHIS responsibilities are to collect statistics from health facilities and to provide information to national policy makers, socio-economic, health personnel and to the public at large. [32] also mentioned that the MIS is charged with collection of data on human resources, health infrastructure, and logistics. The organizational structure of health information system is fragmented across different directorates and institutions leading to poor coordination, analysis, and reporting of health statistics in a comprehensive and timely fashion [30&32].

The NSDI of Namibia is a heterogeneous framework purposely aimed at enabling access and use of spatial data, services and technologies in different disciplines. NSDI for health is a strategic means of developing and strengthening collaboration on health informatics, in order to derive substantial clinical, economic and community benefits from large under-used health data sources. Health informatics is a system that identifies the geographic location and characteristics of health facilities or features and boundaries on earth. This information is particularly valuable for planning and development efforts because it describes the spatial distribution of health resources, demographics and other relevant health factors that contribute to problems of uneven health service delivery in Namibia.

Although geomatics does not belong to a single discipline, it is important to understand how fundamental spatial analysis capabilities can provide significant value to business decisions in the health sector. There is an important relationship between location and health, thus having a geographic perspective assists in public health tasks such as planning to improve healthcare service delivery. Further spatial analysis can be performed to measure the effectiveness of existing health service delivery. Using demographic and socio-economic census data collected by the central bureau of statistics, maps can be created in a GIS that depict where the at-risk groups are concentrated.

It is globally accepted that an effective and efficient health information management system plays a pivotal role in managing rapidly increasing demand pressures on the acute segments of the health systems, as well as improving the general well-being of service users [30]. Furthermore, there is sufficient evidence that a spatial data infrastructure is essential for the planning, coordination and delivery of health services and facilities. The NSDI of Namibia is characterised by a set of technologies, policies, and spatial data and service crafted for promoting spatial health data management, sharing and exchange of geospatial health data at all levels of government, the private and non-profit sectors, and academia [22, 23&24].

The role of the Namibian NSDI in the health sector in relation to, for example, local health improvement programmes or performance management is not identified in any of the core Namibian national health strategies and policy documents, although the potential for using information from primary care systems to support needs assessment and resource allocation is one of the principal areas of usage. NSDI of Namibia's enabled electronic patient record can offer a powerful advantage in visualising unfolding epidemiological events and patterns hidden in aggregated patient records.

Conclusion

This paper presented a diagnosis and assessment of the intricacies of SDIs and SDI models in relation to NSDI of Namibia, conclusively described as policies, standards and objectives of an enterprise viewpoint of the RM-ODP model. The combination of each viewpoint of an SDI model can hopefully result in the next generation of the NSDI. In other words, different viewpoints of SDIs can build upon other supporting components. However, the models that are described in the paper fulfill some of the requirements for modelling the Namibian NSDI, but not all of them. The major result in the Namibian SDI policies is the recent creation of NSA (National Statistical Agency) and the Namibian national spatial data infrastructure. The act of parliament [22] that officially created NSA defines it in the spirit of

current national and global initiatives such as the African Spatial Data Infrastructure (ASDI), South African Spatial Data Infrastructure (SASDI), U.S. National Spatial Data Infrastructure (NSDI), the European INSPIRE, the United Nations Spatial Data Infrastructure (UNSDI) and the Global Spatial Data Infrastructure (GSDI). The Namibian NSDI encourages government agencies to create and share geographic data following the standards and regulations laid out by NSA [22, 23&24].

Appropriate spatial data management and sharing practices are vital to the efficient use of geospatial information and service in heterogeneous disciplines. The establishment of the NSDI of Namibia is a testimony to the fact that Namibia's path towards creating a national spatial data repository is heading in the right direction, but there are still significant challenges to ensure these investments will not be wasted. An investigation to explore actor network modelling of SDIs might be necessary, as more than one modelling approach is needed in implementing a Namibian NSDI. SDI model that covers both health and heterogeneous disciplines can be used by authorities to create an enabling platform for the use and delivery of spatial information and services.

Acknowledgements

We would like to express our sincere gratitude to the contributing authors of this paper as well as to all the GISSA Ukubuzana 2012 reviewers who contributed their feedback on the original manuscripts.This work has been supported partially by the South Africa-Namibia Joint Technical Research Partnership Programme Bilateral Agreement, through the project "Modelling a national health spatial data infrastructure for Namibia".

References

[1] Australian and New Zealand Land Information Council (ANZLIC): "Discussion paper, Spatial Data Infrastructure for Australia and New Zealand, 1998. Retrieved from http://www.anzlic.org.au/anzdiscu.htm.

[2] Australian and New Zealand Land Information Council (ANZLIC): "National spatial data infrastructure for Australia and New Zealand, draft report presented at the Second Meeting of the Permanent Committee on GIS Infrastructure for Asia and the Pacific". Sydney, Australia, 1996.

[3] R. Béjar, M. Á. Latre, J. Nogueras-Iso, P. R. Muro-Medrano and F. J. Zarazaga-Soria: "An architectural style for spatial data infrastructures", *International Journal of Geographical Information Science*, Vol. 23 No. 3,pp. 271–294, Mar 2009.

[4] R. Béjar, M. Á. Latre, J. Nogueras-Iso, P. R. Muro-Medrano and F. J. Zarazaga-Soria: "An RM-ODP Enterprise View for Spatial Data Infrastructures", *Computer Standards & Interfaces*, Vol. 34, pp. 263-272, 2012.

[5] T.O. Chan, M. Feeney, A. Rajabifard and I. Williamson: "The Dynamic Nature of Spatial Data Infrastructures, A Method of Descriptive Classification", Department of Natural Resources and Environment, East Melbourne-Victoria 3002, Australia, n.d.

[6] D.J. Coleman and D. Nebert: "Defining global geospatial data infrastructure (GGDI), components, stakeholders and interfaces", *Geomatica, Canadian Institute of Geomatics*, Vol. 52 No.2, pp. 129-144,1998.

[7] A.K. Cooper, J. Hjelmager, A. Nielsen and P. Rapant: "Description of spatial data infrastructures (SDIs) using the Unified Modeling Language (UML)", *International Cartographic Association (ICA)*, 2003. Retrieved from http://researchspace.csir.co.za/dspace/handle/10204/1776

[8] A.K. Cooper, H. Moellering, J. Hjelmager, P. Rapant, D. Laurent, P. Abad and D. Danko: "Detailed services in a spatial data infrastructure from the computation viewpoint", *24th International Cartographic Conference (ICC)*, Santiago Chile, 15-21 November 2009. Retrieved from http://researchspace.csir.co.za/dspace/handle/10204/3822

[9] A.K. Cooper, H. Moellering, T. Delgado, U Düren, J Hjelmager, M Huet, P Rapant, A. Rajabifard, D. Laurent, A. Iwaniak, P. Abad and A. Martynenko: "An initial model of the computation viewpoint for a spatial data infrastructure", *23rd International Cartographic Conference*, 2007. Retrieved from http://researchspace.csir.co.za/dspace/handle/10204/1455

[10] A.K. Cooper, P. Rapant, J. Hjelmager, D. Laurent, A. Iwaniak, S. Coetzee, H. Moellering and Düren: "Extending the formal model of a spatial data infrastructure to include volunteered geographical information", *25th International Cartographic Conference (ICC)*, Paris, France, 4-8 July 2011. Retrieved from http://researchspace.csir.co.za/dspace/handle/10204/5212

[11] K. Fadaie: "Geographic Information and Geomatics, A Framework and Reference Model", *ISO/TC 211*, Canada Centre for Remote Sensing, Natural Resources Canada, n.d.

[12] Federal Geographic Data Committee (FGDC): "Introduction and guide, Book of Federal geographic data committee", Washington. 1997

[13] Y. Georgiadou, F. Harvey and G. Miscione: "A bigger picture, information systems and spatial data infrastructure research perspectives", *International Institute for Geo-Information Science and Earth Observation (ITC)*, Enschede, the Netherlands, n.d.

[14] Y. Georgiadou, L. Bernard and S. Sahay: "Implementation of spatial data infrastructures in transitional economies", *Information Technology for Development*, Vol. 12 No. 4, pp. 247-253, March 2010.

[15] J. Hjelmager, T. Delgado, H. Moellering, et al: "Developing a modelling for the spatial data infrastructure", Mapping approaches into a changing world, *22nd Cartographic Conference*, A Coruna, Spain, pp 9, 9-16 July 2005. Retrieved from http://researchspace.csir.co.za/dspace/handle/10204/1781

[16] J. Hjelmager, H. Moellering, T. Delgado, et al: "An initial formal model for spatial data infrastructures", *International Journal of Geographical Information Science*, Vol. 22 No. 11, pp. 1295–1309, 2008.

[17] International Organization for Standardization (ISO 19101): "Geographic information, Reference model", *International Organization for Standardization (ISO)*, Geneva, Switzerland, 2002.

[18] International Organization for Standardization (ISO 19115): "Geographic information, Metadata", *International Organization for Standardization (ISO)*, Geneva, Switzerland, 2003.

[19] International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) (ISO/IEC 10746-1): "Information technology, Open Distributed Processing – Reference Model Overview", *International Organization for Standardization (ISO)*, Geneva, Switzerland, 1998.

[20] International Organization for Standardization Technical Committee (ISO/TC 211): "Standards Guide, Geographic Information/Geomatics", 2009.

[21] I. Masser: "The first Generation of National Geographic Information Strategies", *Proceedings of the Third Global Spatial Data Infrastructure Conference*, Canberra, November 1998.

[22] National Planning Commission of Namibia: "Statistics Act, Act No 9 of 2011", *Government Notice*, No. 148, Windhoek, Namibia, 18 August 2011.

[23] National Planning Commission of Namibia: "Draft National Spatial Data Infrastructure Policy of Namibia", Windhoek, Namibia, 12 May 2011.

[24] Namibia Statistical Agency (NSA): "National Spatial Data Infrastructure Standards Schedule of Namibia", *Government Notice*, No. 2011, Windhoek, Namibia, August 2011.

[25] D.D. Nebert: "Developing spatial data infrastructures, the SDI Cookbook", 2004. Retrieved from http://www.gsdi.org/docs2004/Cookbook/cookbookV2.0.pdf.

[26] J. Nogueras-Iso, F.J Zarazaga-Soria and P.R. Muro-Medrano: "Geographic Information Metadata for Spatial Data Infrastructures", *Springer Berlin Heidelberg*, New York, 2005.

[27] G. Percivall: "OGC Reference Model, OpenGIS®, OGC™ OpenGeospatial™ and OpenLS ®", *Open Geospatial Consortium*, United States, 2003.

[28] A. Rajabifard and I. Williamson: "Spatial Data Infrastructures, Concept, SDI Hierarchy and Future Directions", *Spatial Data Infrastructure Research Group*, Department of Geomatics, University of Melbourne, Victoria 3010, Australia, n.d.

[29] K. Raymond: "Reference Model of Open Distributed Processing (RM-ODP), Introduction", *Centre for Information Technology Research*, University of Queensland, Brisbane 4072, Australia, n.d.

[30] J. Thompson, S. Eagleson, P. Ghadirian, and A. Rajabifard: "SDI for collaborative health services planning", *The Centre for Spatial Data Infrastructures and Land Administration*, University of Melbourne, Victoria 3010, Australia, n.d.

[31] A. Vallecillo: "RM-ODP, The ISO Reference Model for Open Distributed Processing", *ETSI Informática*, Universidad de Málaga, n.d.

[32] L. Haoses-Gorases: "Utilisation of Health Information System (HIS) in Namibia, Challenges and Opportunities Faced by the Health Care Delivery System/Health Sector", Faculty of Medical and Health Sciences, University of Namibia, Windhoek, Namibia, n.d.

[33] C.A. Davis and F.T. Fonseca: "National Spatial Data Infrastructure, the Case Study of Brazil", Information for Development Program, the International Bank for Reconstruction and Development / the World Bank, 1818 H Street NW, Washington DC 20433, December 2010.

Contact:
Kisco Sinvula, Centre for Geoinformation Science, University of Pretoria, P.O. Box 5027, Ausspannplatz, Windhoek, Namibia. Tel: +264 81 230-3664, E-mail: kisco_77@msn.com / ksinvula@gmail.com