SPATIAL ENABLEMENT IN A SMART WORLD

EDITORS DAVID COLEMAN, ABBAS RAJABIFARD & JOEP CROMPVOETS

GSDI ASSOCIATION PRESS

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EDITED BY

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David Coleman, Abbas Rajabifard and Joep Crompvoets (Editors)

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ISBN 978-0-9852444-5-3

Cover Designed By Samantha Harris-Wetherbee

Table of Contents

Foreword..I

Peer Review Board...III

About Editors...V

Chapter 1: Spatial Enablement in a Smart World...1

PART ONE : SDI Journey: Examples and Case Studies.................................13

Chapter 2: Convergence of Spatial Data Infrastructure and Data Revolution 15

Chapter 3: Blueprint for the STIG1.0 – setting the performance indicators... 29

Chapter 4: Open Spatial Data Infrastructures for the Sustainable Development of the Extractives Sector: Promises and Challenges................ 53

Chapter 5: Spatial Data Infrastructure in New Brunswick, Canada: Twenty Years on the Web.. 71

Chapter 6: Urban Analytics Data Infrastructure: Critical SDI for Urban Management in Australia.. 95

Chapter 7: The Theory versus the Reality of Alignment between EGov and SDI in Pakistan.. 111

Chapter 8: Democratization of Key Public Sector Information in Zimbabwe. The Road towards Open Information Access? 133

PART TWO : Spatial Enablement: Applications and Data Platforms............ 153

Chapter 9: The Impact of Spatial Enablement and Visualization on Business Enterprise Databases - What your data have been trying to tell you.......... 155

Chapter 10: Smart Disaster Communities: Building a Global Disaster Management Platform.. 173

Chapter 11: Application of the Remote Sensing and Geo-spatial Technology in Terrain Analysis and Terrain Classification in Context of Creation of SDI for Marine & Coastal Regions 191

Chapter 12: Urban Real Property Loss Relief in the Scope of Disaster Governance 213

Chapter 13: Assessing the quality of building footprints on OpenStreetMap: a case study in Taiwan 237

Chapter 14: Applying Geographic Names Information Service in High School Education of Taiwan.. 257

Foreword

This book is the result of a collaborative initiative between the Global Spatial Data Infrastructure Association (GSDI), the University of New Brunswick, the Centre for SDIs and Land Administration (CSDILA) in the Department of Infrastructure Engineering at the University of Melbourne and University of Luven. The articles featured in this peer-reviewed book were mostly the result of the traditional Call for Papers for the GSDI Geospatial World Conference Spatial Enablement in Smart Homeland, including three main topics of Smart Disaster Prevention, Smart Transportation and Smart City, but also contains contributions of full articles which were solicited for publication in this book.

The authors and reviewers were advised of the theme in advance and, in most cases, they addressed this theme in their papers. Even in cases where the theme was not directly referenced, the article reflected the impact and application of spatial data infrastructures that are now being developed worldwide. The peer-review process resulted in 14 chapters that when considered together, reflect how SDIs are enabling us all today, particularly in delivering spatial enablement in a smart world.

We thank the authors of the chapters and the members of the Peer Review Board. We are grateful to the GSDI Association Press for its willingness to publish this work under a Creative Common Attribution 3.0 License. It allows all to use the experiences and research presented in this book to their own best advantage. We would like to thank Mr Yashar Asadi for his editorial assistance in preparation of this publication, as well as Ms Samantha Harris-Wetherbee for the design of the cover.

David Coleman, Abbas Rajabifard and Joep Crompvoets (Editors)
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About Editors

David Coleman (Ph.D., P.Eng., FCAE, FRCGS is a Professor of Geomatics Engineering at the University of New Brunswick and President of the Global Spatial Data Infrastructure Association. Prior to obtaining his PhD, he spent 15 years in the Canadian geomatics industry as a project surveyor and engineer, then an executive with one of Canada's largest digital mapping firms, and later as a partner in a land information management consulting firm. The former Dean of UNB's Faculty of Engineering and Chair of its Department of Geodesy and Geomatics Engineering, David has authored over 150 publications and reports dealing with land information policy development, geomatics operations management, geographic information standards and spatial data infrastructure. He is currently a Fellow of both the Canadian Academy of Engineering and the Royal Canadian Geographical Society. In the past, he has served as President of the Canadian Institute of Geomatics, Canadian delegate to FIG Commission 3, a member of the GEOIDE Research Network Board of Directors, a member of the Mapping Sciences Committee of the U.S. National Academy of Sciences, and a member of advisory boards to public and private organizations in Canada and Australia.

Abbas Rajabifard FIEAust, FSSSI, MISAust. is a Professor of Geomatics Engineering and Director of the Centre for Spatial Data Infrastructures and Land Administration, and Head of the Department of Infrastructure Engineering, at the University of Melbourne. He is Chair of the UN Global Geospatial Information Management Academic Network, and Past-President of Global Spatial Data Infrastructure (GSDI) Association. He was Vice Chair, Spatially Enabled Government Working Group of the Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific (UN-GGIM-AP). He has spent his career researching, developing, applying and teaching spatial information management and strategies particularly for SDI and land administration to deliver benefits to both governments and wider society and is acknowledged as one of the pioneers in the concept of spatial enablement – using location to facilitate decision making.

Joep Crompvoets Joep Crompvoets is an associate professor at KU Leuven Public Governance Institute (Belgium) and secretary-general of EuroSDR - a European spatial data research network linking national mapping agencies with research institutes and universities for the purpose of applied research. He has been involved in several (inter)national project related to the development of Spatial Data Infrastructures (SDIs) around the world. He has written numerous publications dealing with SDIs, GIS, and e-governance.

Chapter 1: Spatial Enablement in a Smart World

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Abstract

The notion of spatial enablement is implicit in the importance of "location" to the development of the "smart cities" and/or "smart communities" concepts. In line with this, the theme of the GSDI 15 Conference organized and conducted by the Global Spatial Data Infrastructure Association (GSDI) in 2016 is "Spatial Enablement in Smart Homeland". Focusing on what is already in place gives us the opportunity to examine how far we have come with respect to spatially enabling "smart city" and "smart country" initiatives worldwide – as well as how much still needs to be done. With this in mind, this book is a compilation of 14 articles from the above-mentioned conference as book chapters presented in two parts, each focusing on different aspects the application of spatial data or spatial technologies to deliver Spatial Enablement in a Smart World. The chapters are written by authors in twelve different countries on five continents, describe a combination of new developments and lessons learned in this journey. All chapters have gone through a full peer review process as part of the conference in 2016.

The Global Spatial Data Infrastructure Association (GSDI) is an inclusive organization of civil society organizations, government agencies, academic and research institutions, and private companies from around the world promoting international cooperation and collaboration in support of local, national and international spatial data infrastructure developments. Its members envision a world where everyone can readily discover, access and apply geographic information to improve their daily lives. Working on issues at the intersection of technological, legal, and socio-economic concerns, the GSDI Association has attracted and applied the expertise and influence of leaders, practitioners and researchers in the fields of mapping an`d geospatial information management since the first GSDI Conference was held in Bonn, Germany in 1996. The Association's mission is to advance geo-information best practices, knowledge

sharing, and capacity building for the improved sharing and application of geographic information.

Before introducing those chapters, let's start by briefly reviewing the roots of "spatial enablement" and its contributions to the concept of "smart" cities, states and other jurisdictions.

1. Background

What is meant by the term "spatial enablement"? How is something "spatially enabled"? Building from an understanding of spatial data infrastructures, Williamson et al (2006) suggested the vision of a spatially enabled government involves …"establishing an enabling infrastructure to facilitate use of place or location to organize information about activities of people and businesses, and about government actions, decisions and polices. The authors believed that, once such an infrastructure is in place, spatial enablement would "…allow government information and services, business transactions and community activities to be linked to places or locations" (ibid).

Rajabifard (2007) introduced the idea of spatial enablement of society, arguing that the creation of economic wealth, social stability and environmental protection could be achieved through developing products and services *based on spatial information* collected by all levels of government. These objectives can be facilitated by cultivating an environment in which "…spatial information is regarded as a common good made available to citizens and businesses to encourage creativity and product development". It was further argued that this would require data to be accessible, accurate, regularly maintained and sufficiently reliable for use by the majority of society who are not spatially aware – as well as some form of "assessment mechanism" and a set of agreed indicators to measure the progress of its development and delivery of its services. Rajabifard et al. (2010) expanded on the notion of a "spatially enabled society" as being the result of a transformative process in which spatial information technologies and spatially equipped citizens change the way economies, people, and environments are managed and organized.

Holland et al. (2010) tied down the meaning of spatial enablement in government (SEG) by posing that to "spatially enable" something usually means: (1) geographically tagging records in a given government database; and (2) the provision and ongoing support of an enabling spatial data infrastructure that allows government to readily make decisions that take account of 'location'. More recently, Conti et al. (2011) offered technical and design considerations which extended the concept of spatial enablement to "spatio-temporal enablement" of the Internet – suggesting an evolution from a paradigm based on the "Internet of Objects" to a new, *spatio-temporally capable*, "Internet of Places", made of "…natively spatio-temporally contextualized web-services".

This notion of spatial enablement is implicit in the importance of “location” to the development of the “smart cities” and/or “smart communities” concepts. Clearly, many different definitions of the term “smart city” exist, and it is acknowledged that that it may have evolved from earlier terms like “Wired City”. No one commonly-accepted definition fits all contexts.

That said, Albino et al. (2015) offer an excellent discussion of the history of the term “Smart City”. The term was first used in the 1990s (Mahizhnan, 1999) with a clear focus on the significance of new ICT with regard to modern infrastructures within cities. The California Institute for Smart Communities was among the first to focus on how communities could become “smart” and how a city could be designed to implement information technologies (Alawadhi et al., 2012).

Significant corporate investment and developments aimed at realizing this concept took place in 2005 when, through the Clinton Foundation, former US President Bill Clinton challenged US-based Cisco Systems to use its technical expertise to make cities more sustainable (Information Age, 2012). In response, through its Connected Urban Development program, Cisco dedicated $25 million over five years to research the topic. Beginning in 2010, through its new Smart and Connected Communities division, Cisco began commercializing the new products and services it had developed through pilot projects conducted with 3 major cities worldwide. Similarly, beginning in 2009, IBM began its “Smarter Cities” program to investigate the integration and application of new sensor, networking and analytics technologies with a specific focus on problems experienced in urban centers.

Why the interest? As of 2015, approximately 54% of the world population lives in cities, with hundreds of thousands of new people arriving and new dwellings being built every day (UN 2014). By 2050, the United Nations expects that 6 billion people – over 66% of the world’s population -- will be living in cities. Cities already account for 75% of total energy consumed and 80% of CO_2 emissions. As the world continues to urbanize, sustainable development challenges will be increasingly concentrated in cities, particularly in the lower-middle-income countries where the pace of urbanization is fastest (UN 2014). Consequently, there is considerable interest in developing technologies, processes, and indeed even cultures that address these challenges in an equitable, sustainable and “smarter” manner.

Deakin and Waer (2011) listed four factors that contribute to modern definitions of a smart city:

1. The application of a wide range of electronic and digital technologies to communities and cities;

2. The use of information and communications technologies (or “ICTs”) to transform life and working environments within the region;

3. The embedding of such ICTs in government systems; and

4. The territorialisation of practices that brings ICTs and people together to enhance the innovation and knowledge that they offer.

Musa (2016) suggests that the goal of building a smart city is "… to improve the quality of life by using technology to improve the efficiency of services and meet residents' needs". He proposes that a smart city engages its citizens and connects its infrastructure electronically, and that it would also possess the ability to securely integrate multiple technological solutions in order to manage such city assets as (e.g.,) local information systems, schools, libraries, transportation systems, hospitals, power plants, law enforcement, and other community services.

Roche et al. (2012) attempt to bring together within a shared framework the concepts of "spatial enablement" and "smart cities". After rightly pointing out that they are related concepts developed by academics and practitioners in different fields, the authors offer examples of spatially-enabled technologies that will support the goals of smart city programs. To the same end, Batty et al. (2012) identify spatial and temporal aspects of planning, analyses and services that will be essential components of any set of goals and research challenges targeted towards smart city developments. Finally, Daniel and Doran (2013) offers an excellent overview of the use of geospatial technologies opportunities in support of Smart Cities initiatives and objectives.

Roche (2014) takes this a step further by proposing that a smart city needs to be spatially enabled and, to accomplish this, must accomplish three things, including: (1) spatial literacy of citizens; (2) an environment conducive to open and shared spatial data; and (3) a technological environment based on globally unified geospatial standards. This brings us back to the mission and values associated with spatial data infrastructure developments around the world – linking together the three concepts of "spatial enablement", "smart cities", and "spatial data infrastructure" in a Smart World

2. Book Outline

This book is a compilation of 14 articles as book chapters presented in two parts each focusing on different aspects of the application of spatial data or spatial technologies to deliver Spatial Enablement in a Smart World. In particular, Part One-focuses on SDI Journey and provides examples and case studies, and Part Two- on Spatial Enablement: applications and data platforms. The chapters presented in both parts have gone through a full peer review process as part of the GSDI 15 World Conference in 2016.

This Chapter 1 is an introductory chapter by the book editors to provide a scene and a context for the book.

Then Part One, SDI Journey- examples and case studies, includes 8 chapters. Chapter 2, on the *Convergence of Spatial Data Infrastructure and Data*

Revolution by Chukwudozie Ezigbalike, Peter Kinyua Njagi, Léandre Ngogang Wandji, and Zacharia Chiliswa, discusses the data revolution as envisaged a (new) partnership involving governments, civil society, development partners and, most importantly, citizens. The authors argue that these partnership and inclusive aspects are already at the core of spatial data infrastructures and has referred that to the Sustainable Development Goals (SDGs), in which context the data revolution was introduced, on disaggregation of data on several topics, but especially (gender and) geography, makes geospatial data indispensable for the data revolution. However, there are challenges with existing structure and system on how to explore and embrace the concepts, practices and the outcomes. They explore SDI, and draw attention to the lessons that the data revolution community should learn from SDI community.

Chapter 3 by Nushi, Bastiaan van Loenen, and Joep Crompvoets then talk on a Blueprint for setting the performance indicators. The chapter starts by discussing how SDI practitioners require user friendly SDI assessment tools to assess the performance of their SDI and provides the next step of the development of such user-friendly assessment tool. The authors define the core SDI Principles based on the Basel Core Principles used to assess financial infrastructures. Additionally, a set of essential and additional assessment criteria for each Core SDI Principle is defined. As such the skeleton of the stress test Stress Test for Infrastructure of Geographic information (STIG) is created. Research challenges remain in modeling the interaction of different risk factors and their impacts. These include: integrating stress testing at different levels and making stress tests workable, realistic and timely remain complicated. These issues will be addressed in the research further developing the Stress Test for Infrastructure of Geographic information: the STIG.

Chapter 4 is on *Open SDI for the Sustainable Development of the Extractives Sector: Promises and Challenges* by Nicolas Ray, Pierre Lacroix, Gregory Giuliani, Pauliina Upla, Abbas Rajabifard, and David Jensen. This chapter starts by discussing how many countries will rely on the extractive sector to generate the inputs and revenues necessary to advance progress towards the Sustainable Development Goals (SDGs). The authors argue that -- while the last decade has seen a strong push for financial transparency in the extractive sector -- it is becoming equally necessary to also include the social and environmental performance of the extractive industries across the entire value chain. However, to maximize the value of this broad range of data for improved stakeholder dialogue and decision making, a geospatial approach is needed for effective data integration, management, analysis, and monitoring. This requires capacity building to extractive companies and to the various transparency initiatives to ensure that reporting and disclosure data is spatially enabled as well as interoperable, open, quality controlled and published to a spatial data infrastructure (SDI) that is publically accessible. Ideally, this SDI can then inform and benefit many stakeholder dialogues, support reforms in natural resource governance, promote more equitable benefit-sharing, and enhance the performance of monitoring of the sector at the concession level. With this background, the authors discuss the benefits and challenges of SDIs in the extractive sector. This is done using the experience gained by the authors in the design and implementation of a new Open Data Platform for the Extractive Sector called MAP-X (Mapping and Assessing the Performance of eXtractive Industries) in the Democratic Republic of Congo.

Chapter 5 shares 20 years' experience of an SDI journey in New Brunswick, Canada. The chapter is by David Finley, David Coleman and Andrew MacNeil. The chapter starts with a short history on the SDI development in the Province of New Brunswick, which became the first jurisdiction in the world to offer World Wide Web-based access to complete and integrated online property mapping, ownership and assessment information covering an entire province or state. Service New Brunswick's Real Property Information Internet Server (RPIIS) was originally developed by Caris/Universal Systems Ltd. (Caris) in conjunction with the University of New Brunswick Department of Geodesy and Geomatics Engineering and with substantial input from Service New Brunswick (SNB) staff. The Caris Internet Server technology on which it was based was recognized, at the time, to be "…the first commercial Internet/mapping GIS" platform.

The chapter examines the twenty-year evolution of land information infrastructure refinement in New Brunswick since that time, beginning with the early vision of linking land information with environmental and resource-based information to support improved decision-making. Since 1996, policy and operational issues encountered by SNB included ones related to charging for data, use of geospatial data in eGovernment and eGovernance, data custodianship and incremental updating, involvement of the private sector, and the contrasting "push-pull" between open data initiatives and personal data privacy concerns – issues also faced by other jurisdictions across North America, Europe and Australasia over the same period.

After discussing early initiatives, challenges and issues mentioned above, the paper then tracks and analyzes the changes in Web-based services offered since 1996 in response to a widening and more sophisticated customer base, shifts in government/business relationships, and changes in technologies for data collection, management and communication. The chapter concludes with a discussion of current key information initiatives of SNB and how they pertain to the fulfillment of the original vision.

Chapter 6 is on *Urban Analytics Data Infrastructure: Critical SDI for Urban Management in Australia* by Abbas Rajabifard, Serene Ho and Soheil Sabri. The chapter describes a new research initiative funded by the Australian Research Council that will see the development of an SDI to support urban analytics and urban research capabilities focused on Australian cities. This is a timely development for Australia, which is not only one of the most urbanized countries in the world, but is also witnessing high levels of growth rates in its urban areas uncommon in western developed countries. The Urban Analytics Data Infrastructure (UADI) intends to support multi-disciplinary, cross-jurisdiction, national-level analytics and through the design of its architecture, seeks to provide the urban research community with a digital infrastructure that responds to current challenges related to data access, sharing and application. Importantly, the UADI will build on significant existing urban research infrastructure, specifically the Australian Urban Research Information Network and its nationally federated Data Hubs. This is both critical and core SDI development for Australia, and will advance governments, industry and academia in undertaking more advanced data-driven modelling to support sustainable development in Australia’s cities.

Chapter 7 *The Theory versus the Reality of Alignment between EGov and SDI in Pakistan* by Walter de Vries and Asmat Ali. The authors will talk on a common notion that the governance and performance of SDIs and Electronic Government (eGov) are closely interlinked. However, in practice this notion does not hold. The authors test why this is so using the empirical context of a developing country -- Pakistan. The main question is thus to which extent eGov and SDI implementation strategies reinforce or obstruct each other. The present research makes use of congruency theory. The conclusion is that, whilst many of the objectives of eGov and SDI in Pakistan are similar, in the process of implementation they are currently insufficiently reinforcing each other. One of the main reasons is that, unlike the eGov projects, the SDI objectives and policies are insufficiently embedded in public awareness campaigns and implementation by multiple public sector organizations. This affects public legitimacy.

Chapter 8 is on *Democratization of Key Public Sector Information in Zimbabwe. The Road towards Open Information Access?"* by Edward Kurwakumire, Sydney Togarepi and Tarirai Masarira. The chapter evaluates spatial data access and key public sector information. E-government is assessed to analyze access of key government services by the public. A move towards improving access to PSI is one stride towards open government in Zimbabwe. This study borrows concepts from the fields of Public Administration, E-government and Spatial Data Infrastructures. The world is building towards knowledge economies in which openness is terms in information and knowledge while good and informed governance is crucial. Public participation should be encouraged in planning and governance issues and in the creation of community based spatial data sets.

Part Two, Spatial Enablement: applications and data platforms, comprises of 6 chapters starting with Chapter 9 on *The Impact of Spatial Enablement and Visualisation on Business Enterprise Databases - What your data have been trying to tell you"* by Yiqun Chen, Abbas Rajabifard, Geoff Spring, Judy Gouldbourn, Gerald Griffin and David Williams. The chapter discusses business enterprises that have been gathering data as part of their “business as usual” operations. The evolution of the digital era has both enhanced this capability and increased the rate at which data is collected at unprecedented levels. The parallel evolution of spatially enabled data, data analytics and the visualization of data presents opportunities to analyze spatio-temporal databases to a degree never before available. The authors argue that this ability provides the opportunity to incorporate the results of this analysis into corporate planning processes, policy and strategy development and risk identification and mitigation. However, this new capability may also address the issues and the deficiencies in historically utilized databases which have led to poor decision making and setting of policy and strategy that has unknowingly limited business performance, misdirected capital investment and impacted resource utilization. By understanding the concept of “concurrency” in database visualization via a spatially enabled decision support tool developed by the Centre for Disaster Management and Public Safety (CDMPS), the University of Melbourne. A special case study is performed to analyze historic incidents and explore response capacities across Victoria (Australia). A snapshot of emergency management data has been subjected to data cleaning, aggregation and harmonization processes to support our proposed analysis methodology. The output identifies key components such as demands and supplies. Each of these components can be investigated at various temporal granularity levels such as daily, monthly and yearly. Besides statistics, the developed tool can also interactively manipulate the results on a 4D visualization engine by using dynamic demand-supply heat maps and spider webs that precisely describe the concurrent characteristics. The developed system helps decision makers better understand when and where demands are triggered and how supplies are distributed in busy seasons and eventually identify research priority needs to enhance their workforce planning capability.

Chapter 10 is again on disaster management, with the topic on *Smart Disaster Communities: Building a Global Disaster Management Platform,* by Katie Elizabeth Potts and Abbas Rajabifard. This chapter aims to present the construction of the Global Disaster Management Platform called GDMP. It first investigates the idea of sharing and collaboration in the field of disaster management, and following that then examines the different stakeholders present. The requirements of a GDMP as suggested by the literature are then explored. The results of a case study into existing disaster management systems and platforms across the Asia-Pacific are then presented and discussed to identify gaps and requirements for a successful global approach to collaborative disaster management. A framework based around the GDMP concept is then developed and discussed before conclusions are drawn.

Chapter 11 is on application of the *Remote Sensing and Geo-spatial Technology in Terrain Analysis and Terrain Classification in Context of Creation of SDI for Marine & Coastal Regions*, by Sarbani Saha, Pravin Kunte and Mahender Kotha. The main objective of the chapter is to understand the topographic features which is the most important part of terrain analysis and for that develop the application of the available geospatial tools for the creation of datasets, which are building blocks of any SDI. The surface analysis of South-Western part of India and Benthic Terrain Analysis of Eastern Arabian Sea is carried out using the NASA Shuttle Radar Topographic Mission (SRTM) data and Geospatial tools to understand the terrain characteristics.

From here, then, Chapter 12 by Zhixuan Yang and Abbas Rajabifard on *Urban Real Property Loss Relief in the Scope of Disaster Governance* describes the importance of urban real property loss relief based on SDI platform. The authors analyze the difference between the loss relief management and loss relief governance and suggest a holistic urban real property loss relief system within the scope of disaster governance. They then propose that the loss relief process should go backward to urban planning phase and cover the whole process of urban development, involving pre-disaster, mid-disaster, and post-disaster phases. At the end, the chapter summarizes the urban real property loss relief system in China as an example and points out the current weakness and future research focuses.

Chapter 13 is on *assessing the quality of building footprints on OpenStreetMap: a case study in Taiwan* by Kuo-Chih Hung, Mohsen Kalantari and Abbas Rajabifard. In this chapter, the authors describe how collaborative mapping platforms such as OpenStreetMap (OSM) have become important sources of geodata and potentially complementary with any SDI initiatives. However, as volunteered geodata were generated by people with varying skill levels, quality issues such as missing details and incomplete content are inevitable with this approach. The authors then frame both the weakness and potential of OSM building footprints using three criteria: completeness, topological errors, and geometric accuracy. Case study areas were set in two major metropolitan areas of Taiwan, Taipei City and Taichung City. The authors compared OSM quality with a reference dataset from authority. The completeness assessment was computed at different scales by unit-based and object-based methods. They found the object-based method more appropriate for assessing the data. This shows OSM has a great potential for field use, particularly in a scenario of disaster management. OSM can be a better source for a large-scale SDI platform and help to enable a resilient and prepared.

The final chapter is on *Applying Geographic Names Information Service in High School Education of Taiwan* by Jinn-Guey Lay, Chang-An Chen and Chia-Jung Wu. The chapter starts with discussion of geographic names which are a reflection of what people think of a particular place, including its surrounding environment, community, culture, and histories. As geographic names carry abundant spatial and historical meanings, the study of geographic names may help to understand the characteristics and development of a place. In order to better manage the geographic names in Taiwan, the Ministry of the Interior (MOI) has created a comprehensive geographic names database and established a Geographic Names Information Service (GNIS) website. The chapter explores the potential of using this website for school education purposes. Specifically, the authors developed 10 teaching modules that can be used for high school classes and organized a series of workshops for high school teachers. The analysis discusses how these teaching modules and workshops were designed and the results of their applications. The authors conclude that geographic names would significantly help to develop the sense of places and strengthen the spatial thinking of students, which are important concepts and skills in geographic teaching.

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PART ONE

SDI Journey: Examples and Case Studies

Chapter 2: Convergence of Spatial Data Infrastructure and Data Revolution

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Abstract

The data revolution envisaged a (new) partnership involving governments, civil society, development partners and, most importantly, citizens.

These partnership and inclusive aspects are already at the core of spatial data infrastructures. The emphasis of the Sustainable Development Goals (SDGs), in which context the data revolution was introduced, on disaggregation of data on several topics, but especially (gender and) geography, makes geospatial data indispensable for the data revolution. However, there are challenges with existing structure and system on how to explore and embrace the concepts, practices and the outcomes.

Starting with a review of data revolution concepts, this chapter explores spatial data infrastructures(SDI), then draws attention to the lessons that the data revolution community should learn from SDI community.

Keywords: Sustainable Development Goals, Spatial Data Infrastructure, SDI Custodianship Principles, data revolution, data communities, data ecosystems.

1. Introduction

The 2015 International Telecommunication Union (ITU) report estimates that there are 3.2 billion people globally using Internet and more than 7 billion mobile cellular subscriptions (ITU, 2015). The McKinsey Global Institute (MGI) report puts the number of people with cross-border social media connections at over 900 million, with another 361 million conducting cross-border e-commerce (MGI, 2016). The EMC Corporation forecasts that by 2020, the phenomenal digitization of global society will create and copy 44 zettabytes or 44 trillion gigabytes of data of data annually (Turner, 2014). In addition, Cisco predicts a growth of 30.6 exabytes per month from mobile data traffic by 2020 (Cisco,2016)

These developments have ushered the 21st century into a world of digitized data, created, stored, and most importantly shared across many platforms (Friedman, 2001). What implications would they have on how regional and global organizations, states and nations manage their information, knowledge, data, and statistics? Traditionally, the process of generating and packaging of data and statistics for decision-making has been, and is still, costly and time-consuming (Kitchin, 2014) for individuals, institutions, and states. The unprecedented advancement in technologies associated with data and statistics not only challenge existing structures and processes of managing data and statistics, but also paradigms underpinning the world of knowledge production and application in decision-making.

The convergence of critical sectors of society on the digitizing and globalizing technologies would mean that these platforms are no longer exclusive domains, but easily accessible to new actors. For instance, with over 7 billion mobile devices connected to multiple networks globally, it means that massive data and information from remote parts of the world can now be accessed by a greater number of people and devices than before. However, the Secretary General's High Level Panel of Eminent Persons on the Post-2015 Development Agenda (HLP-P2015) found that these advances "remain largely disconnected from the traditional statistics community at both global and national levels" (United Nations, 2013) and called for a data revolution. In interpreting the data revolution concept for Africa, participants at a High Level Conference on Data Revolution introduced the concept of data communities, as a way to involve a wide spectrum of stakeholders in the production and management of development data. This chapter argues that this concept has parallels in the work of the Spatial Data Infrastructure community. Therefore, in developing data communites, it is recommended that lessons should be drawn from the work of the SDI community, particularly the custodianship arrangements for spatial data.

2. Data Revolution Concepts

2.1 Data-Driven Societies

As many people from across the world get connected to new technologies of information and communication, digital records of their interactions and transactions are becoming vital sources of ideas and understanding about the society they inhabit (Pentland, 2013). Pentland describes data-driven societies as those that use data to study and/or understand the patterns of social interactions, individual choices, such as, purchase trends, the places they visit, and dietary or even political decisions for the purposes of public planning and decision-making. Along the same lines, Schmidt (2012) had pointed out that harnessing the powers of the social media could improve public planning and decision-making in sectors such as public health. The World Bank (2012) in the report *'Inclusive Green Growth: The Pathway to Sustainable Development'* states that harnessing new technologies could be used to increase input efficiency, such as in irrigation water management, where advances in the use of remote sensing technologies permit estimation of crop evapo-transpiration on farmers' fields and facilitate improvement of water accounting at the regional and basin-wide levels. However, as Schmidt (2012) argues, because these platforms are not integrated into the official baseline data, such as the landholding and health records, changes in the individual user patterns cannot be detected. This is in line with the finding of the HLP-P2015 that too often, development efforts have been hampered by a lack of the most basic data about the social and economic circumstances in which people live. The Panel therefore called for a data revolution.

2.2 The Call for a Data Revolution

Pentland (2013) suggests that since digital records that ICT-enabled individuals and groups leave behind tell a more accurate story of one's life than things they choose to reveal about themselves, the stage is set for the inevitable transformation of the way societies transact businesses, and make data-related decisions. However, he asserts that most public systems such as cities and governments still operate on principles developed centuries ago. This assertion is in line with the findings of the HLP-P2015 that even though there has been a revolution in information technology providing an opportunity to strengthen data and statistics for accountability and decision-making purposes, such initiatives remain largely disconnected from the traditional statistics community at both global and national levels (United Nations, 2013). Therefore, HLP-P2015 called for a data revolution for sustainable development, with a new international initiative to improve the quality of statistics and information available to people and governments. This data revolution "would draw on existing and new sources of data to fully integrate statistics into decision making, promote open access to, and use of, data and ensure increased support for statistical systems."

The Data Revolution Group – the Secretary General's Independent Expert Advisory Group on Data Revolution for a Sustainable Development (IEAG) – argues that the integration of new data with traditional data would produce high-quality information that is more detailed, timely and relevant for many purposes and users, especially to foster and monitor sustainable development. This will lead to more empowered people, better policies, decisions and greater participation and accountability, and ultimately to better outcomes for people and the planet (IEAG, 2014). This is an expansion on the call by HLP-P2015, highlighting the importance of integrated action on social, environmental, and economic challenges, with a focus on inclusion and participatory development that leaves no one behind for the realization of the Sustainable Development Goals (SDGs) (IEAG, 2014). For this to happen IEAG further recommends for significant increase in the data and information that are available to individuals, governments, civil society, companies and international organizations to plan, monitor and be held accountable for their action (IEAG, 2014). The integrated approach to the realization of SDGs, underpins the importance of data disaggregation, without which it is difficult to ensure effective tracking of progress and evidence-based decisions, for both governments and other development agencies. Therefore, a true data revolution happens when there are empowered people, better policies, decisions, and greater participation accountability leading to better results for people and ecology.

2.3 Definition of Data Revolution

In describing the data revolution IEAG, in the report, *A World that Counts,* describes the data revolution as:

> An explosion in the volume of data, the speed with which data are produced, the number of producers of data, the dissemination of data, and the range of things on which there is data, coming from new technologies such as mobile phones and the "internet of things", and from other sources, such as qualitative data, citizen-generated data and perceptions data.
> A growing demand for data from all parts of society.
> (IEAG, 2014)

The report provides a more detailed description for data revolution for sustainable development as:

> The integration of these new data with traditional data to produce high-quality information that is more detailed, timely and relevant for many purposes and users, especially to foster and monitor sustainable development;
> The increase in the usefulness of data through a much greater degree of openness and transparency, avoiding invasion of privacy and abuse of human rights from misuse of data on individuals and groups, and minimising inequality in production, access to and use of data;
> Ultimately, more empowered people, better policies, better decisions and greater participation and accountability, leading to better outcomes for people and the planet.

A more concise definition of data revolution was developed by a High Level Conference (HLC) on Data Revolution. The conference, which was organized in March 2015 as a side event of the eighth AU-ECA Joint Conference of Ministers, in Addis Ababa, Ethiopia, was requested by the seventh AU-ECA Joint Conference of Ministers of Economy that was held in March 2014 in Abuja. The main output of the HLC was an *Africa Data Consensus (ADC)* in which the data revolution was defined, in the African context, as:

> The process of embracing a wide range of data communities and diverse range of data sources, tools, and innovative technologies, to provide disaggregated data for decision-making, service delivery and citizen engagement; and information for Africa to own its narrative.
> (Economic Commission for Africa, 2015)

The definition was necessitated by the view that an action-oriented definition is more suited to the African context that one based on situations that might not exist in Africa.

2.4 Data Communities

A key concept of this definition is that of data communities. The implementation of sustainable development as proposed by the United Nations 2030 Agenda and Africa's Agenda 2063, as well as other national agenda, requires data on more topics than ever before. However, National statistical offices (NSOs) are already overwhelmed with producing timely, reliable and relevant statistics on everything from making investment decisions to gaining intelligence about business opportunities (Lopes, 2016). Therefore, the new data required by different agendas cannot all be effectively collected only by national statistical offices. It has already been established that there are new data sources that can complement existing ones and help statisticians to improve quality, efficiency and timeliness of statistical products. Therefore, new arrangements are needed to harness the additional data needed in the new development paradigm. The Africa Data Consensus (ADC) proposes using "credentialed data communities" for collecting the additional data.

The ADC defines a data community as:

> A group of people who share a social, economic or professional interest across the entire data value chain-spanning production, management, dissemination, archiving and use.
> (Economic Commission for Africa, 2015)

As an example, take Target 2.3 of the UN 2030 Agenda:

> By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through **secure and equal access to land**, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment (emphasis added). (United Nations, 2015)

One of the measures proposed for meeting this target is through "equal and secure access to land." The information needed to meet that requirement would include:

- data for the identification of land parcels or units of holding and/or use;
- interests and rights recognized in land in the jurisdiction;
- current holders of the interests;
- land capability and potential;
- Current uses, taxes and charges assessed, etc.

Such datasets are currently not collected as part of official statistics, and to include them in any of the current statistical surveys would be both expensive and unwieldy. They would be best collected and managed by land professionals who understand the relevant concepts associated with land management, are in the position to collect the data in the course of normal work, Also, because they would need the data in the course of their work, would have the strongest incentives to keep them updated. The best arrangement to serve the society is therefore to constitute them into a "land data community" and give them the mandate to collect and maintain that component of development data. This is the "credentialed data community" proposed by the ADC.

The exact data communities to be established will be jurisdiction dependent. For example, a coastal country would need a data community that deals with marine data and associated economic and social attributes; while it will not be relevant in a landlocked country. The data communities would be dictated by the circumstances of particular countries. But there are common ones that should be available in all countries.

The data revolution envisages an expansion of the national data ecosystem beyond the traditional national statistical systems. The ADC defines the data ecosystem as multiple data communities, all types of data (old and new), institutions, laws and policy frameworks, and innovative technologies and tools, interacting to achieve the data revolution. Obviously, there will be a need for a dedicated and strong coordination function for the arrangement to work. The role of the coordination function would include:

- defining and ensuring the quality of data and compliance with adopted standards within the ecosystem;
- defining the roles and interactions between different actors;
- ensuring continuous capacity building;
- overseeing the financing arrangements for the data revolution; and
- arranging for updating of legal frameworks and for partnerships.

It is expected that this coordination role would be provided by the National Statistical Office at country level. However, the role needs to be clearly defined, and lessons can be learned from the work of the spatial data information community.

3. Spatial data infrastructures

3.1 Key concepts

The term Spatial Data Infrastructure (SDI) is a framework of technologies, policies, and institutional arrangements that together facilitate the creation, exchange, and use of geospatial data and related information resources across an information-sharing community (Kumar and Shekhar, 2014). Such a framework can be implemented narrowly to enable the sharing of geospatial information within an organization or more broadly for use at a national, regional, or global level.

In all cases, an SDI provides an institutionally sanctioned, automated means for, discovering, evaluating, and exchanging geospatial information by participating information producers and users. SDI extends a GIS by ensuring geospatial data and standards are used to create authoritative datasets and polices that support it (ESRI, 2010). SDI is fundamentally about facilitating and coordinating the exchange and sharing of spatial data between stakeholders in the spatial community.

From the Global to the local level, the generic components of an SDI are quite similar. They enable different users to access, locate and retrieve information in an easy and secure way. In general, the fundamental components include:

- Metadata – for the documentation of data, services and other geospatial resources within an organization.
- Clearinghouse – a network applications (now predominantly Internet based) that uses the metadata records to search and discover data across the network.
- Access Infrastructure and services that enable access to the actual data sets.
- Human resource and partnership – training, development and outreach.
- Standards – these include the specifications and formal standards and documented practices, which could include cataloguing and web services standards.
- Data sets – any data that has spatial component such as digital base map, thematic and statistical names.
- Others include policies for acquisition, ownership, pricing, access, sharing, dissemination, custodianship, preservation, governance.

The concept of data communities has been introduced as an effective way of bringing in data from new sources into an expanded data ecosystem. The SDI concept of custodianships offer an approach to organize the data communities.

3.2 Custodianship

A custodian of a dataset, or a component of that dataset, is an agency or other organization having the responsibility to ensure that a dataset is collected and maintained according to specifications and priorities determined through consultation with the user community, and made available to the community under conditions and in a format that conform with standards and policies established for the national SDI (ANZLIC, 2014). The custodianship principle facilitates the proper management of data to make them more accessible. It also eliminates duplication because there is a specific custodian for each dataset at the National level.

In implementing custodianships, synergies must be created at the National level - a proper framework must be in place and each data set assigned to a specific organization for custodianship. That way, key benefits such as accountability and integration of spatial data sets are maintained. Certain rights and responsibilities must be clearly articulated and granted to the custodian on behalf of the community. Key principles must be followed at all levels of custodianship if all the benefits have to be reaped. Such key principles include: setting up of key standards that must be followed; acting as trustees of data for the community; establishing plans for collection, conversion and maintenance of data; acting as the authoritative source of data; maintaining integrity of the data; ensure they have business requirement for which they are collecting data and provide the appropriate access as agreed with the users.

3.3 Partnerships

The success of any SDI initiative requires partnering and data sharing. Partnerships extend local capabilities in technology, skills, logistics and, data, etc. Such partnership initiatives can be seen in academia, to help in research and development. In partnerships, proper governance of the community is essential through a variety of roles and responsibilities. National government and NGOs can also partner with other levels of government and sectors to promote coordination. Partnerships may be through various channels. In data management processes such as collection, preparation and sharing, partnership is key. According to the Federal Geographic Data Committee (FGDC), key elements of partnerships include shared responsibilities, shared costs, benefits and control. All these lead to effective ways of achieving consensus which is key in maintain standards in data communities. It also brings the needed balance and interaction between government entities, clear division of responsibilities and at the same time value addition in all aspects of data management to bring out the win-win situation.

The resources used for collection, management, dissemination and use of spatial data can also be used in partnership with other players so that the data products will be accessible by all instead of duplication of efforts by actors across sectors. SDI provides linkages and close association with societal activities and initiatives.

All these initiatives were in line to foster partnership among the different players, increased capacity for developing and maintaining the National Spatial Data Infrastructure (NSDI), increased capacity for ecosystem-based planning and management of coastal zones, maritime activities and the marine environment, improved geospatial capacities at the partner organizations (SYKE, 2016).

Examples of these include government and private sector partnerships, government partnerships with community organizations (e.g. with environmental bodies, forestry, tourism and other community organizations). Community groups can contribute to SDI development through the sharing of data/information they have collected, and/or through the provision of services and technical infrastructure, private sector partnerships with community organizations, government, private sector and community organization(s) partnerships. These partnerships formed the basis for the establishment of various SDI initiatives in different regions and countries. SDI has generic components depending on the ecosystem and the linkages with other infrastructure along which most NSDI flavors are build. For instance, in Europe, the INSPIRE directive (Infrastructure for Spatial Information in the European Community) is the legal framework that mandates the creation of SDIs. This Infrastructure includes metadata, spatial data sets and spatial data services; network services and technologies; agreements on sharing, access and use; coordination and monitoring mechanisms, processes and procedures, established, operated or made available in accordance with this Directive.

4. Lessons from spatial data infrastructures for The data revolution

Following the SDI custodianship principle, organizations would be assigned custodianship responsibilities for specific data sets. Applying this framework to the data revolution would enable data communities to achieve their goals of being custodians of data in their domains by producing, managing and disseminating data. Similarly, if the Africa Data Consensus has to succeed, the data communities need to be properly identified and given appropriate mandate in their areas of expertise. Among the goals is to have as many players as possible involved in data collection, curation and dissemination. With data widely shared and accessible, the goal of leaving noone behind can then be achieved. It is on this basis that the key SDI principle of custodianship coordination was articulated, and the same can be applied in data revolution. For instance users need to have trust in the data communities, standards need to be set and followed, data needs to be properly collected and maintained as per the business needs and the relevant access allowed to user and all those wishing to have that such data sets.

If the full benefit is to be realized from spatial information, arrangements for custodianship must be made explicit and these arrangements must be implemented in a coordinated and consistent manner, not only between, but also within, organizations (ANZLIC, 2014). This spirit of partnership between organisations has to be maintained to ensure that everyone is involved and remains relevant in their areas of engagement. Adopting these key principles of spatial data management would enable the achievement of the objectives of data revolution.

The roles of each player in the data ecosystem have to be identified for the smooth coordination of its activities. The established framework needs to be followed so that the data gaps are reduced to a minimum. In these data communities, responsibilities need to be outlined just as the emphasis placed on the custodianship. It is also imperative to maintain a proper metadata and register of all data communities so as to enhance communication and discussions. This will ensure that, for instance, missing links are clarified, data quality is improved, and consistency is maintained since all are kept in the loop and read from the same source.

These standards and principles will increase confidence in a particular data set; being from one authoritative single data community would enhance its reliability. This will in turn be an enabler in coordinating activities at the national level as it will eliminate duplication and ensure consistency, easing planning and enabling key decision making processes. For instance, the High Level Conference on Data Revolution proposed the "Community and Citizen Data" community that would be ideal for coordinating population censuses, and the "Land data community" that would deal with land administration. This way of coordination becomes easier if proper standards, procedures and legal framework are followed.

A dedicated strong coordination function to make the data revolution a success has already been underlined in previous sections. This function can learn a lot from partnerships in the SDI. As in the SDI, this function should establish a more explicit framework and program for the implementation of the data revolution, including guidelines that will support the data revolution. These guidelines should specify the roles and interactions between actors, particularly in the production, management, dissemination and archiving of data in and out of the data ecosystem, in mutually strengthening capabilities and research, in mobilization and using resources in the data ecosystem. Partnership will aim, as in the SDI context, to promote collaboration in support of data ecosystem development to address data issues on various areas and topics.

An example of partnership can be between the "land data community" and the National Statistical Office to merge geospatial data with official statistics in particular for the benefit of social and environmental information. Another example could be between National Statistical Office and the "open data community" for the development of methodologies to measure phenomena that have so far unmeasured or only partially measured, using web scraping techniques.

SDIs and the data revolution can be key benefits and are reflected through partnerships and new business opportunities. Maximizing of data usage while avoiding duplication in sharing data needs and their integration leads to better decision making. It is also reflective of proper established SDIs. The identification of custodians and data communities for the principal data sets will enable users to identify those responsible for implementing prioritized data collection programs for developing data standards.

5. Conclusion

In strengthening SDIs and data revolution for statistical development, governments, academia, policy makers and other players will need to play a central role in reviewing and strengthening their National Strategies for the Development of Statistics (NSDS), along with the operational spatial data standards, guidelines and principles. The movement towards this direction means that there are workable undertakings by all stakeholders and high quality data would readily be available for public good to empower every person to be part of the better policies, decisions, and enhancing greater participation and accountability, which will ultimately lead to better results for people and the world. By bringing in more players and sharing of data, technologies and at the same time innovations, it bridges the data gap and help in identifying and overcoming key challenges such as security, capacity building and decision making processes in different sectors. Just like many countries have adopted frameworks for data custodianship and partnerships in management of spatial data, data revolution will need to embrace such frameworks in support of data communities for each of the domains.

Lessons learnt from SDI are useful to make the data revolution a success. However, the governments should make political commitments to support key initiatives related to data revolution and statistical development. These include: sustainable domestic resources for statistics, cross-government open data, fully functional civil registration and vital statistics systems, government ability to generate timely and accurate disaggregated data and geospatial referencing of data to ensure that the benefits of disaggregated data can be exploited at the lowest level of administration. The data revolution needs to be planned and nurtured through an implementation strategy. This strategy could be based on the implementation of the six pillars of the Africa Data Consensus to frame the action plan. The strategy should highlight the need to audit and update statistical legal framework to ensure internal coherence and alignment with data revolution concepts. A strong communication strategy to bring all actors and governments to understand data revolution and to embrace its concepts is required.

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Chapter 3: Blueprint for the STIG1.0 – setting the performance indicators

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Abstract

SDI practitioners require user friendly SDI assessment tools to assess the performance of their SDI. This Chapter provides the next step of the development of such user friendly assessment tool. Core SDI Principles are defined based on the 29 Basel Core Principles used to assess financial infrastructures. Additionally, a set of essential and additional assessment criteria for each Core SDI Principle is defined. As such the skeleton of the stress test Stress Test for Infrastructure of Geographic information (STIG) is created. Research challenges remain in modeling the interaction of different risk factors and their impacts. These include: integrating stress testing at different levels and making stress tests workable, realistic and timely remain complicated. These issues will be addressed in the research further developing the Stress Test for Infrastructure of Geographic information: the STIG.

Keywords: SDI, Stress test, Financial sector, STI

1. Introduction

Increasing the effectiveness, efficiency and transparency of Spatial Data Infrastructures (SDIs) is an on-going concern of the international SDI community. Within the SDI community it has been recognized that increasing the effectiveness of the use of public funds requires the existence of an adequate SDI that meets international standards and that operates as intended. Currently, several SDI assessment methods exist. However, most assessment methods are analyzing the SDI as a whole which does not allow understanding their internal dynamics and none of these appear to meet the requirements of practitioners. As a result, SDI decision makers are still with only little guidance on the success of their SDI.

This chapter will present the next step in the development of a new assessment method towards the Stress Test for Infrastructure of Geographic information (the STIG).

1.1 Reading Guide

Section 2 focuses on the new insides started with the findings and conclusions of our previous STIG research, developments of the SDI indicators and new insides on the Basel Core principles. Finally in this section we are presenting several critics and flaws of the financial stress testing. In section 3 the framework of the STIG development is explained. First we translate the Basel Core principles to the SDI context. After that we explain and define the new set of indicators. At the end we explain the STIG implementation model. Chapter ends with the conclusions and further work needed towards the finalization of the STIG framework in section 4.

2. Performance Principles

Nushi et al. (2015) assessed the extent to which stress test methodologies can be supportive to developing a new SDI assessment method that can provide the required information on the performance of SDIs.

Based on this review of the Spatial Data Infrastructure (SDI) and Financial Infrastructure (FI), Nushi et al. (2015) concluded that the stress test methodology is a promising approach for assessing SDIs and that in the next phase of this research the Core SDI Principles will be defined based on the Basel Core Principles. Additionally, a set of essential and additional assessment criteria for each Core SDI Principle should be defined.

2.1 The Basel Core Principles

The Core Principles for Effective Banking Supervision (The Basel Core Principles) are the de facto minimum standard for sound prudential regulation and supervision of banks and banking systems (BIS, 2012). Originally issued by the Basel Committee on Banking Supervision in 1997, countries use the Core Principles as a benchmark for assessing the quality of their supervisory systems and for identifying future work to achieve a baseline level of sound supervisory practices (BIS, 2012). In the context of the Financial Sector Assessment Program (FSAP), the International Monetary Fund (IMF) and the World Bank uses the Core

Principles to assess the effectiveness of countries' banking supervisory systems and practices (BIS, 2012).

The Core Principles define 29 principles that are needed for a supervisory system to be effective. Those principles are broadly categorized into two groups: the first group (principles 1 to 13) focuses on powers, responsibilities and functions of supervisors, while the second group (principles 14 to 29) focuses on prudential regulations and requirements for banks (BIS, 2012). Table 1 presents 29 Basel core principles.

For assessments of the Core Principles the following four-grade scale is used: compliant (C), largely compliant (LC), materially non-compliant (MNC) and non-compliant (NC). A "not applicable" (NA) grading can be used under certain circumstances where the supervisors are aware of the phenomenon and would be capable of taking action, but realistically there is no chance that the activities will grow sufficiently in volume to pose a risk. A brief description of grading and their applicability:

- Compliant – A country will be considered compliant with a Principle when all essential criteria applicable for this country are met without any significant deficiencies.

- Largely compliant – A country will be considered largely compliant with a Principle whenever only minor shortcomings are observed that do not raise any concerns about the authority's ability and clear intent to achieve full compliance with the Principle within a prescribed period of time.

- Materially non-compliant – A country will be considered materially non-compliant with a Principle whenever there are severe shortcomings, despite the existence of formal rules, regulations and procedures, and there is evidence that supervision has clearly not been effective, that practical implementation is weak, or that the shortcomings are sufficient to raise doubts about the authority's ability to achieve compliance.

- Non-compliant – A country will be considered non-compliant with a Principle whenever there has been no substantive implementation of the Principle, several essential criteria are not complied with or supervision is manifestly ineffective.

Table 1: The Basel Core Principles

Nr	Principle
1	Responsibilities, objectives and powers
2	Independence, accountability, resourcing and legal protection for supervisors
3	Cooperation and collaboration
4	Permissible activities
5	Licensing criteria
6	Transfer of significant ownership
7	Major acquisitions
8	Supervisory approach
9	Supervisory techniques and tools
10	Supervisory reporting
11	Corrective and sanctioning powers of supervisors
12	Consolidated supervision
13	Home-host relationships
14	Corporate governance
15	Risk management process
16	Capital adequacy
17	Credit risk
18	Problem assets, provisions, and reserves
19	Concentration risk and large exposure limits
20	Transactions with related parties
21	Country and transfer risks
22	Market risk
23	Interest rate risk in the banking book
24	Liquidity risk
25	Operational risk
26	Internal control and audit
27	Financial reporting and external audit
28	Disclosure and transparency
29	Abuse of financial services

A stress test could be seen as a 'disaster exercise' for the systemic banks or the entire FI. Systemic banks are banks that may not actually become insolvent because of their size. Should that happen, then it would constitute a direct risk to the financial system as a whole. Possible scenario can be outlined based on these events: sudden fall of the real-estate prices, rising of the unemployment, the economy is stagnating, collapse of the financial markets or even countries cannot repay their debts. Banks should have at least 8% financial buffers reserved for these events so that national governments do not have to get involved in rescuing the banks by paying the financial buffers. The banks have to keep after the stress test more than 5.5% of their capital as a buffer. If a bank fails the stress test, it means that the capital buffers should be supplemented. A bank can supplement the capital buffers itself by trading certain organizational activities or by raising funds on the capital market. If this is insufficient, governments will get involved.

2.2 SDI Indicators

Steudler et al. (2008) presents and discusses major classes of factors which influence, or contribute to, the development of an SDI initiative in the context of key components of SDIs (see Table 2).

Table 2: possible SDI performance indicators per SDI component (Steudler et al., 2008)

Level	***Area***	***Possible Indicators***
Policy	Policy	existence of a government policy for SDI
		handling of intellectual property rights, privacy issues, pricing
		objectives for acquisition and use of spatial data
Management	Standards	standardisation arrangements for data dissemination and access network
		institutional arrangements of agencies involved in providing spatial data
		organisational arrangements for coordination of spatial data
		definition of core datasets
		data modelling
		interoperability
Management	Access Network	access pricing
		delivery mechanism and procedure
		access privileges
		value-adding arrangements
Operational	Access Network	type of network
		data volume
		response time
Operational	Data	data format
		data capture method
		definition of core datasets
		data maintenance
		data quality and accuracy
Other Influencing Factors	People	number of organisations and people involved
		opportunities for training
		market situation for data providers, data integrators, and end-users
Performance Assessment		degree of satisfying the objectives and strategies
		user satisfaction
		diffusion and use of spatial data and information
		turnover and reliability

Steudler et al. (2008) distinguish three SDI organizational levels: the policy level, the management level and the operational level. Each level is associated with one of the key components of an SDI: policies, standards, access networks, people and data (see Rajabifard et al. 2002). Further, Steudler et al. (2008) describes the SDI levels, areas and possible indicators as:

- *Policy Level - Policy:* One aspect to be considered for the policy component is the geographic, historic and social context of the country. A second aspect is how the government handles the overall policy regarding the collection, dissemination and legal protection of spatial data; for example the issues such as intellectual property rights, privacy issues and pricing. Indicators might be the existence of a government policy regarding the mentioned issues and how the issues are dealt with. Good practice is when the government has taken actions for an SDI and when issues have been handled in a comprehensive and satisfying way in relation to the geographic, historic and social context of the country.

- *Management Level - Standards:* The evaluation of the standards component includes how the government administration is dealing with organizational arrangements for the coordination of spatial data. This component may include the assessment of government agencies involved in providing spatial data for land titles, for large- and small-scale mapping. The evaluation has to consider standardization issues like the definition of core datasets, data modelling practices and interoperability at the national level. Indicators for the management level might be a list and the size of government agencies involved in spatial data, their size and activities and how they communicate and cooperate with each other. In order to permit comparisons with other countries, indicators might point out the definitions of the core datasets, the data modelling techniques used for defining spatial datasets and the standardization decisions for the access networks.

- *Management Level - Access Networks*: The evaluation of the access networks component may include issues like the definition of data summaries, formats of available data, delivery mechanisms for the data, whether access will have associated costs and whether data-access privileges will be defined for different user groups. Indicators might point out access pricing, access delivery mechanisms and procedures, whether access is defined by privileges or is open to all users, as well as whether there are inter-institutional links for data access, or value-adding arrangements established with the private sector.

- *Operational Level - Access Network*: The responsibility for the operational level is with the government's operational units that have to make things happen in terms of access network and data provision. The access network component is to be evaluated by considering the type of available network and its capacity and reliability. Indicators might be the data volume and response time and good practice would be when the network can handle a large data volume reliable with a short response time.

- *Operational Level - Data*: The data component can be evaluated by assessing the data models of the spatial datasets of the different agencies, the creation of a national core dataset, the data formats, data capture methods, data maintenance as well as data quality and accuracy. Good practice might be when data is defined in clear and transparent ways (content, quality, accuracy) so that they can easily and readily be shared among the different agencies and users.

- *Other Influencing Factors - People:* The evaluation of the people or human resources component has to take the three groups into account which have been identified as relevant in the SDI context: end-users; data integrators. The evaluation will have to assess the situation within these three groups in terms of personnel, opportunities for training and capacity building and the market situation for spatial data. Good practice will be when end-users are easily and readily getting the data product that they are looking for, when integrators can operate and prosper in favorable market situations and when data providers are able to deliver the data in efficient and effective ways.

- *Performance Assessment*: This aspect is important for the overall assessment of national infrastructures. The assessment might include the review of objectives, strategies, performance and the reliability of the system, as well as user satisfaction. Indicators can be the adoption of SDI principles, its use and diffusion of spatial data and user satisfaction surveys. Good practice can be considered as when all SDI principles are adopted, when there is large use and diffusion of spatial datasets and when users indicate satisfaction about the products and services offered.

Although the areas and possible indicators suggested are only a general framework for evaluating SDIs but are nonetheless useful for providing a first-order evaluation of an SDI and eliciting valuable indicators.

3. Developing STIG – Stress Testing for SDI Assessment

3.1 Translating Basel principles to the SDI context

We assessed applicability of 29 Basel Core Principles with the proposed SDI assessment indicators. We used the following three assessment scores as presented in Table 3.

By using expert opinion judgment as a research method, we compared the 29 Basel Principles and 30 SDI Indicators and provided the compliancy scores of 0, 1 and 2 by evaluating the detailed definition and description for each principle and trying to reflect individual needs and requirements of each indicator SDI. Some of the Basel Core principles are applicable to the SDI context. For example, the principle 1 “Responsibilities, objectives and powers” addresses the operational independence, transparent processes, sound governance, adequate resources and accountability. This principle is reasonably relevant in a SDI context. Therefore, we maintain this principle in the STIG. Several Basel core principles may not all be applicable to the SDI context. The principle 2, “Independence, accountability, resourcing and legal protection for supervisors” addresses the operational independence, transparent processes, sound governance, budgetary processes and legal protection for the supervisor. This Basel principle can be maintained in the STIG but needs to be adapted to achieve applicability with the SDI Indicator “Existence of a government policy for SDI”.

Other principles, such as Basel Core Principle 7 “Major acquisitions” addresses major acquisitions or investments by a bank, against prescribed criteria, including the establishment of cross-border operations, and confirming that corporate affiliations or structures do not expose the bank to undue risks or hinder effective supervision. In an SDI context such issues are unlikely to exist. This Basel Core principle is not in applicability with this SDI Indicator and can't be maintained in the STIG. Major adaptation or a new principle definition is required. In similar way we assessed all Basel core principles resulting in an overall applicability assessment as shown in table 4. For more detailed overview of the final applicability score see Appendix 1.

Table 3: The applicability assessment of The Basel Core Principles with the SDI indicators

Applicability	Score	Explanation	Applicable in STIG
Not compliant	0	This Basel principle is not in applicability with this SDI Indicator. Major adaptation or a brand new principle definition is required.	No
Partially compliant	1	This Basel principle need to be adapted to achieve applicability with this SDI Indicator	Maybe
Compliant	2	This Basel principle is in a close applicability with this SDI Indicator. Only a minor semantic adaptation is needed.	Yes

The 29 Basel principles are categorized into two groups. The first group (principles 1 to 13) focuses on powers, responsibilities and functions of supervisors, while the second group (principles 14 to 29) focuses on prudential regulations and requirements for banks (BIS, 2012). To be able to understand which group of Basel Core principles is more compliant with the different SDI levels and areas, we calculated the average values per Basel Core principles group as shown in Table 5.

Table 4: The overall applicability of 29 Basel Core Principles with SDI indicators

Level			Policy			Management						Management				Operational			Operational					Other Influencing Factors			Performance Assessment					
Area			Policy			Standards						Access Network				Access Network			Data					People								
Nr			1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Possible Indicators		Posible SDI Indicators vs. Basel principles	Existence of a government policy for SDI	Handling of intellectual property rights, privacy issues, pricing	Objectives for acquisition and use of spatial data	Standardisation arrangements for data dissemination and access network	Institutional arrangements of agencies involved in providing spatial data	Organisational arrangements for coordination of spatial data	Definition of core datasets	Data modelling	Interoperability	Access pricing	Delivery mechanism and procedure	Access privileges	Value-adding arrangements	Type of network	Data volume	Response time	Data format	Data capture method	Definition of core datasets	Data maintenance	Data quality and accuracy	Number of organisations and people involved	Opportunities for training	Market situation for data providers, data integrators, and end-users	Degree of satisfying the objectives and strategies	Perfomance of the system	Reliability of the system	User satisfaction	Diffusion and use of spatial data and information	Turnover and reliability
	#	Basel Principle																														
Powers, responsibilities and functions of supervisors	1	Responsibilities,	2	2	2	1	1	1	1	1	1	•	•	•	•	1	1	1	1	1	1	1	1	1	1	1	1	1	1	•	1	1
	2	Independence,	1	1	1	1	1	1	1	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	1	1	1	•	1	1
	3	Cooperation and	2	2	1	1	1	1	1	1	1	•	•	•	•	•	•	•	•	•	1	•	•	1	1	1	1	1	1	1	1	1
	4	Permissible activities	2	2	1	1	1	1	1	1	1	•	•	•	•	1	•	•	•	•	1	•	1	•	•	•	1	1	1	1	1	1
	5	Licensing criteria	2	2	1	1	1	1	1	1	1	•	•	•	•	•	•	•	1	•	1	•	1	•	•	•	1	1	1	1	1	1
	6	Transfer of significant	2	1	1	1	1	1	•	•	•	•	1	1	•	•	•	•	•	•	•	•	•	1	1	1	1	1	1	1	1	1
	7	Major acquisitions	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	8	Supervisory approach	2	2	1	1	1	1	1	1	1	•	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	9	Supervisory	2	1	2	1	1	1	1	1	1	•	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	10	Supervisory reporting	1	1	1	1	1	1	1	1	1	•	1	1	•	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	11	Corrective and	1	1	1	2	2	2	1	1	1	•	1	1	•	•	•	•	•	•	•	•	1	•	•	•	•	1	1	•	•	1
	12	Consolidated	2	2	2	1	1	1	•	•	1	•	•	1	•	•	•	•	•	•	•	•	•	•	•	•	1	1	1	1	1	1
	13	Home-host	1	1	1	2	2	2	1	1	1	1	1	1	•	•	•	•	•	•	•	•	•	1	1	1	1	1	1	1	1	1
Prudential regulations and requirements	14	Corporate governance	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	•	•	1	•	•	•	1	1	1	1	1	1	•	1	1
	15	Risk management	2	2	2	2	2	2	2	2	2	1	2	2	2	1	1	1	1	1	1	1	1	1	•	1	1	1	1	•	1	1
	16	Capital adequacy	1	1	1	1	1	1	1	1	1	1	1	1	1	•	•	•	•	•	•	•	•	•	•	•	1	•	1	•	•	1
	17	Credit risk	1	1	1	1	1	1	•	•	•	•	•	1	1	•	•	•	•	•	•	•	•	•	•	•	1	•	1	•	•	1
	18	Problem assets,	2	2	2	2	2	2	1	1	1	1	1	1	1	•	•	•	•	•	•	•	•	1	•	1	1	•	1	•	•	1
	19	Concentration risk and	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	•	•	1	1	•	1	1	•	1	1	1	1	1	1	1
	20	Transactions with	1	1	1	2	2	2	1	1	1	1	1	1	1	•	•	•	•	1	1	•	1	1	•	1	1	1	1	1	1	1
	21	Country and transfer	2	2	2	1	1	1	1	1	1	1	1	1	1	•	1	•	•	1	1	1	1	1	•	1	1	1	1	1	1	1
	22	Market risk	2	2	2	1	1	1	•	•	•	1	1	1	1	1	1	•	•	1	•	1	1	1	•	1	1	1	1	•	1	1
	23	Interest rate risk in the	1	1	1	1	1	1	•	•	•	1	1	1	1	•	•	•	•	•	•	•	•	•	•	•	1	•	1	•	•	1
	24	Liquidity risk	1	1	1	1	1	1	•	•	•	1	1	1	1	1	1	•	•	1	•	1	•	•	•	•	1	1	1	1	1	1
	25	Operational risk	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	•	•	1	•	1	•	1	1	1	1	1	1	1	1	1
	26	Internal control and	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	•	1	1	1	•	1	1	•	1	1	1	1	1	1	1
	27	Financial reporting and	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	•	1	1	1	•	1	1	•	1	1	1	1	1	1	1
	28	Disclosure and	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	•	1	1	1	•	1	•	•	•	1	1	1	1	1	1
	29	Abuse of financial	2	2	2	1	1	1	1	1	1	1	1	1	1	1	•	•	•	•	1	•	1	•	•	•	1	1	1	•	1	1

To be able to compare the average applicability of Basel Core principles with the SDI levels and areas defined by Steudler et al. (2008) we have set the range of the average values between 0 and 0.75 in red as 'Non-Compliant', between 0.75 and 1.25 (yellow) as 'Need to be adapted' and between 1.25 and 2 (green) as 'In Applicability' with the corresponding SDI levels and areas.

Our analysis shows that the Basel Core principles are in relatively good applicability with general SDI principles and are reasonably straightforward applicable for the assessment of the SDI Policy level and with some minor adaptation for the SDI management level in area of Standards. However, the Basel Core principles need to be significantly adjusted to accommodate with the assessment of the important SDI areas Access network, Data and People. Therefore a new set of essential and additional assessment criteria based on the approach of the Basel Core principles for each Core SDI Principle need to be defined.

Table 5: The average applicability of Basel Core Principles Group with SDI Levels and areas.

Level	Policy	Management		Operational		Other Influencing Factors	Performance Assessment
Area	Policy	Standards	Access Network	Access Network	Data	People	
Powers, responsibilities and functions of supervisors	1,36	0,91	0,31	0,33	0,42	0,54	0,86
Prudential regulations and requirements	1,69	1,28	1,02	0,44	0,46	0,46	0,83

3.2 How to assess SDIs in a new way?

In addition to reduce above mentioned concerns and increase system robustness of a SDI, STIG (Stress Test for Infrastructure of Geographic information) would attempt to provide new robust SDI assessment by aiming to deliver SDI reports that incorporate a more dynamic, multidisciplinary and forward-looking evaluation of SDI. It would try to avoid what often appears as a static approach used by traditional SDI assessment methods. Following the conclusion of Nushi et al. (2015) that the methodology of STIG 1.0 will be created based on the performance indicators based on the Basel Core Principles and application of the baseline quantitative and qualitative indicators. To achieve this goal, the STIG will consist of three main groups of principles and indicators: a subset of the Basel Core principles; a set of quantitative technological principles and indicators; and a set of the progressive quantitative principles and indicators.

3.3 The new set of principles and indicators

The first group, the subset of the Basel Core principles, consists of 10 Basel Core principles carefully chosen using the applicability assessment as presented in table 3. As described in paragraph 3.1, the objective was to screen all Basel Core principles available and strip the list down to those that are absolutely necessary, avoiding too many positive correlating indicators and insuring limited duplication. Having in mind that these 10 selected Basel core principles are mostly in applicability with the Policy and Management areas of SDIs, we decided to add a set of quantitative principles with their corresponding indicators to be compliant with SDI areas Access network, Data and People. This principle is based on the 8 key performance indicators focus on the implementation of the technological components of INSPIRE (INSPIRE, 2016). Furthermore, to be able to assess the organizational aspects of SDI, we have proposed a set of qualitative principles and indicators on several non-technological and technological topics. These principles are described in more details further in this paragraph.

3.3.1 Subset of the Basel core principles

After this detailed compliancy assessment of the 29 Basel principles with 30 SDI Indicators we came to conclusion that the subset of the 4 Basel Core principles which define the ‘Supervisory powers, responsibilities and functions’ and 6 Basel Core principles defining so called ‘Prudential regulations and requirements’ will be adapted to fit the purpose of the STIG SDI assessment. In the category ‘Supervisory powers, responsibilities and functions’ authors have carefully selected and adapted these 4 principles: Principle 1: Responsibilities, objectives and powers; Principle 3: Cooperation and collaboration; Principle 9: Supervisory techniques and tools; Principle 11: Corrective and sanctioning powers of supervisors. While regarding category ‘Prudential regulations and requirements’ we have adapted these 6 principles: Principle 14: Corporate governance; Principle 15: Risk management process; Principle 22: Market risk; Principle 25:

Operational risk; Principle 26: Internal control and audit; Principle 28: Disclosure and transparency (Table 6).

An example of the adaptation of Principle 1 to the SDI context:

- *Name:* Responsibilities, objectives and powers
- *Objective:* An effective system of SDI supervision has clear responsibilities and objectives for each authority involved in the supervision of SDI organization and key SDI stakeholders. A suitable legal framework for SDI supervision is in place to provide each responsible authority with the necessary legal powers to authorize, conduct on-going supervision, address applicability with laws and undertake timely corrective actions to address safety and soundness concerns.

Table 6: Subset of the Basel Core Principles

Nr	Principle
1	Responsibilities, objectives and powers
3	Cooperation and collaboration
9	Supervisory techniques and tools
11	Corrective and sanctioning powers of supervisors
14	Corporate governance
15	Risk management process
22	Market risk
25	Operational risk
26	Internal control and audit
28	Disclosure and transparency

Essential criteria:

1. The responsibilities and objectives of each of the authorities involved in SDI supervision are clearly defined in legislation and publicly disclosed. Where more than one authority is responsible for supervising the SDI system, a credible and publicly available framework is in place to avoid regulatory and supervisory gaps.

2. The primary objective of SDI supervision is to promote the safety and soundness of SDI organization. If the SDI supervisor is assigned broader responsibilities, these are subordinate to the primary objective and do not conflict with it.

3. Laws and regulations provide a framework for the supervisor to set and enforce minimum prudential standards for SDI organization and SDI stakeholders. The supervisor has the power to increase the

prudential requirements for individual SDI stakeholders based on their risk profile and SDI systemic importance.

4. SDI laws, regulations and prudential standards are updated as necessary to ensure that they remain effective and relevant to changing industry and regulatory practices. These are subject to public consultation, as appropriate.

5. The supervisor has the power to: (a) have full access to SDI organization and individual stakeholders boards, management, staff and records in order to review applicability with internal rules and limits as well as external laws and regulations; (b) review the overall activities of the SDI stakeholders, both domestic and cross border; and (c) supervise the foreign activities of SDI organization incorporated in its jurisdiction.

6. When, in a supervisor's judgment, a SDI is not complying with laws or regulations, or it is or is likely to be engaging in unsafe or unsound practices or actions that have the potential to jeopardize the SDI, the supervisor has the power to: (a) take (and/or require a SDI stakeholder to take) timely corrective action; (b) impose a range of sanctions; and (c) cooperate and collaborate with relevant authorities to achieve an orderly resolution of the SDI organization, including triggering resolution where appropriate.

7. The supervisor has the power to review the activities of parent companies and of companies affiliated with parent companies to determine their impact on the safety and soundness of the SDI organization.

The following four-grade scale will be used to assess each principle: compliant (C), largely compliant (LC), materially non-compliant (MNC) and non-compliant (NC). A "not applicable" (NA) grading can be used under certain circumstances.

3.3.2 Quantitative principle and indicators

To accommodate the assessment for the SDI components access network, data and people, the STIG will build on the INSPIRE monitoring methodology the new principle is introduced, "The implementation of the metadata, the data and the networks services". This principle consists of 8 technological INSPIRE indicators as defined in the implementing rules "Commission Decision of 5 June 2009 implementing Directive 2007/2/EC of the European Parliament". These 8 indicators focus on the implementation of the technological components of INSPIRE: i.e. the implementation of the metadata, the data and the networks services. The Table 7 below gives the overview of the 8 key technological INSPIRE indicators.

As stated in paragraph 3.1, there are some gaps which are not addressed by Basel Core principles such as Access network, Data and People. These gaps are partially addressed by introduction of this INSPIRE principle “The implementation of the metadata, the data and the networks services” with the proposed indicators as shown above. Other gaps such as organizational stability, reform capacity and behavior and resilience during the crises will be addressed by new set of qualitative principles and indicators proposed below based on our expert opinion.

3.3.3 Qualitative principles and indicators

For assessing a SDI’s ability and willingness to cope with future organizational risks, it is necessary to take into account a broad array of principles and indicators. To capture this element, the indicators have to go beyond purely technical indicators to capture a meaningful picture of SDI’s long-term organizational prospects and the potential social constraints. For instance, aspects such as legal certainty, the effectiveness and transparency of institutions, governmental steering capacities, as well as questions of sustainability are crucial for assessing a SDIs long-term stability, reliability and predictability and thus have to be included in STIG assessment method. The following section sketches out three basic thematic dimensions covering those qualitative principles: (a) Political, Economic and Social Stability; (b) Steering Capability and Reform Capacities and; (c) Lessons learned from past Crisis Management.

(a) Political, Economic and Social Stability

This dimension incorporates those indicators that are essential for judging a SDIs long-term political and social stability, as well as its performance in delivering sustainable public added value and setting the right priorities for promoting future growth. In this regard, it is necessary to take into account the following principles and their indicators as presented in Table 8.

b) Steering Capability and Reform Capacities

This aspect measures a SDIs effectiveness, efficiency, transparency and accountability. The indicators in this aspect address the issue of the SDIs actual reform capability and ability to act and formulate a range of strategic solutions. The following indicators as shown in Table 9 are taken into account.

Table 7 - The 8 key technological INSPIRE indicators

Indicator Code	Indicator name	Meaning of indicator	Comments
MDi1	Existence metadata	Measures the existence of metadata for the spatial data sets and services	For each dataset and service whether it has or has not metadata
MDi2	Conformity metadata	Measures the conformity of metadata for the spatial data sets and services with the implementing rules for metadata	For each dataset and service whether it has or has not conformant metadata
DSi1	Coverage spatial datasets	Measures the extent of the Member States territory covered by the spatial data sets	The territory covered by the dataset is compared to the relevant territory that could be covered (e.g. x% of all the urban areas in the country)
DSi2	Conformity spatial datasets	Measures the conformity of the spatial data sets with the data specifications and the conformity of their corresponding metadata	Both the spatial dataset and metadata should be conformant
NSi1	Accessibility metadata	Measures the extent to which it is possible to search for spatial data sets and services on the basis of their corresponding metadata through discovery services	For each spatial data set and services it is checked whether it is possible or not to discover it through at least 1 discovery service
NSi2	Accessibility spatial datasets	Measures the extent to which it is possible to view and download spatial data through view and download services	For each spatial data set it is checked whether it is possible to view and download it through at least 1 view and 1 download service
NSi3	Use network services	Measures the use of all network services	Calculated by the annual number of service requests for all network services
NSi4	Conformity network services	Measures the conformity of all network services with the implementing rules for network services	This also includes the performance of the services

(c) Lessons learned from past Crisis Management

To be able to learn from past crisis-management experiences this aspect analyzes a SDI's institutional settings and procedural track record of managing past crises (if applicable) to capture a capacity to deal with future crises. The indicators as presented in Table 10 will be taken in consideration

Table 8 - The qualitative principles and their indicators regarding Political, Economic and Social Stability of SDIs

Principle	Indicator	Meaning of indicator
Rule of Law	Legal Certainty	To what extent do SDIs act on the basis of, and in accordance with, legal provisions or culturally accepted norms to provide legal and practical certainty?
Rule of Law	Independent Judiciary	To what extent do independent auditors control whether organizations act in conformity with the law?
Rule of Law	Separation of Powers	To what extent is there a working separation of powers?
Transparency/ Accountability	Corruption Prevention	To what extent are SDI officials prevented from abusing their position for private interests?
Transparency/ Accountability	Public Participation	To what extent does the SDI organization enable the public participation in the SDI process?
Social Cohesion	Social Inclusion	To what extent is exclusion of SDI from society effectively prevented?
Social Cohesion	Trust in Institutions	How strong is the user approval of SDI objectives and procedures?
Social Cohesion	Societal Mediation	To what extent is there a network of stakeholders to mediate between users (society) and the SDI?
Social Cohesion	Conflict Management	To what extent is the SDI organization able to moderate domestic economic, political, and social conflicts?
Future Resources	Education	To what extent does SDI education policy deliver high-quality, efficient, and equitable education and training?
Future Resources	Research and Innovation	To what extent does SDI research and innovation policy support technological innovations that foster the creation and introduction of new products and services?

Future Resource s	Employment	How successful is a SDI organization in increasing employment?
Future Resource s	Environmental Sustainability	To what extent are environmental concerns effectively taken into account in SDI development and implementation?

3.4 The STIG core principles

The 24 STIG core principles are represented in Table 11.

The first group, the subset of the Basel Core principles, consists of 10 Basel Core principles carefully chosen using the applicability assessment as presented in Table 3. Principle 11 focuses on the implementation of the technological components of INSPIRE. Principles 12 to 15 are qualitative principles with regard to Political, Economic and Social Stability of SDIs. Principles 16 to 18 are also qualitative principles referring to Steering Capability and Reform Capacities of SDIs. , and the last set of Core principles, 19 to 24 are specifically defined as qualitative principles safeguarding the SDI capability to learn from past Crisis Management events.

Table 9 - The qualitative principles and their indicators regarding Steering Capability and Reform Capacities of SDIs

Principle	Indicator	Meaning of indicator
Strategic Capacity	Prioritization	To what extent does the SDI organization set and maintain strategic priorities?
Strategic Capacity	Policy Coordination	To what extent can the SDI organization coordinate conflicting objectives into a coherent policy?
Strategic Capacity	Stakeholder Involvement	To what extent does the SDI organization consult with major stakeholders to support its policy?
Strategic Capacity	Political Communication	To what extent does the SDI organization consult with major stakeholders to support its policy?
Implementation	Government Efficiency	To what extent can the SDI organization achieve its own policy objectives?
Implementation	Resource Efficiency	To what extent does the SDI organization make efficient use of available human, financial, and organizational resources?
Adaptability	Policy Learning	How innovative and flexible is the SDI organization?
Adaptability	Institutional Learning	To what extent does the SDI organization improve its strategic capacity by changing the institutional arrangements of governing?

3.5 How to score indicators?

Each of the proposed STIG core principles will be supported by one or more indicators. To be able to gain objective input from these qualitative indicators each aspect and indicator will be anticipated with the set of possible answers. Given the degree of detail embedded in the existing rating scales of the financial stress testing, it is advisable to use similar ratings which might make the ratings more understandable for the broader public. The following four rating clusters are proposed: AAA to AA- (high answer quality); A+ to A- (medium answer quality); BBB+ to BBB- (low answer quality) and; <BB+ (speculative answer quality).

As an example on the question 'To what extent does SDI research and innovation policy support technological innovations that foster the creation and introduction of new products and services?' regarding the 'Research and innovation' indicator within the principle 15, Future resources, and the following answers could be applicable:

1. SDI research and innovation policy effectively supports innovations that foster the creation of new products and services and enhance productivity (rate AAA to AA-).

2. SDI research and innovation policy largely supports innovations that foster the creation of new products and services and enhance productivity (rate A+ to A-).

3. SDI research and innovation policy partly supports innovations that foster the creation of new products and services and enhance productivity (rate BBB+ to BBB-).

4. SDI research and innovation policy largely fails to support innovations that foster the creation of new products and services and enhance productivity (rate <BB+).

   Whether this proposed scoring fulfils the requirements of SDI practitioners with respect to clarity, simplicity and usability is subject of further research.

4. Discussion: Flaws of the Financial Stress Testing System

The global financial crisis of 2008 exposed flaws in the stress-test methodologies in the area of structured finance evolving into the economic downturn and basically took banks by surprise. Worse, most financial institutions were ill-prepared for such a turn of events, and initially had no idea how to react. Despite the fact that banks have been using stress testing internally for many years, the test results had little-to-no influence on the overall business decisions of banks (Kapinos et al. 2015).

As a consequence, banks built excessive risk positions without considering how vulnerable they would be if things quickly went wrong. These shortages were a key contributor to the dramatic results of this imperfect financial system including the collapse of (until then) 'to-big-to-fail' financial giants like AIG and Lehman Brothers. Stress testing of financial institutions also lacked to produce a timely warning as the US real estate crisis morphed into a global financial crisis. As argued by Kapinos et al. (2015), no credit rating agency (CRA) gave a timely warning regarding Europe's sovereign debt crisis, which eventually overcome Greece, Portugal and Ireland, with its impacts still being felt today. In the rouse of these crises, rating agencies, institutional investors and government oversight bodies have tightened their standards dramatically for judging creditworthiness, with the assessment of sovereign credit risk being particularly impacted.

Table 10 - The qualitative principles and their indicators regarding Lessons learned from past Crisis Management of SDIs

Principle	Indicator	Meaning of indicator
Historical Evidence of Successful Crisis Management	Mastering the crisis	Is there evidence from historical events that the SDI organization have already mastered crisis in the past?
Crisis Remediation	Facilitating during the crises	Does the SDI organization facilitate crisis remediation in a timely manner?
Signaling Process	Communication during the crisis	Is the signaling process between the SDI organization (decision makers) so well established that confusion outcome of decisions by one decision maker on the others can be avoided or at least minimized?
Timing and Sequencing	Procedures during the crisis	Are the SDI procedures for sequencing and timing of countermeasures in a crisis anchored and broadly accepted by all stakeholders?
Protective Measure	Prevention during the crises	Are preventive measures in place that can protect the most vulnerable SDI aspects against the full effect of a crisis?
Automatic Stabilizers	Automatic back-up policies	Are automatic back-up policies and systems sufficiently strong to contain surges of massive SDI system shock?

Based on the above situation, forceful criticism argues against the fundamental appropriateness of stress testing. Kupiec (2014) argues that stress testing amounts to regulators operating financial institutions. He also argues that since regulators are effectively operating the institutions, they may face difficulty in allowing equity-holders and creditors to take losses. According to Hirtle and Lehnert (2014), a closely related concern is that stress testing exposes regulators to reputational risk. If markets perceive that regulators give a particular firm or financial system a passing grade, only for it to fail soon thereafter, the regulators' reputations may be compromised. Another critique is that the requirement to conduct stress testing represents an unreasonable burden on financial institutions, especially smaller and less complex institutions (McLannahan, 2015).

While some reflect valid concerns and may warrant additional analysis going forward, we conclude that, if performed in a sound manner, stress testing remains an appropriate and useful regulatory tool. Unfortunately, many banks consider regulatory stress testing a burden and not an opportunity (Kapinos et al., 2015). Based on the above, we conclude that Basel Core principles for stress testing are a worthy approach for the creation of the new SDI assessment. Having in mind that Stress testing based on the Basel Core principles has not predicted timely and accurately the large economic crisis, the need for a new Basel framework with sound processes to perform the assessment of SDI is evident.

Table 11: Subset of the Basel Core Principles

Nr	Principle
	Subset of the Basel Core principles
1	Responsibilities, objectives and powers
2	Cooperation and collaboration
3	Supervisory techniques and tools
4	Corrective and sanctioning powers of supervisors
5	Corporate governance
6	Risk management process
7	Market risk
8	Operational risk
9	Internal control and audit
10	Disclosure and transparency
	Technological INSPIRE principle
11	The implementation of the metadata, the data and the networks services
	Qualitative principles - Political, Economic and Social Stability
12	Rule of Law
13	Transparency/Accountability
14	Social Cohesion
15	Future Resources
	Qualitative principles - Steering Capability and Reform Capacities
16	Strategic Capacity
17	Implementation
18	System Adaptability
	Qualitative principles - Lessons learned from past Crisis Management
19	Historical Evidence of Successful Crisis Management
20	Crisis Remediation
21	Signaling Process
22	Timing and Sequencing
23	Protective Measures
24	Automatic Stabilizers

5. Conclusion and Further Research

5.1 Conclusions

In our previous research chapter (Nushi et al. 2015) we concluded that stress testing based on the Basel Core principles and used in the financial infrastructures can be a promising approach for assessing SDIs and that the Core SDI Principles will be defined based on the Basel Core Principles. In this chapter we tested the applicability of Basel Core principles with the SDI indicators. After the detailed compliancy analyses of the 29 Basel principles with 30 SDI Indicators proposed by Steudler et al. (2008) we came to conclusion that Basel principles are partially useful for the assessment of the SDIs but cannot be implemented for the assessment of entire range of the SDI areas. This is due to the non-applicability with the important SDI areas as Access network, Data and People. The objective of the compliancy analyses was to screen all Basel Core principles available and strip the list down to those that are absolutely necessary, avoiding too many positive correlating indicators and insuring limited duplication. Therefore a new set of essential and additional assessment criteria based on the approach of the Basel principles for each Core SDI Principle is defined. The STIG assessment method will provide new robust SDI assessment based on subset of the Basel Core Principles combined with the set of the new quantitative and qualitative principles and indicators. The first group, the subset of the Basel principles, consists the four Basel Core principles which define the ‘Supervisory powers, responsibilities and functions’ and 6 Basel Core principles defining so called ‘Prudential regulations and requirements’. The quantitative technological principle is based on the 8 key performance indicators focus on the implementation of the technological components of INSPIRE. To be able to assess the organizational aspects of SDI, we have proposed a set of progressive qualitative indicators on several non-technological and technological topics.

5.2 Further research

Next step in this research process is to test in theory and practice the proposed STIG core principles, indicators and the implementation model. We are aiming to organize a theoretical workshop with SDI assessment experts to test the STIG. In this workshop we intent to assess the relevance and relative importance of each principle and per principle the relative importance of each indicator. The expected constructive feedback will be used to modify the STIG assessment framework and user-friendliness and applicability. In the following workshop with the potential users of STIG assessment method we will try to test the applicability and user-friendliness of STIG in practice. Using different case studies, the STIG will be used to value the impact of a stress event on the SDI. In this process the SDI assessment experts have to go through the statements of each core principle and corresponding indicators using their expertise, and estimate the range and impact of each stressful event occurring. After that, we will calculate the stress factor. Once the new range for each core indicator/principle has been estimated, the total stress failure that the SDI is likely to acquire given the stressful event, will be calculated.

Based on the findings of these two workshops, the final STIG indicators and principles will be implemented in final version of the STIG.

5.3 Acknowledgment

The research on this chapter stands on an ongoing PhD research project on the development of a sound foundation for an academic theoretical framework for the STIG, Stress Test for Infrastructure of Geographic information. Under the auspices of Knowledge center Open data within OTB – Research for the Built Environment of TU Delft / Faculty of Architecture and The Built Environment, this research aims to develop a methodology and set of indicators that provide improvements in SDI assessment landscape.

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7. Appendix 1

The overall applicability of 29 Basel Core Principles with SDI indicators

Level	Area	Nr	Possible SDI Indicators vs. Basel principles	1 Responsibilities,	2 Independence,	3 Cooperation and	4 Permissible activities	5 Licensing criteria	6 Transfer of significant	7 Major acquisitions	8 Supervisory approach	9 Supervisory	10 Supervisory reporting	11 Corrective and	12 Consolidated	13 Home-host	14 Corporate governance	15 Risk management	16 Capital adequacy	17 Credit risk	18 Problem assets,	19 Concentration risk and	20 Transactions with	21 Country and transfer	22 Market risk	23 Interest rate risk in the	24 Liquidity risk	25 Operational risk	26 Internal control and	27 Financial reporting and	28 Disclosure and	29 Abuse of financial
				Powers, responsibilities and functions of supervisors													Prudential regulations and requirements															
Performance Assessment		31	Turnover and reliability	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		30	Diffusion and use of spatial data and information	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1	0	0	0	1	1	1	1	0	1	1	1	1	1	1
		29	User satisfaction	0	0	1	1	1	1	0	1	1	1	0	1	1	0	0	0	0	0	1	1	1	0	0	1	1	1	1	1	0
		28	Reliability of the system	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		27	Perfomance of the system	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	0	1	1	1	1	1	1
		26	Degree of satisfying the objectives and strategies	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Other Influencing Factors	People	25	Market situation for data providers, data integrators, and end-users	1	0	1	0	0	1	0	1	1	1	0	0	1	1	1	0	0	1	1	1	1	1	0	0	1	1	1	0	0
		24	Opportunities for training	1	0	1	0	0	1	0	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		23	Number of organisations and people involved	1	0	1	0	0	1	0	1	1	1	0	0	1	1	1	0	0	1	1	1	1	1	0	0	1	1	1	0	0
Operational	Data	22	Data quality and accuracy	1	0	0	1	1	0	0	1	1	1	1	0	0	0	1	0	0	0	1	1	1	1	0	0	0	1	1	1	1
		21	Data maintenance	1	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	1	1	0	1	1	0	0	0	0
		20	Definition of core datasets	1	0	1	1	1	0	0	1	1	1	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	1	1	1	1
		19	Data capture method	1	0	0	0	0	0	0	1	1	1	0	0	0	1	1	0	0	0	1	1	1	1	0	1	1	1	1	1	0
		18	Data format	1	0	0	0	1	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0
Operational	Access Network	17	Response time	1	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		16	Data volume	1	0	0	0	0	0	0	1	1	1	0	0	0	1	1	0	0	0	1	0	1	1	0	1	1	1	1	1	0
		15	Type of network	1	0	0	1	0	0	0	1	1	1	0	0	0	1	1	0	0	0	1	0	0	1	0	1	1	1	1	1	1
Management	Access Network	14	Value-adding arrangements	0	0	0	0	0	0	0	1	1	0	0	0	0	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		13	Access privileges	0	0	0	0	0	1	0	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		12	Delivery mechanism and procedure	0	0	0	0	0	1	0	1	1	1	1	0	1	1	2	1	0	1	1	1	1	1	1	1	1	1	1	1	1
		11	Access pricing	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Management	Standards	10	Interoperability	1	0	1	1	1	0	0	1	1	1	1	1	1	2	2	1	0	1	1	1	1	0	0	0	2	2	1	2	1
		9	Data modelling	1	0	1	1	1	0	0	1	1	1	1	0	1	2	2	1	0	1	1	1	1	0	0	0	2	2	1	2	1
		8	Definition of core datasets	1	1	1	1	1	0	0	1	1	1	1	0	1	2	2	1	0	1	1	1	1	0	0	0	2	2	1	2	1
		7	Organisational arrangements for coordination of spatial data	1	1	1	1	1	1	0	1	1	1	2	1	2	2	2	1	1	2	2	2	1	1	1	1	2	2	1	2	1
		6	Institutional arrangements of agencies involved in providing spatial data	1	1	1	1	1	1	0	1	1	1	2	1	2	2	2	1	1	2	2	2	1	1	1	1	2	2	1	2	1
		5	Standardisation arrangements for data dissemination and access network	1	1	1	1	1	1	0	1	1	1	2	1	2	2	2	1	1	2	2	2	1	1	1	1	2	2	1	2	1
Policy	Policy	4	Objectives for acquisition and use of spatial data	2	1	1	1	1	1	0	1	2	1	1	2	1	2	2	1	1	2	2	1	2	2	1	1	2	2	2	2	2
		3	Handling of intellectual property rights, privacy issues, pricing	2	1	2	2	2	1	0	2	1	1	1	2	1	2	2	1	1	2	2	1	2	2	1	1	2	2	2	2	2
		1	Existence of a government policy for SDI	2	1	2	2	2	2	0	2	2	1	1	2	1	2	2	1	1	2	2	1	2	2	1	1	2	2	2	2	2

Chapter 4: Open Spatial Data Infrastructures for the Sustainable Development of the Extractives Sector: Promises and Challenges

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Abstract

Many countries will rely on the extractive sector to generate the inputs and revenues necessary to advance progress towards the sustainable development goals (SDGs). While the last decade has seen a strong push for financial transparency in the extractive sector, it is becoming equally necessary to also include the social and environmental performance of the extractive industries across the entire value chain. However, to maximize the value of this broad range of data for improved stakeholder dialogue and decision making, a geo-spatial approach is needed for effective data integration, management, analysis, and monitoring. This requires capacity building to extractive companies and to the various transparency initiatives to ensure that reporting and disclosure data is spatially enabled as well as inter-operable, open, quality controlled and published to a spatial data infrastructure (SDI) that is publically accessible.

Ideally, this SDI can then inform and benefit many stakeholder dialogues, support reforms in natural resource governance, promote more equitable benefit-sharing, and enhance the performance of monitoring of the sector at the concession level. We discuss here the benefits and challenges of SDIs in the extractive sector. This is done using the experience gained by the authors in the design and implementation of a new Open Data Platform for the Extractive Sector called MAP-X (Mapping and Assessing the Performance of eXtractive Industries) in the Democratic Republic of Congo.

Keywords: Spatial data infrastructure, interoperability, extractive industry value chain, mapping, open data, conflict prevention, environmental transparency, sustainable development goal

1. Introduction

Extractive resources such as oil, gas, minerals and timber can have a transformative impact on the development trajectory of a country. They can create jobs, generate revenue and stimulate further economic growth. Over 100 countries will rely on their extractive resources to generate the inputs and revenues necessary to advance progress towards the Sustainable Development Goals (SDGs) (UN, 2015). This is over 50% of the member states in the United Nations, representing approximately 80% of the planet’s land mass and containing around 70% of the population. Moreover, as a recent international inter-agency consultation process showed (WEF, 2016), there are potential direct and indirect contributions from the mining industry toward all of the 17 SDGs.

While the potential benefits offered by the extractive sector are significant, harnessing these opportunities presents numerous challenges and pitfalls. This is especially the case in countries affected by fragility, conflict and violence (FCV). Many of these countries suffer from the "resource curse" (Sachs and Warner, 1995): a term referring to the paradox that countries with abundant non-renewable resources like minerals and hydrocarbons tend to have lower economic performance, more corruption, and worse development outcomes than countries with fewer of these resources. There are debates about the various potential causes of the resource curse (van der Ploeg, 2011), and also about whether sufficient evidence now exists for a sub-national, spatially delimited, resource curse in some countries (Cust and Viale, 2016). Inherent to this resource curse is the fact that in many countries around the world, the extractives sector is plagued by decades of opaque contracts, backroom deals and decisions taken without public consultation or dialogue with local communities. As a result, stakeholder trust breaks down and benefits are not shared equitably, which can generate social grievances and conflicts (e.g. Hilson, 2002; Rustad et al, 2012; Kooroshy et al, 2013). If the extractive sector triggers social violence, any meaningful progress towards the SDGs is undermined.

In 2012, UNEP and the World Bank collaborated as part of a wider UN process to assess key conflict risks across the extractive industry value chain. One of the key findings of this joint work (Rios et al, 2015) was that social conflict across the extractive industry value chain is often related to a lack of transparency and access to authoritative information about concession revenues, risks and benefits. There is little public access to authoritative information about the revenues the sector is generating, or the social and environmental risks it is causing. Lack of access to basic information increases suspicion and mistrust, as well as miscommunication and misunderstandings which then tend to fuel tensions and even violent conflict. The massive information asymmetries among stakeholders in the extractives sector also lead to unfair deals and to the inequitable sharing of benefits and risks between major stakeholder groups.

To address many of these challenges, the last decade has seen a global push for transparency in the extractive sector, essentially toward disclosure of financial and contractual data (Haufler, 2010). This has included details of the call for proposals and bidding process for natural resources exploration and development contracts, the contents and terms of these contracts, payments made by companies to governments (royalties, taxes, signing bonuses, fees), prior informed consent to communities affected by proposed developments, and the distribution of resource rents. At the forefront of his endeavor is the Extractive Industry Transparency Initiative (EITI), a global initiative launched in 2002 to promote open and accountable management of natural resources. In each EITI implementing country, a coalition of government ministries, companies and civil society work together as a multi-stakeholder group to achieve compliance toward the EITI standard (EITI, 2016). Although some studies have shown EITI implementation in countries can be successful in mitigating some of the aspects of the resource curse (Corrigan, 2014), other studies challenge the short term effectiveness of EITI in improving governance and economic development outcomes (e.g. Sovacool et al, 2016) or corruption scores (e.g. Kasekende et al, 2016).

We argue in this chapter that the benefits and impact of financial transparency could be increased by expanding transparency reporting to cover social and environmental dimensions, and by managing this information in an integrated manner using a geo-spatial approach based on a spatial data infrastructure (SDI). We start by discussing the potential benefits of spatial data access, interoperability, aggregation, and visualization for a range of transparency data in the extractive sector. We continue by introducing MAP-X, a new initiative aiming at making extractive data and other geospatial data more accessible and useable in an online open platform, and we finally discuss the challenges of field testing MAP-X in the Democratic Republic of Congo.

2. Open Spatial Data Infrastructures and the Extractive Sector

The past decade has seen numerous initiatives and incentives to make data in all sectors more available, more accessible, and more integrated. Because data production, finding, access, use and dissemination are tightly linked to factors such as standards, regulations, legislation, land use, administrative boundaries, infrastructure and other human factors, this justified the development of Spatial Data Infrastructures (SDI) as an enabling platform for efficient geospatial data workflow, management and analysis. An SDI can be defined as the appropriate set of technologies, policies and institutional arrangements that facilitate the availability of, and access to, geospatial data (Rajabifard et al, 2002; Nebert, 2008). In the context of our chapter, we can further loosely define an "Open SDI" as an SDI that is making use of *open source software* to help data management and publication; *open standards* for enabling interoperable discovery and access to data (Yaxing et al, 2009; Ramage, 2011); and that is encouraging *open data* sharing principles to make as much data and information available for re-use as possible (Arzberger et al, 2004).

Several global level initiatives are currently promoting the creation and implementation of SDIs, and most of them are driving the trend of free and open data due to the benefits it can offer in monitoring impact and development goals (Gurin and Manley, 2015). Today's best global effort to promote large scale data sharing is represented by the Group on Earth Observations (GEO), a voluntary partnership of more than a hundred countries and 95 participating organizations, that is coordinating the implementation of the Global Earth Observation System of Systems (GEOSS, GEO secretariat, 2008). The GEOSS is aiming to act as a gateway between data producers and users providing comprehensive access to environmental data and information on various thematic areas (Giuliani et al, 2011). In its recently renewed work program, GEO has launched its activity CA-06 ("EO data and mineral resources") to foster the use of Earth Observations for improving the monitoring of the mining life cycle with the objective to move towards more responsible and sustainable practices and better addressing the societal acceptability of issues related to mining activities. The United Nations initiative on Global Geospatial Information Management (UN-GGIM, http://ggim.un.org [accessed 14 September 2016]) is also leading the effort for promoting the use of global geospatial information to address key global challenges such as improved land governance and management.

Within geosciences and extractive industries, several initiatives aim at helping to discover and access relevant data and information. OneGeology (http://www.onegeology.org [accessed 14 September 2016]) is an international initiative from geological surveys to create a global dynamic geological map and increase awareness of the geosciences and their relevance (Janssen and Kuczerawy, 2012). Another global initiative is represented by OpenOil (http://www.openoil.net) that allows users to search and access a collection of more than one million records about oil, gas, and mining concessions. This initiative has collected information on the text of contracts, company disclosures and government reports and provides maps of concessions areas. In the same line, the Natural Resource Governance Institute (NRGI, http://www.resourcegovernance.org [accessed 14 September 2016]) aims at improving critical aspects of the natural resource decision chain, and provides access to different online tools to help stakeholders working in the resource governance field to perform quantitative and quality analysis and assessments. NRGI notably provides tools to facilitate access to EITI reports and related data under the form of interactive graphical visualization.

Although some of the extractive sector data are being disclosed and made available at a growing pace, there is still an urgent need to have open SDIs that would capitalize on this information by providing the ability to visualize and analyze this data together with other national, regional and global contextual data sets of interest. There is growing availability of open global data sets in standardized formats, notably through the GEOSS, but also in more thematic portals such as PREVIEW - the Global Risk Data Platform (Giuliani and Peduzzi, 2011). The latter is an interactive geoportal (supported by an SDI) to serve and share global data on natural hazards and related exposure and risk, and it has been at the forefront to enhance availability, accessibility and integration of such data. The availability of such data sets makes it timely to harness the many benefits of multi-sectorial data integration and mash-up for stakeholders in the extractive industries.

3. Potential Benefits of Spatial Data Integration and Visualization in the Extractive Sector

There are many potential benefits that can be drawn from enhanced access as well as analysis and visualization of geospatial data. It has long been known that mapping in general is an appropriate vehicle for communicating information to stakeholders on changes to land use from an extractives project given the inherent geographic context where the impacts will occur. Maps and related graphics are a corner stone for informing public debates and facilitating stakeholder consultation, especially when it is coupled with modern geospatial technology such as remote sensing (see for example Jankowski et al, 2001; Maceachren and Brewer, 2004; Bareth, 2009; McIntosh et al, 2011; Boerboom, 2012).

In the extractive sector, the large and heterogeneous set of data and information from various fields (financial, environmental, socio-economic, etc.) offers a tremendous opportunity to capture potential benefits from improving accessibility, availability and integration of this data. We highlight here six of the most significant benefits based on experience and initial stakeholder consultations.

First, spatially-explicit data combined with other statistical, legal and performance data can support the development of thematic performance maps, spatial relationships among variables, temporal trends, etc. that can inform stakeholders on the range of potential impacts, benefits and risks. This is particularly useful at the outset of a new potential extractive project when communities and governments need access to authoritative information in order to inform their engagement with companies.

Second, in terms of enabling better screening and decision-making for extractive investments, a huge potential lies in facilitating access to and integration of other contextual data such as natural disasters and other risk data (e.g. conflict risk), infrastructure data (e.g. roads, ports, energy) and water availability (hydrographic data). Many countries, and especially low income countries, usually lack the ability to publish this data in an online and accessible national SDI that would facilitate access by companies and private investors for investment screening, selection and decision making.

Third, in countries where concession boundaries information is available and accessible, special overlay of these boundaries with other types of cadaster information and land rights can be very useful to identify overlaps and the need for reconciliation processes. Cuba et al (2014) and Slack (2014) showed how relatively simple overlap analyses between concessions boundaries (minerals, oil and gas) on the one hand, and agricultural land, protected areas and river basins on the other hand, can help cadaster reconciliation, informed discussion and decision-making among Ministries regarding land-use priorities. Showing a lack of overlaps would also help boost investor confidence and reduce potential uncertainty.

Fourth, there is also great potential in aggregating data from industrial mining sector and that from the artisanal and small-scale mining (ASM) sector. However, ASM data is generally much more difficult to get, suffers from great uncertainty, is infrequently updated, and its authoritativeness is often challenged. Nonetheless, many studies have shown the effectiveness of analyzing these various spatial data sources with geospatial tools in an effort to evaluate impacts, dynamics, and governance of natural resources in specific areas (e.g. Baynard, 2011; Hinojosa and Hennermann, 2012; Aistrup et al, 2013; Emel et al, 2014; Patel et al, 2016).

Fifth, online access to this growing information is also becoming increasingly useful as a communications tool among stakeholders and also for the media. Use of interactive maps in concert with a narrative is the core of the relatively new concept of "story maps" (ESRI, 2012), defined as storytelling using information products that allow an online linear exploration of data, information and media (pictures, video, interactive graphs, etc.). Journalists covering the various facets of the extractive industry can also help generate public awareness and pressure towards specific governance reforms using authoritative and aggregated data (Schiffrin and Rodrigues, 2014).

Finally, a concerted national process for an open SDI in the extractive sector demands strong standardization and interoperability among data custodians. One of the barriers often encountered in low income countries is the lack of proper unique identifiers for key variables such as company names or concessions. This can greatly hinder aggregation of data between, for example, national EITI database holding reporting information from companies and the official national mining concession cadaster. However, once such interoperability barriers are solved and aggregated data are available, the many benefits of opening data (CODATA, 2015) can start to unfold, and this can trigger similar initiatives in other sectors.

The six points below discussed benefits by stakeholder group, but it can also be useful to depict the relations between a simplified extractive value chain and some of the possible useful data sets and tools that could be implemented in an extractive SDI, as shown in Figure 1. The depicted simplified value chain takes into consideration the four main components that start with the typical exploration and selection of numerous sites, followed by a "development and construction phase" (i.e., contract acquisition, public consultation, environmental impact assessment, site construction) where still no marketable product come out of the site. Then follows the "operations and processing phase" when products flow out and revenue flow in, and finally "decommissioning and closure" when the site is closed down.

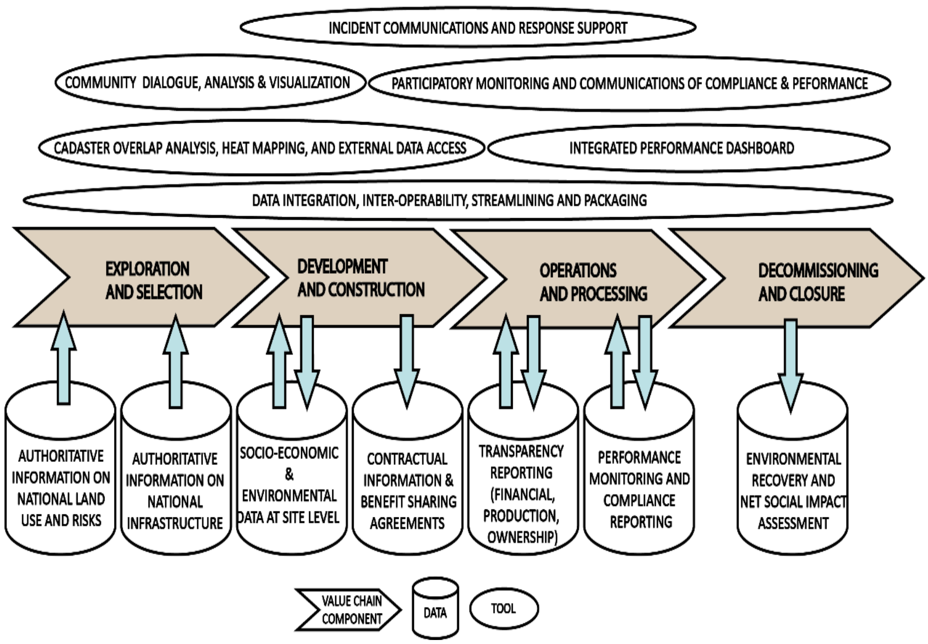

Figure 1. A simplified extractive sector value chain and the potential of providing access to geospatial data and tools in an open Spatial Data Infrastructure. Vertical arrows indicate input/output of data to/from value chain components

4. Governance and Technical Challenges

Despite the many benefits discussed above, several challenges remain for spatially enabling the extractive sector and for streamlining transparency and inter-operability of data. The recurrent challenge, particularly exacerbated in fragile states (i.e. low-income countries suffering from weak state capacity and/or state legitimacy), is the low buy-in and weak mandate from Government bodies to invest and maintain such an SDI. An open SDI in the extractive sector demands a strong level of Government commitment and stakeholder engagement, which demands continuous and considerable work to operationalize and sustain the data sharing workflows. This can further be jeopardized by frequent turnover of key individuals in Governments who can dramatically influence political will on national disclosure and data sharing priorities. The EITI has been engaged for years in pushing for financial and contract transparency and disclosure, but has not fully embraced the need to share this information in a geo-spatial or open manner. However, a major step forward was taken in the revised 2016 EITI standard (EITI, 2016) with the adaptation of an open data policy. The revised standard notes that improving the accessibility and comparability of EITI data can be supported by publishing data in an open format. In particular, the open data policy encourages EITI-Implementing countries to orient government systems towards open data by default and to ensure that this data is fully described, so that users have sufficient information to understand the strengths, weaknesses, analytical limitations, and security requirements of the data, as well as how to process it.

The classical fear of losing data ownership or potential revenues from selling data is also pervasive in the extractive sector, and of course particularly so with data from companies that are in competition for mining concession contracts. A big challenge with companies is to provide them with the right incentives to share their own data, and to provide clarification on commercial versus non-commercial data. The fear of data misuse and especially of unintended consequences of sharing spatially-explicit information in the extractive sector adds to this. For example, we gathered from our stakeholder consultations two such possible unintended consequences: (1) disclosing boundaries of a newly agreed concession could act as an incentive for some individuals and displaced people to occupy lands within the area of the concession in order to obtain financial or other type of compensation when asked to relocate; (2) enabling easy access and display of several natural disaster and other risk maps could highlight high-risk areas where no company will invest, and therefore whose locations could be targeted by groups dealing with illegal mining activities.

Another dire need in many countries is to be able to obtain a measure of the authoritativeness and quality of available data sets. A national open SDI on the extractive industry must find ways to verify and assess the quality of the data sets made available, with clear indication of the intended use of the data (e.g. for visualization, analysis) and its associated precision and uncertainties. The verification and quality control processes must also be tailored to the data collection and reporting capacity of different stakeholder groups. For example, the data quality threshold for local communities should be vastly different from governments and companies.

Besides the governance challenges discussed above, many technical challenges are also present, especially in low income countries. Low IT technical skills, and especially those linked to Geographic Information Systems (GIS) and SDI, are common in many governmental bodies and other stakeholder groups, and could drastically hinder the speed at which geospatial enablement in the extractive sector can be achieved. Many African countries have a low level of SDI implementation (Guigoz et al, *in press*) and the propensity to use an open SDI by local stakeholders can only come after some capacity building of key individuals and leaders in the community (e.g. Giuliani et al, *in press*). This should include specific evidence on how they can benefit from accessing the system and also listening to their needs in terms of developing specific features and functions (e.g. monitoring benefit sharing agreements, showing distribution of employment between villages, or SMS notification of concession contract issuance in areas of interest). Low internet connectivity and a disruptive network can also plague the effectiveness of adoption and use of an open SDI. In the extractive sector, this is particularly true for those potential user groups that are located around mining sites far from large urban centers.

According to the capacity building strategy of GEO (GEO secretariat, 2006), capacity building should be undertaken at three levels when dealing with SDI: human, infrastructure and institutional. This implies a range of activities ranging from education and training of individuals for installing, configuring and managing the required technology, up to enhancing the undertaking of the value of data and information to support decision-making processes (Sten Hansen et al, 2010).

5. Introducing the Map-X Initiative

As an answer to the opportunities and challenges discussed above, UNEP and the World Bank started in 2014 the initiative called 'Mapping and Assessing the Performance of Extractive Industries' or MAP-X. The mission of MAP-X is to strengthen transparency and access to authoritative information on the economic, social and environmental performance of the extractive industries. The goal of MAP-X is therefore to improve the use of authoritative information to support sustainability planning, stakeholder engagement and benefits sharing across the extractive industry value chain. There are three pillars to the MAP-X initiative: the online MAP-X platform (open SDI), the necessary capacity building activities to enable its use, and the standardization process to enable interoperability of existing data and metadata systems.

The online platform consists of three dimensions. The first one is a geospatial web platform providing authoritative spatial information for extractive sector using a combination of dynamic and static data sets, as well as open and restricted data, from different stakeholders (government, company, citizen, experts). Data layers belong to the following categories: (1) Extractive sector: e.g., financial, exportation and production figures that are provided by companies and taxing agencies and reconciled by the national EITI process; national mining cadaster; (2) Development: e.g., World Bank Indicators, socio-economic indicators produced by the National Statistics Institute; (3) Social: e.g., indigenous lands; (4) Environment: e.g., forest loss (Hansen et al, 2013), protected areas (IUCN and UNEP-WCMC, 2016), natural hazard risk (Giuliani and Peduzzi, 2011); and (5) Stresses, e.g., armed groups involved in mineral exploitation and trade. Where feasible this data is dynamically pulled or streamed into the platform in compliance with OGC standards (e.g. Web Mapping Service).

The second dimension of the MAP-X platform is a set of on-line tools to analyze and visualize the geospatial layers. Layers from various sources can be intersected, e.g. mining cadaster and protected areas to support identification of land use conflicts. Heat maps depicting volumes of payments by companies can be overlaid with socio-economic indicators (e.g. poverty rate) to highlight inequality in revenue sharing. A time slider allows visualizing changes over time of variables such as concession type, status, date of issue and owner.

The third dimension is a set of processes for monitoring and communicating benefits, land use changes, environmental risks and grievances. To monitor specific layers of information, users can define a geographic area of interest and receive a text message or email update when new concessions or other land use changes are detected in the area. MAP-X can also provide access to high-resolution satellite imagery as a background image (and in the future to monitor land use change over time). Another process is the documentation and access to the consolidated archive of information that is linked to the agreed benefits by a specific company to affected communities. This is particularly important for civil society members in order to monitor effectively the delivery of these benefits to the population. Finally, the ability to publish and spatially locate the results of environmental assessment studies (e.g. soil/water sample locations and associated information) could improve site-specific performance monitoring across the extractive industry value chain.

Altogether, these three MAP-X dimensions can be considered as the building blocks of a generic open SDI for the extractive sector. An advanced MAP-X prototype has been developed and is currently being deployed in the Democratic Republic of the Congo (DRC) (see below). This prototype is built entirely on open-source software using the following stack of software: R, SHINY-R, Leaflet, GeoServer, PGRestAPI, and GRASS. The prototype is publicly available (http://mapx.org), allowing non-registered users to visualize all public geospatial layers in the DRC. Figure 2 shows screenshots of the MAP-X platform.

6. Deploying Map-X in the Democratic Republic of Congo (DRC)

The DRC has been chosen for the initial pilot-testing and deployment of MAP-X for two main reasons. The first one is that the extractive landscape in DRC makes it likely to benefit from the availability of an open SDI. In line with the resource curse paradox, the mineral potential of the country is immense, with an estimated USD 24 trillion of untapped mineral resources (PNUE, 2012). Mining concessions represent 40% of the area of the country with more than 100 companies in operation in 2016, contributing up to USD 1 billion to the state budget (ITIE-RDC and Moore Stephens, 2015). At first sight, the extractive sector could be seen as an engine for development as it could create jobs, generate revenues, stimulate economic growth and support sustainable development. However, the highest revenues come from the informal sector, which accounts for 90% of mineral production and exports (Geenen, 2012). There are close to two million artisanal miners, and 12 millions of people depend on this sector. This sector operates in an opaque manner, beyond environmental and labor laws. It is estimated that USD 1.25 billion in natural resources are stolen every year by armed groups and transnational criminal networks (UNEP-MONUSCO-OSESG, 2015). More widely, the extractive sector is plagued by corruption, mismanagement and secrecy and is a historical source of conflict financing, which is particularly critical in the current context of political instability. Consequently, trust and effective dialogue between stakeholders of the extractive sector is weakened. It is then critical to facilitate access to authoritative information in the extractive sector in order to manage public expectations, and the prevent misperceptions contributing to conflict.

The second reason for choosing DRC relates to the significant progress made over the past years towards transparency and disclosure of extractive industry data. This was driven by the work of the national EITI-DRC Multi Stakeholder Group (MSG) composed of high representatives of the government, civil society and private companies. DRC started to implement the EITI in 2007 and, as of 2016; it is one of the 29 EITI-compliant countries. DRC has notably been awarded in 2016 by the EITI international Secretariat for having leaded the way on disclosure of beneficial ownership. In its 2014 annual report (EITI-DRC and Moore Stephens LLP 2015) EITI-DRC discloses information about license allocations, licenses registers, contracts and state-participation. This information is available in tabular format.

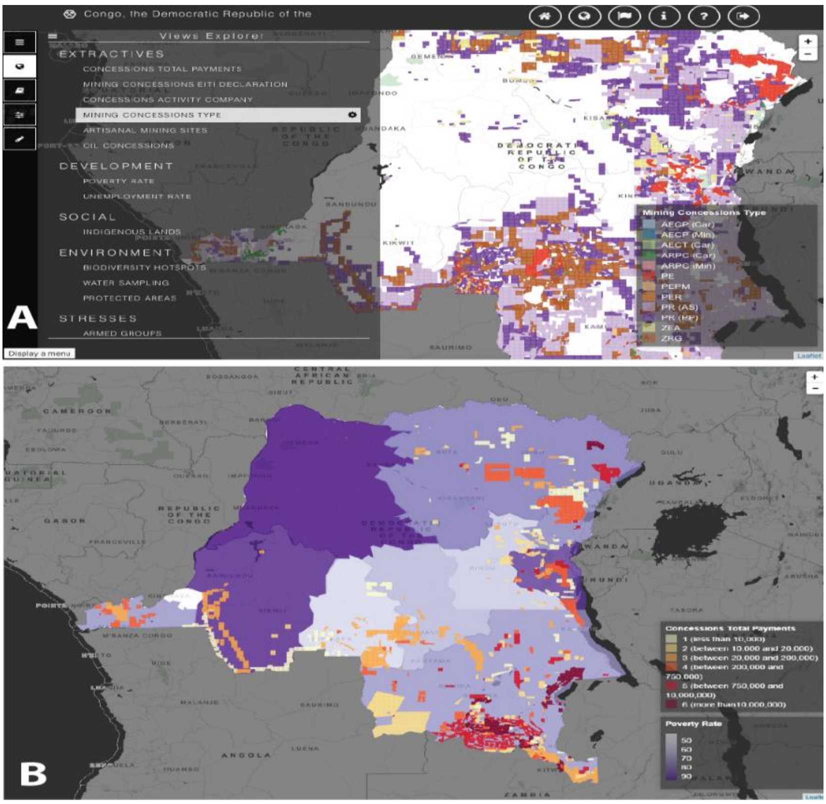

Figure 2. Screenshot of the MAP-X platform showing (A) Concession map of DRC from 2010, (B) heat map of amount of payment to Government by companies owning concessions, on top of poverty rate map per sub-region

In parallel, the DRC Mining Cadaster (CAMI) has published a public national geospatial portal to improve transparency and to promote investment in the country. Developed on the FlexiCadastre technology the portal disseminates information on active concessions (http://portals.flexicadastre.com/drc/en/ [accessed 14 September 2016]): exploitation permits (small mines and tailings), research authorization for quarry substances, authorizations for exploitation, exploitation and research permits along with the holder(s), application, grant and expiration dates, commodity and area. The DRC FlexiCadastre portal is however restricted to the display of a few geospatial datasets (mining concessions, protected areas, geology and satellite imagery), and it does not provide metadata about these layers, analytics (e.g., overlay functions, tools to calculate spatial statistics, download functions) or participatory processes for stakeholder dialogue and monitoring.

Our consultation process started in 2015 with various key stakeholders (MSG, Prime Minister's office, EITI-DRC, etc.). They agreed by consensus that the MAP-X initiative could be of tremendous value to DRC and supported further development and testing at the national and local level. Each stakeholder group identified different benefits they could gain from MAP-X.

For the DRC Government, there is a fundamental need for MAP-X to help establish processes that can identify and resolve boundary overlaps between different cadastral systems and designated land uses. An internal reconciliation process will be required to resolve such boundary overlaps, as they lead to uncertainty and undermine investor confidence. The second need for the Government is the support of MAP-X in resolving local conflicts linked to extractive industry projects, including through the mapping of conflicts, the provision of impartial information and performance monitoring tools. Moreover, the MAP-X initiative could help to drive the process of data standardization and data sharing at national level among governmental bodies.

Representatives of civil society expressed a strong need to access information on the standards, obligations and performance conditions that different extractive concessions and operators have agreed on. Without such information, they cannot perform a watchdog function in terms of informing the national dialogue on compliance monitoring, regulation and accountability.

Finally, representatives of extractive companies in DRC expressed interest in MAP-X for helping to identify different sources of risk to individual concessions, including disasters and conflicts, as well as environmentally sensitive sites and authoritative boundaries of protected areas. Companies would also like a simple mechanism to showcase and publically communicate some of the positive impacts they are making on local socio-economic development, for example, using story maps in the MAP-X platform.

7. Conclusions

Achieving the Sustainable Development Goals will demand a massive concerted global effort to efficiently make use of data sharing, processing and aggregation in a highly multidisciplinary framework. The pervasive role of the extractive sector throughout these SDGs makes it particularly important to implement Spatial Data Infrastructures and associated online geoportals that can deliver many untapped benefits for various stakeholder groups. In particular SDIs are playing an important role in delivering spatially enabled governments and societies.

The technical challenges that we discussed above, notably those linked to the chosen technologies or the low ICT and SDI literacy, should not make us forget that this is only the tip of the iceberg. The bulk of the challenges are the non-technical ones, those related to human behaviors, resistance to change and sharing, buy-in and motivation, just to name a few. Capacity building activities on how the discussed benefits can unfold along the extractive value chain are critically important to carry out, especially in low income and fragile states where an increase in data transparency can make a big difference.

MAP-X is an answer to some of the data management and SDI challenges outlined in this chapter. MAP-X is a partnership between UNEP and the World Bank to strengthen transparency and access to authoritative information on the financial, social and environmental performance of the extractive industries. MAP-X integrates transparency information into an online geo-spatial platform, and offers a combination of analytical and monitoring tools to support stakeholder dialogue and decision making. By offering a dedicated on-line platform for the extractives sector, MAP-X will help to expand and modernize on-going transparency initiatives by: publishing integrated transparency data in an accessible and spatial format; extending transparency to include social and environmental dimensions; and deepening transparency to the site level for monitoring community consultation processes and compliance with legal obligations. Our hope is that the initial deployment of MAP-X in the DRC can pave the way towards the geospatial enablement of the extractive sector, with the potential for MAP-X to eventually be deployed to all 100 countries that have an active extractive sector.

8. Acknowledgments

We thank the EITI-DRC secretariat for having facilitated stakeholder consultations in DRC. We also thank the international EITI Secretariat for valuable comments throughout the MAP-X conceptualization and deployment process in DRC.

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Chapter 5: Spatial Data Infrastructure in New Brunswick, Canada: Twenty Years on the Web*

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Abstract

In September 1996, the Province of New Brunswick, Canada became the first jurisdiction in the world to offer World Wide Web-based access to complete and integrated online property mapping, ownership and assessment information covering an entire province or state. Service New Brunswick's Real Property Information Internet Server (RPIIS) was originally developed by Caris/Universal Systems Ltd. (Caris) in conjunction with the University of New Brunswick Department of Geodesy and Geomatics Engineering and with substantial input from Service New Brunswick (SNB) staff. The Caris Internet Server technology on which it was based was recognized, at the time, to be "…the first commercial Internet/mapping GIS" platform.

The chapter examines the twenty-year evolution of land information infrastructure refinement in New Brunswick since that time, beginning with the early vision of linking land information with environmental and resource-based information to support improved decision-making.

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Since 1996, policy and operational issues encountered by SNB included ones related to charging for data, use of geospatial data in eGovernment and eGovernance, data custodianship and incremental updating, involvement of the private sector, and the contrasting "push-pull" between open data initiatives and personal data privacy concerns – issues also faced by other jurisdictions across North America, Europe and Australasia over the same period.

After discussing early initiatives, challenges and issues mentioned above, the chapter then tracks and analyzes the changes in Web-based services offered since 1996 in response to a widening and more sophisticated customer base, shifts in government/business relationships, and changes in technologies for data collection, management and communication. The chapter concludes with a discussion of current key information initiatives of Service New Brunswick (SNB) and how they pertain to the fulfilment of the original vision.

Keywords: SDI, Web GIS, Internet, Land Administration, Cadastral

1. Introduction:

The Canadian Province of New Brunswick's lengthy history of examining and adopting innovative approaches to land administration and to sharing and distributing the land information maintained by various provincial government departments has been chronicled by Palmer (1984); Coleman and McLaughlin (1988); Loukes and Nandlall (1990); (Doig and Patton, 1994); (Finley et al, 1998) and many others. As early as the 1960s, land information experts recognized the importance of an integrated data bank of information related to land (Dale and McLaughlin, 1988). In New Brunswick, it was recognized that in order for this information to support improved decision-making, it would have to be kept up-to-date and easily accessible; moreover, the public should be involved in the process [McLaughlin, 1991].

In September 1996, the Province of New Brunswick, Canada became the first jurisdiction in the world to offer World Wide Web-based access to complete and integrated online property mapping, ownership and assessment information covering an entire province or state (Arseneau et al., 1997). Service New Brunswick's Real Property Information Internet Server (RPIIS) was originally developed by Caris/Universal Systems Ltd. (Caris) in conjunction with the University of New Brunswick Department of Geodesy and Geomatics Engineering and with substantial input from Service New Brunswick (SNB) staff. The Caris Internet Server technology on which it was based was recognized, at the time, to be "…the first commercial Internet/mapping GIS" platform (Plewe, 1997). In the twenty years since that time, SNB has experienced the peaks, valleys, setbacks and triumphs experienced by public sector organizations world-wide in — especially in today's era of commercial on-line mapping and crowdsourced data — maintaining relevance and influencing the shared collection, updating, authentication and distribution of New Brunswick's provincial mapping and land-related information products.

This chapter examines the forty-year evolution of land information infrastructure refinement in New Brunswick since the mid-1970s, beginning with the early vision of linking land information with environmental and resource-based information to support improved decision-making. After discussing early online initiatives, the authors briefly discuss the changes in related Web-based services, data products, data custodianship & management arrangements implemented since 1996 in response to a widening and more sophisticated customer base, shifts in government/business relationships, and changing technologies. The chapter concludes with a discussion of current key information initiatives of Service New Brunswick (SNB) and how they pertain to the fulfilment of the original vision.

2. The Institutional Framework of The1980s

Like many jurisdictions, the province of New Brunswick faced the benefits and challenges of several major departments collecting geospatial data to serve a variety of engineering, planning, resource inventory, and land administration activities on both short-term, project-related and long-term, program-related bases (Table 1).

Beginning in the 1970's, the provincial governments of Canada's three maritime provinces (New Brunswick Nova Scotia and Prince Edward Island) came together to establish and co-fund a long-term program to establish a shared monumented survey control framework, common topographic orthophoto base mapping, comprehensive property mapping and attribute information built atop this topographic base. By the early 1980s, this program was extended to digital vector mapping and Digital Elevation Model coverage as well (Dale & McLaughlin, 1988). In addition, separate programs were in place within each province to undertake forest and geological inventory mapping, highway mapping, environmental & land-use mapping, land registration and property assessment/valuation.

In the mid-1980's, a provincial "Office of Government Reform" was established in New Brunswick to examine practices and actives in each department which were perceived to overlap with or duplicate those undertaken by another department. Not surprisingly, surveying and mapping activities were identified as being one such category. Despite pressure from some corners to amalgamate such activities within a single service agency, it was decided that a combination of shared and department-specific (but standards-based) geospatial products and services within the provincial government itself rather than the regional LRIS model) would best meet the needs of the province in the coming years (Coleman et al., 1987; Coleman et al., 1989). In 1989, the Province of New Brunswick instituted a Land Information Policy that was intended, for the first time, to provide clear province-wide guidelines for the collection, storage, retrieval, dissemination and use of land information (Simpson, 1990; Aiton, n.d.).

Table 1: NB Government Project- and Program-Related Activities supported by Geospatial Data Products and Services

	Short-Term	**Ongoing and/or Long-term**
Project	Highway Planning, Construction and Upgrading Urban and Rural Land Use Master Plans Adjustment of Electoral District Boundaries	Servicing Land-Use Planning and Change Applications Monitoring anomalies and longer-term effects of program planning and policy-level decisions.
Program	Flood-Plain Mapping School-Bus Route Planning	Forest Inventory & Management on Crown Lands Exploration & Mining Claims Land Registration Property Assessment Emergency Response Planning

To carry out the objectives of the policy, the functions of land registration, property assessment, and mapping in New Brunswick were amalgamated under a single entity, the New Brunswick Geographic Information Corporation (or NBGIC) (Geographic Information Corporation, 1989; Coleman, 1989; Nichols, 1993). NBGIC was established as a Crown Corporation to provide specialized expertise and a broad scope of services in the field of land information. Its responsibilities included (Arseneau et al. 1997):

- Operating the real and personal property registration systems;
- Assessing all land, buildings and improvements for the provincial property taxation system;
- Maintaining the province's surveying and mapping systems; and
- Providing land and geographic information services to the public.

In its early years, NBGIC inherited many of its information resources from earlier initiatives and devoted considerable effort to conversion of the information inherited from earlier initiatives into digital form and the subsequent loading of this digital data into an infrastructure of separate databases which initially included: (1) a *Property Assessment and Taxation Database* to support property valuation; (2) a *Parcel Index Database* containing ownership information and providing a parcel-based index to registered documents on all land parcels in the Province; and (3) a *Property Map Database* which contained a digital graphical representation of the parcel mapping related to the Parcel Index (Arseneau et al., 1997).

NBGIC was, in turn, transformed and enlarged in 1998 into a new government organization called Service New Brunswick (SNB) with a view to consolidating "… in one corporation, the transactional services and information that New Brunswickers need to conduct their personal and business lives" and a mandate to "….improve access to government services and public information" (SNB, 2007). While SNB land information was publicly available at regional offices and could be purchased in hardcopy format or on diskette, studies revealed that a more convenient access mechanism to land-related information was required (Strunz 1994; ADI 1995).

3. Technological Development

Development efforts to this end progressed from the early-1970s onwards (Finley et al, 1998). Early conceptual land information system designs were originally based on large, centralized databases using the mainframe computer technology of the day (Roberts, 1976). However, plans exceeded both budgets and capabilities of the government agencies of the day; government departments instead began developing isolated, project-based spatial and attribute databases, and both organizational and institutional issues impeded the realization of the centralized database design. A shift in the LIS design became necessary, and by the 1980s, technology had advanced enough to support a shift from an LIS model to a Land Information Network (Palmer, 1984). Databases developed and maintained by departments and housed at departmental locations, rather than in a centralized data bank, were linked to other databases by the common parcel identifier. The success of the network model meant that participating government departments had access to shared information. However, the public still had no convenient access mechanism.

3.1 Online Provision of Property Mapping and Parcel Attribute Data

In 1995, SNB staff beta-tested the CARIS Internet Server™ from Universal Systems Ltd. (Or USL — today known as *Caris*) – software originally developed in 1994 as part of a federally-funded initiative involving USL and the Geographical Engineering Group at the University of New Brunswick (Arseneau et al. 1997). While the CARIS Internet Server was one of the earliest Internet-based mapping packages to allow search, query and display functionalities (Plewe, 1997), SNB staff provided enhancement suggestions to ensure it met government requirements including a fee-for-use administrative component (Dawe, 1996).

Based on this CARIS Internet Server™ as its backbone, SNB implemented in August 1996 one of the world's first commercially-available, Web-based land registry systems, providing access to integrated parcel-related data sets covering the entire province of New Brunswick. Known originally as the Real Property Information Internet Service (RPIIS), it allowed clients to access non-confidential, parcel-based information residing at a password-protected SNB Internet site (Figures 1, 2 and 3). Paying users of this prototype service could search for a property by specifying either textual, graphical, place-name or coordinate information, and the service allowed users to view and query maps and attributes, select display layers, and perform (very) limited GIS-type analysis operations (Arseneau et al. 1997).

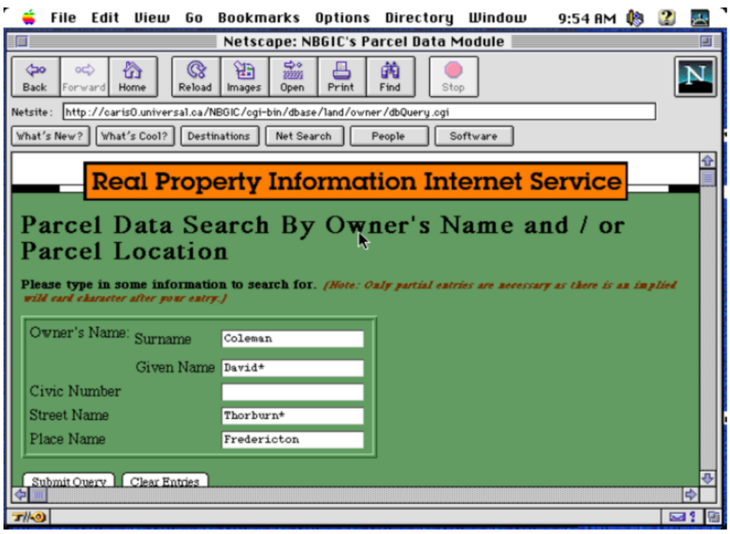

Figure 1: Example of RPIIS Query Screen for NB Parcel Index Data (Arseneau et al., 1997)

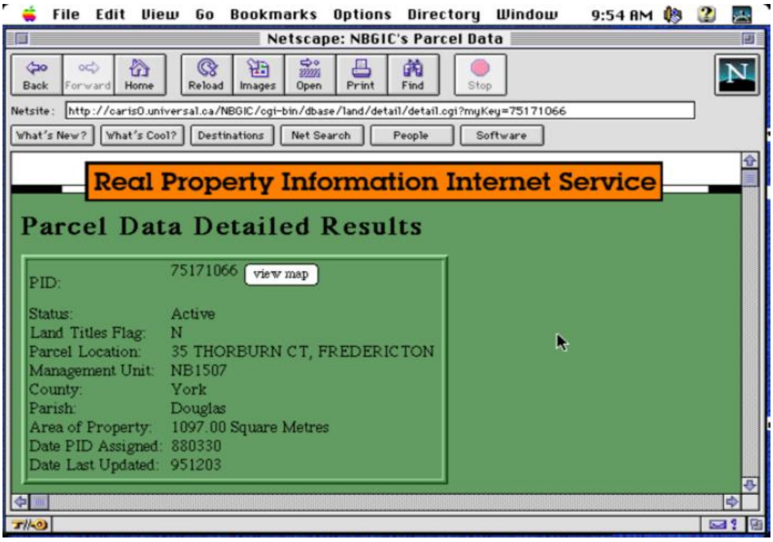

Figure 2: First Screen of Attribute Data Response to Query in Figure 1 (Arseneau et al., 1997)

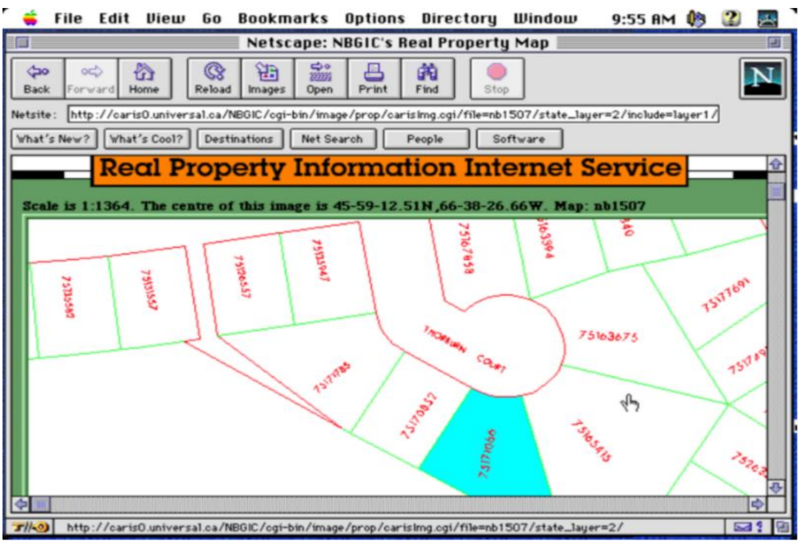

Figure 3: First Screen of Graphics Data Response to Query in Figure 1 (Arseneau et al., 1997)
(Note: Users could zoom in or out from this screen)

An early study of the users and usage patterns of the RPIIS commissioned by SNB and carried out by Hoogsteden and Coleman (2000) reported the number of registered system users had grown to over 700 by July 1999, with over 70% of these users being in the private sector. The pie chart in Figure 4 — adapted from the original report — illustrates the breakdown of RPIIS private sector customers at that time. The classification used for this sub-division was based on clearly identifiable core user-occupations (especially the professions) and specific industrial groupings, e.g. forestry and agriculture.

Lawyers and para-legals formed the largest single user group in those early days (24%), while forestry-related firms accounted for another 15% of the customer accounts. Surveyors, Consultants and Real Estate firms comprised the next tier of users, while a mixture of others made up the remaining users. Of these 700 registered users, approximately 40% were using the service regularly while another 20% showed little sign of activity after the first month.

Subsequent enhancements to the service through the late 1990s, including the launch and refinement of the *New Brunswick Land Gazette*, are described in detail by Arseneau et al. (1997b) and Finley et al. (1998) among others. In 1998, the original system was embedded within a much more comprehensive on-line information system called PLANET designed to support the administrative and legal processes involved in property transfer transactions.

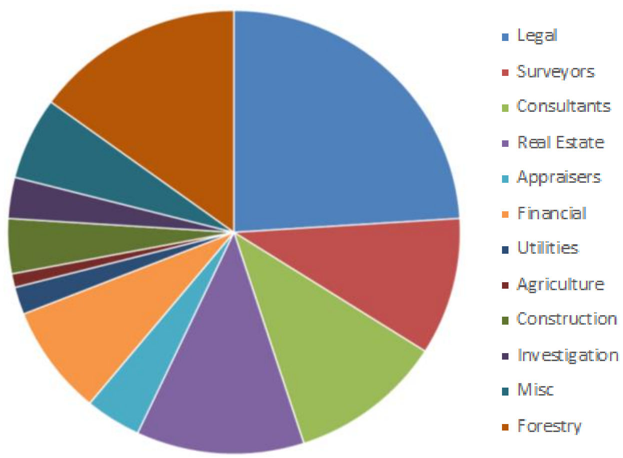

Figure 4: RPIIS Private Sector User Breakdown as of July 1999 (adapted from Hoogsteden and Coleman 2000)

Today, SNB's PLANET system is described as "… a comprehensive, integrated, online source of land registration, assessment, mapping and information services, allowing New Brunswickers to conduct land based transactions quickly, efficiently, and with good information" (SNB 2009). Over the years, the system's name has come to represent, in one word, the attendant concepts and values associated with parcel-based land identification, computerized land registry, provincial government guarantee of land titles and boundaries, "single-window" online access to and transactions associated with property-related information.

The system continues to operate on a subscription basis and also offers a per transaction option (Table 2). Generally speaking the per transaction option is of interest to occasional users of the system whereas the subscription option offers value for frequent users. The system now has 2829 registered users with 694 being government users and the remaining 75% (2135), non-government accounts.

Table 2: PLANET Usage as of July 2016

User type	**Account type**		
	Transaction	**Subscription**	**Sub totals**
Government	511	183	694
Non-Government	1484 (70%)	651 (30%)	2135
Sub-totals	1995	834	**2829**

Using system and subscriber information as of May 2015 and July 2016, provided by Service New Brunswick, a breakdown of registered external PLANET users was prepared by the authors. (See Figure 5.) The user base has grown from 700 users in 1999 to over 2800 today. Government users account for 25% of the user base. The number of different types of users has grown and the number of banks, credit unions and insurance firms accessing the service (i.e., the "Financial" Category) has also increased, as has the number of municipal and federal government users (included in the "Special Government and Misc." Category). That said, lawyers still constitute the largest number of users, with many large law firms possessing multiple accounts (i.e., one or more for each lawyer for billing purposes). Of the 2135 non-government users, 70% (1484) use the per-transaction option.

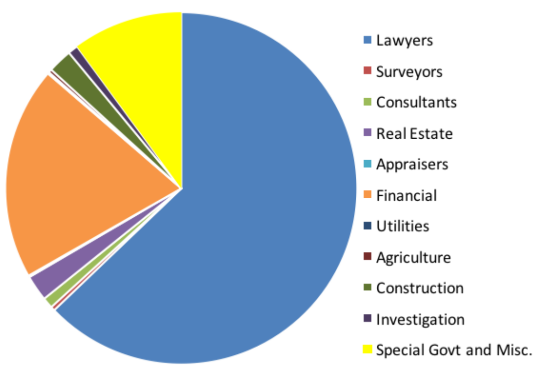

Figure 5: SNB PLANET External User Breakdown as of May 2015

3.2 Online Data Download Services and Web Mapping Applications

As requests for access to information increased and attitudes towards free, open data evolved, in 1999, SNB expanded its offerings to include not only fee-for-service access to the PLANET parcel-related information, but also the ability for users to access and download free digital topographic mapping and Digital Elevation Model datasets produced and distributed by SNB (Figure 6) (Finley et al. 1999).

As a result of a provincial geomatics review in 2005, which among other things identified the need for more robust internet access of integrated data sets rather than simple downloads, a new GeoNB Internet Map Viewer service was developed. Based on Esri technology, it was made available to internal customers in April 2006, with its public launch taking place in 2009 (Figure 7). This version was designed to be a web-based map viewer with all data and functionality contained within the one application. As the user base grew and data was added and functionality increased, this model was at risk of becoming too cumbersome for the general user. SNB program managers realized that -- while a be-all, end-all map viewer might meet some needs of an advanced geomatics technician -- it would likely be too complex for the general use.

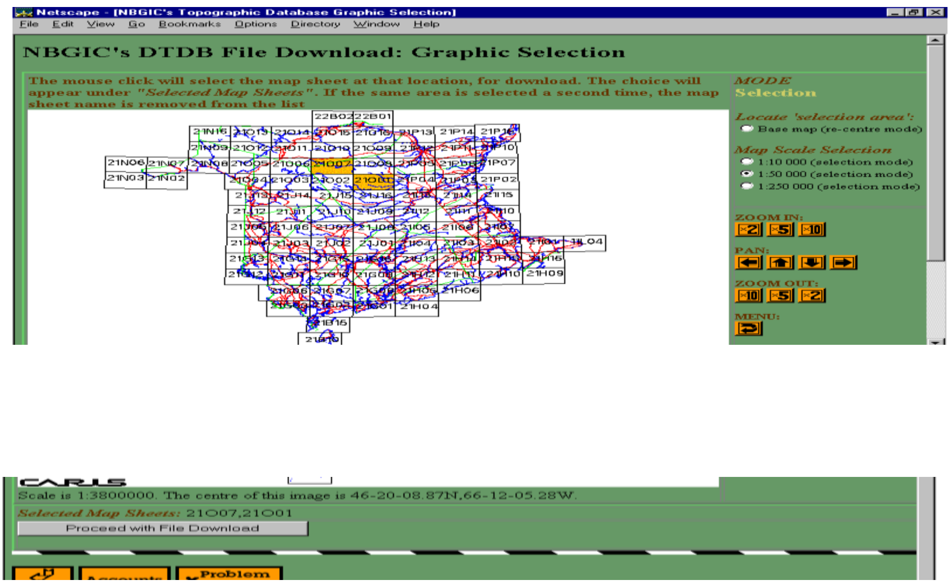

Figure 6: Graphical Interface for Selection of Map Files for Download [from (Finley et al. 1999)]

The result was a redesign of the interface to organize the data, functionality and intended use into separate areas – data download, applications, access to static products, and developer corner. This allowed expansion to include geomatics applications that were non-map based such as the coordinate transformation tool. The redesign, launched in 2013, evolved the single viewer to a "portal to all things geographic" and became known as the GeoNB Gateway (Figure 8). Applications were created with a specific user base in mind and rather than include access to all data and much functionality, each application was designed with limited data and functionality – only what was needed to solve the problem, in an effort to make it easier for the non-geomatics professional to use the tool.

GeoNB utilizes ESRI ArcGIS Server and, in additional to download and Internet viewing, it makes data available as ArcGIS Server map services (http://geonb.snb.ca/arcgis/rest/services). GeoNB uses dynamic map services and tile cached map services. A current list of GeoNB map services can be browsed in the GeoNB REST services directory. Figure 9 provides one example of such a service that identified protected wellfields for environmental purposes.

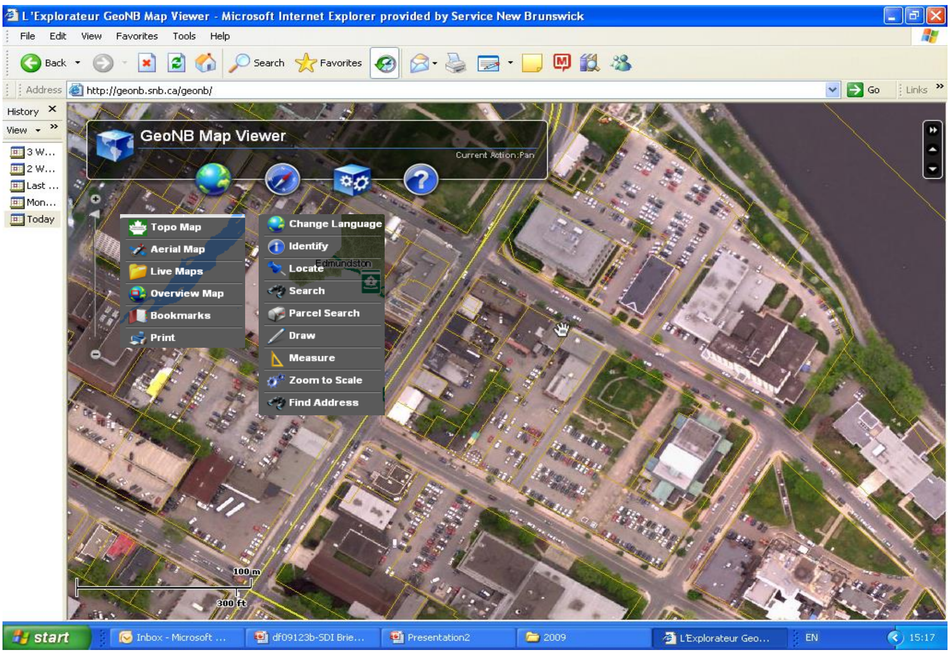

Figure 7: GeoNB Map Viewer 2009

Figure 8: GeoNB Gateway 2013

By mid-2016, in addition to province-wide property mapping, DEMs, scanned historical orthophotomaps, and civic address data, over 40 additional geospatial datasets containing specific features or areas of interest have been developed and are now available for download to GIS users in variety of formats depending on the product, including SHP, DXF, Caris and Esri Geodatabase Format (SNB 2016a). Today, most of the data hosted by GeoNB is available as a map service. When data is available as a map service it can be accessed over the Internet when the data is required. It is not necessary to download a copy of the data to make use of it.

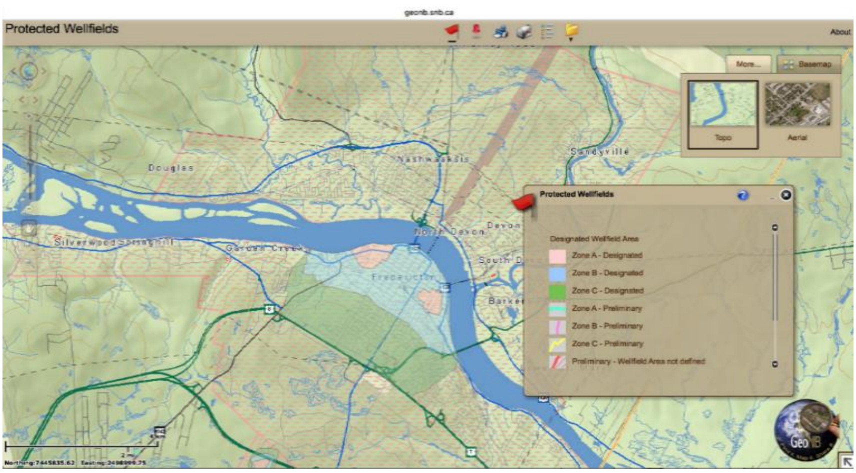

Figure 9: GeoNB Application Mapping Protected Wellfields: Fredericton Area

From the original GeoNB base product, over a dozen additional custom designed applications have since been developed which combine data and value-added functionality intended for specifically targeted user groups. These applications are summarized in Figure 10 (SNB 2016b).

Name / Description	Details	Start Application	Fee
Candidate PNA Map Viewer - Displays the name, location, and size of existing and candidate protected natural areas	More Info	START	Free
Find Address - search and find an address in the Georeferenced Civic Address Data Base (GCADB) and display the address location on a map	More Info	START	Free
Flood Information - Display areas along rivers that have an increased risk of flooding	More Info	START	Free
GeoNB Coordinate Transformation Service (CTS) - an application for transforming coordinates between the common datums and map projections used in New Brunswick. (It is a replacement for the "NB GeoCalc" software)	More Info	START	Free
GeoNB Map Viewer – a general purpose map viewer for New Brunswick	More Info	START	Free
Grant Reference Plan (GRP) Viewer - online map application to provide access to the crown grant reference plans and the crown grant document index	More Info	START	Free
Municipal Election Viewer – maps supporting municipal elections	More Info	START	Free
New Brunswick Control Network - access information related to the conventional control survey network and GPS based infrastructures used to derive coordinates in New Brunswick	More Info	START	Free
Oil and Natural Gas (ONG) Viewer - displays location of leases and licenses for petroleum exploration and production, as well as wellheads for the oil and natural gas industry	More Info	START	Free
PLANET - SNB's Land Registry and Mapping Services	More Info	START	Fees
Protected Watersheds - displays locations of protected watersheds on top of GeoNB base maps	More Info	START	Free
Protected Wellfields - displays locations of protected wellfields on top of GeoNB base maps	More Info	START	Free
Recreation Infrastructure Planning Tool (RIPT) - access to mapped recreation facilities, demographic data, property assessment data, and spatial analysis tools to assist in the planning of the province's built recreation and sport infrastructure.	More Info	START	Free
River Watch Tool - a visual synthesis of forecasted flows and monitoring observations in the Saint John River Basin. It provides awareness of potential flood risks and encourages residents to be prepared for flooding events	More Info	START	Free
Wetlands Mapping - displays locations of regulated wetlands on top of GeoNB base maps	More Info	START	Free

Figure 10: GeoNB Applications from Service New Brunswick (SNB 2016b)

3.3 Data Usage Metrics

Comparison of usage statistics between PLANET and GeoNB indicates and serves to highlight that both the options available for accessing data as well as the methods for monitoring and measuring usage have changed over the past twenty years. Obtaining reliable longitudinal information concerning growth and changes in user demand is problematic. That said, using the latest version of analytical tools now in use, a snapshot of recent usage is possible.

Figure 11 illustrates the monthly number of GeoNB-related data downloads over the past three years. These represent the number of individual files related to topographic mapping, property mapping and thematic overlay data related to the services listed in Figure 7. On average, approximately 23% of these counts relate to downloads of digital property mapping coverage files which are updated regularly.

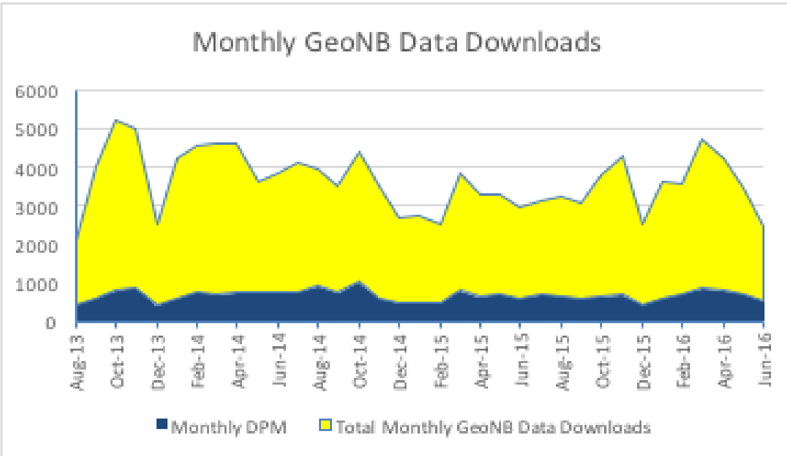

Figure 11: Monthly Count of GeoNB Data File Downloads

In terms of GeoNB Web Mapping Service usage, Figure12 illustrates the growth on a quarterly basis in the number of individual users accessing the service between the fourth Quarter (i.e., October-December) 2014 and the first Quarter (January-March) 2016. Figure 13 provides the corresponding growth in the number of GeoNB page views over that same 3+ year period.

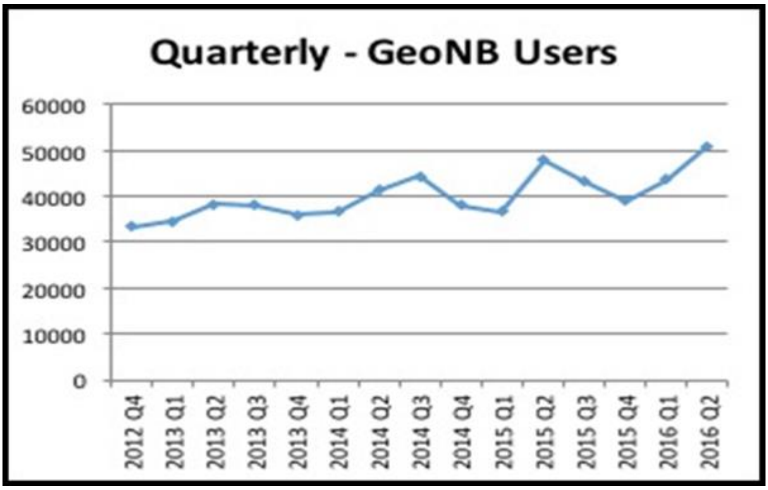

Figure 12: Number of Individual GeoNB Users Q4 2012 – Q1 2016.

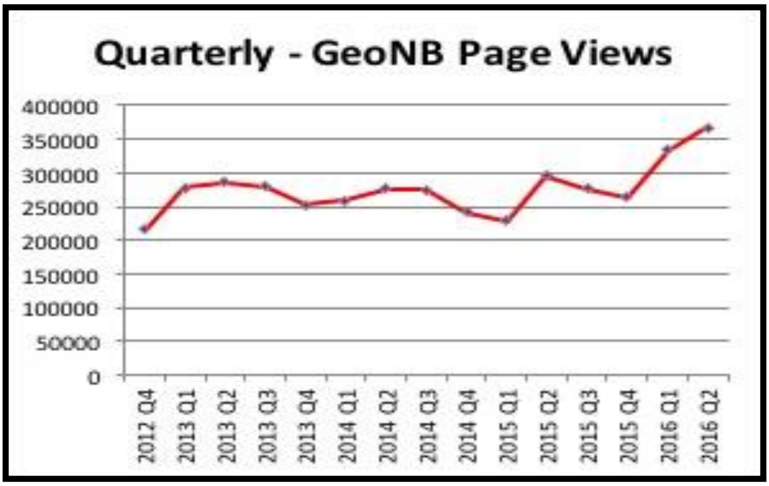

Figure 13: Number of GeoNB Page Views – Q4 2012 to Q1 2016

In terms of usage of GeoNB's Web Mapping applications, Figure 14 illustrates the individual usage activity of fourteen different online mapping services built upon the GeoNB server and data. Clearly, the basic GeoNB service is by far the most widely used, with its tracked activity growing overall from approximately 20,000 hits per month in April 2012 to over 50,000 hits in January 2016. All of the other services offer more specialized thematic information that may appeal to smaller user groups or, in the case of the River Watch flood risk mapping tool (labelled "Flood" in both graphs), are accessed principally during the "spring thaw" months of April and May when there is a higher possibility of flooding along rivers and streams.

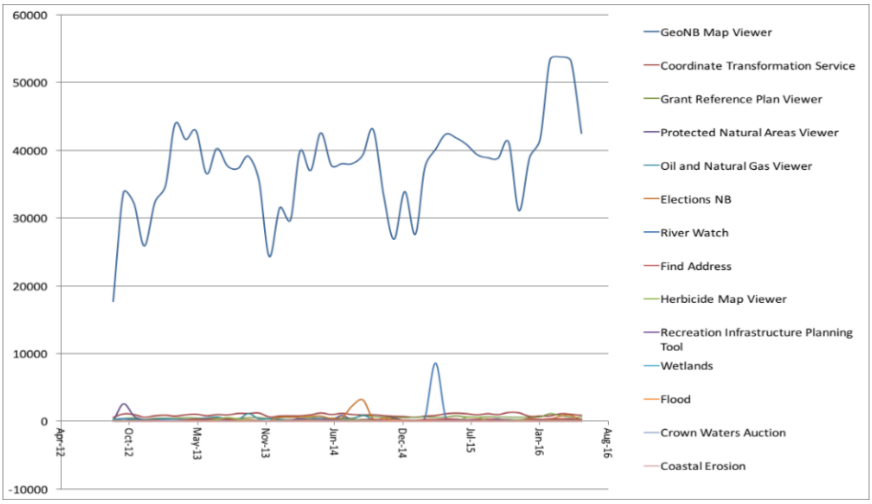

Figure 14: Monthly "Hit Count "of GeoNB Applications

4. Building and Maintaining The current Institutional Framework

These technological developments did not take place in a vacuum. As the scope of Service New Brunswick expanded to include everything from motor vehicle registrations through hunting licenses through personal property registries, increased database management and online service delivery resources were added BUT maintaining and upgrading the geospatial framework itself (i.e., control framework and base mapping) played a smaller and smaller role on the organization and, in an increasingly challenging economic environment, funding diminished accordingly. Once first–round orthophoto, topo mapping and DEM collection was completed, the task was thought by senior decision makers to be finished, that maintenance was not necessary and that SNB could move on to other (deserving) priorities also vying for attention.

At the same time, as GIS, Web Mapping and GPS technologies all became more inexpensive, new mapping and positioning activities began to proliferate within individual provincial government units and new geospatial datasets, databases and services emerged. Some of these took advantage of SNB base data but contained additional thematic data collected on a "project-specific" basis and held internally with little attention paid to provincial or national standards for collection and distribution. As in the 1950as and 1960s, all were collected in support of other government activities, were held internally, and were not seen as vehicles for updating or upgrading existing SNB provincial base data.

Further, in keeping with prevailing attitudes of the time through the 1990's, SNB saw its mapping as one channel of "cost recovery" and therefore charged external customers a fee to download topographic data and to access the PLANET service. As a result – and especially as the topographic, orthophoto and DEM data became increasingly out-of-date -- larger users outside and inside government began collecting their own road network data via GPS and their own digital imagery and LiDAR DEM data using industry contractors, sometimes resulting in duplication of effort and public spending.

Finally, especially in the mid-2000s and later, as services like Mapquest, Google, Bing Maps and others became available, even individual citizens began relying on these online services rather than SNB for up-to-date value-added mapping and (especially) imagery. In fairness, as described by Coleman (2012), the increasing public preference for reliance on emerging commercial and open source Web mapping services was and remains a challenge to the continued credibility and relevance of government mapping agencies across the developed world.

SNB faced these challenges by refocusing on desired outcomes rather than reinforcing existing policies and processes, in order to identify and determine how SNB could remove barriers to allow all users to have access to and use the best geospatial data available.

An internally-commissioned Geomatics Review (AMEC, 2005) confirmed concerns were valid – the New Brunswick geomatics environment was in decline and in trouble unless changes were made. With a strong refocus on geomatics, SNB updated and articulated a "provincial geomatics vision" (Opus, 2016) centered on a more collaborative approach moving forward designed to break down and better integrate the "silos" of geospatial data in place or being developed within the provincial government.

This new vision focused on 5 key result areas – Governance, Policy & Standards, Data, Access (infrastructure), and Communications – each of which is described briefly below.

1. *Governance* – proposed a 3-tiered approach to engage all levels of government, consisting of:

   a. Deputy Minister Oversight & Priorities Committee;

   b. An Assistant Deputy Minister/Executive Director-level committee to align business operations and problems with geomatics opportunities and solutions; and

c. A Technical Committee to coordinate & identify collaboration opportunities, and deal with technical challenges.

2. *Policy & Standards* – focused on a commitment to update and revise policies and standards to mesh with todays' and future environment, in order to make it easy to discover, access and use data.

3. Data – in particular, transitioning from a lead organization with the mandate to develop base layers but with little business need for the data set to a data custodian/data steward model whereby the custodian has a business need for the data and therefore has more impetus to ensure it is maintained.. Furthermore, the approach recommended, was to work collaboratively to build one recognized "authoritative" data set rather than have several organizations independently maintaining different versions of the data.

4. Access (infrastructure) – the importance of establishing an on-line mechanism to provide discovery, access and use of geomatics data to all users was recognized. Related to this was the adoption of and support for principles such as free, open data. It allowed organizations at different levels of maturity and support of the open data principles to buy into the model according to their schedules, thereby slowly building support and momentum for the vision.

5. Communication – focused around building awareness of the potential of and opportunities for geomatics to solve organizational problems. Components of this KRA include: educational, awareness and communication pieces.

4.1 Current status

Implementing this Vision over the past decade has remained a challenge for all the reasons provided earlier. The Governance Model originally proposed has not worked out as well as hoped: while the Technical Committee has met regularly, it has been more difficult to schedule and ensure regular meetings of Deputy Minister- and Executive Director-level managers. Further, it has been more difficult than anticipated to establish an effective operating environment which incorporates effective proactive leadership while ensuring continued communication, "buy-in", and collegial direction from geospatial users across government.

Communication remains an important issue. Today's users of spatial data may employ the latest technologies but possess limited understanding of the capabilities and limitations of the technologies and datasets they are using. Those that do possess the technical background may be relatively new in their positions and have little "institutional memory" of past practices and decisions in terms of land information infrastructure development, and cooperation.

Regardless of the on-going challenges, important gains have been made in terms of addressing the KRAs and fulfilling the vision. For example:

1. The Data Custodian model has been used to develop and maintain the authoritative water base for New Brunswick. Between 2009 and 2012, the Department of Natural Resources (DNR), Service New Brunswick (SNB) and the Department of Environment & Local Government collaborated to produce the New Brunswick Hydrographic Network (NBHN,) a single, vector-based surface water database covering the entire province (NB Government News Release, 2013). The Department of Natural Resources has taken on the data custodian role as it recognized the importance of the NBHN to its core business. Built to a national water data standard and freely available as a database download or service, the NBHN includes vector representations of all surface drainage features (i.e., rivers, streams, lakes, islands, and watershed boundaries) and includes the names for many rivers and streams. Development of the NBHN has resulted in a huge reduction in internal duplications of effort within different departments, saving $300,000 in up-front costs and $50,000 annually in yearly maintenance costs.

2. The infrastructure shortcomings have been successfully addressed. In July 2013, Service New Brunswick's GeoNB Service was recognized with a Special Achievement in GIS (SAG) Award at the Esri International User Conference in San Diego, California. The service was recognized by Esri for its success in: (a) providing all users with easy access to geographic data, value-added applications and maps; (b) Reducing duplication and costs to government through collaboration and the sharing of geographic data and infrastructure; and (c) Promoting and increasing the use of geographic data and maps.

3. In 2015, a collaborative partnership between Service New Brunswick, Public Safety and Ambulance New Brunswick was recognized nationally for its innovative approach to building an authoritative road network. (NB Government News Release, 2015). The road network is available via GeoNB (http://snb.ca/geonb) as a database, download or view. It includes road centreline and related feature data as well as associated attribute information including road names, address ranges, road classification, surface type, and number of lanes. This cooperative approach has reduced duplication and identified annual savings estimated at $500,000.

4. Over the past two years, SNB has worked with the provincial government departments of Natural Resources and Environment in developing a plan for more coordinated and standards-based collection of LiDAR DEM data.

5. Moving ahead…

While much progress has been made on many of the initiatives discussed above, work remains. In particular, maintenance and long-term sustainability are key areas that continued effort is required.

As New Brunswick moves forward there remain a number of challenges and questions yet to be resolved. These include:

- *Geomatics as an Enabler* – the evolution of geomatics and its ubiquitous incorporation into mainstream business. What is the proper role Geomatics can play to help New Brunswick, or for that matter, any jurisdiction, meet its business and fiscal challenges? Not surprisingly, a key component of this challenge will resolve around the communication KRA.

- *Geomatics and Open Data* - The relationship of geomatics data and related efforts with the “open data” movement. Geomatics practitioners have long been recognized as early supporters and early adopters of “open” principles and as a result, geomatics data is recognized as early examples of open data. . As non-geomatics practitioners embrace the “open” movement what impact will it have on geomatics efforts to date and in the future? What will become of provincial and national SDIs?

- *Geomatics as a Service* - As New Brunswick wrestles with serious fiscal challenges, the Province is exploring ways to find efficiencies and cost savings. One topic that has re-surfaced is centralization of geomatics expertise and services. The concept of Geomatics-as-a-Service (GaaS) is being considered as a possible model going forward. The province has followed this approach in a number of areas where overlap exists, including: centralization of Information technology and IT-as-a-Service, centralization of HR and communications. While GaaS has yet to be properly defined, some ideas being discussed include establishing a core group of geomatics expertise to provide service to departments that have not to date invested in geomatics and having a core group ready to be deployed when required to deal with crisis situations.

- *Geomatics Vision* – it has been 10 years since the provincial geomatics vision was re-newed. While much progress has been made toward fulfilling that re-newed vision, much has also changed over that same time period in both the geomatics world as well as the world in general. It would be wise to step back, re-evaluate and review where the province must go and the role geomatics should play.

Of particular interest, given the changing environment, will be determining what role is appropriate for government, and in particular, the traditional mapping organization, and what role should “trusted partners” and even citizens play as we move forward. Is government nimble enough to compete with the time-lines set by non-government geomatics organizations such as Google and Bing and can government meet the increasing demands of the ever-growing geomatics user base and their expectations of instantaneous data?

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Chapter 6: Urban Analytics Data Infrastructure: Critical SDI for Urban Management in Australia

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Abstract

Spatial data infrastructures (SDIs) are fundamental to enabling informed decision-making across a variety of industries and sectors but has primary relevance for managing land and land-related resources. Given the primacy of cities in meeting future sustainable development goals, SDIs are increasingly prominent in supporting the identification and management of urban-related issues such as water, energy, infrastructure and transportation, but also in the implementation and governance of urban policies aiming to deliver economic impact, social equity, housing, accessibility of public spaces and public safety.

This chapter describes a new research initiative funded by the Australian Research Council that will see the development of an SDI to support urban analytics and urban research capabilities focused on Australian cities. This is a timely development for Australia, which is not only one of the most urbanised countries in the world, but is also witnessing high levels of growth rates in its urban areas uncommon in western developed countries. The Urban Analytics Data Infrastructure (UADI) intends to support multi-disciplinary, cross-jurisdiction, national-level analytics and through the design of its architecture, seeks to provide the urban research community with a digital infrastructure that responds to current challenges related to data access, sharing and application. Importantly, the UADI will build on significant existing urban research infrastructure, specifically the Australian Urban Research Information Network and its nationally federated Data Hubs. This is both critical and core SDI development for Australia, and will advance governments, industry and academia in undertaking more advanced data-driven modelling to support sustainable development in Australia's cities.

Keywords: SDIs, cities, Australia, urban management, urban analytics

1. Introduction:

Our cities are complex entities both in terms of the built environment and their social characteristics. Our ability to undertake sound planning, development and management not only ensures that cities continue to be engines of national economies, but also impact positively on global sustainability. Cities are therefore characterized by a plethora of information and in this digital age, the data deluge is both structured and unstructured. How can this data be leveraged, especially knowing that longstanding issues associated with data access, discovery, use and re-use, and governance, continues to be perpetuated by organizational silos variable scale, and a reliance on a range of indicators spanning both objective and subjective aspects, all of which are exacerbated by the sheer volume of available data?

We turn to the concept of spatial data infrastructures (SDIs) to propose a response. SDIs, comprising people (users, producers), data, policies, standards and technologies (Rajabifard and Williamson, 2001), are fundamental to enabling informed decision-making across a variety of industries and sectors through the use of spatial or location-based information but has primary relevance for managing land and land-related resources. Given the primacy of cities in meeting future sustainable development goals, SDIs will have prominent roles in supporting the identification and management of urban-related issues such as water, energy, infrastructure and transportation, but also in the implementation and governance of urban policies aiming to deliver economic impact, social equity, housing, accessibility of public spaces and public safety.

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Importantly, the UADI will build on significant existing urban research infrastructure, specifically the Australian Urban Research Information Network (AURIN) and its federated Data Hubs. This is both critical and core SDI development for Australia, and will advance governments, industry and academia in undertaking more advanced data-driven modelling to support sustainable development in Australia's cities.

2. The challenge of Urban Management

With 70% of the world's population set to be housed in cities by 2050, the imperatives of evidence-based urban management cannot be overstated in future-proofing the sustainable development of cities. Cities may only account for around 2% of global land mass but they have a large economic footprint – generating more than 80% of global GDP (Dobbs et al., 2011), as well as a significant environmental one – contributing more than 70% of the world's greenhouse gas emissions (UN-HABITAT, 2011). Compounding these are a raft of other issues related to urbanization including welfare, housing, accessibility, urban renewal, health, etc.

Yet urban management remains fraught as cities everywhere grapple with the challenges and opportunities that rapid urbanization brings. In our digital society, data has become the main currency in urban management and decision-making. However, a longstanding challenge for urban data is its notorious heterogeneity (Psyllidis et al., 2015). This is further complicated by new streams of data such as big data, social media, etc. – a veritable deluge of data that traditional government decision-making organizations are often unable to accommodate within their regulated frameworks (Sabri et al., 2015). When faced with decisions pertaining to planning and developing complex urban infrastructure, e.g. underground train tunnels and associated stations, urban managers and urban researchers continue to struggle to understand the diversity of urban data available, to access this data, and leverage appropriate data sources for analysis and planning. Typically, analysis around urban developments also tend to involve cross-disciplinary data and analytics (e.g. land ownership, utilities, buildings and vegetation). These diverse data sources need to be interoperable, harmonized and integrated for analysis and modelling purposes.

One of the main ways that urban managers and urban researchers have long sought to overcome the data challenges is through the adoption of spatial data infrastructures (SDIs). That spatial data plays a fundamental role in cites is axiomatic. Cities are complex entities and spatial data, more than any other type of data enables decision-makers to understand what is happening within cities, and more importantly, understand where the phenomena is occurring. Indeed, geospatial data has emerged as one of the most important types of data in urban management and sustainable development (UN-GGIM, 2015).

Consequently, SDIs have become an intrinsic part of the urban decision-making infrastructure. Although nearly 20 years old now, Coleman & McLaughlin's (1998: 37) definition of SDIs (albeit originally in a global context) as those “policies, technologies, standards and human resources necessary for the effective collection, management, access, delivery and utilization of geospatial data” remains relevant in today’s digital society. Rajabifard & Williamson (2001) built on this definition, but emphasized the importance of interoperability – both among data and people components – as the key to delivering the integration that SDIs promise.

There are numerous examples of urban SDI initiatives around the world and they can exist at multiple levels. For example, Brazil has recently launched DataGEO as a state-level SDI initiative. This platform integrates spatial data across the state of São Paulo, providing several government and research institutes with access to and management of a repository of environmental spatial datasets to assist with monitoring, reporting and planning activities. In the same vein, the Global Earth Observation System of Systems (GEOSS) Common Infrastructure is an example of a global SDI initiative as it allows users from all member countries and participating organizations of Earth Observations to access, search and use the data, information, tools and services available through GEOSS.

Such initiatives continue a trend of substantial SDI developments that have been initiated over the last three decades both in developing and developed countries. For instance, the INSPIRE (Infrastructure for Spatial Information for the European Community) directive has facilitated addressing interoperability and harmonization issues among several European jurisdictions (Villa et al., 2011). Plan4all is an initiative that was developed on the basis of the INSPIRE directive to address spatial planning data for cross-jurisdictional cooperation (Pineschi and Procaccini, 2013). However, location-based and evidence-based city planning and policy-making reportedly still lacks access to robust data sharing and spatial platforms that can support practical analytics and data-driven decision making (Kyttä et al., 2013; Sabri et al., 2016).

There are several initiatives worldwide that address the issues of urban data accessibility. For instance, the Urban Big Data Centre (UBDC) is an initiative by the UK Economic and Social Research Counci, at the University of Glasgow, in partnership with six other UK universities. The role of UBDC is to manage, link and analyze massive amounts of multi-sectorial urban open and authorized data in a portal allowing diverse users to conduct research and analysis (http://ubdc.ac.uk/). Similarly, the Urban Centre for Computation and Data (UrbanCCD) at the University of Chicago has developed a platform called Plenarion to facilitate urban data discovery, exploration, and application of open city data (Catlett et al., 2014). There are many other similar initiatives; however, these have also served to illustrate the challenges that a lack of a holistic infrastructure to address harmonization within structured and unstructured data, as well as data semantics and ontology issues across different jurisdictions and disciplines associated with urban analytics and management (Thakuriah et al., 2016; Catlett et al., 2014; Villa et al., 2011).

In addition, urban planners need new predictive modelling tools that can help them understand the potential future impact of different scenarios, policies and decisions on the urban landscape and population (Bettencourt 2014). Increasing availability of open government data, social media data and real time sensor data streams are driving a demand for sophisticated data integration, analysis and visualization services (Caragliu et al., 2011). SocialGlass, for instance, is an attempt to incorporate various data streams from social media platforms, sensors, and periodical datasets from local governments to facilitate city-scale event monitoring and assessment (Psyllidis et al., 2015). Balduini et al. (2015), developed the ‘CitySensing’ system to integrate social media streams and anonymous Call Data Records (CDR) to visualize the emerging patterns and monitor their dynamics in city scale. CDR is also used to infer land use patterns in against zoning regulations in urban areas (Toole et al., 2012). Additionally, integrating public participatory GIS (PPGIS), web-based visualization and geotagged crowdsourced data in a platform called “SoftGIS” provided a valuable method to understand local perceptions in the implementation of urban consolidation projects in the inner-city of Helsinki, Finland (Kyttä et al., 2013).

Although there is a trend towards making such decision-making tools and planning support systems easily available through cloud services (Pettit et al., 2015; Catlett et al., 2014), there remains a lack of access to standardized and harmonized data, which in turn limits the applicability of such services. Furthermore, current geo-databases were also initially developed to be used in local- or domain-specific purposes, whereas city planning, management, and monitoring activities are likely to require more organized and complex SDIs that can respond to integrated spatial planning and programming activities.

Establishing SDI as a digital infrastructure is now increasingly important especially since the steep trajectory in data production has really occurred over the last decade (SINTEF, 2013). Even as cities continue to struggle with reaping the benefits of the urban data deluge, in parallel, they are also having to contend with the information demands associated with the global smart city movement. Smart cities are often referred to distinct factors of economy, mobility, people, environment, living, and governance, which leverage smart infrastructure with a strategic use of innovative technology and approaches to enhance the efficiencies and competitiveness of cities (Habitat III, 2015). Smart approaches often argue that the use of information and communication technologies (ICTs) will improve our understanding about community through analysis of urban efficiencies, address urban resilience challenges and enhance the quality and effective delivery of services. In his speech at the 2015 Geospatial World Forum, Carsten Rönsdorf, the Head of Advisory Services at Ordance Survey International, demonstrated that smart cities rely on multiple streams of digital data and networks for data reuse and innovation – amongst which spatial data, and hence SDIs, remains vitally important in future urban management.

3. Urban Management in Australia

Australia is one of the most urbanized societies in the world. One of its greatest challenge over the next 50 years will be urban management, acknowledged in the Australian government's decision to appoint the first national minister for cities in late 2015. Urban planning research is increasingly important to devise strategies that will ensure the sustainability of our cities in the face of massive population growth, changing demographics and changing weather patterns (Shrestha et al., 2014). These factors are placing increasing pressure on the infrastructure in our cities, including public transport and roadways, power, water and waste systems, and population health within the urban environment. Urban renewal, redevelopment and high density living in inner cities are also driving an increase in strata titles and the demand for new 3D planning tools (Badland et al., 2014).

Evidence-based data-driven urban planning, will deliver specific, quantifiable, and measurable initiatives over various urban scales (Villanueva et al., 2015). It will highlight attributes that address residents' concerns and expectations (Hadavi et al., 2015), unlock complex planning challenges while directing local authorities and state governments to achieve evidence driven decision making. The research to practice in Australia, however, is yet to be widely appreciated and there is a limitation of practitioners being engaged with research outputs (Randolph, 2013; Troy, 2013). The reason seems to be the lack of infrastructure to mediate the research and practice information exchange (Taylor and Hurley, 2016).

Consequently, there has been substantial investment recently in urban data initiatives in Australia. Of significance is the $24 million investment by the federal government to establish the Australian Urban Research Infrastructure Network (AURIN) project. AURIN has succeeded in establishing urban data hubs across Australia to facilitate a range of research activities related to urban settlements (Sinnott et al., 2011). This has resulted in thousands of datasets being made available nationally representing the social, economic, environmental and physical characteristics of the urban built environment. A large proportion of this is held by the federated Data Hubs within the AURIN platform, which is accompanied by a range of analytic tools and services. However, in addition to AURIN, there are also numerous other important key datasets that contain vital information and data about the urban built environment and new emerging sources of relevant data. These are distributed across all levels of government across the country, and some are available through open government data initiatives such as the NICTA National Map and data.gov.au; others flow from a growing volume of social media content and real time sensor data streams.

While these initiatives constitute a major advancement towards enabling urban analytics for decision-making in Australia, the potential research capability offered by these initiatives for urban management is still yet to be fully maximized due to the fragmented and disparate operation of these initiatives. In addition, current urban data repositories are disparate and discrete, and an absence of consistent data structures prevents this data from potentially serving cross-jurisdictional and national-level analysis (Sinnott et al., 2015). There are some foundations for potentially enabling interconnected urban analytics in Australia e.g. “State of Australian Cities Research Network”, but these continue to operate separately. Such fragmented operation of urban analytic activities is contributing to a static, undifferentiated, and information-poor planning environment.

Consequently, we identify three distinct challenges in urban research in Australia today: a fragmented urban data landscape, which results in disparate and disconnected urban data repositories, which also implies differentiation among user access levels. These challenges are illustrated in Figure 1 above. Increasingly, there needs to be a dynamic, richly diverse, and interconnected operating system, which will reduce the cost of urban data acquisition and analysis to stakeholders and the community (Bettencourt 2014).

Over the last few years, AURIN, specifically, has succeeded in taking the preliminary steps in addressing these challenges and has established urban research infrastructure accessible to academic researchers across Australia. However, there is still more that needs to be done to more broadly support urban research for urban management in Australia.

4. The Urban Analytics Data Infrastructure Project

Digital infrastructure and tools are one of the key ingredients in making a city smart (Komninos, 2002). While this includes the communications hardware to ensure ubiquitous connectivity, a more challenging component of digital infrastructure is the data and the tools that add value to the data and support the data-information-knowledge-wisdom pyramid (Rowley, 2007). In addition to physical infrastructure, the availability of knowledge communication and social infrastructure (human and social capital) increasingly determines urban performance (Caragliu et al., 2011). Importantly, the current state of urban analytics in Australia motivates the need to leverage current initiatives. This will not only improve fragmentation but also advance the capabilities and maturity of urban analytics in Australia. Therefore, any project in this area must build on the sizeable investment and those outcomes represented in AURIN.

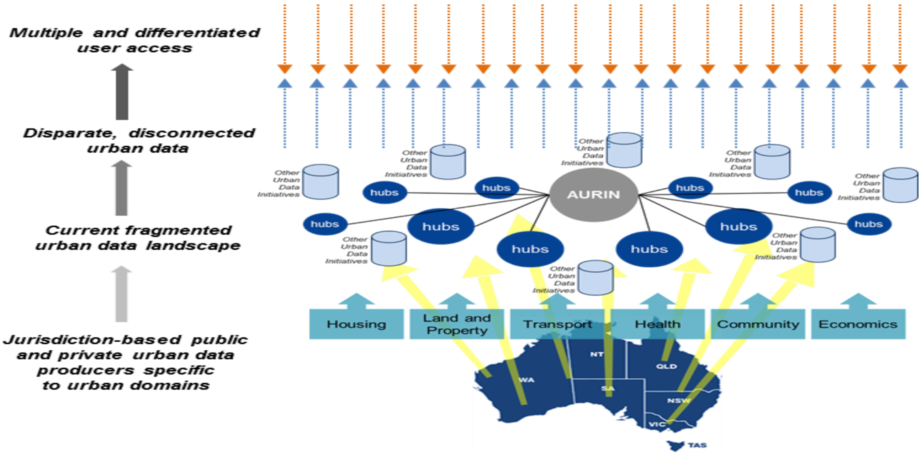

Figure 1. Current urban data landscape in Australia

The Urban Analytics Data Infrastructure (UADI) Project is a collaborative effort between consortiums of urban research centers across Australia and is funded by the Australian Research Council. The consortium comprises the Centre for SDIs and Land Administration at the University of Melbourne; City Futures Research Centre at the University of New South Wales; the eResearch Lab at the School of ITEE, and the Centre for Population Research, both at the University of Queensland; the Planning and Transport Research Centre at the University of Western Australia; the National Centre for Social and Economic Modelling at the University of Canberra; and the SMART Infrastructure Facility at the University of Wollongong. Collectively, these research centers represent expertise in the domains of land and property, housing, transport, health, community and economics.

By bringing together such diverse expertise, the project aims to develop the critical digital infrastructure required to underpin the next generation of data driven modeling and decision-support tools to enable smart, productive and resilient cities in Australia. The project will leverage the collaborative utility and latent knowledge that has been developed through AURIN to embark on a focused development of a data infrastructure that responds to the specific requirements of multi-source, cross-domain and cross-jurisdictional urban analytics. The principle aim of the proposal is to develop an SDI that will facilitate:

- The integration of the AURIN data hubs in each state, with other relevant data sets available via national, state and regional government agencies1 who are adopting open data policies.

- The extraction of latent knowledge existing in these data sets through the development of a set of integration and analytical services that respond to the specific requirements of different urban analytic activities associated with: people (quality of life indicators, socio-economic indicators, population demographics); land (3D cadastre, housing affordability); urban infrastructure (energy, water, transport).

Figure 2 provides a conceptual overview of the proposed UADI and its intended response to current challenges in urban analytics identified in the previous section. This requires not only a consistent and systemised ontology-based metadata/data harmonization and mapping framework across disparate domains and disciplines to support rapid integration and scaling-up, but also a focus on multi-dimensional (3D and 4D data) and dynamic (time-series and real-time) data analysis.

4.1 Ontological Foundations

Advancing on the traditional notion of an SDI, data interoperabilty will be facilitated in the UADI through an ontology-based integration of datasets.

Specifically, an ontological framework that links policies, actions and urban quality of life indicators for smart sustainable cities will be developed to assist in the evidence-based policymaking and adaptive management cycles. In a bid to overcome many of the institutional and political challenges associated with data sharing, the UADI will focus on a data-driven approach based on urban data dictionaries and workflows to develop IS0 37120 indicators (The Smart City Standard). Fundamental datasets will be established and these can be scaled up to dynamically produce city indicators on Australia's urban settlements.

The priority will be on the standardization and harmonization of data sets in AURIN across Australian jurisdictions using already established international spatial infrastructures, which will provide capacity for more comparative and collaborative urban e-research as well as a robust platform for urban planning and decision making. This project will also seek to extend the Global City Indicator ontology to harmonise different indicators and link indicators to policies and programs. It will also aim to homogenise data standards.

[1] Including the Australian Bureau of Statistics, Bureau of Meteorology, Departments of Transport, Public Works, Housing and Planning.

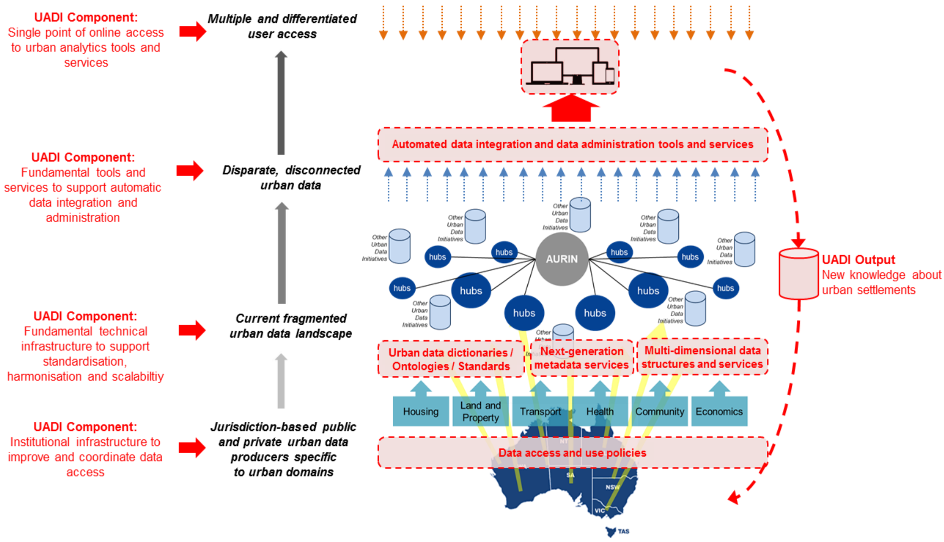

Figure 2. Proposed Urban Analytics Data Infrastructure concept

Common urban data ontologies will also facilitate the development and use of semantic inferencing services. This will firstly serve to automate data integration within the UADI, which will enable changes in the system to cascade automatically throughout related integrated datasets. Secondly, it will facilitate the development of a range of semantic web services that will advance multi-source urban data integration and analysis.

4.2 Multi-dimensional (3/4D) Data Structures and Services

One of the distinctive features of the UADI will be its explicit focus on enabling dynamic and multi-dimensional data. This will mainly be focused on the development of 3D and 4D data structures and services to enable the query and visualization of 3D content (e.g. 3D strata titles, 3D visualizations of sub-surface utilities). One aim is to provide 3D modelling and visualization services using virtual globes. This requires the development of key data and metadata tools that will enable multi-dimensional data generation and automation, including spatial-statistical data cubes to permit 3D/time series and sub-surface visualization/exploration on virtual globes using Cesium. The 4D-focused component of this project aims to provide 4D modelling and visualization services for improved dynamic and flows analysis.

4.3 Single source access

The project aims to establish a web portal that will enable users to have a single source of entry to AURIN and other urban data initiatives by developing open APIs. However, this may be limited by current licensing agreements.

4.4 Advanced analytic tools

In recognition that traditional spatial datasets tend to be limited in their level of granularity – where micro-level analysis may be necessary for specific planning tasks, the UADI intends to utilize micro-simulation capabilities developed by the National Centre for Social and Economic Modelling (part of the project consortium). This will enable the integration of unit record survey and census data to generate new synthetic data for small areas to provide measures on constructs (e.g. poverty, wealth, housing stress, etc.) not measured in traditional spatial datasets provided by agencies like the Australian Bureau of Statistics.

It is also the project's intention to develop openly available urban analytic tools and services to support spatio-statistical analysis of data sets related to their areas of practice, identify and quantify new relationships between parameters; develop new predictive modelling and visualization interfaces – specifically focusing on land management/housing, socio-economic analyses, people flows, transport/roads and utilities (water, power, waste management) in an urban environment.

5. Discussion and Conclusion

This project addresses the critical need for an SDI that can help deliver harmonized, interoperable data services, semantically enabled to support the modelling, designing, planning and management of the growth of Australian cities. The development of the UADI will support urban management, which requires consistent and complete urban datasets across a number of domains including housing, transport, utilities, demographic change and the economy.

The UADI intends to improve the state of urban analytics in Australia, and capitalizes on significant urban data initiatives in this country, specifically AURIN, thereby adding more value to existing functions. It provides the capability to shift the current landscape towards one that is more consistent across jurisdictions, and build up the requisite intellectual capital to support evidence-based decision-making that transcends traditional disciplinary domains. This is vital for realizing a sustainable urban future for Australia.

Current research in urban analytics is highly fragmented due to the lack of a relevant urban data infrastructure. The research activities among the project's partners provide ample evidence. For instance, while the City Futures Research Centre houses a comprehensive set of urban data regarding the Sydney metropolitan area, this is not accessible for other research centres. Moreover, the same centre has been involved in a study on affordable housing, urban renewal and emerging practices in planning in the states of New South Wales, South Australia and Queensland. However the lack of a data infrastructure presents a barrier in extending the same study to other jurisdictions. Some emerging data collection methods and supporting facilities such as automatic validation of crowd sourced data conducted by the Centre for SDIs and Land Administration on the North West Metropolitan Region of Melbourne could theoretically be replicated by other relevant research centers in Australia, but is currently not practically possible due to lack of a holistic infrastructure that facilitate the harmonization and standardization of data and integration of streamed and (semi-) static periodical data from different government departments such as state and local governments.

The proposed UADI could potentially overcome these limitations and enable more mature urban analytic activities to be derived from current data-driven initiatives. At a broad level, this supports greater return on investment from those initiatives; at an application level, it will enable planners and researchers to undertake urban analytic activities that are to date, simply not possible due to the ongoing limitations in linking, integrating, harmonizing and scaling multi-source data.

As one of the most urbanized countries in the world, the ability of the broader research community to undertake such activities is fundamental to planning for a more sustainable urban future. In addition, the development of the proposed UADI will provide an example and a practice case for other jurisdictions around the world seeking to overcome the challenges of extracting knowledge from federated datasets. Future work aims to develop the system architecture and implement it by using a set of use case scenarios.

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Chapter 7: The Theory versus the Reality of Alignment between EGov and SDI in Pakistan

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Abstract

A common notion is that the governance and performance of Spatial Data Infrastructures (SDIs) and Electronic Government (eGov) are closely interlinked. However, in practice this notion does not hold. We test why this is so, using the empirical context of a developing country, Pakistan. The main question is thus to which extent eGov and SDI implementation strategies are re-enforcing or obstructing each other. The present research makes use of congruency theory. The basic tenets of congruency theory are that governments perform well to the extent the authority patterns are congruent with the authority patterns of other units of society, and if those patterns exhibit balanced disparities. In this chapter the theory is applied to evaluate past and current activities in eGov and SDI in Pakistan and to assess the degree of congruence between the two. Proxies of authority patterns include adjacency, contingency, and proximity.

The assumption is that if all authority proxies of both eGov and SDI are high then the authority patterns are considered congruent with each other. Performance is evaluated based on durability, civil order, legitimacy and decisional efficacy. If all these proxies are high, then performance is high. If both authority patterns in eGov and SDI are high as well as performance of both SDI and eGov is high then both are congruent. If any of the proxies are not congruent then this is probably the reason for low performance. Finally, balanced disparities are evaluated using mimetic, coercive and normative isomorphism. The proxies were evaluated for Pakistan for the period 2010-2016 based on personal communication and experience on the one hand and documentary evidence on the other hand. Initial results suggest that there appears some degree of congruency, but based on the comparison of the proxies for durability and legitimacy there are also considerable differences. Finally the degree of isomorphism is only partial. In particular, mimetic isomorphism is low, indicating limited crossovers between the two communities. This implies that only partial congruence exists. The conclusion is that whilst many of the objectives of eGov and SDI in Pakistan are similar, in the process of implementation they are currently insufficiently reinforcing each other. One of the main reasons is that unlike the eGov projects the SDI objectives and policies are insufficiently embedded in public awareness campaigns and implementation by multiple public sector organizations. This affects public legitimacy.

Keywords: SDI, Electronic government, Congruency theory, Pakistan

1. Introduction

A common notion is that the development of Spatial Data Infrastructures (SDIs) and Electronic Government (eGov) are closely interlinked and strengthening each other. Hansen et al. (2011) note for example that the adoption of the INSPIRE Directive in Europe, a fundamental cross-country agreement to develop a European wide SDI, has not only put SDI on national agendas but also led to combined strategies for eGov initiatives. The reasoning behind the required connection has always been that once data infrastructures are in place it becomes easier to share and exchange data amongst government agencies which would also facilitate interactions between government and citizens. Hence, if the organization and governance to develop SDIs would be in line with the requirements of eGov the performance of both would increase at a similar rate.

There are however several reasons to believe that this assumption is either not entirely valid from a theoretical point of view, or proves to be difficult to validate in practice. First of all, earlier policy-based and literature-based evaluations show that whilst policy objectives and applied instruments to develop either SDI or eGov are resembling each other (i.e. standardization, development of information architecture, incorporation of legal and institutional issues in the development), in reality there is often a mismatch in policy emphasis and a fundamental disconnect between the professional and epistemic communities developing each these (de Vries 2007, de Vries 2008). As a result, policies defining the main goals of either SDI or eGov tend to rely on different meaning that the developers of the policies have assigned to either SDI or eGov (Silva 2007).

Secondly, given this difference in origin where the logic and frames of either SDI or eGov strategies have been developed, the process of connecting the two is challenged by the manifestation of different socio-technical systems. Policies and strategic technical choices reflect certain orientations which have been established and often institutionalized over several decades (de Man 2006). Given this legacy, it would take considerable transaction cost to convert such choices to more aligned solutions. Apart from that, operating costs of technical maintenance of web services of eGov or SDI related applications and back-end software licenses tend to prevent full integration (Wolfram and Vogel 2012).

Thirdly, professional and administrative actors find themselves confronted with multiple inter-related strategic plans in the implementation of SDI and eGov strategies.

On the other hand, the alignment of eGov and SDI is not completely absent. Partly as a result of the practical disconnect between SDI and eGov implementation different scholarly attempts have aimed to bridge the gap. The constructs of spatial enabled government (Masser, Rajabifard, and Williamson 2007) and spatially enabled society (Williamson et al. 2011), which bring the notion of SDI building and development closer to the daily practice of governance and responding to societal needs, aim to bridge part of this gap. The constructs have furthermore brought the discourse of SDI practitioners closer to the discourse of politics and politicians. By explaining the construct using examples of globally known spatial technology such as Google maps and linking this to every-day examples such as property ownership, or electoral statistics the construct has started to make more impact on every day governance than the technical associations with SDI have had in the past.

In addition, several authors have pointed to the relevance in a specific application context in which SDIs are gradually constructed. Richter (2011), for example, argues that ongoing property management and urban governance practices in India are de facto shaping the SDI. Consequently, the emerging SDI is not the result of certain SDI design efforts, but rather it is a reflectance of whose interests are best served by any SDI development. Domain specific governance, whether supported with digital technology or not, is thus the key driver for adoption of technology, instead of the other way around.

This brings out the question to which degree the endeavors to develop and align SDI and eGov are coherent and congruent, as well as which factors are practically preventing or supporting such alignment? These questions are especially timely and opportune for countries which are at the brink of setting up or of intervening in their socio-technical infrastructures, with or without external support or financial and development assistance. One of such examples is Pakistan. Earlier reports have shown that the government of Pakistan has been actively working on both the eGov and NSDI strategy and implementation for a number of years, even with the support of external donors, yet various studies have been showing a gradual decline in both SDI and eGov outcomes (Ali and Ahmad 2012, Ali 2008, 2010). This brings out the dilemma whether the inter-linkages are not there, or whether efforts into the two policy domains are obstructing each other. In short, is the governance of SDI and eGov actually in sync, or are other factors preventing both types of implementation strategies?

We therefore look into this question in three subsequent steps. First, a theoretical framework of congruence is chosen. This framework specifies how to define and evaluate congruencies of policies and implementation of policies. It further derives an analytical framework to evaluate the degree of congruency empirically. With this analytical framework it is possible to describe, qualify and compare recent and current policy and implementation strategies in Pakistan. From these empirical data we infer in the discussion section, both the degree of congruence and which factors are either supportive or obstructive. The concluding section provides both a generic view on the issues of SDI and eGov congruence as well as a set of recommendations for researchers and practitioners working in the respective domains.

2. Theoretical Analytical Framework to Evaluate Congruence

The present research makes use of congruency theory (Eckstein 1997). The basic starting point of congruency theory is that governments perform well to the extent the authority patterns are congruent with the authority patterns of other units of society, and if those patterns exhibit balanced disparities. In other words, two different types of policies are reinforcing each other only if their governance is sufficiently grounded in existing governance structures or sufficiently resembling existing (known or legitimate) governance structures. In the case of SDI and eGov this theory and its basic elements can help to identify if and how both policy systems are sufficiently congruent.

The three main elements in congruency theory are:

1. Authority patterns
2. Performance and
3. Balanced disparities

Each of the three components can be further detailed for empirical analysis. Proxies of authority patterns include:

1. Adjacency. This is assessing to which extent the social and educational background of the practitioners is rooted in similar institutions.
2. Contingency. Dealing with to which extent the norms and values have been derived from each other. This indicator is sued to evaluate whether two different domains use the same origins and means of socialization and proximity. In other words, are the social units dealing with two distinct policies closely tied, related to each other, and does one unit serve another?
3. Proximity. This indicator addresses which social units are carrying out the eGov or SDI program respectively. Is there for example any reference from SDI to eGov or vice versa in any documentation? To which extent does one serve another?

If all three indicators are high (or considered significant based on a qualitative assessment) then authority patterns are considered to contribute to congruency.

Performance is evaluated based on:

1. Durability – persistence of a polity over time
2. Civil order – absence of collective resorts to violence, or other coercive actions, to achieve private or public objectives
3. Legitimacy – the extent to which a regime is considered by its members as worthy of support
4. Decisional efficacy (or output efficacy) – the extent to which governments make and carry out policies in response to (political) demands and challenges

If all scores are high, then there is evidence of high congruency.

Balanced disparities are inferred by relating findings on authority and performance to the degree of isomorphism. The latter relies on isomorphic theory (DiMaggio and Powell 1983). Isomorphic theory has been applied also in earlier evaluations of the implementation of information technology (Tingling and Parent 2002, Van Veenstra, Janssen, and Tan 2010) and the degree of spatial information sharing and exchange (de Vries 2013). A disparity is considered the opposite of an isomorphic feature. There are three main types of isomorphism:

1. Mimetic
2. Coercive and
3. Normative

Mimetic is isomorphism derived from reacting to uncertainty in the environment. If uncertainty is high, policies and organizational systems tend to mimic others. Coercive is the isomorphism derived from formal legislative pressure and compliance. Normative isomorphism is derived from collective pressure, for example from professional colleagues. If there is a significant degree of isomorphism then the disparities are considered balanced.

Although the theory has been especially applied in evaluating congruence of types of governance and types of policy systems, the basic tenets of the theory can be also applied to evaluate the congruence of past and current policy implementation activities in eGov and SDI. The basic assumption is that the policy systems of eGov and SDI are at least partially overlapping, as suggested by de Vries (2007), with regards to supporting government systems, relying on ICT, and largely dependent on both ICT professionals as well as organizational policy development and implementation professionals. The first expectation is therefore that this partial overlap is gradually leading to congruence, because of continuing communication and networking. In this case there would be balanced disparities because of mimetic isomorphism. People would consider the issue of SDI and eGov alike, hence they would copy one practice of given solution in one field to another field.

Similarly, the question is whether the policy frameworks of SDI and eGov are gradually becoming similar. In that case one can derive that a certain degree of balanced disparity emerges because of coercive isomorphism. Finally, there could be a practice where professionals working in both fields are gradually relying on a joint framework of norms (for example on ICT solutions and choices), on the basis of which they make their daily decisions. This would suggest normative isomorphism.

3. Case of Pakistan

We choose to evaluate the congruency for the case of Pakistan. There are various reasons why both eGov and SDI received more attention than other policy areas. One reason is rooted in the environmental domain. Heavy monsoon rains submerged nearly one-fifth of Pakistan in 2010, affecting an estimated 20 million people. The floodwaters destroyed homes and businesses, washed away bridges and roads, ruined crops, killed livestock, and claimed about 1,800 lives (Kronstadt, Sheikh, and Vaughn 2010). As bad as it was, *Science* Magazine indicated that the damage and death toll could have grown in the weeks that followed, were it not for the novel use of Earth observations (Stone, 2010). For instance, "analyses revealed that flooding had knocked nearly 200 tuberculosis clinics out of commission. Forewarned, aid agencies scrambled to steer patients to functioning health centers (ibid)." A number of international organizations used satellite data to generate maps of flooded areas in relation to physical and social infrastructure(Seemaps):http://www.reliefweb.int/rw/rwb.nsf/doc404?OpenForm&rc=3&emid=FL-2010-000141-PAK) to support rapid response and humanitarian relief (e.g., UNOSAT, UN OCHA, WFP, WHO, iMMAP, MapAction, Floodmaps, ITHACA (Information Technology for Humanitarian Assistance, Cooperation and Action), USAID/OFDA, US DoS HIU, Pacific Disaster Center (PDC), Dartmouth Flood Observatory, International Federation of Red Cross and Red Crescent Societies (IFRC), etc.). Each of these organizations worked in varying degrees with the government agencies of Pakistan (e.g., SUPARCO, National Disaster Management Authority) and local NGOs.

The 2010 disaster also called for more spatial data being available and accessible in Pakistan. Reality in Pakistan shows that the government has been actively working on its NSDI implementation. At the same, however, eGov rates / ranks shows a decline in eGov outcomes (Ali 2010). Hence, despite both national and international initiatives the two policies seem not to have re-enforced each other at first glance. What happened in reality and how this could be representative for other countries is thus the main issue of this chapter.

The case of Pakistan is evaluated using primary and secondary data sources. The primary sources constitute personal communication and involvement in the SDI development process by one of the authors of the present chapter. These are however complimented and triangulated with documentary sources (e.g. policy documents, progress reports, web sites) and grey literature (unpublished articles, magazine articles, web posts and blogs).

4. Results

As the SDI development in Pakistan is referred to as the National SDI we use the term NSDI to reflect the SDI structures and implementation strategies in Pakistan. Similarly we refer to eGov when discussing the E-Government strategy of Pakistan. Table 1-3 provides the empirical findings on authority and performance patterns of both eGov and SDI in Pakistan with respect to adjacency, contingency and proximity tenets of congruency theory. Whereas Table 4-7 provides the empirical findings on performance patterns of both eGov and SDI in Pakistan with respect to durability, civil order, legitimacy and decisional efficacy tenets of congruency theory.

Comparing eGov and SDI on **adjacency** reveal that the eGov implementation was based on similar educational and training strategies as SDI strategies, i.e. emphasizing introduction and adoption of new technologies. Difference however was, the eGov experts and directors were trained broader than the SDI professionals and within eGov strategies there has been a more consistent focus on improving government services in a broader context. The educational background within eGov activities is primarily informatics, computer sciences and public administration. At the implementation level in Electronic Government Directorate (EGD), technical teams headed by directors who are experts of various disciplines such as databases, information security, Local & Wide Area Networks (LAN/WAN) and Web technologies etc exist. But in participating organizations, trained professionals in the relevant disciplines are deficient. For SDI related activities the background is primarily developed within context of the work of Survey of Pakistan (SoP), the national surveying and mapping organization of the country. As a result, most of the professionals involved have land surveying, mapping and/or geomatics background.

Public administration experience is however relevant. Still, there is lack of the trained professionals of the relevant disciplines. Even in the leading organization (SoP) no PhD of the relevant field exists at the moment. Although the Norwegian Mapping Authority (SK) is providing financial and technical support for setting up geographic information dissemination system as NSDI concept. But the question is, what would happen when they leave as donor and technical experts after three years? Therefore, it would have been much better if SK can financially support two or three SoP employees to carry out PhD and/or MSc in SDI related field for sustainability of Pakistan's SDI (PAK-NSDI).

For **contingency** aspect it is clear that the main norms are agreed upon on multilateral levels, such as within the OECD, whereas in the SDI community these are primarily derived from international associations such as GSDI (http://gsdiassociation.org/) or international donors. For eGov, the main norms and values of Pakistan's eGov are in alignment with the OECD principles of on digital government as expressed by the OECD guidelines (http://www.oecd.org/governance/eleaders/Draft-OECD-Principles-for-Digital-Government-Strategies.pdf), however the implementation on ground is still not quite visible to the majority. Regarding the NSDI norms presently, PAK-NSDI (http://www.surveyofpakistan.gov.pk/nsdi.php) is most active at the policy level as a standard and set practice. Almost all the set policy objectives are influenced by the in line with norms and values set by GSDI and the international community writing about NSDIs. The means of socialization and information distribution in relation to eGov is using print and electronic media. This has actively contributed to reach politicians and bureaucrats to spread the message of eGov needs. Regarding PAK-NSDI, the main socialization means were through individual organizational efforts such as seminars and workshops to distribute the message. Pakistan Bureau of Statics (PBS) with the collaboration of UNFPA and UN HABITAT conducted workshop in 2013 to highlight importance of Geospatial Information (GI) standards and the need to have NSDI in the country (Asmat & Munir 2013). Survey of Pakistan (SoP) has created awareness among public and private sector organizations through in-house and cross organizational meetings on the agenda of PAK-NSDI.

Table 1: Adjacency

Questions to derive empirical proxies of congruency tenets	**eGov**	**NSDI**
What is the educational background of the actors implementing this policy / programme?	At the implementation level in EGD directorate, technical teams headed by directors who are experts of various disciplines such as databases, information security, Local & Wide Area Networks (LAN/WAN), Web technologies etc exist. But in participating organizations, trained professional in the relevant disciplines are deficient.	There is lack of the trained professionals of the relevant disciplines. Even in the leading organization (SoP) no PhD of the relevant field exists at the moment. Although the Norwegian Mapping Authority (SK) is providing financial and technical support for setting up geographic

		information dissemination system as NSDI concept. But the question is, what would happen when they leave as donor and technical experts after three years? Therefore, it would have been much better if SK can financially support two or three SoP employees to carry out PhD and/or MSc in SDI related field for sustainability of PAK-NSDI. Please see attachment

On the aspect of **proximity** both eGov and SDI practitioners include a broad variety of contributors. However in the eGov community there are also economists involved, whereas in the SDI community this is less. Active social units in eGov include civil society, researchers, politicians, economists, NGOs and bodies like UN, US-Aid etc are pushing for the implementation of the initiative (Ali and Ahmad 2012). For the SDI, researchers of Pakistan Agriculture Research Council, Pakistan Science Foundation, PMAS-Arid Agriculture University Rawalpindi (http://www.uaar.edu.pk/), Bahria University Islamabad and NGOs like WWF-Pakistan, and bodies like GSDI, JICA, UN, US-Aid etc. are pushing for the implementation of the initiative (Ali and Ahmad 2012). It is important to mention that with collaboration of Survey of Pakistan, PMAS-Arid Agriculture University Rawalpindi is the only university of the country where PhD level research on SDI is presently going on. Recently, also the SDI Norway was launched as part of Digital Norway initiative. Here the SDI and eGov come more congruent through a single project initiative.

Table 2: Contingency

Questions to derive empirical proxies of congruency tenets	**eGov**	**NSDI**
What are the main norms and values? (as can be seen in the policy ? where do they refer to? (e.g. GSDI? Other countries?)	The main norms and values of Pakistan's eGov are in alignment with the OECD principles of on digital government; however their implementation on ground is still not quite visible to the majority. Moreover, no substantial evidence from research literature could have been found to cite.	Presently, PAK-NSDI is at policy level. Almost all the set policy objectives are in line with norms and values set by GSDI and other countries. What would be achieved at operational level is a matter of choice of national policy implementation instruments and the resources made available.

How is the message distributed? What is the means of socialization?	Print and electronic media have actively contributed in addition to politicians and bureaucrats to spread the message. Workshops? Some workshops and conferences on e-government of Pakistan have been conducted by LUMS and National Policy Institute in the past.	Yet no proper arrangements at institutional level are visible. However, individual organizational efforts are being made such as seminars and workshops to distribute the message. But, certainly a degree of mistrust exists there. Pakistan Bureau of Statics (PBS) with the collaboration of UNFPA and UN HABITAT conducted workshop in 2013 to highlight importance of GI standards and the need to have NSDI in the country (Asmat & Munir 2013). SoP is yet making preparations to hold seminar on PAK-NSDI.

The aspect of **durability** is much more prominent in the eGov than SDI development. Formal institutional policies were much earlier developed and accepted. The E-government policy in Pakistan was approved in 2000 – see p.7 (Government of Pakistan 2005). In 2002, Electronic Government Directorate (EGD) was established to focus on its implementation. The document on Pakistan's E-Government Strategy was made public in 2005. So far, the eGov policy has not been revised as a whole however incremental changes to support its implementation were introduced. For example, Prevention of Electronic Crimes Ordinance 2009, Telecommunication System Clock, Time & Date Synchronization Regulations 2010, MoU between PTCL and MoIT for hardware & data center hosting facility 2013, launch of Broadband Quality of Service Regulations in 2014. Preparation of draft of "Telecommunications Policy", which was circulated to stakeholders on 3rd July 2014 for comments and creation of National Information Technology Board (NITB) in February 2015. Similarly, realizing the needs of having standards for successful implementation of the initiative, policy document on E-Government Standards was introduced in 2009.

Table 3: Proximity

Questions to derive empirical proxies of congruency tenets	**eGov**	**NSDI**
Which social units are carrying out the eGov / SDI programme?	Mainly, civil society, researchers, politicians, economists, NGOs and bodies like UN, US-Aid etc are pushing for the implementation of the initiative	Mostly, researchers of Pakistan Agriculture Research Council, Pakistan Science Foundation, Bahria University, Islamabad and PMAS-Arid Agriculture University NGOs like WWF-Pakistan, and bodies like GSDI, JICA, UN, US-Aid etc. are pushing for the implementation of the initiative

Is there any reference from SDI to eGov or vice versa in any documentation?	Digital Norway is a good practical example to cite. In Denmark, They started with eGov and SDI was part of it In the context of "authentic registrations" Key spatial data sets are part of the Dutch eGov policy. The geo-portal (PDOK) has a spatial focus. It also contains the Dutch INSPIRE portal. (Discussion on RG with **Arnold Bregt**)	SDI Norway was launched as part of Digital Norway initiative.
To which extent does one serve another?	That to which extent eGov does serve NSDI or vice versa but definitely both complement each other	

Regarding the SDI policy, in 2012 the policy to implement NSDI was started (Ali and Ahmad 2012).The announcement was made public in 2014 through newly approved Surveying and Mapping Act, 2014 (Ali and Ahmad 2014). The ICT working group developed a national spatial database plan for 2015 (http://www.pc.gov.pk/?p=1705). The SDI policy developed with the support of Norway would be enhanced after conducting a feasibility study with the assistance of foreign experts on the subject.

Regarding the aspect of **civil order** eGov policies rely on a wide variety of policy goals, including efficiency and effectiveness combined with quality aspects of public service delivery. Instead, the SDI policy primarily emphasizes financial underpinnings. The original eGov document of (Government of Pakistan 2005) refers to three major policy aims of E-Government in Pakistan: Efficiency and Effectiveness, Transparency and Accountability, Delivery of Public Service. This document with its main policy aims has been undisputed so far. On the other hand, the NSDI policy has faced quite some resistance. The financial aspects/costs are facing resistance from the relevant ministry due to huge cost involved. The concerns have been shown on number of occasions during presentations to the ministry.

With reference to the aspect of legitimacy of the use of ICT to deliver services has been prominent in eGov justification politically and organizationally (Government of Pakistan 2005). Pakistan has incorporated basic strategic steps in their e-government framework (Reddick 2010). NSDI in contrast has been primarily legitimized by the argument of sharing of data especially among public sector organizations and to overcome duplication in collection and maintenance of spatial data (Government of Pakistan 2014). Though this has received wide political support, the national policy on SDI is not publically available, so its pros and cons are not yet reflected with additional evidence.

On the aspect of **decisional efficacy** there is a major difference between the type(s) of organization(s) responsible for the implementation. It is the difference between a shared and single responsibility. The implementation of the eGov policy is carried out by the Directorate (EGD) established as a unit within the Ministry of Science and Technology and the Accreditation Council in the premises of National Telecommunication Corporation, following (Government of Pakistan 2005). In addition there are active contributing organizations such as National Information Technology Board by merger of Pakistan Computer Bureau and the Electronic Government Directorate (Dawn 2014), National IT Development and Promotion Unit www.nidu.gov.pk/, National Electronic Government Council (NEGC) (Government of Pakistan 2005).

Table 4: Durability

Questions to derive empirical proxies of congruency tenets	**eGov**	**NSDI**
When did the policy start?	E-government policy in Pakistan was approved in 2000 (Government of Pakistan, 2005). In 2002, Electronic Government Directorate (EGD) was established to focus on its implementation. However, document on Pakistan's E-Government Strategy was made public in 2005.	In 2012 the policy to implement NSDI was started. The announcement was made public in 2014 through newly approved Surveying and Mapping Act, 2014 Development of National Spatial Database is part of recently approved Vision 2025 plan.

When was it revised?	So far, the policy has not been revised as a whole however incremental changes to support its implementation were introduced. For example, Prevention of Electronic Crimes Ordinance 2009, Telecommunication System Clock, Time & Date Synchronization Regulations 2010, MoU between PTCL and MoIT for hardware & data center hosting facility 2013, launch of Broadband Quality of Service Regulations in 2014. Preparation of draft of "Telecommunications Policy", which was circulated to stakeholders on 3rd July 2014 for comments and creation of National Information Technology Board (NITB) in February 2015. Similarly, realizing the needs of having standards for successful implementation of the initiative, policy document on E-Government Standards was introduced in 2009.	The policy would be enhanced after conducting feasibility study with the assistance of foreign experts on the subject. The subject study is proposed during the financial year 2014-15.
How was it revised each time?	Not revised as such but some supplementary policy documents as complement to the main policy were launched. Please see above remarks.	The policy was revised to increase financial cost in the document.
Which policy documents have been produced over time?	National IT Policy and Action Plan 2000.Electronic Transaction Ordinance (ETO) 2002. Work is also underway on the Data Protection Act, Electronic Signature Law and Electronic Crimes Act.	So far, two policy documents first in 2010 and second in 2013 have been produced which are not open to public yet. But it is expected to be publically available after incorporating results of feasibility study next year.

Table 5: Civil Order

Questions to derive empirical proxies of congruency tenets	eGov	NSDI
Which policy items have been followed up without resistance? (Which ones had resistance; if so from whom? Why?)	Efficiency and Effectiveness. Transparency and Accountability. Delivery of Public Services.	The financial aspects/cost are being facing resistance from the ministry due to huge cost involved. The concerns have been shown on number of occasions during presentations to the ministry. Whereas the degree of acceptance or resistance of remaining items of the policy would be measureable once it is presented to stakeholders including the general public.
Which coercive actions were undertaken? Which issue was done which coercion?		
Which policy items addressed private sector action? Which ones public sector action?	The eGov policy addressed both public and private sectors as Public Private Partnership (PPP) was picked up as policy implementation instrument.	The NSDI policy addressed both public and private sectors as Public Private Partnership (PPP) was chosen as policy implementation instrument.

The National Electronic Government Council (NEGC) has framed the main challenges, still following (Government of Pakistan 2005). Page 19 of (Government of Pakistan 2005) refers specifically to a number of principles underlying the actions, such as:

- Relying on a comprehensive plan instead of piece-meal projects
- Priority on high-impact agency specific applications
- Interoperability of applications
- Outsourcing of project execution

In contrast the main reported / documented challenges for NSDI Pakistan include (Ali and Ahmad 2012):

- Institutional Issues
- Data Policy
- Legal Framework

- Data Management
- Coordination
- Data Cost
- Technical issues include: Standards, Metadata, Technical Arrangements & Data Quality

These challenges relate in different ways to political demands. The main objectives of Pakistan's eGov are:

- Create more accountability and transparency in the public sector
- Modernize public services in which joined-up Government institutions communicate and work more effectively and efficiently
- Increase responsiveness of Government sector in delivering public services
- Bring Government close to citizen by providing them with easier access to information through personnel computers, kiosks, telephone and other resources.
-

Table 6: Legitimacy

Questions to derive empirical proxies of congruency tenets	**eGov**	**NSDI**
Which policy items received wide political support/ organizational support?	Use of ICT to deliver services.	Information sharing especially among public sector organizations received wide political support.
Which policy items gained attention in grey literature / Organizational documents/ Policy documents?	Pakistan has incorporated basic strategic steps in their e-government framework.	As the national policy on SDI is not publically available, so its pros and cones are not yet reflected in the grey literature.
Which justification is used for the policy and its actions?	Better service delivery to the citizens.	To overcome duplication in collection and maintenance of spatial data page.

In contrast, the actions of the NSDI include monitoring of development projects, creation of national spatial databases, fulfilling data needs of water and agriculture sectors were basically the political motives for PAK-NSDI. Later on, other challenges such as reduction of duplication efforts in data collection and maintenance were realized by most of the major stakeholders and added by SoP in 2013, too. Documented evidence is available but it is not public information.

Table 7: Decisional Efficacy

Questions to derive empirical proxies of congruency tenets	**eGov**	**NSDI**
Who is carrying out policy?	Directorate (EGD) established as a unit within the Ministry of Science and Technology. Accreditation Council in the premises of National Telecommunication Corporation National Information Technology Board by merger of Pakistan Computer Bureau and the Electronic Government Directorate National IT Development and Promotion Unit www.nidu.gov.pk/ National Electronic Government Council (NEGC)	Survey of Pakistan (SoP) through Surveying and Mapping Act 2014 has been mandated to establish and maintain NSDI for Pakistan with collaboration of stakeholders. Therefore, SoP as lead organization is carrying out the policy with the collaboration of stakeholders and very limited technical and financial support from Norwegian Mapping Authority (SK).
Who is formulating the challenges and actions?	National Electronic Government Council (NEGC)	Although time, technology and user demands are shaping the challenges and the actions needed. However, SoP is realizing challenges and outlining the needed actions with support from Norwegian Mapping Authority. But to realize the dream of NSDI Pakistan, SoP has to seek assistance from many other international organizations like GSDI, US-Aid, JICA, World Bank etc. The challenge is twofold i.e. financial and technical assistance.
What sort of challenges and actions are carried out?	Poor IT infrastructure, low literacy rates, slow e-government services development, and adoption	Institutional Issues: Data Policy, Legal Framework, Data Management, Coordination, Data Cost

		Technical issues include: Standards, Metadata, Technical Arrangements & Data Quality
Which challenges and actions are connected to which political demands?	The main objectives of Pakistan's eGov are: • Create more accountability and transparency in the public sector • Modernize public services in which joined-up Government institutions communicate and work more effectively and efficiently • Increase responsiveness of Government sector in delivering public services • Bring Government close to citizen by providing them with easier access to information through personnel computers ,kiosks, telephone and other resources These are not only the objectives but challenges as well faced by GOP.	Initially, monitoring of development projects, creation of national spatial databases, fulfilling data needs of water and agriculture sectors were basically the political motives for PAK-NSDI. Later on, other challenges such as reduction of duplication efforts in data collection and maintenance were realized by most of the major stakeholders and added by SoP in 2013, too. Documented evidence is available but it is not public information.

5. Discussion

When considering the empirical evidence, the degree of isomorphism is moderate. There are indeed some overlaps in policy items, such as a mutual focus on increased efficiency and effectiveness and an increased uptake of ICT to generate public services. One could however qualify this as mimetic isomorphism. In other words, public sector managers of different agencies use similar –often non-disputed arguments to justify the organizational and informational changes. These arguments are rather broad and can be easily copied. In this sense, eGov and NSDI developments follow a line of the global changes in the public sector. The way to execute these are largely mimetic, as they follow similar paths despite the difference in original starting data (2000 for eGov compared to 2012 for NSDI).

Remarkable is however the lack of coercive and normative isomorphism. One would expect that the implementation of a change process where the main focus is on adopting and adapting to ICT requirements would rely on similar coercive mechanisms to make things happen. This is however not the case. There is no specific law guiding either of the policies and in particular NSDI 'project' faces large challenges getting the message across and making significant changes. There could have been a learning curve and shared experiences which could be mutually reinforce. There is however no specific evidence of this. Similarly for the normative isomorphism. Both the justification for the introduction of the policies and the basic norms underling the policies are different. This could be explained by the fact that there is not a large overlap between the people and organizations which are primarily converting the policy into implementation. These constitute two epistemic communities with their own professional values. In this sense they may be similar, but rather as a coincidence than as a planned structured practical plan.

What does this tell about the balanced disparities between SDI and eGov at large? In fact, we may conclude that the disparities are not sufficiently in balance. Otherwise put, the way the implementation of either policy is occurring is insufficiently re-enforcing each other. The balance is somewhat present for the aspects of civil order and legitimacy, but rather absent or even contradictory for the aspects of contingency and decisional efficacy. The main reasons could be that the duration could be an important element of implementing ICT-related polices. eGov has had much more time to develop, to endure and absorb criticism and to get some sort of acknowledgement within the political community. As a result, the government structures are readily adapting to new policies and organizational structures in-line with some of the intended goals.

A limiting factor for the NSDI is perhaps also the fact that its policy is so confined to one government organization only, the Survey of Pakistan. This may cause other agencies to stay out of the development and implementation of the policy. The new initiative sponsored by the Norwegian government tries to deal with this aspect by broadening the basis of stakeholders. This is obviously not evident. Mobilizing resources and/or relying on other resources with previously different destinations requires political tact and convincing power (besides coercive mechanisms through laws or regulations). Obviously, the disasters only led to a limited amount of change within the established responsible organizations in this respect.

6. Conclusions and Recommendations

Going back to the main question of this research: to which extent are eGov and SDI implementation re-enforcing or contradicting / obstructing each other in reality and what does that say about the governance of the digital infrastructure? The analytical framework relying on congruency theory has enabled to show that the current two policies are only re-enforcing each other in a limited way. There is no single governance framework which guides the digital infrastructure. Instead, the resulting implementation strategies are largely rooted in pragmatic efforts and gradual change and adaptation. There is no specific learning path exchanged from eGov to NSDI or vice versa. Rather, the two policy developments are separate.

Good is perhaps that the policy implementations are not obstructing each other. They are largely developing in isolation, supported by separate professional communities. Whilst this a positive finding in terms of the rate and success of policy implementation, at the same time it may also be considered ineffective in terms of government resources.

Regarding the method and theory employed, congruency theory overall has been a useful tool to evaluate the congruency of different policies which seem similar or adjacent. It requires however a clear translation into evaluating empirical indicators. We have relied primarily on a qualitative evaluation as the amount of documentation and access to important policy documents and operational strategies was not always possible. Further research could build on these basic documents, but could also extent to more explanatory questions, such as searching for the main reasons why the two professional groups would not work together on similar data and information issues.

Finally, for practitioners in government it is recommended to seek mutual links with other policies when formulating new policies and to learn from how previous trajectories were prepared and executed. Especially if the designer of the policy have the feeling that there are large overlaps, or mutual benefits, it would make sense to build in a systematic learning phase in which experiences of other domains are reviewed and assess on possible applicability in other professional or organizational domains.

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Chapter 8: Democratization of Key Public Sector Information in Zimbabwe. The Road towards Open Information Access?

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Abstract

The world today has evolved into an information society. Information is key to the operation of government and all sectors of the economy. Good information is needed to formulate informed decisions. The information needs to be accurate and timely. Online access of basic information and services by citizens through the creation of one stops is the concept that most governments are advocating to achieve. This is known as e-government which is one of the themes under discussion in this study. This study concentrates on Public Sector Information (PSI) which includes fundamental spatial data sets that are created and maintained by the national mapping agency. Enhanced access to spatial data and other public sector information has a bearing on good governance, sustainable development and eventually the adoption of open government by nations. A comprehensive study is done in government departments, academia and private sector firms to determine what public sector information access mechanisms, interagency exchange methods currently exist and information sharing policies in use. The availability and extend of electronic services is assessed in municipalities. Spatial data access between different stakeholders including public sector, non-governmental organizations and private sector agencies is reviewed. Factors motivating and impeding organizations to share spatial data and PSI are also analyzed. The benefits of sharing key information across government are discussed.

This study evaluates spatial data access and key public sector information. E-government is assessed to analyze access of key government services by the public. A move towards improving access to PSI is one stride towards open government in Zimbabwe. This study borrows concepts from the fields of Public

Administration, E-government and Spatial Data Infrastructures. The world is building towards knowledge economies in which openness is terms in information and knowledge while good and informed governance is crucial. Public participation should be encouraged in planning and governance issues and in the creation of community based spatial data sets.

Keywords: Democratization, Open Data, PSI, E-government

1. Introduction

The world today revolves around information due to globalization and the emergence of the information society. Information today practically drives the world and economies. There is definite need for good and timely information to support various decision making. Information has turned into a basic need without which humankind cannot live without. In this study, public sector information (PSI) is put into consideration. The PSI comprises of information from public sector organizations and fundamental spatial data sets such as topography, aerial photographs and cadastral information that are produced and maintained by the national mapping agency in Zimbabwe.

One of the ways to share and access timely government information is through e-government implementation. E-government can be defined as the use of information and communication technologies (ICT), for the production and delivery of information and services by government (Fountain, 2001). One of the ultimate aims of e-government is to provide one-stop shops for government services to the public. Governments are increasingly employing the web to deliver services and information to the public and other stakeholders (Layne and Lee, 2001).

The world now portrays an information society as society becomes more empowered by information (Homburg, 2008). Governments are trying to democratize information through making public information widely accessible. This is being done through e-government initiatives that also have an aim of bringing government closer to the citizens through e-services.

1.1 The Nature of Public Sector Information

Public sector information is essentially a public good or basic necessity especially in the information society where information is an enabler to empowering societies. Public goods and services are characterized by properties such as non-excludability and non-rivalry (ANZLIC, 2010; Samuelson and Nordhaus, 2005). Non-excludability means that the goods and services must be available to all citizens. Non-rivalry means that there is no competition in the use of the goods and services. At the same time use by one person or organization does not reduce the amount of spatial data available for other organizations (ANZLIC, 2010). Public goods and services often provided by the state, governments, or largely public sector organizations. The public sector provides goods for 'general interest', that is, for the good of the public or citizens. Public services, due to their nature of public interest often enjoy government subsidies to promote wider access and thus do not always follow the laws of demand and supply which are the market forces.

1.2 The Nature of Spatial Data

The complexity of spatial data lies in the fact that it can be viewed both as a public and economic good. It is, however, the notion of spatial data as a public good that is of interest to this study with emphasis on only fundamental data sets. Spatial data is a public good in the sense of for example, a public road where no individual should be excluded from using it. In this regard, access should be available to all but not necessarily for free. In the view of spatial data as a public good, the data is used for public or national interest such as in formulating and effecting public policy.

Of interest is the social role that spatial data plays with intend to effect public good in form of societal benefits (Pickles, 1995; Sheppard, 1995). It is from this role that partly the concept of spatial data being a public good stems from. A spatial information infrastructure should ideally improve access to spatial data by the public and all sectors which leads to the concept of democratization of information and equity benefits discussed by (Sawicki and Craig, 1996) and (Tulloch and Epstein, 2002).

2. Research Problem

Governments worldwide are under pressure to deliver better services and information in a timely fashion. The world today faces an explosion of information which has become part of mankind's livelihood. This concept is referred to as the information society. On the other hand, the world is targeting towards a knowledge economy in which good information is key to success. Information is important to support good decisions by government, business and the public. This makes access to information very important. This information includes both spatial and non-spatial information that all forms part of Public Sector Information (PSI).

It is increasingly important for citizens to have good and easy access to government services which is normally facilitated through e-government. Some developing countries including Zimbabwe, still lag behind in terms of implementation and diffusion of e-government within local government and the public sector in general. There is also growing need for good and informed governance. Citizens want to interact more with government, while the governance structure should be open and transparent. This study investigates the existing information access mechanisms and how to improve upon them in the context of Zimbabwe. The status of e-government in the public sector and local government is investigated leading to development of strategies to improve the implementation of digital government. A framework for sharing data across different organizations is also proposed as part of this study.

3. Related Work

3.1 Spatial data sharing

Different organizations have different pricing models and licencing conditions (Welle-Donker and van Loenen, 2006). This impedes a common ground for access and sharing of spatial information. Welle-Donker and van Loenen (2006) suggests the use of the "creative commons" concept in the development and promotion of uniformity and transparency in licences for Spatial Information. There is need for consistent data access policies and pricing strategies within government and the private sector (Welle-Donker and van Loenen, 2006). Some data sharing techniques include: Open ('Free') Access, Paid Access and Cost Recovery.

3.1.1 Open ('Free') Access

In this model, the user accesses spatial data at the cost of dissemination. The logic behind this model is that spatial data sets are created using public funding and as such the taxpayer should only pay once to use or reuse the data. However, this leaves a void on the proper functioning and maintenance of the system. On the other hand, should the funding be reduced or stopped, this impacts on the frequency of data updates and maintenance. However there are minimal restrictions regarding data use in this model (Welle Donker, 2010).

3.1.2 Paid Access

This is where by users, including the public, have to pay a designated fee in order to access spatial information. The fee can include cost of collection, processing, customization and packaging. The cost of the information product or service, also referred to as a price, is normally based on a pricing or business model.

3.1.3 Cost Recovery

The cost recovery model is a user-pay system aimed at recovering all costs incurred in the production and dissemination of spatial data. In this regard, the user incurs all these costs. The data in this case is made available for reuse but often under restrictive licensing conditions regulating its use and further dissemination (Welle Donker, 2010).

3.2 E-government

Electronic government, also referred to as digital government is employed to improve efficiency and effectiveness regarding service delivery by government and access to services and information by the general public and other organisations from different economic sectors within a nation. As a result, the use of information and communication technology has become paramount in service provision. In this case, ICT is an enabler for government to achieve the operational efficiency the public demands while achieving performance gains as public sector organisations (Brown, 2007). However, having a fully functional and mature e-government initiative remains a complex task particularly in the developing world. The e-government implementation should traverse through a number of stages which represents its maturity. As the implementation becomes more mature, so does the performance and productivity gains. This concept of e-government development springs from maturational models in which progress follows a linear, sequential and stepwise manner (Brown, 2007). An example of such a model is presented in (Layne and Lee, 2001). Within each step of development, organisations need time to adjust to technological innovations before they move to the next stage.

Layne and Lee (2001) define four stages of growth of a fully operational electronic (digital) government system. These stages of development are cataloguing, transaction, vertical integration and horizontal integration.

In cataloguing, governments seek to be available on the internet through the creation of websites. Emphasis is on having various forms online for application for different services by business, other government departments and the general public. Governments at this stage avail some key information, notices and documents on their websites for access by the citizens. The cataloguing stage is characterised by digitizing of hardcopy documents towards full automation (Layne and Lee, 2001).

The second stage of transaction enables citizens to transact with government. Citizens can make service requests and make necessary payments online. Citizens are able to pay utility bills and fees for a wide range of service requests. Websites are in this case connected to some government databases to facilitate e-transactions. There is integration with ecommerce to facilitate such transactions (Layne and Lee, 2001).

The last two stages are vertical and horizontal integration. Vertical integration connects local, state and federal governments so that functions or services appear or can be accessed seamlessly. Focus is on expanding and interlinking government services. Horizontal integration aims at creating one stop shops for different services through connecting various government departments. The public only needs to interact with one point of government to access different services (Layne and Lee, 2001).

E-government projects have been initiated to provide digital information and services to business and the general public (Lofstedt, 2012). Their intent is to offer easy access to government services and information to different stakeholders. E-government has the potential of increasing the quality of services in terms of efficiency and effectiveness and providing a platform for public participation in different democratic processes. E-government is about reinventing the manner in which government interacts with the public, business and other agencies while at the same time, improving democratic processes (Lofstedt, 2012).

As the e-government initiative matures, the public and other organisations develop more trust in it. Trust can determine successful adoption and use of technology and as such the e-government system should be citizen centred, reliable and secure while providing timely information. The acceptance of technology within and outside the society can also be highly context dependent meaning that factors influencing success in one country or organisation might not have the same impact in another organisation or setting.

4. Methodology

The e-government evaluation is done based on the framework provided in (Layne and Lee, 2001) using indicators adopted from (Brown, 2007). In this regard, websites for municipalities and were evaluated to determine access of information though notices, downloadable documents and forms and the presence of online transactions.

A questionnaire survey was conducted to gather information regarding the following major themes: Spatial Data Sharing Policies, non-spatial Public Sector Information sharing policies, e-government status and open government. The questionnaire was circulated to academia were there were 7 respondents, 4 from the public sector organizations as well as 4 from the private sector organizations dealing with public sector information. Municipalities where chosen on the basis of their size in terms of acreage and population, economic activity and tourism facilities with only 2 municipalities responding. In total 17 questionnaires were completed of the 35 send out which constituted a response rate of 48%. The questionnaires were analyzed using SPSS software.

5. Findings and Analysis

5.1 E-Government Evaluation in Local Government

Table 1 shows the results for the assessment of local government websites in Zimbabwe. 16 municipalities were chosen with 7 having operational websites at the time of the survey. The surveyed municipalities are Harare, Bulawayo, Chitungwiza, Gweru, Kwekwe, Kadoma, Masvingo, Chegutu, Norton, Kariba, Victoria Falls, Shurugwi, Zvishavane, Karoi and Hwange (see table 2). The website evaluation indicators regarding voter registration and property registration were removed as they are only done at national level through the Electoral Commission and the Deeds Registry respectively. However, the processes of property and voter registration would be in principle more efficient if decentralized to local level at which municipalities would handle such tasks within their jurisdictions.

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Table 1: Online Services at Local Government Level

	Municipalities						
Online services	**Co H**	**Co B**	**Co C**	**Co M**	**K M**	**VF M**	**HWM**
Council Agenda Minutes	X	X	-	-	-	-	-
Online Communications	X	X	X	X	X	X	X
Communications less than 60 days old	-	-	-	-	-	X	-
Ordinances/Bylaws	X	X	X	-	X	X	X
Employment information (Vacancies)	X	X	-	X	-	X	X
Downloadable Forms	X	X	-	-	X	X	X
Submit-able online forms	-	-	-	-	-	-	-

Requests for Services (Tenders)	-	-	-	X	-	X	X
Electronic Newsletters	X	X	-	-	X	-	-
Government Records Request	-	X	X	X	X	X	X
Spatial data downloads	-		-	-	-		-
Downloadable Government Information	X	X	-	X	X	X	X
Permit Application	-	-	-	-	-	-	-
Tax payment	-	-	-	-	-	-	-
Utility bill payment	-	-	-	-	-	-	-
Streaming video	X	-	-	-	-	-	-
Fines/Fees payment	-	-	-	-	-	-	-
Business license application	-	-	-	-	-	-	-
Tourism Information	X	X	-	X	X	X	X
Basic Contact information	X	X	X	X	X	X	X
Email	-	X	X	X	X	X	X
Service faults reporting system/ Helpline	X	X	X	X	X	X	X

X: represents services availability. -: represents service unavailability

The results show that, e-government is still in its infancy in Zimbabwe as the majority of municipalities have not even established an online presence. Of the few municipalities who are available online, the functionality they have from the websites reflect that they are in the cataloguing stage described in the e-government development model by (Layne and Lee, 2001). The municipalities have a few information documents that can be downloaded online including forms for service applications. However, there are no online application forms that can be submitted through the websites and it is not possible to pay for services online. However, there are partnerships between municipalities and a private companies and banks to facilitate payment of different services mostly through mobile banking. It is not possible to access spatial data from the websites. Spatial data is only accessible though visiting the offices of the respective organization.

Table 2: List of Municipalities

CoH	City of Harare
CoB	City of Bulawayo
CoC	City of Chitungwiza
CoM	City of Masvingo
CoK	Kariba Municipality
CoVF	Victoria Falls Municiplality
CoHW	Hwange Municipality

5.2 Open Data and Open Government

This section is based on the questionnaire survey. According to field work findings, 78% of the respondents indicated that they prefer to receive data in electronic format. 23% of the respondents still share data via hard copies. 56% of the respondents have their operations computerised with some of their data in digital format. (See table 3).

Table 3: Data Access

Item	% of respondents
Prefer to receive data in digital format	78
Share data via hard copies	23
Amount of data in digital format	67
Agree spatial data and other government information should be available for free	33

With regards to whether spatial data and other government information should be available for free, 33% of the respondents were of the opinion that it should be made available for a fee to the public. This is against the 11%, which preferred free data for all, while 33% of the respondents are not sure whether the data should be free or a fee should be levied for the data (see table 4).

Table 4: Opinions on free and Paid Access

Item	% of respondents
Government data should be made available for a fee to the public	33
Prefer free data for all	11
Not sure whether the data should be free or a fee should be levied	33
All should pay for data	23

All respondents were agreed that government data should be classified as key public sector information. 11% of the respondents were of the opinion that there should be open access to key PSI. This study revealed that 56% of the respondents from the questionnaire survey do not have functional websites. At the same time, 44% of the respondents were against the idea of having key PSI freely available on websites.

Of the 44% of organizations with functional websites, 67% revealed that they have public sector information published on their websites for access by the public. 40% of the organizations were motivated to share PSI based on government data sharing policy while 26% is motivated by their organizational mandate and 34% by organizational data sharing policies (see table 5).

Table 5: Drivers to Share PSI

Item	% of respondents
based on government data sharing policy	40
motivated by their organizational mandate	26
organizational data sharing policies	34

Interestingly 31% of the respondents were of the opinion that the best way of sharing PSI is when organizations buy data from each other as well as exchanging data through memorandums of understanding while 38% indicate that organizations should exchange data freely. For datasets that are paid for 56% have a pricing mechanism or policy for data, while 22%, and do not have any pricing mechanisms in place. Of the respondents selling data 27% of them charge commercial prices for their data, while 27% try to recover their costs of extraction and storage media. However, a common framework for sharing data is of importance particularly in the public sector as their information is normally intended for the wellbeing of the public and the nation at large.

The term e-government is fairly known by the respondents as 56% of the respondents showed awareness. However, 44% of the respondents do not have e-government systems in their organizations. Of those organizations with e-government systems, only 22% have services available online and these services being offered online are mainly payment of rates and fees.

Only 33% of the respondents were of the opinion that the public should participate in government activities such as policy formulation through ironically 100% of the respondents agreed that e-government promote good and informed governance. Findings reflected that all the respondents agree that people with access to information are more empowered; and improved access to information improves decision-making and policy formulation in government organizations and that exchanging information would save data collection costs in the public sector.

78% of the respondents acknowledged that policies at government level would improve sharing and access of public sector information and that e -government would increase access to public sector information and services. 78% of the respondents concurred that government policy should detect which data sets are free and those that are accessed through payment.

6. Discussion

6.1 Towards Open Data and Open Government

This study revealed that there exists misconception regarding what PSI constitutes. The general view is that PSI is information with direct impact to national security and should remain behind closed doors and not be availed for public use.

Fieldwork findings revealed that organizations prefer accessing digital information to suit today's digital work environment needs. However, there is lack of complete trust in digital systems as some respondent's preferred analogue data. Public sector organizations are making an effort to computerize operations and convert data into digital format but dissemination through digital means such as on websites is inadequate. Websites are also not frequently updated and thus, the general public cannot access timely information.

Fieldwork results reflected that the majority of respondents are of the opinion that spatial data should not be accessed free of charge and neither should the non-spatial PSI be openly accessible. This is interesting to note since all this data is collected and compiled using public funds. On the other hand, public sector organizations are not implementing a cost recovery approach as funding for their sustenance comes from national government.

The response that PSI should not be openly accessible can translate to unwillingness to share information, authority and autonomy issues. The organizations essentially view the information they create as their own and not for public consumption. This results in organizations creating barriers to access of information due to their autonomy over the information. The barriers mean either no access or lengthy bureaucratic protocols to access information. Other than having standard way of accessing data, this results in informal information sharing arrangements that rely on the relationship between the information requester and the provider. The situation is worsened by lack of policies at national level that promote the sharing and access of public sector information.

Some organizations preferred selling data as the best way of sharing which could be typical for data vendors which were not part of this study. Organizations have even developed pricing mechanisms for their data. Public sector organizations prefer exchanging data free of charge amongst themselves with pricing levied on other users.

The major drivers for sharing data are government and organizational policies and organizational mandates. These drivers need to be coupled with the willingness to share between the organizations.

Even though some information is available via the websites of the organizations it is insufficient as only a small component is published. This means the information regarding operations of government in different sectors such as housing, education and agriculture is not widely available. The possibility for public participation in policy formulation is limited while at the same time, citizens cannot effectively participate in national issues when furnished with inadequate information.

Public sector organizations have awareness of the e-government concept even though: (i) diffusion of e-government is minimal, (ii) e-government is still at grass root level and only exhibiting online presence and (iii) there is no evidence of use by the public. Fieldwork findings reflect that e-government can definitely promote good and informed governance. On the contrary, only a third of the surveyed population supported public participation in national issues. The question that arises then is whether officials are serving the needs of the public or only for the technocrats. The view of the e-government system is that it should be used by government and public sector organizations while excluding other parties.

Regarding the spatial public sector information, Zimbabwe is operating in isolation of worldwide trends. The greatest barrier to access of fundamental data sets is the lack of a spatial information infrastructure and the availability of documents in analogue format. This means that users of spatial data have to travel to the two Surveyor General's departments in the country to access spatial data. Spatial data is key to aid in public policy implementation and decision, which can greatly improve the quality of life of the citizens. Citizens can greatly influence development that happens in the spaces they live through interaction with local government.

Open data and open government in Zimbabwe requires organizations to change their mindsets regarding (i) what constitutes effective data sharing, (ii) what constitutes democratization, (iii) what constitutes classified information, (iv) what constitutes good governance and (v) the positive role of the public in government operations. The national government has a larger role to play in achieving open data in Zimbabwe. This is due to the fact that, the majority of respondents acknowledge that only policies implemented at national government level can improve access to PSI though the e-government highway. On the other hand, government policy should also detect which data sets are free and those to be paid for.

From the discussion above, the public cannot participate effectively in national issues due to barriers regarding access to public information. This means, the gap between the public and government is not reducing and there is no positive progression towards open government. The more government is open regarding its operations through improved access to information, the better the chances to realize open government. There is need to develop mechanisms to make both the spatial and non-spatial PSI available which is discussed in the following subsections.

6.2 Towards a PSI Sharing Framework

Spatial data has a characteristic that it is costly to collect while the costs of reproduction and distribution are minimal. This makes sharing spatial data crucial between agencies. In order to effectively share the data, there is need to eliminate duplication in the collection of spatial data. The first call is to identify core or fundamental data sets and the respective data custodians. The data custodians will be responsible for the collection, maintenance and distribution of a particular data set. The significance of data custodians is through their responsibility towards maintenance and ensuring consistent quality of data. It is also important to note that, non-spatial PSI is equally important.

E-government calls for different kinds of interactions regarding service delivery to include: (1) G2G – Government to Government, (2) G2B – Government to Business and (3) G2C – Government to Citizen. Data sharing strategies can in essence be developed to cater for these different kinds of interactions. The data sharing policy should stipulate different sharing methods between government, business and the citizens.

One of the major barriers to sharing spatial and non-spatial data are their presence in analogue format. So there is need to digitize and scan analogue data sets so that they can be accessible through a wide range of media.

There is definite need to develop a data sharing policy framework. (See figure 1 for proposed framework). In this framework, it can be stipulated which framework data sets and key PSI are available openly. If this data is openly available, that may motivate its use in decision making by government departments. Geographic information systems have not been widely adopted across local government and public sector and as such key personnel need to be sensitized on the importance of spatial analysis for decision making and trained as well.

Some data sets result from value addition and as such can be priced based on the ‘value added’. Data sharing arrangements in form of agreements and memorandums of understanding can be developed on an organisation to organisation basis to ease sharing of data, but they should be recognized by the data sharing policy framework.

6.3 Towards an E-government Implementation Framework

This study proposes e-government implementation according to the model presented in (Layne and Lee, 2001). The development of a fully functional e-government system requires time and commitment of resources. It is therefore logical to develop it sequentially and logically (see figure 2 for proposed framework) as stipulated in the maturational model proposed in (Layne and Lee, 2001). At each stage, there is need for both organization and community learning, as well as community engagement. The services provided need to have influenced the communities otherwise the public will not use them. Organizations have to go through some reforms including restructuring and change to incorporate the use of information and communication technology in their operations. There is need for staff development so that employees can use the new technology to ensure successful e-government implementation. The employees will also need to adapt to new workflows that will emerge as a result of the migration from an analogue to a digital environment. There is need to understand how society adapts to technology, otherwise governments can implement expensive infrastructures that do not affect society.

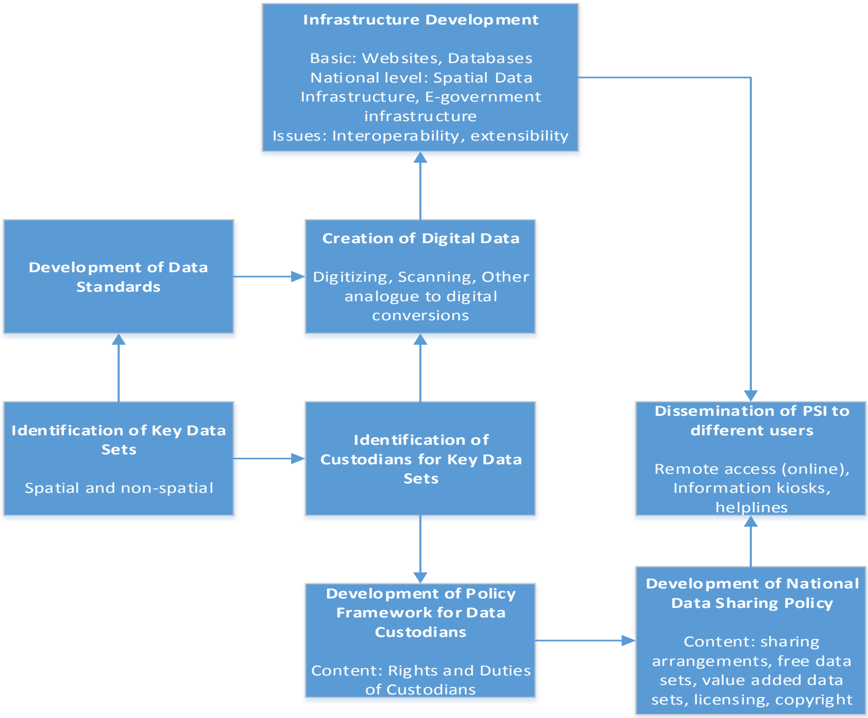

Figure 1: Public Sector Information Sharing Framework

Within the implementation framework, it should be realized that benefits do not accrue overnight but over time as well. Some benefits accrue faster while some take time. Some are tangible and easier to measure while some are intangible and more complex to measure. There is need for a monitoring and evaluation system to determine the success of the e-government system and its value or impact to the society that uses the technology.

Successful e-government implementation may require restructuring in the governance structure and some governance procedures. The ultimate aim other than the creation of one-stop shops is to improve governance, the quality of life of the public and eventually promote transparency, accountability and openness in government. At this stage, democratization will have been achieved not only regarding access to PSI but in the governance as well.

As individual systems from different organizations mature, they need to be integrated vertically and horizontally. This way the public can access services from multiple organizations from one portal. This requires key databases to be interlinked to make transactions possible from different service points and more secure as well.

There is need for several partnerships or collaborations with the service industry, which include banks and retail outlets so that there is ecommerce activity on government websites to support different forms of transactions.

7. Conclusions

While the benefits of e-government are clear and well laid out from a research point of view, the concept of PSI is not fully understood in the Zimbabwean context. In some cases, there is misconception that all government information should be classified. This is true for some information, but a considerable amount of public sector information is suitable for public consumption and could positively influence decision making by the business community as well. Even through the study revealed that, organizations prefer that the public should not be involved in government; public participation will in essence improve interaction and communication between government and citizens. Nations should be governed for the wellbeing of the citizens, and their involvement in the governance structure assists in voicing their needs. There is agreement that data sharing will be cost cutting and that data sharing policies at national level will facilitate this exchange of information. Use of information from different agencies should be encouraged for decision-making as it gives a more complete perspective of the problem at hand and possible solutions. Different agencies should also work jointly in projects. This in turn enables organizations to learn from each other regarding their operations and their overlaps and in turn identify ways to assist each other in e-government implementation. There is definite need to at least ensure, online presence for all municipalities and public sector organizations. The departments that are already online should take a leading role towards traversing to the transaction phase of e-government development. They should integrate operations with ecommerce to enable citizens to transact with government online. Partnerships between government, the private sector and specific service industries like the banking sector should be enforced to facilitate an improvement in the current e-government implementations. E-democracy and open government are benefits that can in principle be realised with maturity of e-government systems. The starting point is to make services and information closer to citizens while improving the interaction of government and the public. Zimbabwe currently does not have a spatial information infrastructure, which is one of the barriers impeding access to geographic information, despite the absence of a policy framework.

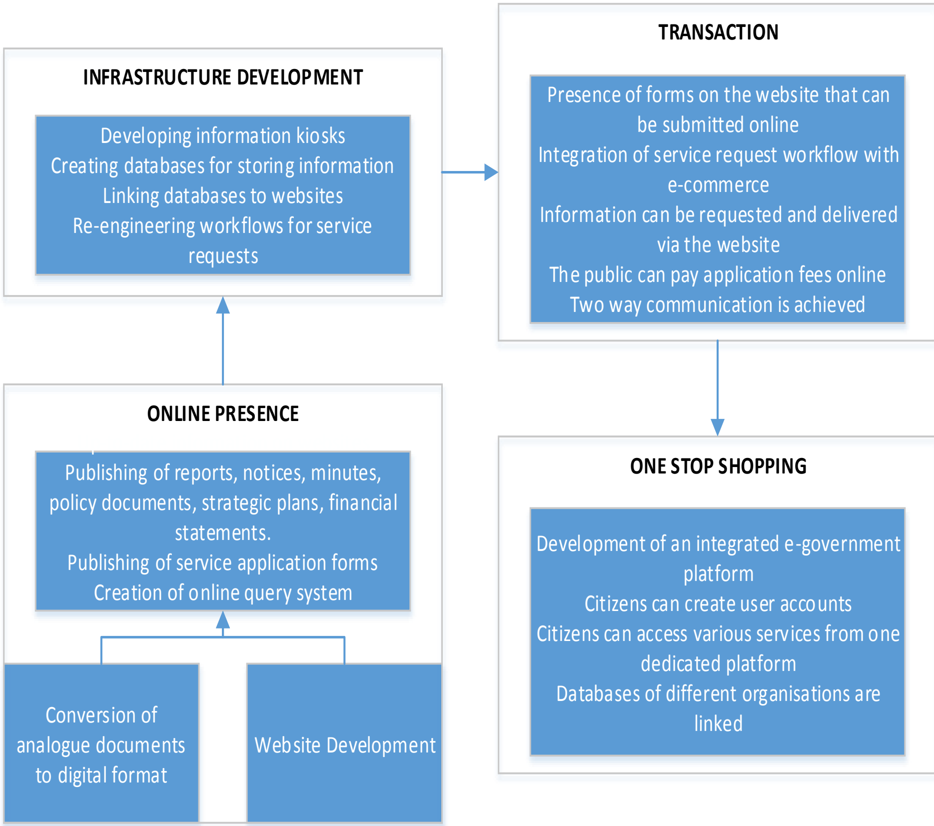

Figure 2: Proposed E-government Implementation Framework

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PART TWO

Spatial Enablement: Applications and Data Platforms

Chapter 9: The Impact of Spatial Enablement and Visualization on Business Enterprise Databases - What your data have been trying to tell you

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Abstract

Historically business enterprises have been gathering data as part of their "business as usual" operations. The evolution of the digital era has both enhanced this capability and increased the rate at which data is collected at unprecedented levels. The parallel evolution of spatially enabled data, data analytics and the visualization of data presents opportunities to analyze spatio-temporal databases to a degree never before available. This ability provides the opportunity to incorporate the results of this analysis into corporate planning processes, policy and strategy development and risk identification and mitigation. However, this new capability may also identify deficiencies in historically utilized databases which have led to poor decision making and setting of policy and strategy that has unknowingly limited business performance, misdirected capital investment and impacted resource utilization.

This chapter will address these issues by understanding the concept of "concurrency" in database visualization via a spatially enabled decision support tool developed by the Centre for Disaster Management and Public Safety (CDMPS), the University of Melbourne. A special case study is performed to

analyze historic incidents and explore response capacities across Victoria. A snapshot of emergency management data has been subjected to data cleaning, aggregation and harmonization processes to support our proposed analysis methodology. The output identifies key components such as demands and supplies. Each of these components can be investigated at various temporal granularity levels such as daily, monthly and yearly. Besides statistics, the developed tool can also interactively manipulate the results on a 4D visualization engine by using dynamic demand-supply heat maps and spider webs that precisely describe the concurrent characteristics. The developed system helps decision makers better understand when and where demands are triggered and how supplies are distributed in busy seasons and eventually identify research priority needs to enhance their workforce planning capability.

Keywords: spatio-temporal data analysis, disaster management and decision making, 4D visualization.

1. Introduction

Disaster and emergency management is a global practice the need for which is rapidly growing in order to deal with events caused by environmental and or human intervention. The quality of the outcomes from the management of individual or multiple emergencies with their potential to scale to major disasters relies on the quality of the decision making processes underlying the preparation for, response to and the recovery from these events. Traditionally these processes have relied on personal experience and training is supplemented with information from disparate databases that is often not readily accessible.

The emergence of today's and the future's digital and IP based environment will continue to significantly change this situation so that the quality of outcomes and their associated decision making processes can be transparently examined, evaluated and improved through the use of spatially enabled data, data analytics and visualization tools. Importantly the application of these tools to historic databases should be expected to expose deficiencies in the data and data collection processes which will need rectification, particularly where these databases inform policy decisions and strategy development associated with the allocation and use of high-value discreet resources. A big challenge here is how to reveal the characteristics of spatio-temporal enabled data in an interactive and intuitive fashion (CDMPS, 2014; Rajabifard et al., 2015). It requires sound knowledge of data, articulated analysis methods and elaborate visualization means.

This chapter provides information about the methodology used to produce a set of tools for spatio-temporal database analysis and visualization, especially to facilitate decision making process. The Centre for Disaster Management and Public Safety (CDMPS) in the University of Melbourne was engaged by Volunteer

Fire Brigades Victoria (VFBV) to develop a suite of such tools that could be applied to a sample from the Fire Incident Reporting System (FIRS) developed and used by the Country Fire Authority (CFA) in Australia to record data resulting from use of Fire Brigades in the management of major bushfires in the State of Victoria in Australia. The developed tools may be applied to the management of high-value discrete resources i.e. the lives of those involved in public safety activities that underpin community resilience to emergencies and disasters.

2. Methodology

We start a spatio-temporal analysis from tackling the temporal attributes. Usually, temporal values are treated as continuous variables; therefore, attributes directly attached to each time frame could be too sparse to form patterns. This indicates that a time window is required, within which non-temporal attributes can be aggregated (or accumulated) so that their characteristics are more identifiable. Here the concept of “concurrency” is introduced to formulate a universal analysis framework.

Given two timestamps ***t0*** and ***t1*** on the time axis **T**, where ***t0*** < ***t1***; then a time window is constructed and denoted as [***t0***, ***t1***]. An event has a start time and end time denoted as ***st*** and ***et*** respectively, where ***st*** < ***et***; then event lifespan **LS** can be denoted as [***st***, ***et***] Figure 1 illustrates all six possible relationships between **LS** and **TW**, only four of them (green lines) can be considered as concurrent (or “on-going”) events within **TW**, they satisfy either of following criteria:

(1) ***st*** < ***t0*** and ***et*** > ***t1***

(2) ***st*** < ***t0*** and ***et*** < ***t1***

(3) ***st*** > ***t0*** and ***et*** < ***t1***

(4) ***st*** > ***t0*** and ***et*** > ***t1***

The criteria can be further simplified as:

(5) ***st*** < ***t0*** and ***et*** > ***t0***

(6) ***st*** > ***t0*** and ***st*** < ***t1***

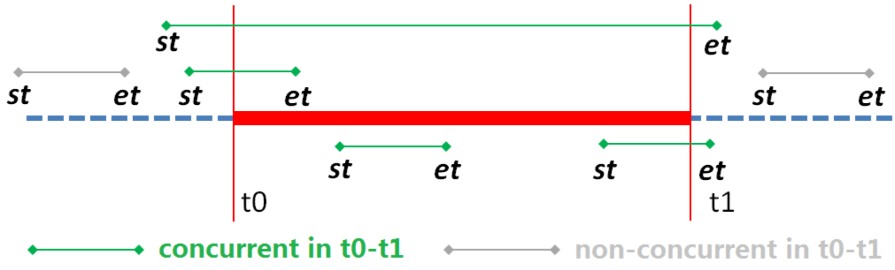

Figure 2 Time window and concurrent events. Four green lines can be considered as concurrent events within time window [*t0*, *t1*]

Thus, given a time window [***t0***, ***t1***], all concurrent events within that period can be selected out by adopting either criterion (5) or (6). For a long LS incident, it contributes the count to each TW it crosses. For example, the top green line in Figure 1 represents an incident that starts before ***t0*** and ends after ***t1***. This incident's LS covers two additional TWs before and after [***t0***, ***t1***], therefore, it will be counted as a concurrent incident for each of three TWs. This process is a discretization of continuous variables and can accurately measure the number of concurrent incidents in a given time window. The width of time window controls the granularity of discretization, which also affects further spatio-temporal pattern analysis.

There is no ubiquitous rule for picking granularity values. The decision highly relates to the temporal features of data as well as the goal of analysis. Setting an "impropriate" granularity might hinder the pattern identification process or impact the performance of analysis. In this work, to help VFBV identify temporal patterns for incident occurrence and resources allocation, three granularity levels (i.e., day, month and year) were selected to describe time windows. The raw FIRS data were also aggregated at these three levels respectively to speed up answering questions such as "which day is the busiest day in 2015" or "how the amount of distributed resources fluctuates in every January during the past 10 years".

As for spatial analysis, besides classic methods such as clustering (Diggle, 2013, Sturup et al., 2015), autocorrelation (Griffith, 2013), regression (Fortin et al., 2012) etc., this part can be enhanced by using advanced 4D spatial visualization techs (CDMPS, 2014), which are regarded as a highly effective and intuitive way to recognize and understand spatial patterns. Again, there is no best visualization means for all cases, the selection of various visualization means is subjected to different purposes. Each visualization means has its own merits as well as disadvantages; therefore, when interpreting the outputs, we should be aware of their limits and pitfalls.

In following sections, we will take a real world database as an example, and demonstrate how to identify and interpret the spatio-temporal patterns by adopting proposed methodology.

3. Sample Database- Fire Incident Report System

Victoria is a state in the south-east of Australia and it is one of the most bushfire prone areas in the world (Jones, 2011). Since the 1850's community volunteers have come together to establish volunteer fire brigades and this led to the establishment of the Country Fire Brigades in January 1891 which was monitored by the Country Fire Brigades Board. Over the next fifty years, Victoria suffered a number of devastating bushfires including the 1926 Gippsland fire (60 fatalities), 1939 'Black Friday' bushfire in Narbethong (71 fatalities) and 1943/44 state-wide fires (51 fatalities and 700 injured) (Jones, 2011). The Stretton Royal Commission was established to conduct inquiries into the management of bushfires and this led to the establishment of the Country Fire Authority (CFA) on 2 April 1945 (Jones, 2011). Since this time the CFA has grown to become one of the largest volunteer and community-based emergency service organizations in the world. The CFA manages over $240 million worth of assets and has an annual income of over $500 million (CFA, 2014).

One of the most valuable assets of CFA Victoria is the historical incident reports recorded in FIRS (Fire Incident Report System). Back to 1990, CFA Victoria had used FIRS to manage incident related information. It is a giant database and has accumulated over 1 million records of incident and brigade logs over decades. For incidents (i.e., demands), FIRS contains key information such as when and where they occur and how long they lasts; for brigade (i.e., supplies), FIRS records where they are, how many resources (e.g., trucks and personnel) are taken to incidents as well as how long the support last. FIRS is a classic spatio-temporal database and well suits for our proposed concurrency analysis methodology.

3.1 Data Structure

Five critical data tables from FIRS are investigated in this chapter for concurrency analysis. The entity relation diagram is shown in Figure 2 with only key attributes listed. FIRS has evolved over years and its database schema was also adjusted for several times to support system compatibilities. Though its structure becomes obscure to understand, it won't impede the data analysis process.

3.1.1 Table firs_primary_report_header

This table contains key information for an incident as well as its primary brigade, such as incident start time (*incident_datetime*), end time (*stop_datetime*), location (*geom*), its primary brigade id (*brigade_no*) and when its primary brigade is notified (*brigade_advised_datetime*).

3.1.2 Table firs_support_report_header

This table contains information for all support brigades of incidents, such as support brigade id (*brigade_no*), when a support brigade is notified (*brigade_advised_datetime*).It links to the incident table using foreign key (*primary_report_id*).

3.1.3 Table firs_brigade

This table contains information of brigades, such as name (*brigade_name*) and location (*geom*).

3.1.4 Table firs_report_resource

This table contains trucks dispatch logs for both primary and support brigades. It uses *report_type_flag* attribute ('P' for primary and 'S' for support) to differentiate which report header table its *report_id* should reference to. It also contains the timestamp for when a truck is sent out (*mobile_datetime*) and when it returns (*in_station_datetime*).

3.1.5 Table firs_report_personnel

This table contains people dispatch logs for both primary and support brigades. Similar to table *firs_report_resource*, it also uses *report_type_flag* attribute ('P' for primary and 'S' for support) to differentiate which report header table its *report_id* should reference to. However, it does not contain timestamps for when a person is sent out and when he returns.

3.2 Data Preparation

For this research, CFA provided us with a database backup file containing the five selected data tables. It comprises all incident and response logs recorded between July 1999 and April 2016. Current FIRS utilizes MSSQLServer as its database which lacks spatial data structure, storage and analysis support and is not useful for our work. PostgreSQL is an open-sourced, object-relational database system and with its PostGIS plugin, it supports for geographic objects (e.g., point, line, polygon primitives) and can be used as a spatial database for geographic information systems (GIS). We set up a PostgreSQL server on the NecTAR Research Cloud and used the following steps to port data from MSSQLServer to PostgreSQL:

1. Restore backup file to an instance of MSSQLServer
2. Create functions to dump data into PostgreSQL INSERT script files
3. Create data table schemas in PostgreSQL
4. Execute INSERT script files
5. Create point geometries based on values
6. Create (spatial) index for each table

From 1999 to 2016, FIRS has collected 688,910 incident reports attached with over 1.73 million trucks and 8.28 million personnel allocation logs respectively. With the assistance from the FIRS database admin from CFA, attributes *incident_datetime* and *stop_datetime* in data table ***firs_primary_report_header*** are selected to identify incident start time (st) and end time (et). However, a further data check shows that about 8% incident records have invalid *stop_datetime* value, either it is an empty value or it contains a time before *incident_datetime*. The data quality problem is most likely caused when manually logging information into FIRS. Though the proportion of issued records is relatively low, it does affect the understanding and judgment of surge analysis outputs, particularly when the results are visualized on map. To overcome this, we used the *last_truck_return_time* (ltrt) of an incident to correct its end time if its original value is problematic. After the correction process, 99.3% incident records have valid st and et values and are ready for surge analysis.

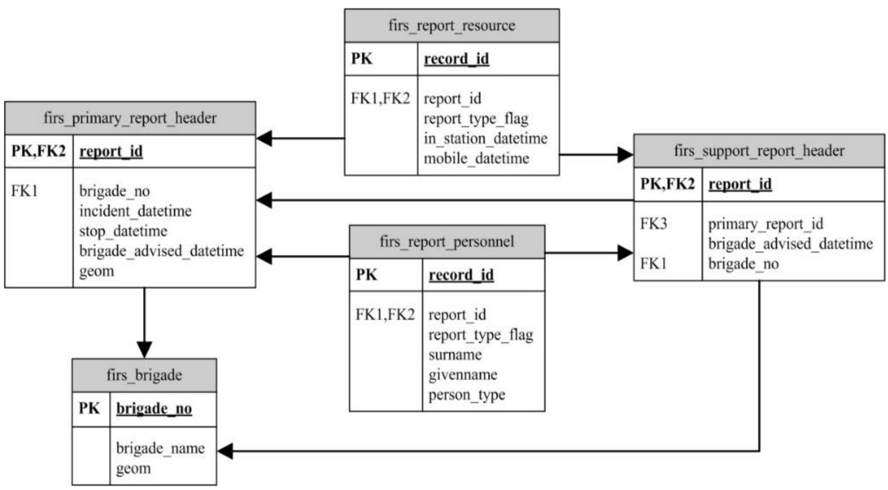

Figure 3 Entity relation diagram for FIRS key tables. Only key attributes for each table are listed

Similarly, for the truck operation logs, we selected *mobile_datetime* (st) and *in_station_datetime* (et) from data table ***firs_report_resource*** to measure the period a truck committed to supporting an incident. However, FIRS does not specifically record the time involvement for personnel. It cannot identify when a CFA employee (or volunteer) is devoted to an incident and when he retreats from it. To measure the personnel allocation over time, we assume that all FIRS recorded personnel from a brigade are allocated to an incident from *brigade_advised_datetime* (st) of brigade till *stop_datetime* (et) of the incident. This might overestimate the actual number of involved personnel at a given time period at brigade level, but certainly, gives a right indication of how personnel resources are allocated during the entire incident lifespan.

3.3 Data Aggregation

The main purpose of data aggregation in this work is to avoid complex database queries that will be repetitively executed in the application runtime. Aggregation data will also boost the performance of surge analysis.

By using the concurrency concept described in the previous section, nine aggregation data tables are created by crossing three aspects (i.e., incident, truck and personnel) in surge analysis with three granularity levels (i.e., year, month and day), as Table 1 shows.

Table 1 Nine FIRS aggregation tables. 18, 204 and 6210 records will be created in each table if it is aggregated by year, month and day respectively

	Year (18)	Month (204)	Day (6210)
Incident	aggr_incident_y	aggr_incident_m	aggr_incident_d
Truck	aggr_truck_y	aggr_truck_m	aggr_truck_d
Personnel	aggr_personnel_y	aggr_personnel_m	aggr_personnel_d

All aggregated tables share similar data structure with three key columns *st*, *et* and *total_num*. Surge peak analysis in section 4.1 will directly come from these tables.

3.4 Data Visualization

Besides charts and statistics, it is imperative but more challenging to reveal the spatio-temporal patterns on the map to decision makers in an interactive and intuitive fashion. In this work, we introduce dynamic heatmaps, demand-supply lines and a set of queryable map markers to visualize surge interactively on a 4D map.

3.4.1 Incident (Demand) Heatmap

Incident heatmaps are ideal to illustrate spatial distribution patterns of incidents' concurrency intensity. It becomes a particularly useful when a set of time serial heatmap frames are stitched together so that the continuous change patterns can be observed. To build a single frame of the incident heatmap, the algorithm takes incident location and intensity aggregated at a given time period as inputs. The location of the incident is described by its longitude-latitude coordinate, which will affect the heat cores' location. The intensity value of incident can be designated either as the total number of trucks or as the total number of personnel (default option). This parameter affects the coverage radius of heat cores.

3.4.2 Resource (Supply) Heatmap

Similar to incident heatmaps, resource heatmaps depict the spatial distribution patterns of concurrent allocation of resources. Unlike incident heatmaps which are created by using incident parameters, resource heatmaps are built upon brigade parameters including its location and the amount of its committed resources (the total number of trucks or personnel).

3.4.3 Demand-Supply Line

Heatmap offers an overview of the changing patterns of demand-supply spatial distribution over time; however it fails to reveal the relationships and details of demand-supply at a finer level. For example, by using heatmap only, we cannot tell where exactly the resource supplies of a single incident come from, nor can we tell which incidents a brigade is supporting simultaneously. Therefore, we introduce demand-supply lines to illustrate this missing nexus.

As its name indicates, a demand-supply line connects an incident to all brigades that send resources to it. From a brigade's standpoint of view, this line also shows all incidents that it is committed to at the same time. The demand-supply lines form a spider-web-like structure and reveal complex linkage patterns between incidents and brigades. In this work, we use the line width to illustrate the strength of the connection, which can be presented as the total number of trucks or personnel.

3.4.4 Queryable Map Markers

To make visualization self-explained, we introduce a series queryable map markers, they are summarized in Table 2. If a brigade responds to multiple incidents simultaneously, multiple brigade markers will be created around the real location of the brigade so that demand-supply lines can be connected individually.

4. Investigation on Black Saturday Bushfires 2009, Victoria

The Black Saturday Bushfires were a series of bushfire started around the 7th of February 2009 in Victoria, Australia. It is the worst bushfire catastrophe in Australia history and killed 173 people, injured 414 people, destroyed 2,100 homes and displaced 7,562 people (BSB, 2014; Victoria Police, 2009). It is estimated the energy released by the Black Saturday Bushfires, was the equivalent of 1,500 Hiroshima atomic bombs and 1.1 million acres were burnt in total (Cameron et al, 2009; BSB, 2014).

Black Saturday provides a good example for investigating surge behavior. In the following section, we articulate the analysis outputs during the period from 4th to 28th of February 2009.

4.1 Surge Peak Analysis

Figure 3 shows a single peak of concurrent incidents on the 7th of February 2009. On that day, FIRS recorded 407 incidents happened in parallel. The number plunged over the next three days till 10th of February and then fluctuated at 150. For CFA Victoria, the average daily concurrent incident number in busy season (from January to March) is 129 and for the rest of year, the number is 101. Given this, the critical fire situation in February 2009 was clearly a huge challenge to CFA Victoria.

In Figure 4, the concurrent trucks usage is turned on (green line), which tells the same story. The number increased sharply on 7th February to 2035, which is four times of 504 recorded on 6th February. The concurrent truck usage well correlates with the number of concurrent incidents. For CFA Victoria, the average daily concurrent number of the truck on road in busy season (from January to March) is 367 and for the rest of year, the number is 250. It demonstrates that the CFA were under great pressure of resource allocations during the Black Saturday period.

Table 1 Map marker icons and descriptions.

Markers	Description
	Incident marker
	Primary brigade (pink) and support brigade (blue)
	Brigades that only send personnel (P) to an incident
	Brigades that only send truck (T) to an incident
	Brigades that respond but not (N) send any resources to an incident

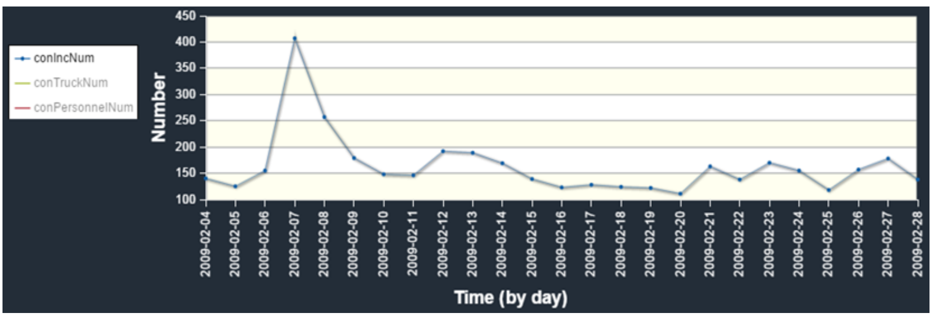

Figure 4 Concurrent incident (blue line) analysis on Black Saturday Bushfires, from 4th to 28th February 2009

In Figure 5, the concurrent number of personnel (red line) allocated is also appended. Although the numbers are distorted due to our assumption, from the people resources perspective again, CFA was also stressed in February 2009.

For CFA Victoria, the average daily concurrent number of people allocated in busy season (from January to March) is 4262 and for the rest of year, the number drops to 2051. The red line remains four times above the average number of busy season for two weeks and then follows by two more peaks appeared on 23rd and 27th of February. This indicates how exhausted CFA staffs were in that critical period.

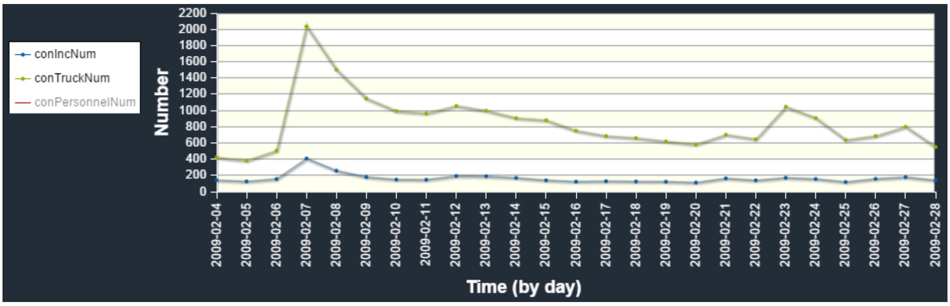

Figure 5 Concurrent incident (blue line) and truck (green line) analysis on Black Saturday Bushfires, from 4th to 28th February 2009

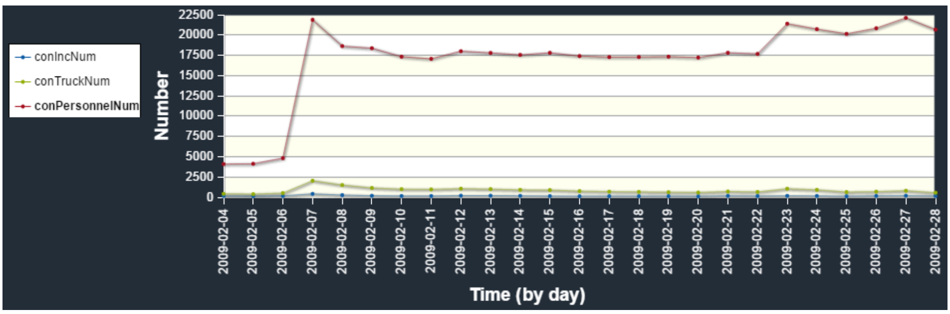

Figure 6 Concurrent incident (blue line), truck (green line) and personnel (red line) analysis on Black Saturday Bushfires, from 4th to 28th February 2009

4.2 Surge Visualization

We ran a surge simulation for Black Saturday Bushfires from 4th to 28th February 2009. A series heatmaps were generated to illustrate the spatial distribution patterns of demand and supply over time. Our developed system can fluently and interactively visualize the continuous change patterns and offer an intuitive understanding of the surge behaviors. In this chapter, the outputs of four days (4th, 7th, 15th and 23rd) were selected and put together to demonstrate the capability of surge analysis.

Figure 6 shows the incident heatmap over four days. On 4th February, main incidents (red areas on the map) concentrated in the mid of Victoria, but on 7th, the situation deteriorated in the mid and started sprouting to the east region. Isolated but critical incidents were reported in the north-west part as well. One week later on 15th February, the situation cleaned up particularly in the mid and east regions; but on 23rd February, the situations in west and east regions became worse again.

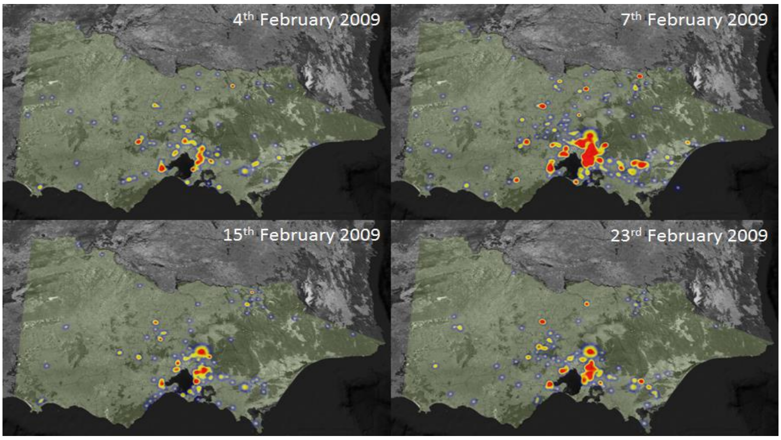

Figure 7 Incident heatmaps on 4th, 7th, 15th and 23rd February 2009. Red areas represent the location of major incidents and blue areas indicate the location of minor incidents

Figure 7 shows the surge from the resource (i.e. personnel) supply perspective. CFA Victoria has 1724 brigades distributed across the entire state. On 4th February, the significant resources (white areas on the map) were mainly allocated to the mid and east regions; we can see there are widely scattered, insignificant supply dots in the west and north part of Victoria as well. But the situation changed dramatically on 7th February. The mid, north-east, south-east and south-west were all under the pressure of significant supply. The situation remained intense and did not notably mitigate in next two weeks. This visualization heatmap is well aligned with the surge peak analysis outputs shown in Figure 5, and it reveals how widely the brigades in Victoria were affected during the disaster.

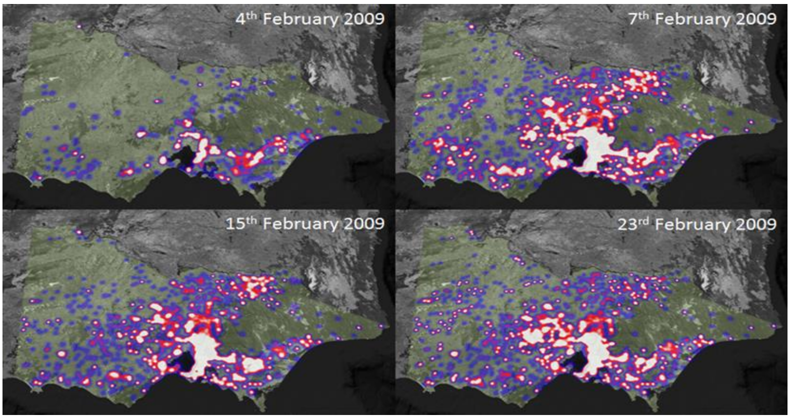

Figure 8 Resource (personnel) heatmaps on 4th, 7th, 15th and 23rd February 2009. White areas represent where significant supplies locate and blue areas indicate where insignificant supplies locate

Figure 8 overlaps the demand and supply heatmaps on one picture. It seems that both heatmaps well fit with each other geographically, especially in the mid region. It might give a wrong impression that supplies for incident mainly come from local brigades. Actually, that is far from the truth in Black Saturday.

The demand-supply lines (yellow lines on the map) are drawn in Figure 9, which demonstrates the linkage between incidents (red marker) and brigades (blue/pink flags). On 4th February, resources located in the far west and north region were dispatched to support incidents in the mid and east regions. The long yellow lines indicate that the supplies came from distant brigades rather than local ones. In the following days, more brigades got involved in the north and west part to support both local and remote incidents.

Figure 10 gives a detailed view of the demand-supply lines. On the map, a significant incident drew resources from 605 brigades across Victoria; the width of yellow lines stands for the number of people dispatched from each brigade. Quantitative incident information such as start-end time, number of involved brigades, personnel, trucks, average travel distance, etc. is accessible by clicking the incident marker on map. Comprehensive brigade response data including number of dispatched personnel, trucks, attendance time, support duration etc. is presented in a similar way.

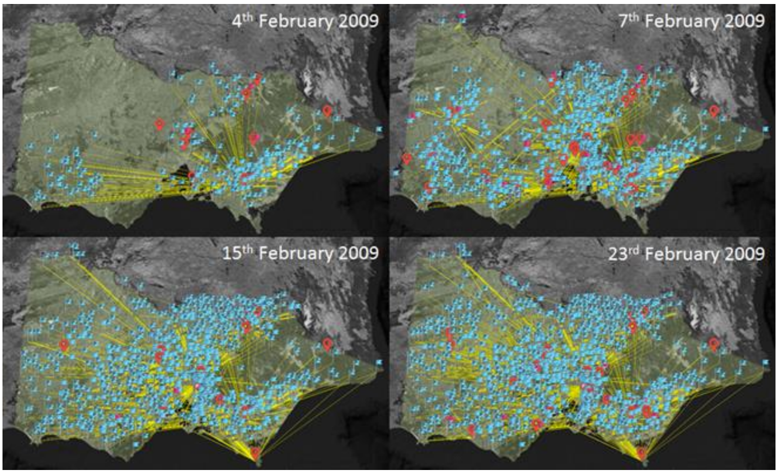

Figure 9 Demand-supply lines (yellow) on 4th, 7th, 15th and 23rd February 2009. Table 2 shows the marker legend information

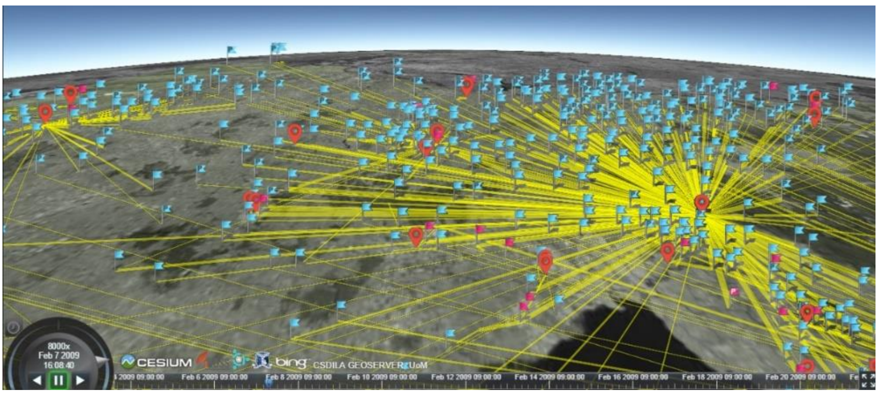

Figure 10 A detailed views of demand-supply lines (yellow) on 7th February 2009. Table 2 shows the marker legend information

5. Conclusion

This chapter proposed a new methodology for exploring the concurrency characteristics hidden in spatio-temporal databases. Taking the Fire Incident Report System (provided by CFA Victoria) as an example, we started from scratch and went through each step of data preparation and data aggregation. Then we successfully developed a 4D online system and performed surge analysis for the Black Saturday Bushfires in 2009. The analysis results and visualizations intuitively reveal the details about how the incidents and resources were managed during the fatal calamity in Australia. It also strongly demonstrates the capabilities, effectiveness and potentials of our developed system as a spatially enabled decision support tool for stakeholders.

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Chapter 10: Smart Disaster Communities: Building a Global Disaster Management Platform

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Abstract

As the disaster management community grows, so too does the need for a smart disaster community where all researchers in the field can coordinate, collaborate, and interact to develop and deliver the best outcomes for wider society. In the area of disaster management research there are many organizations, groups, centres and individual researchers working towards the common goal of improved disaster management practices through disaster risk reduction, minimizing and mitigating against the impacts of disasters, better responding to disasters, and developing resilient communities. In order to ensure that these groups are not working in isolation, a networked approach is needed to facilitate sharing, collaboration, engagement, integration, and to minimize duplication and isolation of research. A Global Disaster Management Platform is one possible solution to address this growing need – a platform that can bring together and connect disaster management specialists, disaster management groups, and international organizations dedicated to this field, and enable them to share and collaborate on disaster management issues. The Centre for Disaster Management and Public Safety at the University of Melbourne proposes to develop such a platform, which aims to increase awareness of the advances, developments and initiatives underway in the area of disaster management while connecting disaster management research at the global level.

The Global Disaster Management Platform (GDMP) is based around a vision for this rapidly growing field: more sharing, increased collaboration, and enhanced awareness of the current research taking place. A platform such as the GDMP has the goal to facilitate the expansion of international collaboration and engagement resulting in long-term research and training activities, and to provide a forum for researchers to share and become aware of different disaster related research taking place. Under the GDMP researchers from all countries and all organizations will have a platform to list information about their research and view and learn of other research taking place worldwide. So far, in the development of the GDMP, the focus has been on facilitating collaboration with Asia, Latin America, and wider societies for the development of disaster management research and engagement. As part of these developments, two international events – one in September 2014, and a second in October 2015, have been held to help formulate the GDMP.

The events enabled the showcasing of research and breakthroughs in the field of disaster management and the opportunity to foster engagement and support collaboration between local and international industry, government and academia. These events attracted participation from over 15 countries, and at a small scale demonstrated the value of international collaboration and engagement in the area of disaster management research. This chapter will detail the establishment of a Smart Disaster Community enabled through the conceptualization and development of a Global Disaster Management Platform.

Keywords: disaster management, smart disaster communities, technical platform

1. Introduction

Effective collaboration, coordination and communication are key elements to success for almost any undertaking. In the context of disaster management, it is no different. In disaster management, disaster risk reduction efforts, disaster mitigation, disaster response and disaster recovery endeavours are all drastically improved when the workload is shared and teamwork takes place (UNISDR 2015). In order to efficiently manage this sharing, robust systems to enable collaboration, coordination and communication is needed. This linkage should facilitate not only information sharing and partnerships, but also engagement and integration.

As events of varying scales continue to take place around the world continued work towards developing a supportive global network for disaster management is needed. The overarching goal of the GDMP initiative is to facilitate the expansion of international collaboration and engagement resulting in information sharing and interoperability, long-term research and training activities, collaborative disaster management activities, and networked researchers and contributors to strengthen the disaster management community. It is envisioned that a platform such as the GDMP would bring together new and existing systems and connect disaster management specialists, disaster management groups, and international organizations dedicated to this field, and enable them to share and collaborate on disaster management issues, fulfilling the vision of creating a smart disaster community.

Work and extensive efforts towards achieving these goals has taken place, however there is still more to be done to further strengthen and provide support to the disaster management community. This chapter first investigates the idea of sharing and collaboration in the field of disaster management, and following that then examines the different stakeholders present. The requirements of a GDMP as suggested by the literature are then explored. The results of a case study into existing disaster management systems and platforms across the Asia-Pacific are then presented and discussed to identify gaps and requirements for a successful global approach to collaborative disaster management. A framework based around the GDMP concept is then developed and discussed before conclusions are drawn.

2. Methods and approach

In order to develop a framework a number of steps were taken. First, a case study of the Asia-Pacific context was undertaken. This involved investigation into current initiatives currently active that complement the smart disaster community vision. This enabled a better understanding of the types of resources being developed and those currently being used in the disaster management environment and the applications of these resources that could potentially contribute to a global disaster management platform. Secondly, two international workshops involving representatives from over 15 countries were held to identify the needs and requirements of potential users of a global disaster management system (Nielsen 1997).

Based on this information the framework was developed featuring four key component to address each of the needs resulting from the case study and workshops – an interactive platform to perform real-time data collection, management, analysis, distribution, and visualisation of information for enhanced situational awareness and scenario planning for governments and decision-makers; a tool to support bottom-up user-based disaster and risk management of land and property; a tool to support networking between government, non-government, civil sector, and private sector organizations and in particular academics and researchers working in the disaster management field; and a portal that brings together education and training resources relevant to disaster management. Each element complements an identified factor from the studies conducted. These initial components were built upon to develop the GDMP framework. The development of the framework and details of identified GDMP elements are discussed in this chapter.

3. Background

There is varied opinions and thoughts of what a global disaster management platform is, what it should looks like, what function it fulfils, and what information and resources it includes. The vision that this chapter explores includes one that focuses on sharing and collaboration and the key stakeholders involved in disaster management. To this end, these two topics will be explored first, followed by a review of different suggestions that have so far been put forward as requirements for an effective networked disaster management system.

3.1 Sharing and collaboration

There have been many disaster incidents in recent years where sharing and collaboration have been raised as issues of importance that impacted on the management of a disaster event. The benefits of sharing and collaboration are well documented (Janssen et al. 2010; Bharosa et al. 2010; Horan and Schooley 2007; Waugh Jr. and Streib 2006; Comfort et al 2004). (Yi and Yang 2014) suggest that it prevents duplication of efforts, enhances teamwork among researchers, and also improves the process of decision making, while (Dues Jr. 2007) argues that this approach reduces the number of unaware citizens, and in turn has ongoing positive impacts such as less waste in time, investment and resources due to overlapping efforts. In many cases, a lack of sharing and collaboration in disaster situations has hindered response and overall management (Palttala et al 2012; Junglas and Ives 2007; Pan et al 2005; Helsloot 2005; Dawes et al. 2004). The difficulty in sharing has been suggested to be related to the unpredictable, dynamic and complex nature of collaborative group environments (Kapucu 2006; Auf der Heide 1989).

Recent developments in technology can ease this challenge though, and promote a sharing and collaborative approach (Yates and Paquette 2011). What is now needed is a way to integrate the different sharing and collaborative initiatives that are in place to expand the possibilities and develop a robust global sharing and collaboration network. Smart disaster communities can only grow and succeed when resources and tools are available to educate, support and empower the community.

The next step in enabling smart disaster communities is to develop a way to provide information through a unified platform to assist members of these communities to access and quickly understand the situation in times of disaster

(Digitimes 2014). To effectively achieve this, an understanding of the community and the stakeholders involved is first needed.

3.2 Key stakeholders in disaster management

The literature has identified five key stakeholder groups in the field of disaster management, namely, government organizations, non-government organizations; private sector organizations; research institutions; and citizens. Disaster events today are increasingly complex and require the simultaneous involvement of many stakeholders, which required transnational cooperation between these different groups (Palttala et al 2012).

Of all the stakeholders, in disaster management, governments are often seen as having the highest responsibility, and have the quintessential role to protect citizens from harm (Comfort 2005). This widely accepted role has led to the adoption and implementation of public policies and actions by governments all over the world to mitigate against and treat risks, prepare citizens to manage risk, and assist them in recovering from disaster events (May and Williams 1986; May 1985). As the overarching managers of disaster events, governments across all jurisdictions from national to local all have a specific role to fulfil in the event of a disaster. The resources of government enable the best information to be often made available, however, as with all organizations, internal communication problems can exist which impact on the overall effectiveness of the disaster preparations and response (Palttala et al 2012).

The stakeholders of non-government organizations such as United Nations agencies, the private sector, and research institutions all have a lesser but equally important role to play in disaster management. Much of the research and development emerges from these groups, and for these reasons, interaction, networking and collaboration is vital to ensure that the needs of society are being met (Waugh Jr. and Streib 2006).

Citizens are the key stakeholders and deal with the direct impact of disaster events (Pandey and Okazaki 2005). Arguably the consequences of disaster events impact the community the greatest, however, as shown, in most situations the government holds the key responsibility. Therefore, it is critical that citizens are considered and included in all aspects of, and decisions made, regarding disaster management. In order for disaster management activities to be sustainable and have an impact, the community needs to participate and interact in disaster management activities (Pandey and Okazaki 2005; Victoria 2002). Empowering them through access to information and networks enables them to take ownership in disaster management activities and start to foster a smart disaster community.

3.3 Requirements for a networked disaster management system

The literature has identified a number of requirements for an effective networked disaster management system. A study conducted by Rego (2001) detailed a number of elements highlighting communication facilities as a key component, which act as the cornerstone of preparedness planning and mitigation implementation. Currion et al (2007) suggest that adoption of FOSS (free and open source software) as critical to success at a global level to support interoperability across countries and platforms. Rajabifard and Potts (2014) agree with this notion, stating that such a system needs to be interoperable and have open standards in order to be effective.

The literature on smart disaster communities adds further requirements for an effective networked disaster management system including the need for natural disaster alerts, remote environment monitoring, real-time transmission of information, damage analysis and evaluation, decision support, and integration of geographic information with cloud applications (Digitimes 2014).

In relation to stakeholder networking Rajabifard et al (2014) suggests that there are five key functions for a disaster management platform for stakeholder networking, namely, disaster research project registration and management; spatial visualization of disaster research projects; search engine; user profile management; and online discussion forum.

Less attention has been given to systems that aim to connect and support all types of stakeholders in sharing and collaboration. The strength of a networked approach cannot be overlooked however. Further research into systems which can support stakeholders in a range of disaster management applications is required to strengthen this area of application.

4. Results and Discussion – The global Disaster Management Platform Framework

This section details the result of the case study conducted in the Asia-Pacific context which was used to inform the development of the GDMP.

4.1 Case study on Asia-Pacific

The framework that describes the global disaster management platform was developed from preliminary research carried out in the Asia-Pacific context. The case study involved a study into the arrangements of existing disaster management systems and platforms and the features and applications of each system. The results of this case study found that there are a number of resources already in existence addressing many different aspects and stakeholder groups within the disaster management field. It also revealed that many countries do not have public-open systems for disaster management, and many are managed internally in government. For that reason, only a number of countries with publicly accessible systems are listed below. Of the most comprehensive and publicly available resources were the United Nations coordinated systems that were global in their scope and diverse in the resources they offered. The results are summarized in table 1.

The results in table 1 show that across the Asia-Pacific a number of disaster management initiatives is underway, offering various services and support to a multitude of stakeholders. Of the range services provided by the systems and centres, four major themes emerged. The first was an interactive geospatial portal. Some of the systems featured interactive maps and the ability to view data. Some systems offered data that could be downloaded, but there was no display mechanism for this data. The most effective systems offered a viewing platform as well as the data. Making data available enables improved disaster management practices, however systems that support user viewing of the data and especially those that support analysis or manipulation of the data in some way are the most effective. The second theme was supporting citizen users. While much of the information seemed for government, non-government, private or academic use, there was information present specific to citizen use, although this information was limited.

The most commonly available was news and updates, however one system provided maps with the intention that citizens could identify for themselves threats to their location and implement disaster management practices based on that information. The importance of citizens in disaster management cannot be overlooked, and the gap identified in this small case study shows a need to focus on citizen users to better support them in their disaster management practices. The third theme relates to stakeholder networking. This was a common feature in many systems to encourage collaboration and coordination between different stakeholders. The approach differed across the systems, however the aim was consistent with the common goal to support and facilitate engagement and foster sharing for the greater benefit of all users and stakeholders. The final theme is around capacity building and education. Many systems aimed to support education around understanding disasters and learning skills to improve disaster management practices.

Table 1: Summarized results of case study into Asia-Pacific DM platforms

System name	**Country**	**Aim and Features**	**Hazard focus**
Australia Emergency Management Knowledge Hub	Australia	To provide information on past disaster events for educational purposes. Features archived data on past hazard events in Australia displayed on an interactive map interface.	All hazards
Australia Institute for Disaster Resilience	Australia	To bring together disaster resources in Australia Lists organizations in Australia involved in disaster management, links to the Australia Emergency Management Knowledge Hub.	All hazards
Indonesia Disaster Management Information System (SIPBI)	Indonesia	To provide enhanced decision-making capabilities; provide reliable data distribution during disaster events; accelerate the availability of information. A portal system that features a GIS/mapping component.	All hazards
National Natural Disaster Knowledge Network	India	To expand international relations and promote sharing of information and technology; to be a 'network of networks'. It is a platform to facilitate an interactive dialogue with all government departments, research institutions, universities, community based organizations and individuals. Features a digital library and access to other disaster management resources for registered users, as well as e-training.	All hazards

Vulnerability Atlas of India	India	To make disaster management information readily available to the planners, administrators and disaster managers; to help people identify hazards relevant to their particular location. The Vulnerability Atlas contains the following information for each State and Union Territory of India: seismic hazard map, cyclone and wind hazard map, flood prone area map, housing stock vulnerability table for each district, indicating for each house type, the level of risk to which it could be subjected sometime in the future.	Earthquakes, Cyclones, Floods
National Disaster Risk Reduction and Management Council Forum	Philippines	To support the protection and welfare of the people during disasters or emergencies. It is a first port of call for many people wanting to get updates regarding disaster events. The system is a website that posts news and updates from and relevant to various government, non-government, civil sector, and private sector organizations.	All hazards
Central Committee for Storm and Flood Control	Vietnam	To encourage information sharing on disaster events between sectors, and to the community. The system is a disaster communications system, operational 24/7 – the official system for transmitting disaster damage and needs to government offices, and staff in the field. Features an intranet system with general disaster management information, including: event summaries, official damage assessment reports, archived damage reports, disaster management reference materials, programs and projects taking place. Also has a GIS with decision support capabilities.	Storms and Flood

Asian Disaster Preparedness Centre	Asia	To improve disaster risk management capacity. The Centre works closely with local, national and regional governments, governmental and non-governmental organizations, donors and development partners.	All hazards
Asian Disaster Reduction Centre	Asia	To provide information on how to build disaster resilient communities and to establish networks among countries through many programs including personnel exchanges in this field. The Centre undertakes projects focused on specific problems.	All hazards
UN-SPIDER Knowledge Portal	Global	To provide universal access to all types of space-based information and services relevant to disaster management by being a gateway to space information for disaster management support. The system provides details on different groups and organizations in the disaster management and space communities, provides details on training and events to facilitate capacity-building and institutional strengthening, assists global and regional networking of organizations and institutions, and provides access to data.	All hazards
Prevention Web UNISDR	Global	To provide resources for disaster risk reduction. The system features information on a range of hazards and disaster events and resources in training, networking, news, available maps and data, and publications.	All hazards
Global Disaster Alert and Coordination System	Global	To improve alerts, information exchange and coordination in the first phase after major sudden-onset disasters	All hazards

In addition to the case study conducted on disaster management systems in Asia-Pacific, a number of international workshops were held to provide additional input into the development of the framework. These workshops were conducted across the span of two years and involved representation from countries from all across the globe.

The first workshop was held in September 2014 in Melbourne, Australia in conjunction with a symposium event that aimed to consider partnerships among academia, industry and government and how these ties can be leveraged to effectively respond to the challenges of sustainability and resilience at the local, national and global level. The workshop was held at the conclusion of the symposium event. Key topics discussed in the workshop included global collaboration, governance, communications, policy and open standards within the context of disaster management.

The second workshop was held in October 2015 as a part of the 2nd International Symposium on Disaster Management was held in Melbourne, Australia which attracted more than 130 delegates from 15 countries. The theme for the symposium event was ‘working together for a safer world’, and the 3-day symposium event began with a day of workshops focusing on disaster management trends and issues, followed by the main symposium event which included 63 presentations on 13 key topics. The GDMP focused workshop was held at the conclusion of the symposium event and discussed relevant topics that had emerged from the symposium event including the latest innovation, research and practice in disaster management. How to better establish and extend partnerships was also raised and discussed, and how to more effectively exchange ideas to develop the future research agenda.

The outcomes of the workshops confirmed the themes that emerged from the case study on Asia-Pacific, and provided greater details on the need for certain components. In particular, the networking component, and the user-based systems were identified as key elements that should be focused on.

Figure 1: The GDMP Framework

Each component of the framework focuses on a different identified areas of need. In total there are four key components identified, however these four components are not exhaustive and additional components may need to be included as communities adapt and stakeholder needs change. The four components identified include an interactive geospatial platform, a user-based land and property disaster management tool, a stakeholder networking tool, and a disaster management education portal. Each component is explained in detail below.

4.2 An interactive geospatial platform

An interactive geospatial platform has been identified as a key component required to support global disaster management. A system such as this has many technical requirements to support the range of stakeholders that may make use of such a system. Of all the requirements, technical interoperability will be key, supported by semantic, legal and organization interoperability for a global system which works off open standards to support all users. The system should be interactive, perform real-time data collection, management and analysis, and enable distribution and visualisation of the information. These capabilities will support enhanced situational awareness for public safety officials and scenario planning for governments and decision-makers.

4.3 A user-based land and property disaster management tool

The user-based land and property disaster management tool should support bottom-up user-based disaster and risk management of land and property. The research revealed a limit on the support available to enable citizens to implement disaster management practices. To address this gap in resources, the user tool should assist citizens in carrying out risk assessments to their land and property by enabling them to identify threats, analysing the threats, and developing risk management strategies to mitigate the impacts of these threats.

4.4 A stakeholder networking tool

The stakeholder networking tool should be a tool to support networking between government, non-government, civil sector, and private sector organizations and in particular academics and researchers working in the disaster management field. The need from improvements in this areas was highlighted in the workshops and through the case study. A networking tool supports interaction and the sharing of ideas to strengthen the outcomes for disaster management and promotes further advances in the field. The tool should support all types of stakeholders through providing a central online environment to share research, projects and initiatives, search for other organisations working in similar areas to promote collaboration, and increase awareness of the work taking place.

4.5 A disaster management education portal

The disaster management education portal should aim to bring together the available education and training resources relevant to disaster management at a global scale. These resources should be able to be sourced from a central location to enable easier access and discovery of the information available to support disaster resilience and disaster risk reduction activities.

All of these modules described as a part of the GDMP initiative are key towards establishing a smart disaster community where communities near and far are connected and supported by a collaborative disaster management group.

5. Development of the GDMP

So far, a number of initiatives developed within the Centre for Disaster Management and Public Safety (CDMPS) at The University of Melbourne fit the description of some components proposed by the GDMP.

5.1 An Intelligent Disaster Decision Support System (IDDSS)

The Intelligent Disaster Decision Support System (IDDSS) was developed to facilitate scenario planning for urban disaster events. The system provides a dashboard for the strategic, tactical, and operational decisions arising during an urban disaster. The technical aspects of the system include a web mapping component, a crowdsourcing component, a modelling component, and an optimisation component. Additionally, a mobile application for the system has been designed and developed which enables the sharing of incident information and can be accessed through a computer, smart phone or tablet device.

This component aligns with the proposed GDMP component – an interactive geospatial platform. With further developments that take into consideration all the requirements detailed in the GDMP framework, the IDDSS system could be utilised in or leveraged off to support the development of the first GDMP component.

5.2 RiskFinder

RiskFinder is a land and property risk assessment tool designed to assist citizens in understanding what hazards present a threat to their land and property by visualizing where these hazards exist in relation to the location of each individual users' land and property. It is a user-centred system and supports the user by guiding them through the risk management process to help them identify, analyse, evaluate and determine treatment for each risk identified. The output of the system is a report detailing the results of the risk assessment and the risk treatment options identified, as well as available resources for the user to pursue. The objectives of this system are to present information relevant to manage risks affecting land and property; to provide guidance on how to utilise this information; to be accessible by all stakeholders through a web-based interface; to have an interface which would allow users to input location based on address or coordinate information; to be able to verify location information; and to have a user centred viewpoint. With further consideration and a broadened scope, this tool could too be utilised to support the GDMP.

5.3 The Disaster Management Research Register (DMRR)

The final tool under development is the Disaster Management Research Register (DMRR), which is an online portal that acts as a repository of disaster management research worldwide. The goal of the DMRR is to provide a place for researchers to share and learn about different disaster related research across all phases of disaster management, for all types of hazards and disaster events, and from countries worldwide. Each researcher can create a profile page to list information about themselves and their research. The intent for this tool is to support collaboration in disaster management research, increase research awareness, collate disaster management research worldwide, and to deliver a common infrastructure for assembling, coordinating and sharing information related to disaster management globally.

This tool is similar in its intent to the third component of the GDMP framework – the stakeholder networking tool. Currently, this tool is focused primarily on the academic stakeholders, however with further development the tool could be built upon to address the aims of the proposed GDMP component.

As the summary above has shown, all of these three developments could be made us of and considered a good fit for implementation or integration into the GDMP framework.

6. Conclusion and Future Direction

This chapter has highlighted the need for collaboration and sharing in the field of disaster management, and the importance of all stakeholders working together to achieve smart disaster communities. A case study into disaster management systems available in the Asia-Pacific to support stakeholders was conducted and four themes emerged which highlighted key areas to focus on and informed the development of the GDMP framework. Within the GDMP framework four components were identified which were: an interactive geospatial platform; a user-based land and property disaster management tool; a stakeholder networking tool; and a disaster management education portal. Three tools currently underway that align with the description and objectives of the components of the GDMP were detailed and identified as potential foundation systems in the development of the GDMP components. What is required now is further investigation into the proposed GDMP framework to determine the most effective and efficient way to realize the concept, and further research into existing systems that could be utilized to contribute to the system to prevent duplication of work occurring, and to support collaboration across the disaster management field.

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Chapter 11: Application of the Remote Sensing and Geo-spatial Technology in Terrain Analysis and Terrain Classification in Context of Creation of SDI for Marine & Coastal Regions

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Abstract

The ever increasing urbanization along the coasts resulting destructive pressures on the Marine and coastal regions. Developing area/region specific SDI's, using developments in remote sensing and geospatial technologies, will surely add strength to the National and Global SDIs. The main aim of this study to understand the topographic features which is the most important part of terrain analysis and for that develop the application of the available Geospatial Tools for the creation of datasets, which are building blocks of any SDI. The surface analysis of South Western part of India and Benthic Terrain Analysis of Eastern Arabian Sea is carried out using the NASA Shuttle Radar Topographic Mission (SRTM) data and Geospatial tools to understand the terrain characteristics. The terrain analysis of southern Maharashtra and Goa region is validated using ASTER 3D remote sensing data. The geospatial study is carried out to generate base-level information for terrain analysis and classification.

Using improved e-topo2 bathymetry data and Benthic Terrain Modeller (BTM) extension of Arc GIS version 10.2, bathymetry position Index (BPI) at different resolution/scale (broad, fine and standard scale) is achieved for preparing slope, depth, and rugosity maps. Based on bathymetry derivative maps, benthic terrain map of the Eastern Arabian Sea are generated and are used to classify benthic

environment of the Ocean. The study demonstrates that Geospatial technique as most efficient, cost-effective and easiest tools for surface/benthic terrain analysis and mapping provides most of the data for the development of SDIs for Coastal and marine regions.

1. Introduction

Spatial Data Infrastructure (SDI) are used to summarize activities, relationships, processes, and physical entities that provide integrated management of spatial data, information, and services and Promotes geospatial data sharing and facilitates data use. Although, there have been several definitions of Spatial Data Infrastructure (SDI) in literature (Wright, 2009), in general the SDI is defined as "the relevant base collection of SDI offers improved access to data, reduced duplication of effort in data collection and maintenance, enables interoperability between dataset, modernization of administration, risk management, and spatially enabled governance (Gourmelon et al., 2012; Strain et al., 2004). Topography refers to the surface characteristics i.e. the relief of an area. The topography of land surface is represented by digital elevation dataset in GIS which consists of elevation of a large number of sample points distributed throughout the area being represented. These sample points are commonly organized as grid points, essentially as a raster form of organization. An alternative form of representation is the Triangulated Irregular Network or TIN used in vector based system.

Surface analysis is one of the important components to understanding the geomorphological characteristics. Surfaces represent phenomena that have values at every point across their extent. The values of the innumerable number of points of the surface are derived from a limited set of sample values. These may be based on direct measurements, such as height values for an elevation surface, or temperature values for a temperature surface; between the measured locations. Surfaces can also be mathematically derived from other data, such as slope and aspect surfaces are derived from the elevation surface, a surface of distance from bus stops in a city, or surfaces showing the concentration of criminal activity or probability of lightning strikes etc. (Surface creation and analysis-http://resources.esri.com/help/9.3/arcgisengine/java/gp-toolref/geo-processing/surface creation_and_analysis.htm). The benthic zone is the ecological region at the lowest level of a body of water such as an ocean or a lake, including the sediment surface and some sub-surface layers". The extent of the benthic region of the ocean covers from the shoreline (intertidal or EU littoral zone) and extends downward along the surface of the continental shelf towards the sea. The continental shelf is a gently sloping benthic region that extends away from the land mass. At the continental shelf edge, usually about 200 m. deep, the gradient increases greatly and is known as the continental slope. The continental slope drops down to the deep sea floor. The deep-sea floor is called the abyssal plain and is usually about 4,000 meters deep. The ocean floor is not all flat but hasx submarine ridges and deep ocean trenches known as hadal zone (http://en.wikipedia.org/wiki/Benthiczone).

GIS-based terrain analysis techniques are well established as a potential approach to marine geomorphological mapping in deep water (Wilson et al 2007). Multibeam bathymetric data can be used to generate derived quantitative variables describing the seafloor terrain. Dorschel et al (2010) detected canyons in the Irish offshore by their increased slope inclination of canyon walls (steeper than 5°) compared to the surrounding seabed (rarely steeper than 2°). Micallef et al (2012) outline a method (semi-automated) to map shallow coastal water habitats based on the high-resolution multi-beam bathymetry and backscatter data. Textural and morphometric analyses are combined in this method to map and plot the distribution of the predominant habitats offshore NE Malta. The ground-truthing with ROV and dive observations are used to confirm the validity of their approach.

Several studies for the development of Coastal and Marine SDIs (Gourmelon et al., 2012, Strain, 2006) were attempted by different countries, which led to several SDI initiatives at different levels: local, regional, national, international and global levels (Cömert et al., 2008; Idrees et al., 2015) with varying development and progress. India with its vast coastline and the population that lives along the coast needs an immediate initiative for the development of SDIs for coastal and marine regions that facilitates the better management of these areas for promoting tourism, better facilities for fisheries, and preventing the loss due to natural hazards. Due to limited access to the scattered available comprehensive information about marine and coastal areas, the present study showcases a simple and easy way to develop small databases using the satellite data with the functions with the help of software available in public and as well as commercial domains. Therefore, the main objective of the present study is to demonstrate work as an initiative towards the creation of the database as part of developing region specific SDI with the application of Terrain Analyses of the topographic and benthic surface using the geospatial tools applied on the SRTM & ASTER datasets.

For the present study, the Land and Ocean interface area enclosed within 60º E to 78º E longitudes and 7º N to 21º N and latitudes is chosen for deriving the terrain characteristics expressed in terms of several variables that help in understanding the morphology of the study area. The main purpose of benthic terrain mapping is to classify the benthic terrain and to identify the seafloor geomorphological features. The classification is used for the benthic habitat mapping and predictive mapping for the benthic environment in the studied region.

2. Area of Study

The study area extends from 60º E to 78º E longitude and 7º N to 21º N latitudes and covers Eastern Arabian Sea, Sourashtra, Gujarat, western Maharashtra, Goa, Karnataka and Kerala states of India (Figure 1). Benthic terrain analysis and topographic terrain analysis is carried out only in the Eastern Arabian Sea and South-western part of India respectively. The Western Ghats, a mountain range of about 1600 km that runs almost parallel to the western coast of the drainage systems that drain almost 40% of India. Except a small part of the Indian peninsula, is

Area around Mumbai, and along the eastern limits, the State of Maharashtra presents a monotonously uniform, flat-topped skyline. The Eastern part of Arabian Sea extends from the lower part of Gujarat to southern part of India and consists of Arabian Basin, some part of the Chagos-Laccadive Islands and ridges, Laccadive Plateau. In the South-Western part of the Arabian Sea, some part of the Carlsberg Ridges are covered in the present study area.

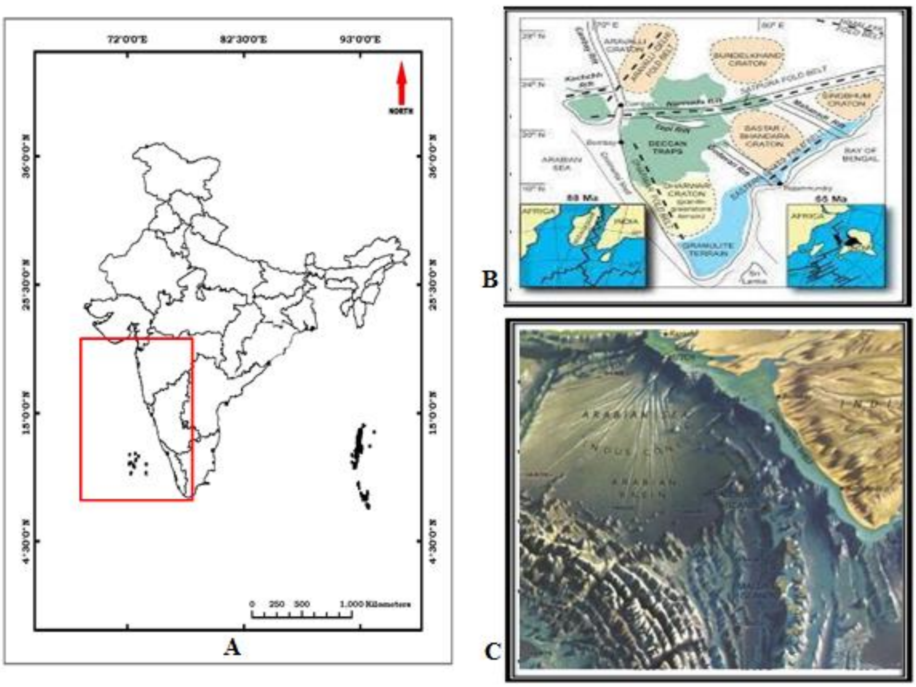

Figure 1 A) India map showing study area B) Structural and topographic map of South IndiaC) Map showing sea bottom topography of Eastern Arabian Sea

3. Materials and Methodology

3.1 Data

The materials used in the present study is essentially the satellite-derived elevation data available free from various sources and the GIS software tools.

The NASA Shuttle Radar Topographic Mission (SRTM) data available at http://www.cgiar-csi.org website with a resolution of 90m (mosaicked 5^0 x 5^0 tiles) is used to carry out the topographic analysis of the western India to derive the terrain variables slope; terrain variability (rugosity) and relative position (Benthic Position Index (BPI)) from the bathymetric data. The ASTER 3D remote sensing data also with 90 m resolution is been taken from http://www.landcover.org site is used to validate terrain analysis of southern Maharashtra and Goa region.

The Bathymetry data (ETOPO) was downloaded from the Intranet web-site (http://colva.nio.org) of CSIR-National Institute of Oceanography, India. The ETOPO bathymetry data set is based on satellite altimetry digitization of depth contours greater than 200 m. Hence, data is not useful for shallow water regions. An improved shelf bathymetry for the Indian Ocean region (20°E to 112° E and 38°S to 32°N) is derived by digitizing the depth contours and sounding depths less than 200 m from the hydrographic charts published by the National Hydrographic Office, India. The digitized data are then gridded and used to modify the existing ETOPO5 and ETOPO2 data sets for depths less than 200 m (Sindhu et al 2007).

The study makes use of the spatial analyst tools in Arc GIS 10.2 software and the Benthic Terrain Modeller extension of Arc GIS 10.2 version is used to obtain slope, depth, and rugosity maps using broad scale BPI, fine scale BPI, standardized BPI'S to the classification of benthic terrain using the above-mentioned derivatives. Slope calculations provided information on the characteristics of the seafloor and indicate regions of the flat and undulating seabed and helped in identifying 51 areas of rock outcrop and seafloor structures such as sandbanks and other bedforms. The rugosity analysis helped to identify areas with potentially high biodiversity by describing a topographic roughness with a surface area to planar area ratio.

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3.2 Methodology

The general workflow of on the methodology adopted in the present study is given in Figure 2. The following paragraph discusses the steps involved in surface analyses for generating a surface model of the study area.

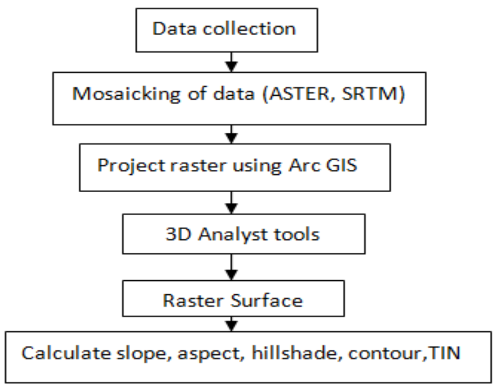

Figure 2. Methodology flow chart

3.2.1 Surface Analysis

The surface analysis involves several kinds of processing, including extracting new surfaces from existing surfaces, reclassifying surfaces, and combining surfaces. For this analysis, we have used spatial analyst Extension and 3D analyst extension of Arc GIS 10.2. This methodology is described in the steps to create a surface model with Triangulated Irregular Network (TIN) command in

ARC/INFO toolbox. The model will focus on steps to calculate the independent variables of topography i.e. Slope, Aspect, and Elevation. Surface analyses using the mosaicked tiles of SRTM data and ASTER data were carried out to generate the surface. Since, Slope and Aspect play a vital and role in terrain analysis, hill shading and 3D view, the Topographical functions were run to derive the two important terrain parameters, i.e. slope and aspect. The Slope tool calculates the maximum rate of change from a cell to its neighbours, which is typically used to indicate the steepness of the terrain. The ASPECT tool calculates the direction in which the plane fitted to the slope faces for each cell. The aspect of a surface typically affects the amount of sunlight it receives (as does the slope); in northern latitudes, places with a southerly aspect tend to be warmer and drier than places that have a northerly aspect. Hill shade shows the intensity of lighting on a surface is given a light source at a particular location; it can model which parts of a surface would be shadowed by other parts. After calculating slope, aspect, and elevation, it is necessary to convert the DEM type data into the functional TIN format. TIN store slope and aspect information as attributes of the TIN facets. Rather than deriving slope and aspect for TIN surfaces (as one does with raster terrain models, which only store the elevation values), one simply needs to extract that information from the facets to a set of polygons (Figure 3).

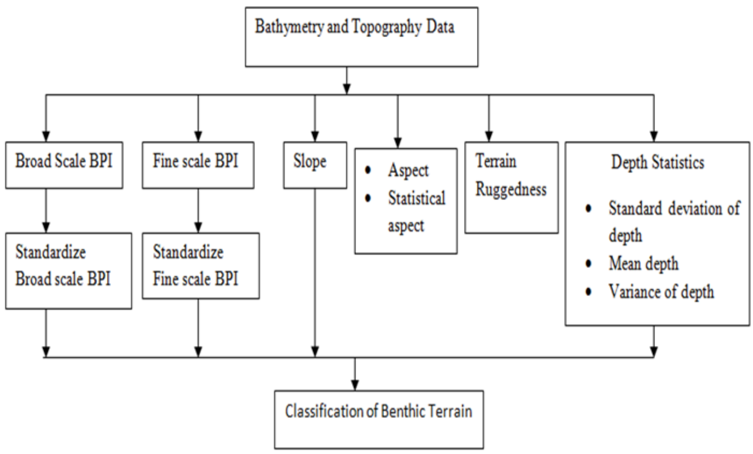

Figure 3 Flow chart depicting classification of Benthic Terrain model

3.2.2 Benthic Terrain Classification and Mapping of Eastern Arabian Sea

The Benthic Terrain Modeler (BTM) algorithm originally developed by Lundblad et al. (2006) which available as an ArcGIS Tool was adopted in the present study for the classification of benthic features. The tool was developed in 2005 to facilitate the mapping and characterization of benthic morphological features that are sometimes associated with some kinds of marine species. Rockfish, for example, is commonly found on or near hard complex structures, sand eel is normally associated with sand banks. Following Sidhu et al., 2007 the ETOPO2 data set has been used in the Benthic Terrain Modeller for ArcGIS functions to calculate the following parameters from the Bathymetry Data that are shown in Figure 3.

Bathymetric Position Index (BPI) Grids: Terrain analysis applications used for mainly to understand the topographical features and to find out its suitability for habitat mapping. To understand the topographical features in marine environment it's important to generate the Bathymetric position index. So that it can be further used for habitat mapping. Without identifying the topographical features it is nearly impossible to map the marine habitats. Creation of Bathymetric Position Index (BPI) data sets at two different scales is central to the methods behind the benthic terrain classification process. BPI is a derivative of the input bathymetric data set and is used to define the location of specific features and regions relative to other features and regions within the same data set. Bathymetric position index is normally determined at three scales:

- **Broad-Scale BPI** (broad-scale BPI data set is created that allows identification of the larger regions within the benthic landscape);
- **Fine-Scale BPI** (a fine-scale BPI data set to identify smaller features within the benthic landscape) and the
- **Standardized BPI** (a standardized BPI data sets that actually is used to classify/ identify various benthic zones and structures.

The derived benthic parameters for mapping the study area include the *Aspect* and *Slope* (the raster maps to be used for classification tools). Slope and aspect have been calculated to understand the topography of the ocean floor and help us in habitat mapping. Due to slope, habitats of certain species has been changed. **T**he *Curvature* (surface of 'slope of slope' raster, that can be used optionally to calculate plan and profile curvature), *Depth Statistics* (mean, variance and standard deviation, over a set neighbourhood size which are useful predictors in understanding the benthic zones in analyses tasks like habitat classification). Depth statistics are very useful parameter to understand the depth variation which occurred due to the variance in topographic features. The marine habitats are mostly dependent on depth variance. Species variation in ocean mostly occurred by the changes in the depth.

The "Classify" function of Benthic Terrain Modeller creates a user-defined structures layer based on BPI's, slope, standard deviation breaks, and depth. The benthic zones in the output layer include various features (crests, depressions, flats, and slopes) of geomorphologic interest. The identified benthic structures in the output layer include narrow depression, local depression on flat, lateral mid-slope depression, depression on crest, broad depression, broad flat, shelf, open slopes, local crest in depression, local crest on flat, lateral mid-slope crest, narrow crest, and steep slope (Figure 3).

The Terrain Ruggedness (VRM) function measures terrain ruggedness, or rugosity, as the variation in the three-dimensional orientation of grid cells within a neighbourhood. Terrain ruggedness is an important parameter for analysing the terrain classes because due to the rugosity the depth varies and which influence the marine habitats. Vector analysis is used to calculate the dispersion of vectors normal (orthogonal) to grid cells within the specified neighbourhood. This method effectively captures the variability in slope and aspect into a single measure. Ruggedness values in the output raster can range from 0 (no terrain variation) to 1 (complete terrain variation). Typical values for natural terrains range between 0 and about 0.4.

4. Result and Discussion

The results obtained from the Terrain analysis using the SRTM, ASTER and ETOPO data for identification of the various Geomorphologic features have been summarized in the following paragraphs

4.1 Results from SRTM and ASTER datasets

Surface characteristics derived from the SRTM data have been interpreted to understand the Geomorphology of a part of Gujarat, Maharashtra, Goa, and Karnataka. The higher/steep slopes (higher values shown in yellow, Figure 4) have been observed that correspond to the Western Ghats region, along the Tapi rift the slope. Some part of the Karnataka Plateau also is showing high values in slope. Hillshade maps are interpreted to understand the intensity of lighting on a surface, given a light source at a particular location that can model which parts of a surface would be shadowed by other parts. Hillshade map of the Western Ghats region, Tapi rift the Hillshade value is low, showing the shadows of the hill due to the high range of the slope. The aspect of a surface typically affects the amount of sunlight it receives (as does the slope). Along the Western Ghats, Tapi rift the slope direction varies from southeast to North West (Figure 4). The aspect values depend on upon the slope of that area.

A clear demarcation of the geomorphological setting is observed from the TIN surfaces wherein the regions of the Western Ghats, Deccan trap and the Tapi Rift showing higher values and the west coast with lower slopes showing the very low TIN values. The prepared contour map based on the SRTM data at 100 meters' interval is quite sufficient enough to differentiate the mountainous regions from that low-lying coastal areas for the study area. Comparable results have been obtained from the slope, aspect and Hill shade surface derived from ASTER data.

(Figure 5). The entire Goa region shows relatively low values in contours (Figure 6).

4.2 Bathymetry and Topography Data

For the Classification of Benthic Structures of the study area, the digitized ETOPO2 dataset is used to identify and understand the various terrain features present. The study area has been classified into following 7 different structures (1. Broad flat terrain, 2. Depression, 3. Mid-slope Ridges, 4. Open slopes, 5. Upper slope ridges, 6. Mid-slope depressions and 7. Lower bank shelf) based on the general classification scheme of benthic terrain (Figure 7)

The land portion of the study area depicted as a broad flat terrain. The Arabian Basin area classified as the depression because of the low slope value. Along the west coast, the continental slope area classified as the lower bank shelf area. Chagos-Laccadive ridges and some part of the Carlsberg ridge and minor ridge such as Laxmi ridge classified as upper slope ridges. Indus cone area classified as mid-slope areas with ridges and depressions.

4.2.1 Bathymetric Position Index: The creation of Bathymetric Position Index (BPI) data sets at two different scales is central to the methods behind the benthic terrain classification process (Figure 8). BPI is a derivative of the input bathymetric data set and is used to define the location of specific features and regions relative to other features and regions within the same data set.

The results of BPI are scale dependent, different scales identify fine or broad benthic features. To achieve the best BPI zone and structure classifications grids were created for study site. The broad scale grid created with a scale factor of 250 is used to identify the broad-scale features of the Eastern part of the Arabian sea extension of the area is 60°0’0” E to 80°0’0” E and 0°0’0N to 20°0’0N, and also the broad-scale features of the entire study area. The broad scale BPI for the Arabian basin area is shown in purple colour. The BPI value ranges between 4080 to -3078. Depressions and depth areas are showing the lower values.

Ridges and broad flat terrain areas are showing higher values. The Fine-scale BPI grid was created with a scale factor of 20. The main features identified from the fine scale BPI is the continental slope area along the west coast shown in brown colour (Figure 8) wherein values range between 2661 to -1503. With the major feature like continental slope, mid-slope, and upper slope ridges, Abyssal plain area can also be identified. High values indicated steeper slope areas and lower values indicated the depression and flat areas. For the present study, the Standardized BPI dataset is used to identify various benthic zones and structures.

4.2.2 Slope: The Slope, representing a terrain’s angle of inclination in relation to a flat surface at sea level, expressed in degrees is the measure of the steepness of first-order derivative, which has been derived using the ArcGIS BTM spatial analyst extension, was used for the classification benthic structures. The Arabian basin area is clearly identifiable with its lower values suggesting a relatively lower/gentler slope (Figure 9).

4.2.3 Curvature: Curvature is used to determine the slope of the particular slope. It can be different types profile curvature or plan curvature. For this study, we prepare curvature map which was used in the classification scheme of benthic terrain (Figure 9).

4.2.4 Aspect: Aspect was used to describe the direction of slope of the study area. Aspect raster had been used for the classification of benthic structures (Figure 10).

4.3 Statistical Aspect

4.3.1 Sin (Aspect) raster

It is the sine function of input surface aspect. In this output surface aspect values range between -1 and 1. The Arabian basin area is showing higher values whereas the ridges and continental slope areas are showing in lower values and relatively darker in colour than the Basin area or flat areas (Figure 11).

4.3.2 Cos (Aspect) raster

It is the Cosine function of the input surface aspect. In this output surface aspect values varies from -1 to 1. In this statistical aspect calculation, it is showing the opposite of the sine function. The flat areas and depressions are showing low values and relatively darker than Ridges and slope areas. Chagos-Laccadive ridges, Carlsberg ridges, and slopes are showing higher values and lighter in tone than the depressions and Basin areas.

4.3.3 Depth Statistics

Depth statistics, such as mean, variance, and standard deviation, over a set neighbourhood size, has been calculated for the study area. These statistics used as predictors in understanding the benthic zones in analyses tasks in benthic structures classification.

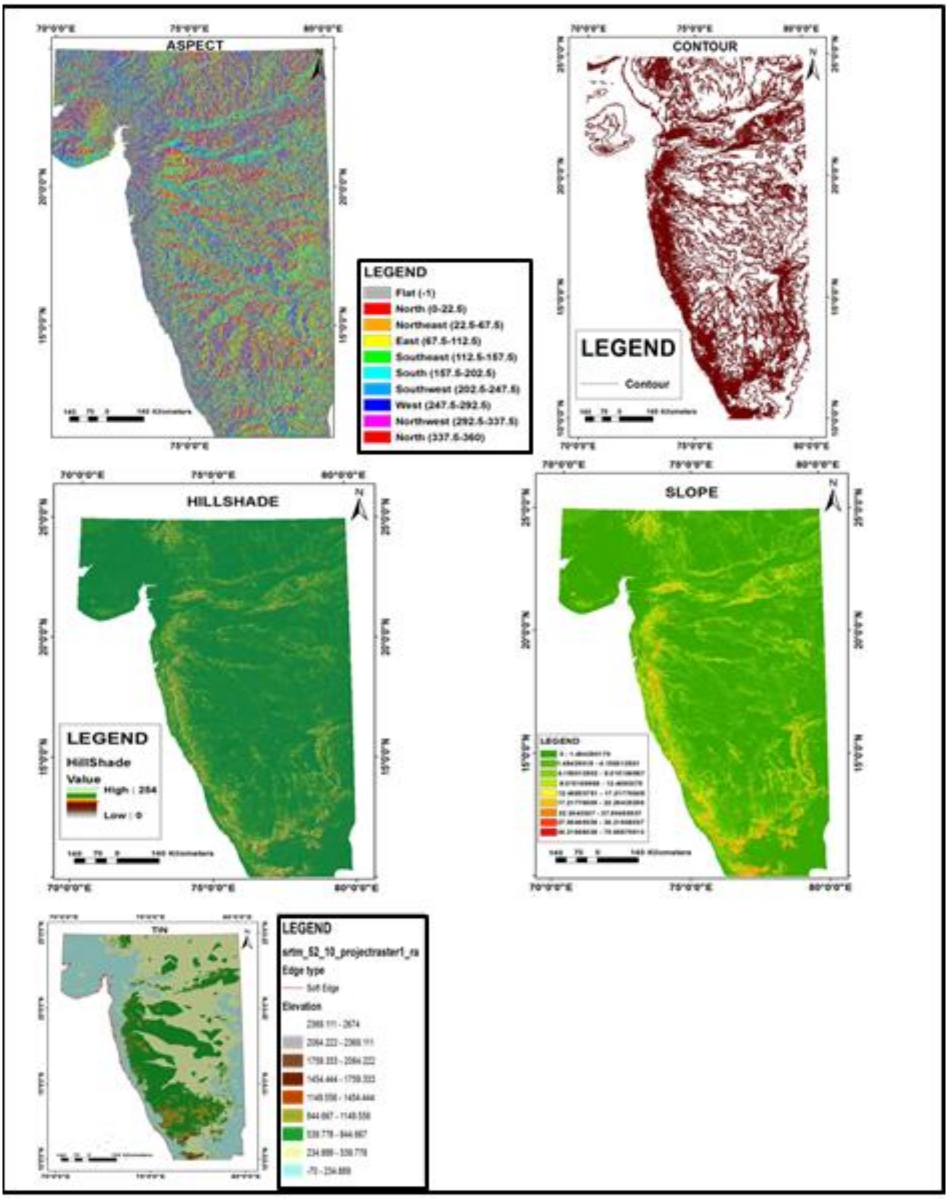

Figure.4 Maps like slope, aspect, counter and Hill shade deduced from Digital Terrain model using SRTM dataset

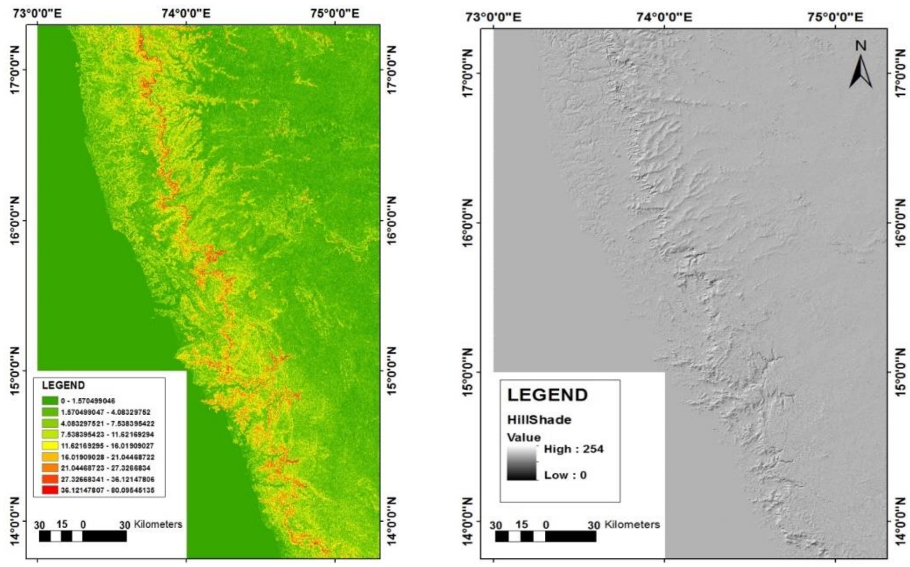

Figure 5. Slope and Hill-shade maps of south-west India derived using ASTER data

<u>Mean Depth</u>: Mean of depth has been calculated on the average over the neighbourhood, ranges between 1590.25 to -4992. The Arabian basin area is showing negative values and in a darker tone. The flat terrain and Chagos-Laccadive and some part of Carlsberg ridges areas are displaying positive values and relatively lighter in tone than compared to Basin areas.

<u>Standard Deviation and Variance of Depth</u>: Standard deviation and Variance are two forms of the same statistical measure. It is used to identify the differences/variation within the data. The value of standard deviation of the depth of that area varies from 0 to 912.909. The Basin area is showing lower values and the continental slope areas and Chagos-Laccadive ridges and other ridges are showing higher values relatively darker tone. The Basin area is showing lower values and the continental slope areas and Chagos-Laccadive ridges and a part of Carlsberg ridge are showing higher values (Figure 12). Carlsberg ridge is showing higher values and relatively darker tone.

<u>Terrain Ruggedness measures rugosity</u>, as the variation in the three-dimensional orientation of grid cells within a neighbourhood. Ruggedness values in the output raster can range from 0 (no terrain variation) to 1 (complete terrain variation). Rugosity values near one indicate flat, smooth locations; higher values indicate areas of high-relief. Rugosity calculated using this technique is highly correlated with the slope. The highest rugosity values show a relationship with the high slope and lower rugosity with a low slope. In the Arabian basin area, rugosity is low because it related with the low slope. But along the oceanic ridges of Chagos-

Laccadive and Carlsberg and minor ridge along the northern part of Arabian Sea Laxmi ridge the rugosity value is high and it is related.

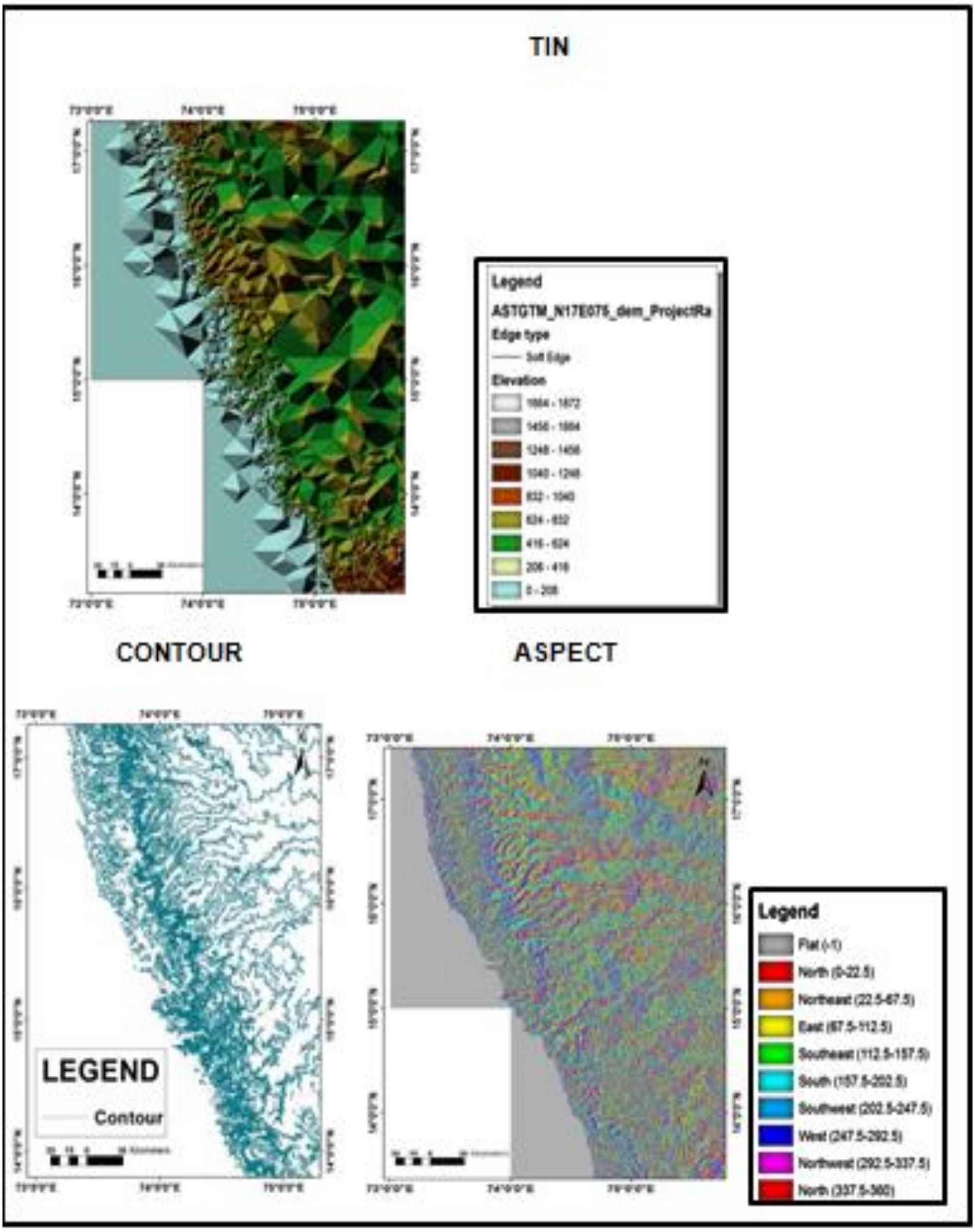

Figure 6. Contour, Aspect and Tin maps of south-west India derived using

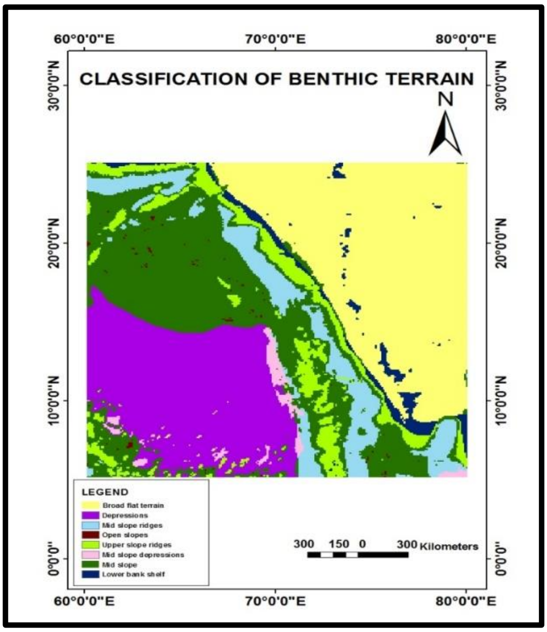

Figure 7. Benthic terrain classification map of Eastern Arabian Sea

5. Conclusions

The classification scheme developed introducing the concepts of BPI zones at a broad resolution (depressions, slopes, flats) and structures (finer features within zones) around the study site provides an important dataset for understanding the Geomorphology of the benthic terrain. The terrain was classified by measuring rugosity, slope, depth at a broad scale, small scale, and standardized BPI'S. Benthic Terrain analysis of deep-water bathymetry is complicated by the fact that on the continental slope we obtain data at different resolutions. We have shown that a variety of methods exist for terrain analysis on these data and these have been successfully applied to the generation of a suite of quantitative descriptor variables of relevance to benthic terrain classification. Using the Benthic Terrain Model in Arc GIS 10.2 version the methodology adopted in this work can be easily transported to the study of other areas and other types of terrain classification. It constitutes an interesting alternative for the good exploration of pre-existent data which could be re-analyzed seeking regional scale habitat prediction. Increased awareness and availability of multi-scale and Multibeam Hydrosweep echosounder data methods should help promote their use in terrain analysis using bathymetric data for terrain classification mapping and related work.

This benthic terrain modelling can be used for identification of marine resources and habitats. It can be useful for identifying different ecosystems in the marine environment. Benthic terrain mapping can be useful for the spatial planning of marine and coastal areas. It can be done at regional and national level planning for management purposes. For better management purpose it can be correlated with sediment data, geology data, distribution of different marine species and fisheries data. This will help to improve the socio-economic level of the coastal and marine areas.

Terrain analysis is a key element in 3D Visualization, Flight Simulation, Project Cost Estimation, Cut and Fill Calculations, Route Feasibility, Environment and Risk Assessments, Line of Sight Analysis, Surface Analysis, Watershed Analysis etc. At present, it seems GIS-based methods are the most readily available to the scientific community. However, further development of wavelet methods may yield more efficient and flexible computation in the future. The study demonstrates that Geospatial technique as most efficient, cost-effective and easiest tools for surface/benthic terrain analysis and mapping provides most of the data for the development of SDIs for Coastal and marine regions.

6. Suggested Work plan for Developing Coastal and Marine Spatial Data Infrastructure (CMSDI)

Identify data holder's/service providers, conduct training/awareness programs, determine user requirements (formats for distribution, metadata required, data needs, areas for focus), Develop roadmap for SDI implementation, Developing, and implementation and finally to Establish support and engagement.

7. Acknowledgements

We express our gratitude to the Director of the National Institute of Oceanography, Goa and Vice-chancellor, Goa University for encouragement and necessary facilities. The author[1] would like to thank Dr. R Annadurai, SRM University for facilitating internship at NIO. This is the contribution number -------- of National Institute of Oceanography, Council of Scientific and Industrial Research (CSIR), Goa, India.

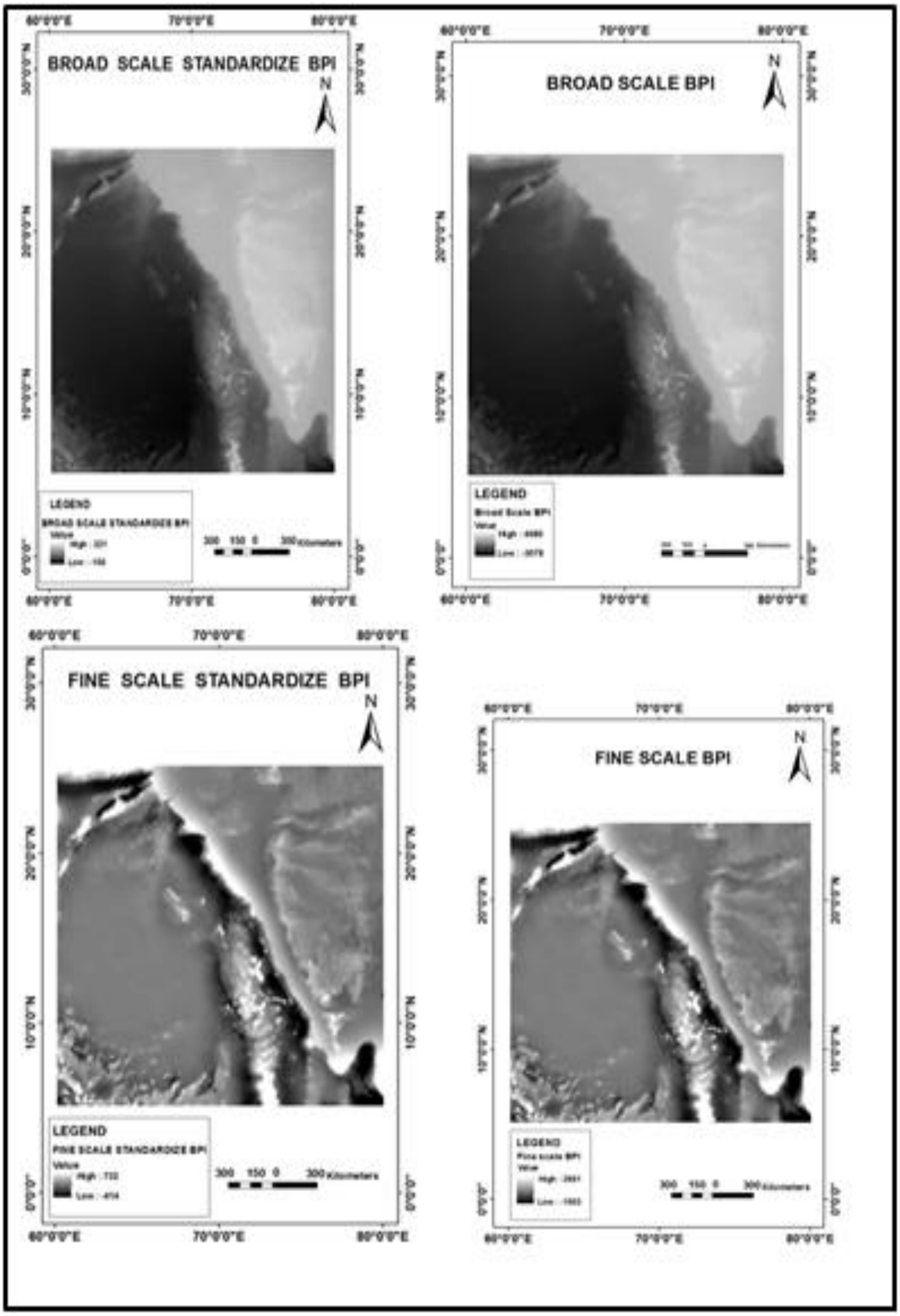

Figure 8. Maps showing the benthic terrain classification using Bathymetric Position Index (BPI) data sets at fine, broad and standardized scale

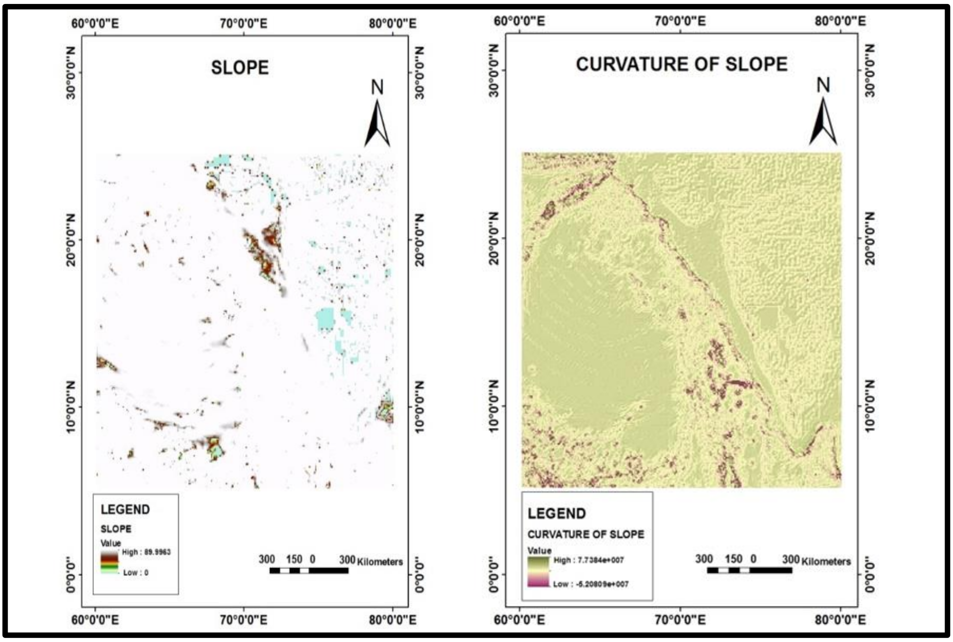

Figure 9. Slope and curvature of slope maps of Eastern Arabian Sea

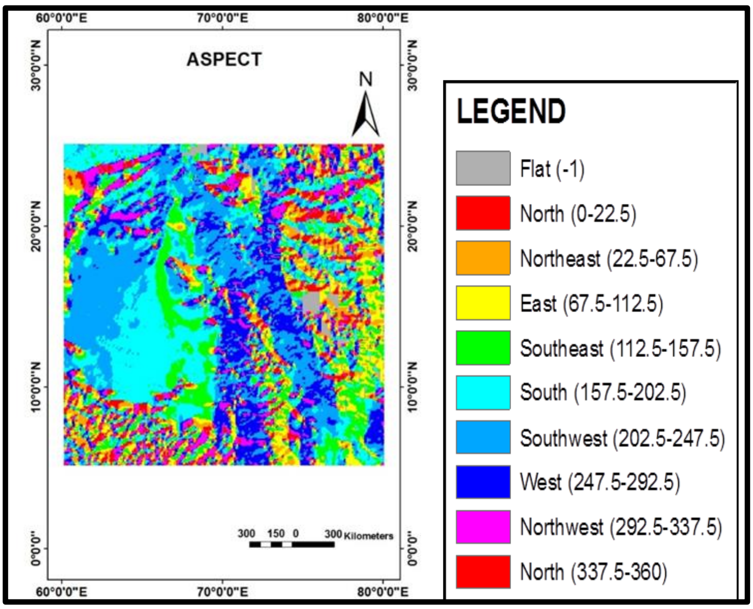

Figure 10 Aspect map of Eastern Arabian Sea

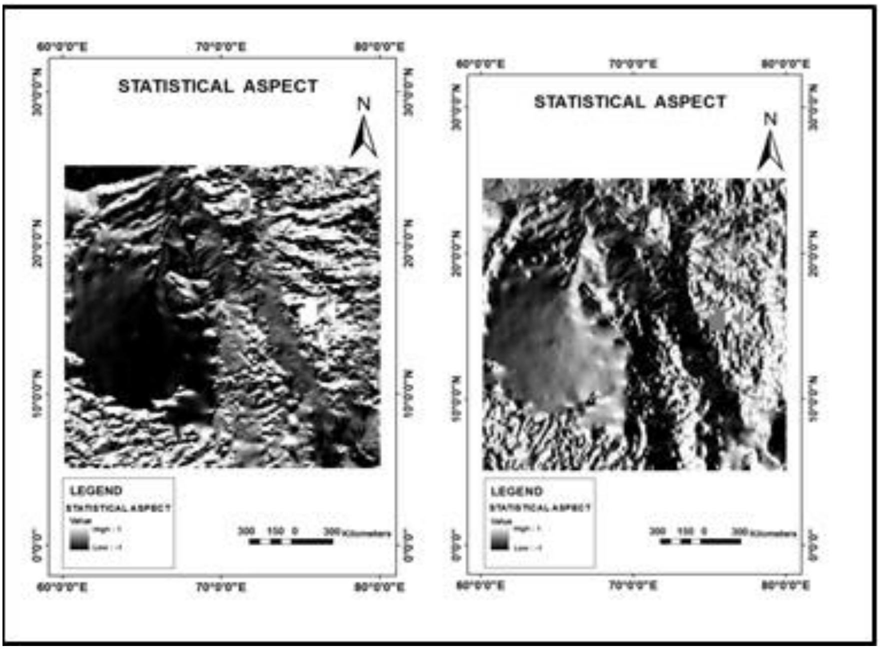

Figure 11. Statistical (Sin & Cos) Aspect map of Eastern Arabian Sea

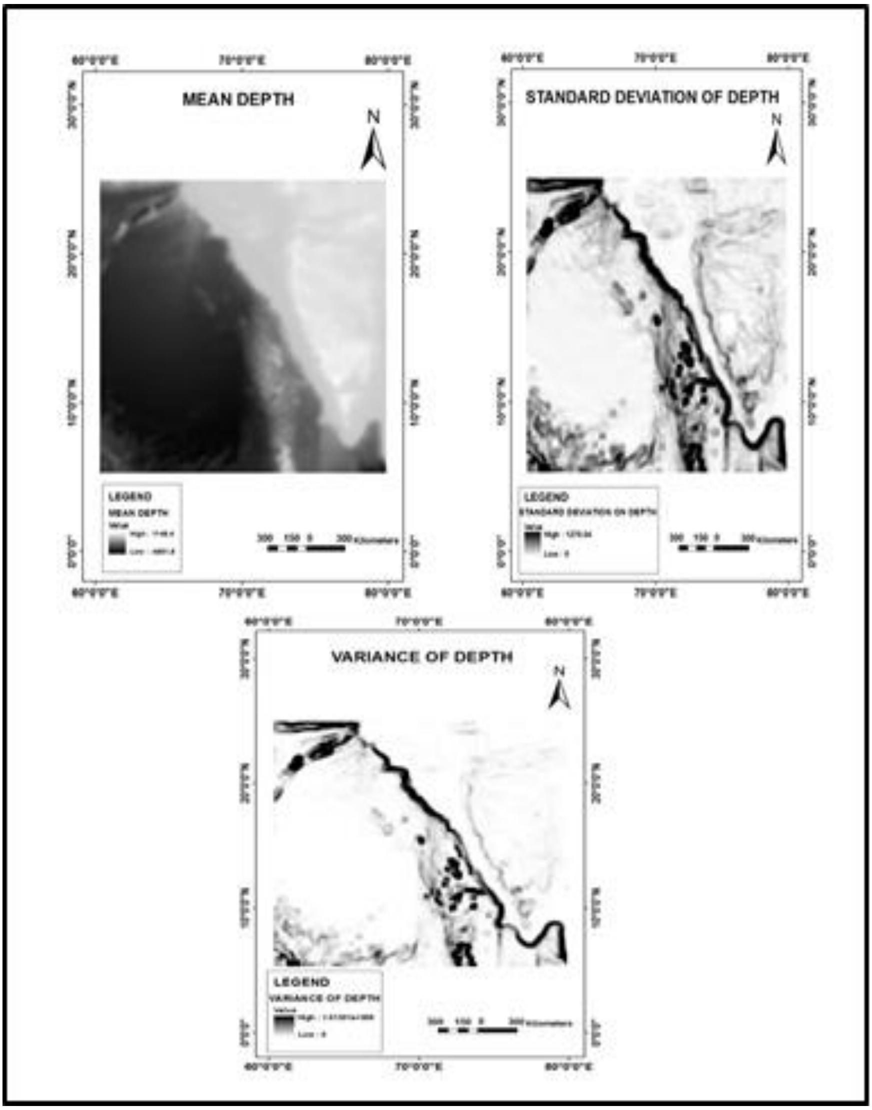

Figure 12. Standard deviation and Variance depth maps of Eastern Arabian Sea

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Chapter 12: Urban Real Property Loss Relief in the Scope of Disaster Governance

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Abstract

Over the last ten years, natural disasters, such as earthquake, flood, typhoon, debris flow and landslide, have cost the tremendous loss of real properties in China. The losses include the loss of real property structures, facade damage of land and building, and loss of property rights due to land loss. The background of unprecedented urbanization which drives the increasing number of people living in urban areas involves the urban real properties in the hazard-prone district. Meanwhile, As the urban development raises the dwelling density, urban real properties are exposed to the vulnerable environment in the face of disasters. The reasons cause the loss of urban properties could be tremendous.

In the current state of affairs, the Chinese central government is the main organization that takes the responsibility of post-disaster loss relief. Neither disaster insurance nor private-public loss relief cooperation has grown maturely in tandem with the need of market taking over this responsibility from the central government. Therefore, there is a current debate on whether there is a need for private sector to take some responsibilities for an effective loss relief in China. At the same time, the focus of disaster management is mostly in the post-disaster phase, while in the pre-disaster phase, the importance of disaster governance is not fully understood.

The chapter suggested an urgent need for urban real property loss relief study in the scope of disaster governance. To further develop the theory of loss relief governance, the chapter defined the differences between loss relief management and loss relief governance and establishes the concept model of loss relief governance, and pointed out the importance of multi-level cooperation in building real property loss relief system in China.

For the purpose of exploring the current urban real property loss relief system in China, the research team conducted a review of regulations and obligations of governments, CIRC and PICC, and field investigations of CIRC and PICC. The finding is that the urban real property loss relief system in China has experienced two stages: mainly *ex-post* funding from the central government and some coverage by insurance systems while government acts as the main source of finance.

The main contributions of the chapter are as follows. Firstly, the chapter proposed the importance of urban real property loss relief. Secondly, the chapter analysed the difference between the loss relief management and loss relief governance and suggested a holistic urban real property loss relief system is within the scope of disaster governance. Thirdly, the chapter proposed the loss relief process should go backward to urban planning phase and cover the whole process of urban development, involving pre-disaster, mid-disaster, and post-disaster phases. Lastly, the chapter summarized the urban real property loss relief system in China and pointed out the current weakness and future research focuses.

Keywords: real property, natural disaster, loss relief, disaster governance, urban China

1. Introduction

In 2015, the Chinese urbanization rate was approximately 56.10%, involving more than 600 million residents living in urban China. Urban agglomeration and expansion regarding size, density as well as complexity cause the vast range of real property construction, accommodating people in urban areas (Yang, Tuladhar et al., 2015.). Due to urbanization, more people are exposed to potential disaster hazards than before. Meanwhile, as the urban density grows, the living density is intense in core cities, resulting in the surge of energy consumption. Furthermore, as the urban boundary expands, the urban area extends to the hazard-prone districts and disaster-prone urban fringe areas are involved in the urban range (UNISDR/UNESCAP, 2012; Tierney, 2012).

Nowadays, the most common natural disasters in urban areas (i.e., those being caused by atmospheric or tectonic disturbances) are storms, floods, drought, and earthquakes (Gallardo, 1984). China has become a country rather frequently affected by natural disasters. In recent years, Chinese cities frequently suffered such major disasters as the 2008 “5-12” Wenchuan earthquake, the 2012 Beijing "7-21" heavy rainfall, the 2013 "Fit" super typhoon, and the"4-20" Sichuan Lushan earthquake. The hits to cities have brought great loss not only economically but also socially, particularly resulting in tremendous loss of real properties, which exposed the problem that the existing urban natural disaster loss relief system is vulnerable. The restructure of disaster loss relief system in the domain of disaster governance is desperately needed (Raschky, 2008).

2. The importance of urban real property loss relief

Currently, there is insufficient research into the question of whether or not disaster loss in urban areas is lesser or greater than that incurred in rural areas. However, the previous research focus of disaster relief was mainly in rural areas. The main reason is that recent great disasters happened in China concentrated in the countryside and city fringe. Taking China Wenchuan earthquake[2], for example, this massive earthquake with a magnitude 8 on the Richter scale happened in Wenchuan, Sichuan Province, resulting in hundreds of billions of property losses. The significant loss in the earthquake is up to 850 billion RMB, most of which was in rural towns and villages (Wang 2008) (Table 1).

However, the importance of urban real property loss relief should not be ignored. Accompanying with the rapid urbanization, urban real properties that symbolized as the modernized image of contemporary urban development are erected almost everywhere that urban boundary reaches. Whereas lacking prudent urban planning scheme, the expansion only considers absorbing the rural population into urban areas, acquiring rural land, eliminating the village and integrating the difference between the rural and urban recklessly (Afshar and Haghani, 2012). More urban areas involve hazard-prone districts in the process of rapid urbanization (Douglass, 2013). Meanwhile, “Rapid growth and population concentrations in megacities in less-developed countries render those urban regions even more vulnerable, particularly from the perspective of large-scale losses of lives, and also harder to govern effectively.” (Tierney, 2012).

[2] Wenchuan earthquake is the worst earthquake event happened recently in China since the M7.8 Tangshan Earthquake in 1976 (Wang 2008)

Table 1: Summary of direct economic loss in Wenchuan earthquake

(Unit: 100 million RMB, about 15 million US Dollar)

Loss item	Sichuan	Gansu	Shannxi	Chongqing	Yunnan	Ningxia	Total
Countryside houses	**1,624.23**	230.54	145.27	38.96	12.40	0.83	2,126.90
City buildings	**74.67**	--	--	--	--	--	--
Indoor property	**307.52**	16.92	1.05	0.05	0.03	--	325.57
Outdoor property	**37.94**	0.53	1.04	--	--	--	39.51
Sum	**2,044.36**	247.99	147.36	39.01	12.43	0.83	2,491.98

Source: Impact of intensity and loss assessment following the great Wenchuan Earthquake (Yuan 2008)

At the same time, energy consumption in cities has speeded up due to the fast growth of cities, particularly in central business districts (or "CBDs"). Developed commercial centers, as well as residential agglomerations, assimilate energy-exhausted cities especially regarding water and minerals that mostly are extracted from underground. It results in uneven seismic activities. Furthermore, a large number of factories and automobiles emit carbon dioxide and harmful gasses, causing climate change regularly, which results in unpredictable rainfall and temperature anomaly. Natural disasters, such as earthquake, land subsidence, floods, intense heat and extreme cold weather, are becoming common meteorological activities. However, the seemingly common phenomenon hides huge disaster risk. Besides, the location of most economy-developed cities in coastal areas adds the additional challenges of sea rises and heightened vulnerability to extreme weather events. Once the disaster takes place, the loss will be innumerable. Urban real property loss relief deserves significant attention as the population consolidation leads to high dwelling density and the linkage effect of buildings to disasters is disastrous.

2.1. Population consolidation and dwelling density

It is a well-known fact that China is a populous country. Chinese cities constitute a significant percentage of the population and raise dwelling densities. According to "Demographia World Urban Areas 12th Annual Edition (2016)", the average population density in China is 5700 people per square kilometers among the investigated 224 cities which occupy 21.9% urban China with a total population 429 million.

Twenty-three (23) Chinese-region cities (including China: Taiwan and China: Hong Kong) rank in the Top 100 most populous cities globally (Table 2). Shanghai ranks the 8th with the estimated population 22,685,000, population density 5800 people per square kilometer and land area 5885 square kilometers.

Table 2: Population, land area, and population density

Rank	Geography	Urban Area	Population Estimate	Land Area		Population Density	
				Square Miles	Square Kilometers	Per Square Mile	Per Square Kilometer
8	China	Shanghai, SHG-JS-ZJ	22,685,000	1,500	3,885	15,100	5,800
11	China	Beijing, BJ-HEB	20,390,000	1,520	3,937	13,400	5,200
13	China	Guangzhou-Foshan, GD	18,760,000	1,475	3,820	12,700	4,900
25	China	Shenzhen, GD	12,240,000	675	1,748	18,100	7,000
28	China	Tianjin, TJ	11,260,000	775	2,007	14,500	5,600
31	China	Chengdu, SC	10,680,000	650	1,684	16,400	6,300
41	China：Taiwan	Taipei	8,500,000	440	1,140	19,300	7,500
42	China	Dongguan, GD	8,260,000	625	1,619	13,200	5,100
44	China	Wuhan, HUB	7,620,000	510	1,321	14,900	5,800
45	China	Hangzhou, ZJ	7,605,000	490	1,269	15,500	6,000
47	China	Chongqing, CQ	7,440,000	375	971	19,800	7,700
51	China: Hong Kong SAR	Hong Kong	7,280,000	110	285	66,200	25,600
52	China	Quanzhou, FJ	7,020,000	635	1,645	11,100	4,300
57	China	Nanjing, JS	6,380,000	515	1,334	12,400	4,800
61	China	Shenyang, LN	6,200,000	390	1,010	15,900	6,100
62	China	Xi'an, SAA	6,150,000	360	932	17,100	6,600
64	China	Qingdao, SD	5,970,000	615	1,593	9,700	3,700
70	China	Zhengzhou, HEN	5,755,000	500	1,295	11,500	4,400
74	China	Suzhou, JS	5,380,000	490	1,269	11,000	4,200
83	China	Harbin, HL	4,915,000	220	570	22,300	8,600
87	China	Xiamen, FJ	4,715,000	225	583	21,000	8,100
94	China	Dalian, LN	4,300,000	300	777	14,300	5,500
99	China	Fuzhou, FJ	4,080,000	170	440	24,000	9,300

Source: Demographia World Urban Areas 12th Annual Edition: 2016.04

For the purpose of analysis, two pictures are outlined for visual comparison among the top populated cities in China (Figure 1 & Figure 2). The population density has a positive correlation with the degree of population consolidation. In Figure 1, Shanghai ranks first with the total population of 22,685,000; Beijing ranks second and Guangzhou-Foshan ranks third. In Figure 2, Hong Kong has the densest degree of population consolidation with 25,600 people per square kilometer; Fuzhou ranks the second and Chongqing ranks the third.

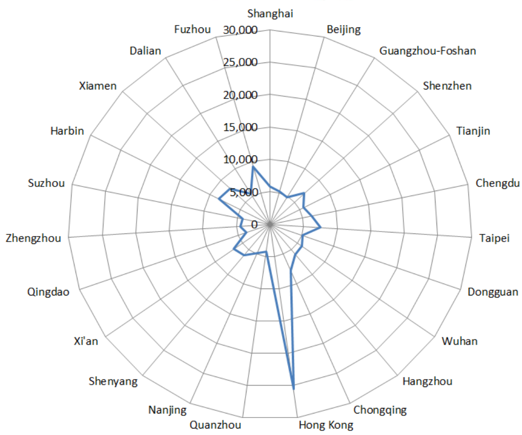


Figure 1: Total Population

Figure 2: Population Density[3]

Population agglomeration promotes the real property consolidation while reducing the population flow rate. When a disaster happens, localized disasters will affect a large number of residents and real properties, and evacuation difficulties will cause worse damage to people and properties.

2.2. Linkage effects of buildings to disasters

[3] Population density represents the number of populaiton in per square kilometer.

Most Chinese citizens live in high-rise apartments, especially for city residents. Newly built buildings are made of concrete structures, particularly in economy-developed regions. The concrete structure of buildings pays attention to the overall performance of buildings. The advantage is to enhance the ability of the building as a whole to fight against external attack. However, the disadvantage is that as the structure of apartments determines the correlations among upper-level and lower-level housing, a part of building's damage may cause the whole building's demolition. The linkage effect among separate apartments in one building is impressively significant in disaster loss relief analysis.

Taking earthquake, for example, the disaster damage to a building foundation results in the overall building collapse, causing tremendous loss to the whole building. Therefore, the linkage effect of building enlarges the property loss suffered from disasters. To minimize the loss, research in disaster loss relief should restructure the concept and rebuild the real property loss relief system in the domain of urban disaster governance.

Precisely, the first and foremost step of loss relief is in the pre-disaster phase. Prudent urban planning, strict building codes and regulations and thoroughly clear loss relief awareness are the most important matters in the pre-disaster phase. Multi-level organizations' cooperation is the secondary importance in mid-disaster. Moreover, in post-disaster phase, reasonably government subsidy and insurance compensation are the third importance. The pre-disaster loss relief preparedness and multi-level involvement are vital to the success of real property loss relief.

The current understanding of disaster loss relief emphasizes the importance of loss recovery and real property reconstruction after the disaster. Moreover, theoretically, loss relief is under the domain of disaster management. It is necessary to discuss the difference between loss relief management and loss relief governance.

3. Real property loss relief governance

3.1. Loss relief management VS. Loss relief governance

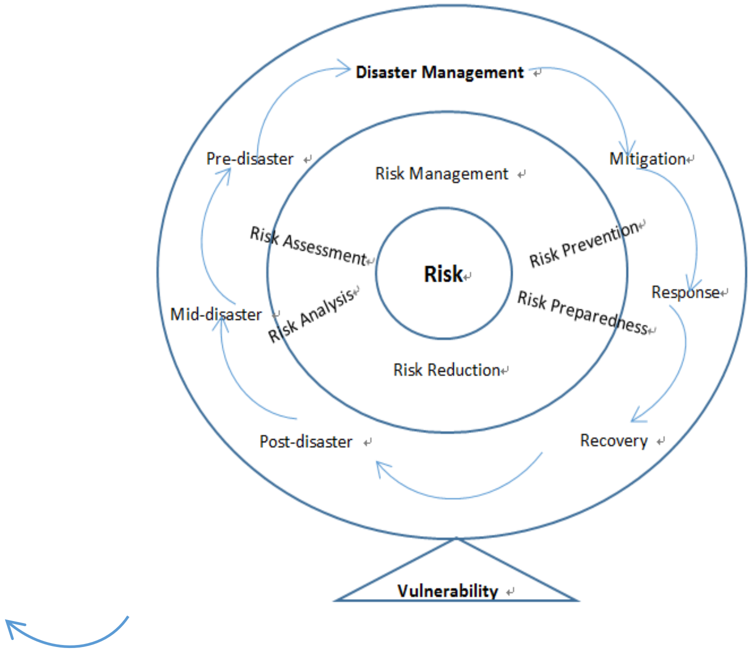
Traditionally, loss relief is regarded as post-disaster loss alleviation and loss management, and loss relief management is in the domain of disaster management (Hur 2012). In common, "disaster governmental process and risk reduction are the main focuses in disaster management as opposed to the concept of governance. The risk was defined as the possibility (probability) of loss, and consequently economic risks as the possibility of the loss of property or loss of function of buildings, utilities, *etc*." (Kárnik, 1984). The factors entering into the estimation of risk are value, vulnerability, and hazard. The elements at risk are any objects or activities exposed to certain dangers.

The core concept of disaster management is the risk. The concept model of disaster management encompasses risk management (RM), risk assessment and risk analysis (RA), risk reduction (RR), risk preparedness and risk prevention (RP) (Figure 3) (Jametti and von Ungern-Sternberg, 2010; Lin Moe and Pathranarakul, 2006). The risk period covers pre-disaster (*ex-ante*) phase as well as post-disaster (*ex-post*) phase (Linnerooth-Bayer, Warner et al., 2009). The main focus of loss relief management is risk reduction and response capacity, as well as minimizing the environmental vulnerability in the disaster administrative process (Weichselgartner, 2001).

3.2. Loss relief governance: multi-level governance

Governance means "the process of decision-making and the process by which decisions are implemented (or not implemented)" (Kezar and Eckel, 2004; UNESCAP, 2009). Distributed governance power diverts from traditional centralized government power. It lies in public institutions (government), private organizations (industry associations and other non-governmental organizations), or both public and private sectors, requiring balance and decentralization. Meanwhile, governance theory advocates the interaction in the governmental process, encouraging the participation through mutual dialogue, coordination, and cooperation. The goal is to establish common objectives, achieve maximum utilization of various resources, and ultimately reach a win-win management pattern through both top-down and bottom-up vertical management (Xi-dong, 2005; Yang, Tuladhar et al., 2015).

Temporarily, disaster governance is not yet a widely used term in the literature. Nevertheless, the basic understanding of disaster governance is widely accepted. Comparing to disaster management, "disaster governance is a more inclusive concept in that disaster management, and risk-reduction activities take place in the context of and are enabled (or thwarted) by both societal and disaster-specific governance frameworks." Disaster governance is often a form of "collaborative governance or activities that bring together multiple organizations to solve problems that extend beyond the purview of any single organization" (Tierney, 2012).



Representing information flows in the scope of disaster management

Figure 3: Loss relief management: core and process

The governance process determines the first and foremost emphasis is the stakeholders' participation. In this chapter, stakeholders include counterparts who bear risks either in pre-disaster or post-disaster phase, particularly urban residents. Good disaster governance should focus at least four factors, accountability, transparency, participation and predictability (UNESCAP, 2009; Ahrens and Rudolph, 2006). Different from urban governance, disaster governance emphasizes accountability and allocations of accountability among multi-level participants. The accountability should be well allocated between governments and insurance companies. To enhance the accountability, multi-level organizations' participation and information transparency are rather important. The main purpose of disaster governance is minimizing the loss caused by disasters, and therefore predictability is the key factor in the governmental process (Figure 4). The main difference between loss relief management and loss relief governance lies in the degree of multi-level organizations' participation and public involvement. As for real property loss relief, public input is critical in all aspects of disaster risk planning from central to local governments and community levels. It is important to decentralize policies and customize them according to local needs and priorities (Douglass, 2013; Tierney, 2012). Moreover, multi-level involvement provides an impetus for regional collaboration as multi-level governance separates authority from local contexts (Maldonado, Maitland et al., 2010; Ahrens and Rudolph, 2006; Haghani and Oh 1996).

Real property loss relief governance evolves through four stages mostly on the foundation of economic development in one country[4]. China as a country stands at "Stage 2: Mainly *ex-post* funding from the central government" and is evolving to "Stage 3: Some coverage by insurance systems; government is still the main funding source" regarding real property loss relief governance.

4. Urban real property loss relief system in China

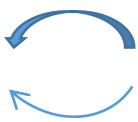
China real property loss relief system is a government-oriented system, which includes three vertical lines that are headed by government subsidy, public insurance policy and commercial insurance (Figure 5). Government-oriented real property loss relief system against disasters is, of course, stronger as insurance markets have limited capacity to diversified catastrophic risks. Government reinsurance is also an effective option covering significant losses caused by major catastrophe (Lewis and Murdock, 1996). In the system, financial solvency is a key support factor to the success of the real property loss relief. Targeted large disasters are designed to under cover of governmental subsidy and public insurance policy, whereas, small disasters are under relief by commercial insurance.

4.1. Methodology

The research adopted desk research and interviews with China Insurance Regulatory Commission (CIRC), insurance companies and citizens. Desk research was for gathering soft documents from official websites of governments, ministries, CIRC and insurance companies. The desk work also reviewed published regulations and official obligations from the Ministry of Finance, the Ministry of Housing and Urban-rural Development, and the Ministry of Civil Affairs, and local finance bureau, urban construction bureau and civil affairs bureau, and CIRC and local CIRC. To investigate the practical implementation of real property loss relief, the research team conducted interviews with CIRC, Property

[4] "Stage 1: Very limited funding from central government; heavy reliance on donors; Stage 2: Mainly ex-post funding from the central government; Stage 3: Some coverage by insurance systems; government is still the main funding source; Stage 4: Significant (re)insurance penetration; government supplements by allocating catastrophic risk capital" (Michel-Kerjan, Zelenko et al. 2011).

Insurance Company China (PICC) and individual citizens. During the interviews, the team collected first-hand information of current real property loss relief system in China.



Representing information flows in the scope of disaster governance

Representing information flows in the scope of disaster management

Figure 4: Loss relief governance: core and process

4.2. Government subsidy

Government subsidy is from top-level government, central government, through the Ministries subordinated to the central government and impact on the local government and its subordinated local bureaus and finally reaches urban residents (Melo Zurita, Cook et al., 2015). The central government is responsible for the national disaster loss relief regulations and decisions. Its subordinate ministries, such as the Ministry of Finance, the Ministry of Civil Affairs, and the Ministry of Housing and Urban-Rural Development are the direct organs taking responsibility for urban real property loss relief regulations and decisions. Moreover, they convey the regulations to local governments. Similar to the central governmental process, local governments are in charge of local loss relief implementation with the subordinated departments, the civil affairs bureau, urban construction bureau, and finance bureau.

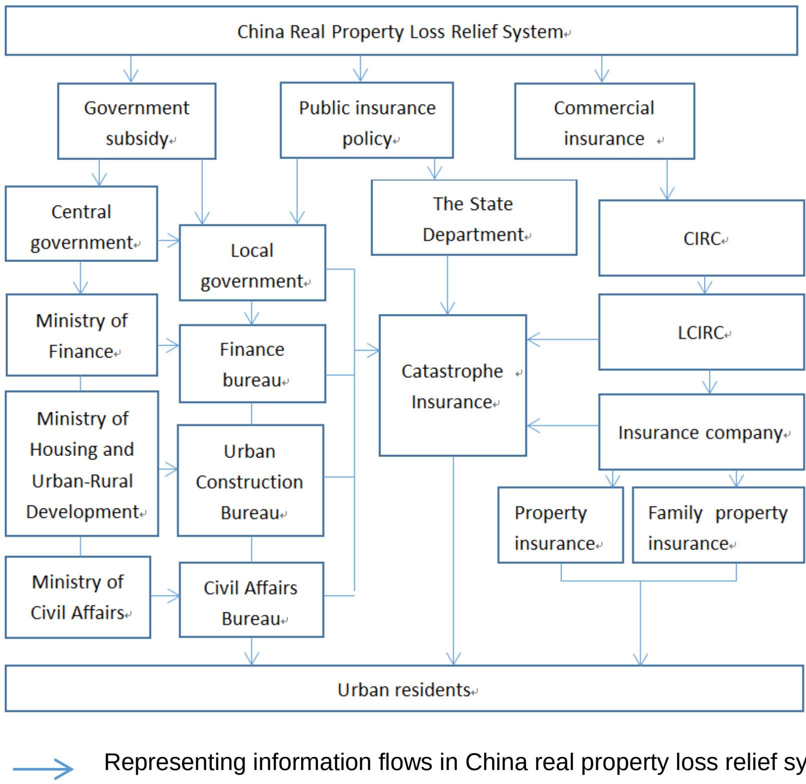


Figure 5: China real property loss relief system

The government subsidy was the most common way for the enormous disaster loss relief although it was an uncertain governmental relief method comparing to commercial insurances (Raschky, Schwarze et al., 2013). The 850 billion loss of Wenchuan earthquake was mostly covered by the government relief and charitable donations. Although the local financial capacity is vital to the successful implementation of local loss relief, as the high state financial payment and local finance expenditure, local governments bear the burden of the fiscal deficit. Meanwhile, due to the limitied capacity of reinsurance, the subsidy mechanism is rather weak in the current institutional environment (Shi, 2012).

4.3. Commercial property insurance

Commercial property insurance is a market mechanism for real property loss relief. It is deemed as an effective way of governance (Ericson, Doyle et al. 2003). In China, the implementation of commercial property insurance is through China Insurance Regulation Commission (CIRC), Local China Insurance Regulatory Commission (LCIRC), local insurance companies to individual insurers. CIRC is one of the State Council agencies, which is particularly responsible for the supervision of insurance industries. The subordinated department of property and casualty insurance undertakes the monitoring obligations of property insurance companies and reinsurance companies. The main function is formulating regulations and property insurance actuarial system, monitoring the insurance company's asset quality and solvency, inspecting and regulating market behavior, and protecting insurers' rights.

Since losses are highly correlated geographically as well as insurance companies have regional risk resistance awareness, first insurance companies frequently seek product design, rate control, and reinsurance to manage their exposure to natural disaster losses(Lewis and Murdock, 1996; Kárnik, 1984). Therefore, regarding insurance product design, insurance company maintains its profit through the following rules of product design (Kárnik, 1984):

"*(a) The insured event has to occur with a certain regularity, in a given period;*

(b) The sustained damage must be measurable; it must be possible to calculate the probability of occurrence and the degree of harm;

(c) The risks must be spread geographically;

(d) The amount of damage must be limited. "

There are considerable difficulties in bringing financial mechanisms designed for frequent small losses to efficiently and profitably relate to rare catastrophic losses as the significant risk is hard to transfer (Lewis and Murdock, 1996).

Property insurance products consist of two types, which are basic insurance and comprehensive insurance (Kunreuther, 1968). In China, the most influential property insurance company, PICC, provides similar insurance products to residents. The research team investigates the PICC with interviews. The interviews are with the chief manager of Property Insurance and Reinsurance Department. During the interviews, the research team finds that PICC engages two main products that are property insurance and family property insurance. Property insurance includes basic insurance clause, comprehend insurance clause and complete insurance clause with diverting insurance rate (Table 3). Family property insurance includes basic insurance clause plus additional clauses and comprehensive insurance provisions. Generally speaking, the insurance clauses advise the insurers to choose among the three clauses and different insurance rate, which differentiate the insurance objects and liabilities by package prices (Table 4).

In the investigation, the research finds that the insurance companies cannot bear the massive disaster risk. The insurance product is designed to bear property loss caused by property stealing and other housing regular low risk. Market mechanism has limited capacity to protect real property from disaster loss, not even mentioning loss relief, which is the market failure aspect of insurance relief. “Market failure in natural disaster insurance is widely recognized. Most natural disaster insurance schemes include various degrees of public-sector participation” (Jametti and von Ungern-Sternberg, 2010). Moreover, the prevalence of commercial disaster insurance is affected by the income level of one country (Tierney, 2012). In China, the real property commercial insurance market is not mature enough as citizens’ insurance awareness is considerably low and insurance companies have difficulties in expanding marketing channels, which leads to even worse results. Thus, it is not surprising that Wenchuan earthquake insurance compensation is under 0.2% after the disaster. In all, the loss relief is insufficient to rely solely on commercial insurance. In fact, when catastrophic disasters occur, the majority of commercial insurance risk has transferred to the central government and local government.

4.4. Public insurance policy: a governance framework

The governmental process focuses on loss management through official channels. The main purpose is to assure the real property loss can be compensated after disasters through government payments by humanitarian considerations and insurance companies by insurance contracts (Van Asseldonk, Meuwissen et al., 2002). However, as for catastrophic disasters, it is out of the consideration that the shocking loss is over the finance capacity of local governments. Moreover, as the low insurance awareness, limited insurance companies’ propaganda, and insufficient cooperation with multi-level organizations, the real property loss relief is almost an impossible task for local governments (Jaffee and Russell, 2006). As mentioned above, in Wenchuan earthquake, the responsibility of real property loss relief was undertaken by the central government mostly at last. The disaster risk was not allocated fairly in the social system. Moreover, such case should not be a model for future relief-system reconstruction.The research team conducted interviews with the real property insurance company PICC and the Department of Property and Casualty Insurance, CIRC to investigate public-private multi-level cooperation regarding real property loss relief system. The multi-level cooperation includes the cornerstone insurance policy, the loss relief pilots of catastrophe insurance, and the establishment of catastrophe insurance loss relief. It symbolizes China has moved from the stage 2 to stage 3 regarding real property loss relief system.

4.4.1. Cornerstone insurance policy

The cornerstone in real property loss relief is the introduction of policy “Several Opinions on Accelerating the Development of Modern Insurance Services” on 13 Aug 2014. The policy proposed 2020 development goals of insurance industries. “By 2020, insurance depth (premium income divided by gross domestic product) would reach 5%, the insurance density (premium income divided by total population) reached 3500 RMB per person, enabling real property insurance as the social ‘stabilizer’ and ‘booster.'” Meanwhile, it emphasized the need for corporating insurance into the disaster prevention and rescue system; particularly, it decided the establishment of catastrophe insurance system. This policy outlined the blueprint of the route of insurance industries by 2020 and promoted the necessity of incorporating private insurance companies into governmental loss relief system.

4.4.2. Catastrophe insurance: loss relief pilots

From 2013 to 2015, pilot cities such as Shenzhen and Ningbo took the first step to catastrophe public insurance loss relief using public government insurance. The government of Shenzhen made active exploration in this area. By the end of 2013, the Shenzhen municipal government passed through the "Shenzhen catastrophe insurance pilot scheme," according to natural disaster’s frequency and unique geological characteristics. The scheme included 15 risks such as typhoons, landslides, floods, nuclear security, *etc*. All of Shenzhen residents were involved in the program protection. Every year, the government invested 36 million RMB in buying such a loss-resistant protection (Table 5).

Table 3: Property insurance clauses

Property insurance clauses_PICC_2009 Edition			
Basic insurance clause	Insurance liability	Clause 5	During the period of insurance, the insurer shall be liable for compensation by the contract, for the loss of the insured subject to the following reasons: (a) fire; (b) explosion; (c) lightning; (d) flying objects and other aerial objects falling.
	Liability exemption	Clause 7.4	Earthquake, tsunami and its secondary disasters
		Clause 7.8	Storm, flood, storm, tornado, hail, typhoons, hurricanes, snow, ice, dust

			storm, sudden landslide, collapse, debris flow, sudden ground subsidence
Comprehend insurance clause	Insurance liability	Clause 5	During the period of insurance, the insurer shall be liable for compensation by the contract, for the loss of the insured subject to the following reasons: (a) fire and explosion; (b) lightning, heavy rain, flood, storm, tornado, hail, typhoon, hurricane, snow, ice, sudden landslide, collapse, debris flow, suddenly the ground subsidence of; (c) flying objects and other aerial objects falling.
	Liability exemption	Clause 8.5	Earthquake, tsunami and its secondary disasters
Complete insurance clause	Insurance liability	Clause 5	In the period of insurance, as a result of natural disasters or accidents causing direct damage or loss of the insured object (hereinafter referred to as "loss"), the insurer shall be liable for compensation by the contract.
	Liability exemption	Clause 7.4	Earthquake, tsunami and its secondary disasters

Table 4: Family property insurance clauses

Family property insurance clauses_PICC_2009 Edition			
Basic insurance clause	Insurance liability	Clause 4	In the period of insurance, the insurer shall be liable for compensation by the contract for the loss of the insured subject to the following reasons: (a) fire; (b) lightning; (c) explosion; (d) the falling of flying objects and other air operated objects, not of the collapse of the other buildings and the fixed objects that are used by the insured.
	Liability exemption	Clause 7.2	All losses caused by the earthquake and its secondary disasters;

		Clause 7.8	Storm, flood, storm, tornado, hail, typhoon, hurricane, snow, ice, dust storms, sudden landslide, collapse, debris flow, sudden ground subsidence
Additional clauses	Insurance liability	FJ01.	Tornado, storm, heavy rain, snow, and ice additional insurance clauses
Comprehensive insurance provisions	Insurance liability	Clause 5	In the period of insurance, the insurer shall be liable for compensation by the contract for the loss of the insured subject to the following reasons: (a) fire, explosion; (b) lightning, typhoon, tornado, storm, flood, snow, hail, ice, landslide, collapse, debris flow, and sudden ground subsidence; (c) the falling of flying objects and other air operated objects, not of the collapse of the other buildings and the fixed objects that are used by the insured.
	Liability exemption	Clause 7	(a) nuclear radiation, nuclear explosion; (b) Earthquake, tsunami and secondary disasters.

Table 5: Catastrophe insurance pilot cities

City/ Province	**Pilot time**	**Insurance objects**	**Government payment per year**
Shenzhen	Dec 2013	Typhoon, debris flows, floods and nuclear power security, *etc*.	36 million RMB
Ningbo	Nov 2014	Flood, debris flow, typhoon, landslide, *etc*.	57 million RMB

Similarly, Ningbo, according to the geological location and natural disasters, included flood, debris flow, typhoon, landslide, *etc*. in the catastrophe scheme. The Ningbo government funded 57 million RMB for the city's 1000 million residents (including foreigners) to purchase sum-up 700 million catastrophe insurance. The insurance compensation including 300 million RMB due to typhoons, rainstorms and floods and other natural disasters and secondary disasters, 300 million RMB due to household's property loss, 100 million RMB due to the sudden major public safety incidents fulfilled in the year 2014 (Table 5).

4.4.3. Establishment of public catastrophe insurance

The CIRC issued the "Establishment of Urban-Rural Residential Earthquake Insurance System Implementation Plan" on 11 May 2016. It was the symbolism of the official implementation of the catastrophe insurance system

The earthquake catastrophe insurance is introduced as a breakthrough in the development of urban and rural residential earthquake catastrophe insurance products, symbolizing the establishment of Chinese residential earthquake insurance community. Adhere to the "government promotion, market operation and residents' livelihood security" principle; the catastrophe insurance establishes solid public-insurance foundations using well-deigned mode selection, solvency, fund collection, liability limitation and pricing model.

<u>Mode selection</u>

The Implementation plan clarifies that the government is the main driver to promote market operation. The government implementation scheme promotes the refinement effect for the design of the system, legislation and policy support; and the determination of market operation, the insurance market, especially residential earthquake community is responsible for the specific operation, which is called "government-community combination mode."

<u>Solvency</u>

The implementation plan establishes the rule of risk sharing and grading burden by risk layering techniques that allocates disaster risks among five-layer dispersion mechanism. The mechanism involves insurers, insurance companies, reinsurance companies, earthquake catastrophe insurance special reserve, government financial support.

<u>Fund collection</u>

The implementation plan is a "voluntary" plus "positive incentives" mode, that is, to encourage local public finance for the implementation of premium subsidies, and to give tax incentives to insurance companies and insurers, which merges advantages of compulsory insurance and voluntary insurance (Michel-Kerjan, Zelenko et al. 2011).

Liability limitation

The implementation plan clearly defines liability limitation in an earthquake. Under the fixed value premise, actual losses and liability are cured into three gears to ensure clear and straightforward operation. Basic insurance coverage 20,000 RMB and 50,000 RMB together with the maximum sum 1 million RMB are covered under the public insurance policy. When the insurance sum spills over 1 million, the loss relief can be resolved through the commercial insurance. The actual amount limits explicitly define quasi-public goods from the private product.

Pricing model

The pricing model is designed to the level of regional risks, building construction types, and urban-rural differences in differentiated insurance rates. The important setting-up threshold in the plan is that buildings should meet the requirements of the national building quality (including seismic fortification standards). The principle means the insurance object should be the buildings with national construction quality requirements (including seismic fortification criterion) and indoor ancillary facilities. Moreover, the main insurance liability covers devastating earthquake vibration caused by the tsunami, fire, explosion, subsidence, landslides, and landslides secondary disasters.

China real property loss relief has experienced from government subsidy, commercial insurance to policy-driven public insurance, which fully reflects the transition trend from disaster management to disaster governance. The current system highlights the multi-level involvement in the process of loss relief including government instruction and regulation as well as private insurance companies' cooperation. Although the market mechanism functions weakly, NGOs and individual residents hopefully participate actively in the future. China has moved a vital step forward towards a more inclusive and coordinated real property loss relief system.

5. Discussion

Researchers' attention in real property loss relief was mainly in rural areas. Nevertheless, the chapter suggests urban disaster and its damage to urban real properties cannot be ignored because urban consolidation causes high property density. And the linkage effects of buildings to disasters are dangerous. With the background of rapid urbanization, the research on urban real property loss relief is a vital research topic in the current environment.

Beyond the analysis of section 3 and 4, the chapter finds out on the topic of urban real property loss relief; there are some other practical issues vital to the implementation. Firstly, holistic governance concept is influential to the success of real property loss relief system. Holistic governance should cover pre-disaster, mid-disaster, and post-disaster phases, emphasizing the coordination of urban planning, urban construction, and urban development stages. It is critical to identify urban hazards before urban planning, reasonably plan urban districts, firmly abide by building construction codes and sustainably enhance urban security regarding energy consumption, emergency infrastructure, and evacuation facilities (Lodree Jr and Taskin, 2008).

Secondly, as disaster governance's core concept is the stakeholder, it is vital to enhance stakeholders' awareness of loss prevention and self-relief methods. Extensive evidence shows that residents in hazard-prone areas have not sufficient awareness to conduct loss prevention measures voluntarily (Kunreuther, 2006), particularly in developing countries (Linnerooth-Bayer, Warner et al., 2009). During the interviews, the research team finds out except for officers in CIRC and managers in insurance companies, most of the citizens have no idea that property insurance is a necessary way for real property loss relief. It is urgent to develop channels for insurance propaganda and enhance people's insurance awareness (Wang, Liao et al., 2012).

Thirdly, regional loss estimation methods are not clear. Basing on real property loss degree the estimation includes extreme-loss estimation, medium-loss estimation, and low-loss estimation. In general, extreme-loss estimation goes to the government through government subsidy; medium-loss estimation goes to insurance companies and reinsurance companies; the low-loss estimation goes to insurance companies and individuals. Official earthquake damage estimation instruction is mostly for individual buildings. As for regional earthquake loss, researchers propose isoseismal map method (Yuan, 2008) while for other common disasters, regional loss estimation method is not well developed (Downton and Pielke, 2005). The low and medium loss estimation follows market price or the replacement cost of damaged parts, which is prevalently used in the market. Meanwhile, direct loss and indirect loss relief are well defined in the research. Terminologically, the direct loss reflects damage to plant, equipment, and infrastructure plus loss of income as a direct result of damage. The indirect loss is any loss other than direct loss (Cochrane, 2004). For individuals, indirect loss includes income loss expect for the direct real property loss. Whereas for regional and national levels, indirect losses become more significant. It includes regional and national facilities damage, infrastructures damage, an indirect loss for inter-industry and postponed impacts, rebuilding assistance, unemployment compensation, survivor benefit payments, tourism offset and so on so forth. The indirect loss could be more harmful to the whole economic system than the direct loss. Therefore, mentioning real property loss relief, it is necessary to take not only the direct loss but also the indirect loss into account.

Last but not least, the most influential disaster to urban areas, the flood, is not well researched. The urban disaster frequency study suggests that floods are the most influential natural disasters in urban areas[5] (Gallardo, 1984). However, no matter private insurances or government public insurance has not established the solid floods loss relief system.

6. Conclusion

The rapid urban transition involves people and real properties in disaster hazards in core cities and hazard-prone areas due to urban consolidation as well as urban boundary expansion. The importance of urban disaster and its damage to urban real properties should be highlighted in disaster researches.

There is a significant difference between loss relief management and loss relief governance, which causes divert key research processes and focuses. Loss relief management is in the domain of disaster management which underlines risks as the core concept; while loss relief governance is in the scope of disaster governance which emphasizes stakeholders as the core focus. It is necessary to build real property loss relief system under the framework of disaster governance that consists of four key factors accountability, transparency, participation and predictability, paying attention to multi-level organizations' cooperation.

The research team conducted regulation revisions and field investigations and found out real property loss relief system in China has experienced two stages that are mainly *ex-post* funding from the central government and some coverage by insurance systems while government as the main source of finance. Currently, China real property loss relief system includes government subsidy, commercial insurance, and public insurance policy, implementing the multi-level cooperation although market mechanism still relatively weak.

The research team will continue the research in urban real property loss relief in the four specific fields discussed in section 5, which are urban hazard identification, insurance channel development, insurance awareness cultivation, regional loss estimation, and flood loss-relief system development specifically in the future.

7. Acknowledgements

The authors would like the aid from the Ministry of Education, Humanities and Social Sciences Research Youth Foundation, Project Number 15YJC630158 [教育部人文社会科学研究青年基金项目， 项目批准号15YJC630158].

[5] Floods 52 %, earthquakes 17 %, hurricanes 15 %, drought 7%, volcanic eruptions 3%, others 6% (Gallardo, 1984).

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Chapter 13: Assessing the quality of building footprints on OpenStreetMap: a case study in Taiwan

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Abstract

In recent years, an emerging trend in the information community is the growing use of web applications to collect and share geographic information. Such initiatives have increased the accessibility of geodata. Collaborative mapping platforms such as OpenStreetMap (OSM) have become important sources of geodata and potentially complementary with any Spatial Data Infrastructure initiatives. However, as volunteered geodata were generated by people with varying skill levels, quality issues such as missing details and incomplete content are inevitable with this approach.

In this study, we aimed to understand both the weakness and potential of OSM building footprints from three criteria: completeness, topological errors, and geometric accuracy. Case study areas were set in two major metropolitan areas of Taiwan, Taipei City and Taichung City. We compared OSM quality with a reference dataset from authority. The completeness assessment was computed in different scales by unit-based and object-based methods. We found the object-based method more appropriate for assessing our data. The completeness of corresponding building footprints ($C_{overlap}$) was 15.8% in Taipei and 11.7% in Taichung respectively; the highest complete location was Dari district of Taichung ($C_{overlap}$ = 66.2%). Completeness results were mixed between high-density and low-density districts. Generally, the central business districts had higher completeness than low-density areas and the variation was significant. An interesting finding was that the resolution of OSM building footprints in several districts of Taichung was higher than the reference dataset. Based on an inquiry of the OSM contributor community, we believe the high-resolution footprints were likely due to the promotion of university education in those areas.

Subsequently, we assessed topological errors and found that 2.9% of OSM building footprints in Taipei and 2.0% in Taichung had overlapping errors. In contrast, the reference dataset had no errors. Then, 384 OSM building footprints with a 1:1 relation to the reference building identified by the overlap method were randomly sampled to measure geometric accuracy. Using a turning function, the geometric accuracy assessment identified that 12% were very similar to reference buildings yet 10% were highly dissimilar. Through visual analysis and computing the sum of the number of vertices, we concluded that the reference dataset was more complex in building representation. As the Taiwanese OSM contributor community intended to tag building footprints for evacuation, we tried to identify the completeness of evacuation buildings in the two cities. The results showed that 47.1% of evacuation buildings can be identified on OSM.

This all indicates that the general completeness of OSM building footprints is not consistent, and they are mostly under-represented. Nevertheless, OSM building footprints in several districts of Taichung possess higher resolution than authoritative data, and the completeness of both building footprints and evacuation centres is higher than 50%. This shows OSM has a great potential for field use, particularly in a scenario of disaster management. OSM can be a better source for a large-scale SDI platform and help to enable a resilient and prepared society.

Keywords: Data Quality, Volunteered Geographic Information, Building Footprint, Spatial Data Infrastructures.

1. Setting the scene

The innovations of information and communication technologies (ICTs) have brought numerous benefits to the real world. Instant and content-rich spatial data from websites and mobile apps are easy to share and access on the Internet. Today geographic information is not only produced by authoritative organizations but also by lay people without professional cartographic skills. This phenomenon, termed Volunteered Geographic Information (VGI), encapsulates the idea of collecting, maintaining, and distributing geographic information by volunteers (Goodchild, 2007).

There is no fixed form of VGI. It may be citizen-generated geographic content including images, videos, and textual information (Craglia et al., 2012; Dransch et al., 2013). In terms of vector data to represent physical features such as roads and buildings, OpenStreetMap (OSM) is the most famous of VGI initiatives. OSM is a collaborative mapping platform wherein volunteers can digitalize features based on high-resolution imagery, or leverage Global Positioning System (GPS) tracks to create a street map. As it is free and open, it has been an alternative geodata source to authoritative venues. In contrast, authoritative geodata from Spatial Data Infrastructure (SDI) initiatives are expensive to create and update; in addition, users are often required to pay fees for access to authoritative data.

OSM has therefore played a critical role in areas without a good quality digital map and where geodata are limited by access. For example, after the devastating earthquake in Haiti in 2010, OSM became the default basemap for responding organizations (Zook et al., 2010). In recent years, the number of OSM registered user has risen rapidly, increasing tenfold between 2010 and 2016, reaching 2.4 million. Yet as OSM data are contributed by volunteers with various motivations and skills, quality issues such as vandalism, missing details, and incomplete content are inevitable and have been critical research problems.

In our experience using OSM, the quality of building data is highly uncertain. Buildings comprise one of the most important physical elements of human society. The need for building data is high in many domains such as urban planning (e.g. analysis of land use change) and emergency management (e.g. developing an evacuation system or damage assessment). We therefore conducted a case study to assess the quality of OSM building footprints in regions of Taiwan. We measured completeness, topological errors, and geometric accuracy in OSM building footprints by comparing OSM data with authoritative data and the GIS analyzer. Moreover, as recent studies pointed out that VGI could be used for pre-disaster planning and preparation (Haworth and Bruce, 2015; Schelhorn et al., 2014) and the Taiwanese OSM's contributor community has begun annotating evacuation locations, there was a need to obtain complete information on OSM regarding evacuation buildings. This study integrates several existing methods to understand both the weakness and potential of OSM building footprints from the aspects of internal and external quality.

The remainder of the chapter is organized as follows: Section 2 provides a brief review of quality elements and methods of OSM quality assessment. Section 3 describes the methodology of the study. Section 4 demonstrates the results of data quality assessment. In section 5, we discuss our results compared to similar studies, draw conclusions, and provide insight into OSM quality issues.

2. Quality Issue of OpenStreetMap

2.1 Quality Issues of VGI

Spatial data and services are usually provided by authorities with sufficient knowledge, technology, and labor for capture, analysis, and digitalization through a top-down approach. However, the cost of production, integration, updating, and delivery is expensive. And most SDIs typically deploy only participants who have professional spatial information skills, leaving a large part of society with a nominal role (Budhathoki et al., 2008; Ho and Rajabifard, 2010). These issues can potentially be complemented by VGI. As VGI is a bottom-up approach in which citizens act as sensors; data are usually free and open access. It is beneficial specifically where authoritative data fall short in satisfying the needs of a particular situation (Feick and Roche, 2013).

Though VGI has many advantages, it lacks structured sampling and rigorous measurement methods; data quality is a major concern (Goodchild and Glennon, 2010; Goodchild et al., 2012). Generally, data quality represents for the user the fitness of the dataset for a potential application (Aalders, 2002). As data holds a perceivable level of similarity between the data produced and the real-world phenomena described, assessing quality in relation to the absence of errors in the data is the measurement of internal quality (Devillers et al., 2007; Fisher, 1999; Guptill and Morrison, 1995). Common quality elements have been defined by standard organizations. For example, ISO 19113 described five elements including completeness, logical consistency, positional accuracy, temporal accuracy, and thematic accuracy. Another aspect of data quality is external quality. It represents how well internal specifications fulfill the user needs. The assessment relies on measures of internal criteria and explicit objectives for intended use (Poser and Dransch, 2010).

When using authoritative data, quality criteria are often documented in the metadata. This helps end users realize data quality. However, when using VGI, these criteria are absent in the metadata, so quality is uncertain and has become a barrier for OSM for end-users. In this study, we measured three criteria of OSM building footprints: completeness, topological errors, and geometric accuracy. Completeness is a measure of presence and absence of features. It describes the relationship between objects and the abstract universe of all such objects (Goodchild, 2008; ISO, 2013; Veregin, 1999). Geometric accuracy assesses the positioning and geometric resolution from the ground reality. In OSM quality assessment, the two criteria often use a reference dataset for comparison (e.g. Girres and Touya, 2010). Topological errors often occur due to a fallible mapping which violates predefined rules of geometry and results in logical inconsistency. Possible polygon errors include (1) unclosed rings, (2) gaps and overlapping between polygons, and (3) self-intersection (Servigne et al., 2000).

2.2 Assessment Methods

Methods for OSM quality assessment differ in features and criteria. The comparison method, which assesses quality by comparing OSM data with similar high-accuracy data, is essential and widely applied in the literature. For example, to assess positional accuracy of OSM road networks in England, Haklay (2010) used a buffer zone to calculate the percentage of overlap between VGI and authoritative data; the results showed OSM had approximately 80% overlap. Haklay (2010) also calculated the total length of OSM roads, and compared the values with the authoritative dataset in grid units for the completeness assessment. Besides this, OSM studies have measured quality at different scales and times (e.g. Zielstra and Zipf, 2010), or focused on automated feature matching comparison (e.g. Koukoletsos et al., 2012). Various methods of quality assessment have been developed. Results showed that OSM data can be very rich with good quality, but it is heterogeneous in the details of features. The researcher also concluded that OSM quality should be evaluated both locally and globally (Zheng and Zheng, 2014).

With regard to assessing quality of polygon features, researchers have developed several methods related to our objective criteria. For example, Hecht et al. (2013) developed unit- and object-based (i.e. feature matching) methods for measuring completeness of OSM building footprints. Targeting geometric accuracy, Girres and Touya (2010) calculated polygonal granularity (i.e. the shortest segment) and compactness of lake features, and the result demonstrated a great difference in granularity between OSM features and references. However, the two methods lack a good way to interpret results. Methods such as the Hausdorff distance or surface distance were also used (Eckle and de Albuquerque, 2015). Comparing these methods, we found that shape similarity is a better measure for geometric accuracy. This measure uses the turning function developed by Arkin et al. (1991) and has been tested (e.g. Mooney et al., 2010; Fan et al., 2014). As for topological errors, assessment does not require reference data, and tools with robust algorithms are available. A case in point is Sehra et al. (2016) investigated topological errors on line and polygon features on OSM and found a large number of errors.

In this section, we briefly introduced the assessment methods and findings in the literature. Note that as quality assessment usually requires a reference dataset for comparison and mass processing and measurement, the OSM quality control among contributors still relies on crowdsourcing and social approaches (Goodchild and Li, 2012). Several free online quality assessment and assurance tools (e.g. OSM Notes) have been developed to get detailed OSM quality information from users.

3. The study area and assessment methodology

This section describes the data used in this study and the assessment methodology. We integrate several existing methods from previous research on OSM quality (e.g. Hecht et al., 2013; Mooney et al., 2010; Fan et al., 2014).

3.1 Study Area and Data Collection

The areas selected for this study were two major metropolitan areas of Taiwan, Taipei City and Taichung City. As OSM data quality highly depends on the density of OSM contributors, we assumed that the quality of building data was potentially better than other administrative districts since contributor density in the urban districts of Taipei and Taichung was high (Chuang et al., 2013, Haklay et al., 2010a). Additionally, Taichung is composed of four areas with great variance of population density. The assessment results in the low-density areas (Shanxian and Haixian) provide a reflection of other such urban areas.

Figure 1: The study area: Taipei City and Taichung City

The OSM dataset (shapefiles) was extracted from the OSM data provider Geofabrik[6], which was updated to 12 March 2016. The reference dataset used as a baseline for assessment was the Taiwan Electronic Map, supplied by the National Land Surveying and Mapping Centre (NLSC) at a scale of 1:2500. Through visual comparison between the reference dataset and Satellite Map, it was highly complete. This comparison can be seen in a web mapping platform[7]. The data were not free to the public currently; a Web Map Service (WMS) was provided.

3.2 The Unit-Based Completeness Assessment

The basic completeness measurement was built on the unit-based method defined by Hecht et al. (2013). It measures the proportion of total number or area of OSM building footprints and references within a given unit. There are two indicators of completeness. C_{No} measures the completeness of total number and C_{Area} measures the completeness of total area. The definitions of C_{No} and C_{Area} are:

$$C_{No} = \frac{\sum BuildingNoOSM}{\sum BuildingNoRef} \qquad (1)$$

[6] https://www.geofabrik.de/ [accessed 12 March 2016]
[7] http://emap.nlsc.gov.tw/gis103/ [accessed 1 July 2016]

$C_{Area} = \frac{\sum BuildingAreaOSM}{\sum BuildingAreaRef}$ (2)

In this study, we used the administrative districts as defined units and assessed the completeness at three scales: city, township, and village. The results would be presented by tables in the township units and maps in the village units

3.3 The Object-Based Assessment

The unit-based method does not consider feature-matching relation. Building data production requires huge manual processing, and the outcome has different standards. A building footprint can represent several buildings, or a single building. Therefore, there are six relations existing between reference polygons and OSM building polygons: 1:1, 1:n, 1:0, 0:1, n:1, and n:m. Identification of OSM building footprints corresponding to at least one reference building (1:1, 1:n, n:1, or n:m) enables the assessment to be calculated in relation to their representatives.

The feature-matching rule is an important research setting in an object-based method. In our previous study, we used an attribute similarity ratio and a buffer search for the corresponding public property (Kalantari and La, 2015). However, this was not applicable to building footprints, as a name attribute was absent. Therefore we used the overlap method, which computes the overlap area between two polygons. We defined that the ratio of the overlap area in the minimum footprint area between OSM and reference had to reach 30% to be regarded as corresponding features (Hecht et al., 2013; Fan et al., 2014). Otherwise, it was regarded as non-matching (1:0 or 0:1). Completeness based on the overlap method ($C_{overlap}$) is defined as:

$$\text{For corresponding building,} \frac{BuildingOverlapArea}{\min(Area(OSM_i), Area(Refj))} > 30\%,$$

$C_{overlap} = \frac{\sum CorrespondingBuildingAreaOSM}{\sum BuildingAreaRef}$ (3)

Figure 2 is an example of the identification of corresponding features. The seven reference building footprints in blue line were marked as A to F. The reference building C was a non-matching feature since the overlap area was only 9% of the reference building area. By contrast, other overlap areas (B and D~G) matched more than 30% of the minimal footprint area. Thus associated building footprints were regarded as matching.

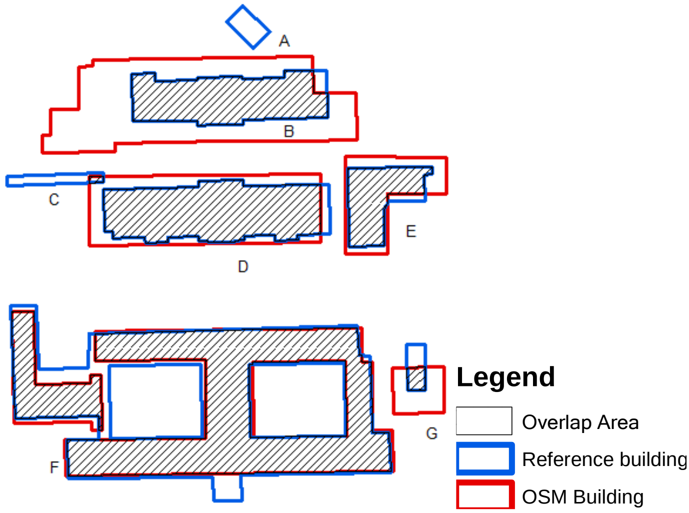


Figure 2: An example of using the overlap method for feature matching, the reference building C has 9% overlap area, thus it is non-matching

3.4 Methods for Geometric Accuracy and Topological Error Assessment:

As mentioned, there are several methods used for geometric accuracy assessment in the literature. In this study, we measured to what extent OSM shape is similar to the reference shape. The method used in this study was based on the similarity algorithm (i.e. turning function) developed by Arkin et al. (1991). It transforms a polygon as a list of angle–length vertices in a counterclockwise direction and the perimeter is rescaled as 1. The similarity between two polygon shapes can be defined as the distance between their turning functions. This distance is normalized to the range [0, 1]. Through visual analysis, Mooney et al. (2010) defined the similarity between two shapes by normalizing the distance into a similarity value, where 1 represents identical shapes, and the lower the value, the less similarity. Corresponding polygons have a very similar shape while a similarity value is greater than or equal to 0.8, and a value of 0.5 or less represents very dissimilar shapes. The major limitation of this method is that it is independent of the size of the shape.

For the shape similarity assessment, we implemented the source code provided by Gene Ressler[8] on ArcGIS. As the calculation requires much manual manipulation to assign matching IDs of the corresponding polygon with a 1:1

[8] https://www3.cs.stonybrook.edu/~algorith/implement/turn/distrib/sim.c [accessed 12 March 2016]

relation, we used simple random sampling to extract the OSM buildings. Sampled buildings in various locations were identified by the overlap method mentioned in the previous section. The sampling size was determined at the 95% Confidence Level (CL) and 5% Margin of Error (MOE) commonly used in statistics. By applying the geometric accuracy assessment, we were able to measure differences in building footprint representation between OSM and the reference dataset.

As for topological error detection, the OSM data used in this study were shapefiles. A shapefile is a non-topological data structure that does not explicitly store topological relationships. According to the specifications, shapefile polygons do not pose the problem of self-intersection[9]. Therefore, we investigated unclosed rings and overlapping between polygons. The topological errors were assessed by the ArcGIS topology tool with cluster tolerance at 0.001 m.

3.5 Completeness of the Evacuation Centers

In February 2016, a devastating Earthquake struck Taiwan (Tainan City) and caused numerous injuries and deaths. How to use OSM as a disaster information map for civic resilience became a serious topic in the Taiwanese OSM's contributor community. They decided to identify evacuation centres and tag them on OSM buildings.

In correspondence to this action, we were interested in how many evacuation buildings could actually be identified. We therefore conducted a survey on the completeness of evacuation buildings in OSM in Taipei and Taichung. The evacuation locations were extracted from the governmental Open Data platform[10] and then converted to point data in GIS. Evacuation locations in open space such as parks were manually excluded. The unit-based method (C_{No}) was adopted to measure completeness. We computed the portion of the number of evacuation locations intersecting OSM building footprints and the total number of evacuation locations within the city and township units. This was defined as:

$$C_{evacuation} = \frac{\sum EvacuationLocationIntersectNo}{\sum EvacuationLocationNo} \qquad (4)$$

[9] http://support.esri.com/white-paper/279 [accessed 24 August 2016]
[10] http://portal.emic.gov.tw/pub/DSP/OpenData/EEA/Shelter.xml [accessed 12 March 2016]

4. Quality assessment Process and results

4.1 Preprocessing

There were several preprocessing steps before the assessments. First, the coordinate systems of the two datasets were different. To make a comparison, the coordinate system of the OSM dataset was transformed to 2-degree Transverse Mercator projection (TWD97 TM2, EPSG Code 3826), the same as the reference dataset.

Second, as both datasets were mainly digitalized from remote sensing images, there were some small polygons which were not building footprints. These features were mainly a cabin, garage, or public toilet on the map. For example, Figure 3 shows that a polygon in the reference dataset was actually not a building. To exclude non-building features, we removed building footprints with an area smaller than 20 m^{2}, in accordance with findings from a previous experiment (Hecht et al., 2013).

Figure 3: An example of building footprint area under 20 m2 in the reference dataset (Base Map/ Street View data ©2016 Google)

Third, all the building footprints were spatially joined with the administrative districts to assign the district name. As there were a small number of buildings located on the boundary of the administrative district (e.g. MRT station), the value was null after the join. We determined the value by the location of the centroid for assigning the district name. Figure 4 demonstrates that the MRT building was located on the boundary between two villages. As its centroid is located in Village B, the building was labelled as Village B.

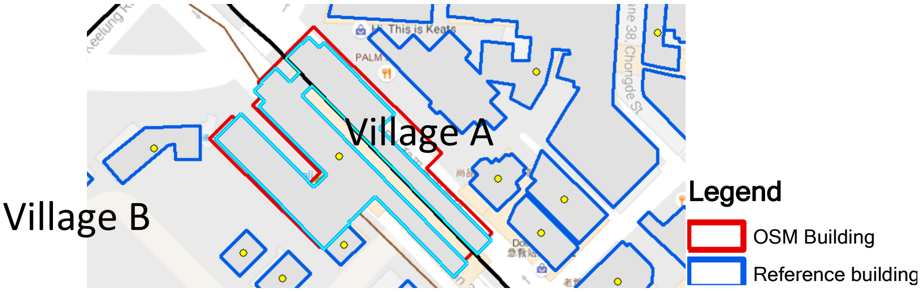


Figure 4: A MRT station across two districts is labeled in the district of its centroid (Base Map ©2016 Google)

Additionally, our preliminary evaluation found that the coordinates of the evacuation locations (point data) were not precise enough, in that some evacuation locations do not intersect with building footprints (Figure 5). Because of this, we used a 20-meter buffer circle instead of the point of evacuation location in the measurement of $C_{evacuation}$.

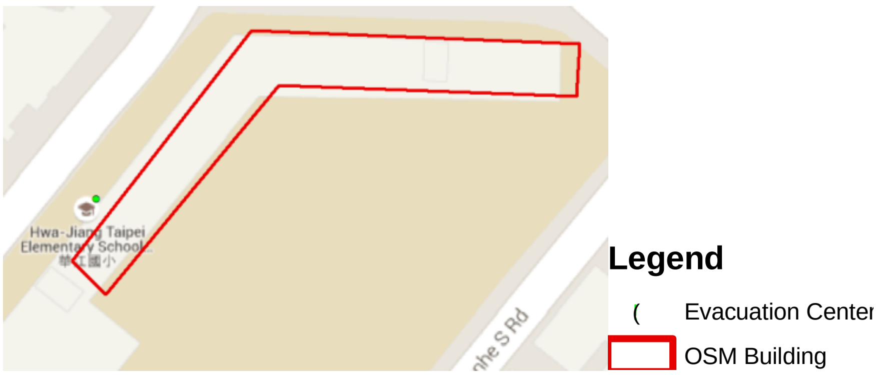


Figure 5: Positional accuracy issue of evacuation location (Base Map data ©2016 Google)

4.2 Completeness Assessment

After preprocessing, the total number of reference building footprints was 62,823 in Taipei, and 198,276 in Taichung. By comparison, the total number from OSM was 7,638 in Taipei, and 102,958 in Taichung. The completeness of total numbers (C_{No}) was 12.2% in Taipei against 51.9% in Taichung. However, when computing the completeness of total area (C_{area}), the result was contrary. The total area was 17.4% complete in Taipei, and 12.8% complete in Taichung. By assessing completeness in higher granularity and visual inspection, we found that the total number of building footprints in several districts of Taichung was more than the reference dataset (e.g. Central, East, and Nantung district of the inner city), that C_{No} was higher than 100%. This caused opposite results between C_{No} and C_{area} in the city units. Due to the resolution of building footprints, C_{No} was not appropriate to be used in Taichung.

After the assessment of the unit-based method, completeness was re-calculated by the object-based method. $C_{overlap}$ was 15.8% in Taipei and 11.7% in Taichung. Between C_{area} and $C_{overlap}$, we tried to identify which measure was more appropriate to interpret completeness. We concluded that $C_{overlap}$ can exclude part of the topological errors (see: Discussion and Conclusion). Here we present $C_{overlap}$ in detail. Table 1 summarizes the result in the township units of the two cities. The spatial distributions of $C_{overlap}$ in village units are presented in Figure 6.

By examining the values across the townships and villages of Taipei, the central business districts (CBDs) exhibited higher completeness than other areas (Figure 6). These areas were Zhongzheng, Daan, and Nangang (Table 1). Important traffic and education facilities such as Taipei Railway Station, National Taiwan University, and Academia Sinica were located in these districts. On the other hand, completeness was low in low-density areas. For example, Shilin had the lowest completeness (Coverlap = 8.2%) as it contained a large mountain area. The building footprints were not quite complete and only important facilities were mapped. A visual comparison of the building footprints around the National Palace Museum in Shilin is illustrated in Figure 6a.

Table 1: The completeness assessment of the OSM building (Coverlap)

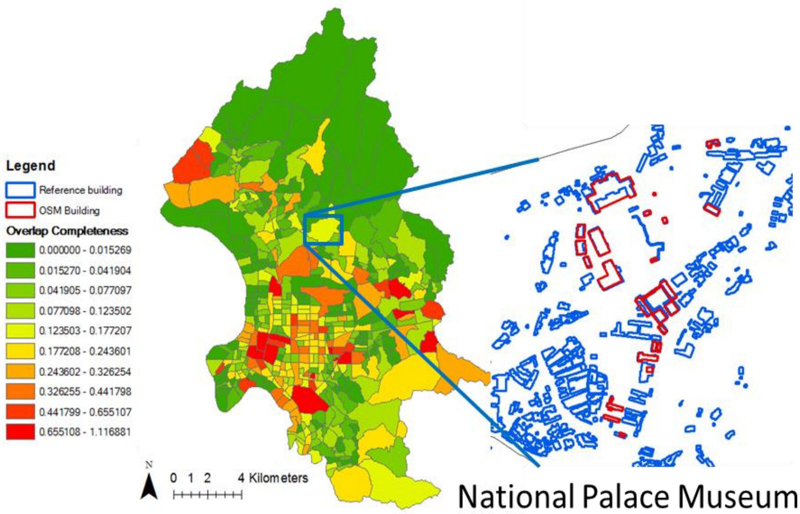
A. Taipei City

	Beitou	Zhongshan	Zhongzheng	Neihu	Nangang	Shilin
$C_{overlap}$	16.2%	19.8%	38.1%	18.4%	24.6%	8.2%
	Datong	Daan	Wenshan	Songshan	Xinyi	Wanhua
$C_{overlap}$	9.1%	26.2%	11.2%	17.4%	21.6%	13.4%

B. Taichung City

Inner city	Central	East	West	South	North	Xitun	Nantun	Beitun	
$C_{overlap}$	62.0%	58.8%	4.7%	6.9%	5.5%	8.7%	58.5%	5.1%	
Tuen Mun	Wufeng	Dari	Taiping	Wuri					
$C_{overlap}$	42.2%	66.2%	1.1%	4.6%					
Haixian	Qingshui	Dajia	Shalu	Wuqi	Daan	Dadu	Longjing	Waipu	
$C_{overlap}$	2.0%	0.01%	3.4%	3.2%	0.01%	0.01%	2.7%	1.2%	
Shanxian	Fengyuan	Donshi	Daya	Houli	Tanzi	Shigang	Shengang	Heping	Xinshe
$C_{overlap}$	1.0%	1.0%	0.01%	0.9%	1.1%	25.1%	0.2%	1.8%	0.2%

A. Taipei City



B. Taichung City

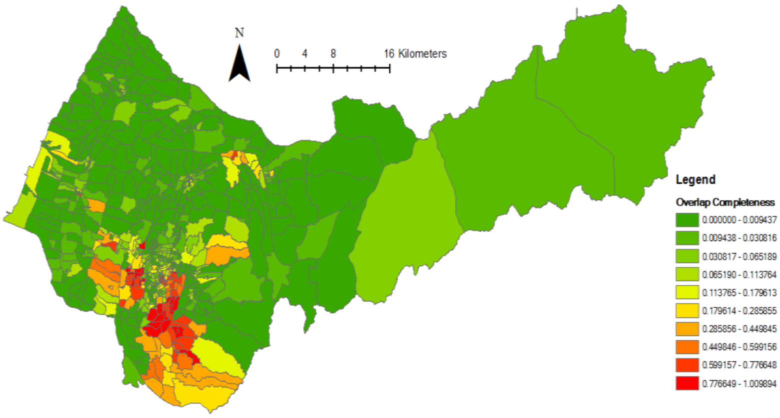


Figure 6: The map of OSM building footprints completeness assessment

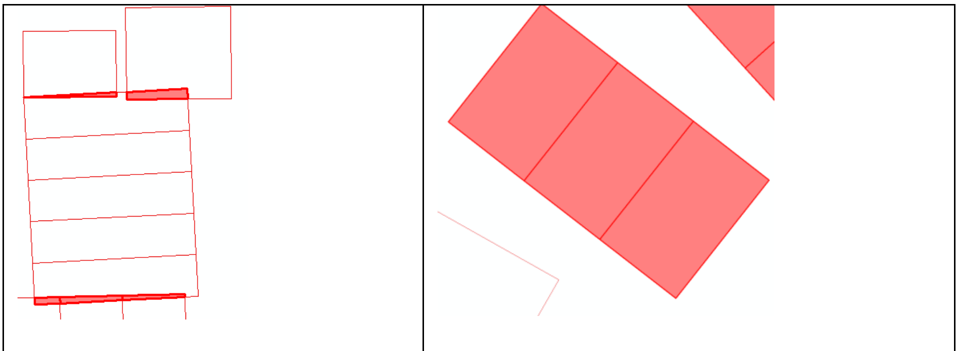
In the case of Taichung, $C_{overlap}$ of several townships was even higher than any district in Taipei. Generally, building footprints in these townships had higher resolution as compared to the reference dataset. For example, $C_{overlap}$ in the districts around Chaoyang University of Technology and Taichung Railway Station was very high. Nevertheless, in most districts, even West and South of the inner city (CBD), $C_{overlap}$ was under 7%, and it was under 4% in the low-density areas (most districts in Haixian and Shanxian). The variance of the completeness in Taichung was more significant.

In summary, the completeness of OSM building footprints in the two cities demonstrated mixed results. The variation is significant. $C_{overlap}$ reached 30%~75% in a few specific districts, but it was often low (under 10%) in low-density areas. We concluded that OSM does not represent a complete record in its current state in Taiwan. Nevertheless, the high-resolution building footprints in several districts of Taichung can be an advantage. Building footprints in these districts can benefit the user who requires a detailed edge of a specific building.

4.3 Topological Errors and Geometric Accuracy Assessment

In the topological error assessment, we found there were 182 and 3,956 overlapping errors in Taipei and Taichung respectively. The percentage was 2.9% in Taipei and 2.0% in Taichung. By contrast, there were no errors in the reference dataset. Polygons in the two datasets had no unclosed rings. The results indicated that overlapping errors were still common in OSM building footprints. Two of the most common overlapping issues identified are illustrated in Figure 7.

As for the geometric assessment, 384 buildings with a 1:1 relation to the reference dataset were sampled randomly in various locations, manually, according to 95% CL and 5% MOE. We further examined the geometric accuracy of OSM building footprints (i.e. shape similarity). Using the turning function to measure the similarity ratio, the values of the 384 sampled building footprints ranged from 0.254 to 0.929. The mean was 0.641 and the standard deviation was 0.124. We used visual analysis to check results and confirmed the threshold defined by Mooney et al (2010). Our assessment showed that only 12% of OSM building footprints with a value greater than 0.8 were very similar to the reference building. 77% of OSM building footprints with a value between 0.5 and 0.8 were regarded as dissimilar and 11% of OSM building footprints with a value under 0.5 were very dissimilar. Figure 8 shows three examples of different similarity ratios.



a. Overlapping between adjacent building footprints	b. Duplicated polygons with various resolution (3 small building footprints within the big one)

Figure 7: Examples of the topological errors

In addition to the computation of similarity ratios, we found that the number of vertices in OSM polygons was only 35% as compared to the reference dataset. Considering topological errors, the ratio of dissimilar building footprints, and the number of vertices in OSM polygons, we concluded that the OSM building footprints are mostly under-represented. The reference dataset is more complex in its building representation.

Value = 0.9182	Value = 0.6413	Value = 0.2680
"Very Similar"	"Dissimilar"	"Very dissimilar"

Figure 8: Examples of the shape similarity assessment (Base Map ©2016 Google)

4.4 Completeness Assessment of Evacuation Centers

In the final assessment, we aimed to know how many evacuation buildings have been mapped on OSM. The results showed that 58.0% in Taipei (246 out of 424) and 36.8% in Taichung (165 out of 448) of the evacuation buildings could be identified from OSM building footprints respectively. In summary, 47.1% of the evacuation buildings were mapped.

When we further investigated the cause of the incompleteness, the main reason was the activity center of each village was not mapped. In contrast, the evacuation building in education facilities (schools and universities) were mostly mapped on OSM. For example, 82% of the evacuation buildings were education facilities in Nangang of Taipei and 71% were mapped.

To use OSM as a disaster information map for evacuation, the completeness of OSM building footprints might be below user expectation (i.e. around 35%~50%). Yet, if the OSM contributor community can be made aware of the reason for incompleteness and start an action to map to specify building footprints such as activity centers, it still has a great potential to reach acceptable completeness.

5. Discussion and conclusion

OSM are regarded as a potential complementary source for any SDI initiative yet its quality is a major concern. tTo understand the weakness and potential, this chapter conducted a case study of OSM quality assessment from multi-criteria: completeness, topological errors, geometric accuracy; the case study area was set in Taiwan.

Our completeness assessment used both unit-based and object-based methods. As we found that there were duplicated polygons with various resolutions (Figure 7b), we concluded that the object-based method can deal with such errors better and reflect actual completeness. A reminder here is that processing to delete duplicated polygons can increase the accuracy of results. Future refinement of the overlap method should consider this issue. This processing might also be a requirement for the OSM contributor community.

As for completeness in different areas, we found that the areas with highest completeness were located in the CBDs, particularly a district with important transport and education facilities. Comparing our results to a previous study in Germany (Hecht et al., 2013), the completeness of building footprints in Taiwan was a bit lower; a visible difference can be perceived on OSM. Since the population density in Taipei and Taichung is much higher than the German states, this indicates that the Taiwanese OSM's contributor community has lacked sufficient motivation to map building footprints.

An interesting finding is that OSM building footprints have higher resolution than the reference dataset in several districts of Taichung. Figure 9 shows a visual comparison between OSM and the reference dataset around the Nantung district. Using the OSM dataset, a user can locate a specific building easily. Some building footprints even possess an address tag. The high-resolution building footprints in Taichung can provide more utility in the scenario of disaster management. For example, the emergency sectors need building data in high resolution to locate an exact building boundary for operations. The reference datasets do not fulfill this need (i.e. current building data in Taiwanese emergency management information system are provided by the private sector). Although the completeness of OSM building footprints is not good enough, they have great potential for research use, as high-resolution building data are often limited by access.

Further checking the production process of these building footprints through an inquiry in the OSM contributor community, we found that the features were mapped from a project by the Department of Landscape and Urban Design at the Chaoyang University of Technology. The students used the JOSM (Java OpenStreetMap Editor) governmental address data service, and Google Maps with ground surveys to digitalize the building footprints. The integration of various data and techniques helped contributors map high-resolution data. This implies that the education system itself might be the key to quality improvement of OSM. However, these high-resolution data are only available in a few districts and most building areas outside CBDs are not mapped. This causes inconsistency.

Besides, from our topological error and geometric accuracy assessment, we addressed two issues: (1) various topological errors, particularly duplicated polygons, and (2) the fact that most building footprints are under-represented. The simplified OSM building representation raises a complicated question: how good is good enough (see: Figure 9)? We further applied visual analysis of OSM in several cities, supposing that under-representation was a common issue. Perhaps OSM must develop a better standard for building representation and mapping.

Although the quality of OSM building footprints is not as great as authoritative data, it still has the advantages of open and free access. This study addresses that OSM data have the potential for finer resolution than other data sources. One lesson learned from this case study is that promoting OSM in education can enhance its quality. For example, if high school students can learn the fundamentals of OSM skills to edit and map evacuation buildings on OSM, this can help students learn about their living environment for disaster prevention. This strategy can help achieve the vision of OSM, that everyone and anyone can access underlying geodata freely, as well as enabling a resilient society. While from the point of view of geospatial education, we have to remind ourselves that such teaching plans must be promoted in both the global and local OSM communities.

OSM	The reference dataset

Figure 9: The OSM building footprints have higher resolution than the reference dataset in Taichung (Base Map ©2016 Bing, ©2016 Google)

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Chapter 14: Applying Geographic Names Information Service in High School Education of Taiwan

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Abstract

Geographic names are reflection of what people think of a particular place, including its surrounding environment, community, culture, and histories. As geographic names carry abundant spatial and historical meanings, study of geographic names may help to understand the characteristics and development of a place. In order to better manage the geographic names in Taiwan, the Ministry of the Interior (MOI) has created a comprehensive geographic names database and established a Geographic Names Information Service (GNIS) website. This research aims to explore the potential of using this website for school education. Specifically, we developed 10 teaching modules that can be used for high school classes and organized a series of workshops for high school teachers. The analysis discussed how these teaching modules and workshops were designed and the results of their applications. In summary, the findings showed that the participants felt very positive to the use of the website above-mentioned and encouraged to introduce it in the classroom. They agreed that geographic names would significantly help to develop the sense of places and strengthen the spatial thinking of students, which are important concepts and skills in geographic teaching.

Keywords: geographic names database, high school education

1. Introduction

A geographic name, which is usually given by its residents or settlers, is a major component of the identity of a place. It often portrays the characteristics of the surrounding environment, community, culture, and history of a particular place (Chen, 2006). Because geographic names carry abundant geographical and historical meanings, the study of them may contribute to understanding of the characteristics and evolution of a place (Tsai *et al.,* 2013). Taiwan has great diversity in its geography, history, and culture, so it has accumulated a rich collection of geographic names. These geographic names first appeared on maps in the early 17th century, when the Portuguese, Spanish and Dutch explorers “discovered” Taiwan. However, it was not until the late 19th century that the geographic names of Taiwan began to be surveyed and recorded comprehensively by its ruling powers, namely the Qing Empire, which claimed its sovereignty over Taiwan from 1683 to 1894, and the Japanese colonial government, which ruled Taiwan from 1895 to 1945. Today, the management of geographic names in Taiwan is an important responsibility of the Ministry of the Interior (MOI). Along with the digital archive project and National Geographic Information System project, the government of Taiwan has made great efforts to create and maintain a geographic information database and related websites since 2000. In order to manage these geographic names, which are a precious part of the heritage of Taiwan, the MOI has created a geographic names database, the "Geographic Names Information Service (GNIS)" website[11].This openly accessible website provides a wide range of data and functions. Thus, a major concern of the MOI is the promotion of the application of this website.

Research interests focused on geographic names in Taiwan are diversified. The areas of research topics include the humanities approach, focusing on ethnic issues; the ethnolinguistic perspective, focusing on languages and phonetic issues; and historical perspective, focusing on the evolution of places and names (Tsai *et al.,* 2013; Chen, 2004; Chen, 2007; Lu, 2014; Lu, 2015). In the recent decade, increasing studies have focused on relevant education issues. Chien (2003) noted the advantages of integrating geographic names into native education in elementary and high school curriculums, yet comprehensive information on the development and transformation of geographic names in Taiwan is lacking. Chen (2005) noted the importance of geographic names in map teaching and created sample teaching materials on classification of geographic names. Yu (2002) also suggested that geographic names are important components of maps and stressed the importance of accurately marking geographic names on maps.

Supported by the MOI, this research team conducted a series of tasks to promote the GNIS website and database. Among the many possible applications and potential users, we think high school teachers are the most promising targets of promotion. An important reason is that students begin to learn about the history

[11] The website address: http://gn.moi.gov.tw/GeoNames/index.aspx

and geography of Taiwan in high school. It should also be noted that, with democratization of the society and the rising awareness of the Taiwanese identity, the emphasis on history and geography in school education has increased over the past two decades. Furthermore, since use of Geographic Information System (GIS) is currently promoted in high school education in Taiwan, open GIS resources such as the GNIS could be an inspiring tool for both teaching and learning.

Therefore, this research attempted to explore the potential for applying the GNIS website to high school teaching. Specifically, we developed 10 teaching modules and organized a series of workshops for high school teachers. The rest of this chapter consists of three sections and a conclusion. Section 2 discusses the nature and value of geographic names in Taiwan. Section 3 introduces the content and functions of the GNIS website. Section 4 describes our promotion efforts and the results. The chapter concludes with a summary of the study and the important findings.

2. Geographic name in Taiwan

The geographic names in Taiwan are quite diverse due to both geographical and historical reasons. Geographically, the physical environment and cultural landscape in Taiwan are very rich, thus providing many characteristics that lend themselves to place names. For example, the features of mountains, rivers, plains, vegetation, and local animals have widely been adopted as the names of places. Furthermore, Taiwan is densely populated, with settlements of various sizes spread all over the island. Each place requires a name to differentiate it from others. Historically, in addition to its indigenous people, Taiwan has accommodated explorers or settlers from many different countries, such as Spain, the Netherlands, China and Japan (Abe, 1937; Sun, 2007). These people brought or created names for places in Taiwan. As a result, a single place in Taiwan may have several different names that reveal the environmental perceptions and cultural heritages of the various peoples who once lived here. Even among the Chinese immigrants who immigrated to Taiwan at different times, the Hoklo, Hakka, and Mandarin speakers often used different words in various dialects for the same features (Wei, 2004). All these factors have contributed to the diversity of geographic names in Taiwan.

According to Abe (1938), a Japanese scholar who pioneered the study of geographic names in Taiwan during the Japanese colonial period, Taiwanese geographic names derive mainly from five sources: natural topography, natural resources, land development and ethnic groups, industrial production, and oral histories. Based on Abe’s findings, we further categorized the geographic names in Taiwan into the following six groups:

(1) Topographical features: Located at the boundaries of tectonic plates and strongly influenced by active geological processes, Taiwan has very

complicated landform. The terrain of an area may change dramatically within a short distance. These abundant terrain features are often adopted for naming places, such as *San-Jz-Jiao* (山仔腳; foot of hills), *Pin-Ding* (坪頂; top of terrace), *Lun* (崙; hill) . Overall, topographical features are the most prominent attribute of geographic names in Taiwan (Abe, 1937; Chen, 1993).

(2) Plants /Animals: The flora and fauna of a landscape are commonly adopted in naming places as well. For example, *Citong* (莿桐; erythrina variegata), *Jiadong* (茄苳; autumn maple tree) and *Jiuqiong* (九芎; subcostate crape myrtle) are plant names, while *Lu* (鹿;deer), *Qiang* (羌/羗; muntiac), *Gui* (龜; turtle) are animal names widely used in geographic naming in Taiwan (Wang *et al.,* 2006). These names reflect the local plants or animals of the area. Furthermore, the plant or animal names are often combined with other spatial terms (such as up, down, or foot) to form a full name (Shuie, 2006).

(3) Land Development: Along with the development of land and agricultural reclamation, explorers 200-300 years ago established collaborative organizations to jointly develop areas in Taiwan. The cooperation modes of these organizations were often conferred on the areas being developed, such as *Wugu* (五股; corporation of five interested parties) (Shiu 1996). Besides developments conducted by the private sector, some developments were conducted by official rulers assigning military forces to different areas, resulting in places names such as *Xinying* (新營; New Camp), *Zuoying* (左營; Left Camp) and *Linfengying* (林鳳營, Lin-feng Camp) (Jhang, 2012; Lee, 2008).

(4) Industrial production: This type of geographic name is related to plantations or agricultural productions (Lin, 1997). Since the 17th century, tea, sugar and camphor have been important local industries in Taiwan. Therefore, many places names are associated with these economic activities, such as *Zhangliao* (樟寮; the place where camphor is produced).

(5) Ethnic groups: The peoples of different ethnic groups created geographical names based on their own cultural backgrounds. A common example is that the Hakka people would use the word *Wu* (屋) in the name of a small village, while the Hoklo people would use the name *Cuo* (厝) for the same entity. Such geographic names reveal the cultural and ethnic backgrounds of the early settlers (Wei *et al.*2013; Wei, 2004).

(6) Indigenous people: Before the arrival of Han immigrants, the indigenous people created geographic names for their own use. Many of these names have been lost, while some have remained preserved in the oral languages of the surviving tribes. In addition, some geographic names related to indigenous people were associated with Taiwan’s colonial history. For

example, names with *Fan* (蕃; native people) and *She* (社; native tribes) were given by the Japanese during the colonial period, which indicated settlements of indigenous people (Lu, 2014; Lu, 2015).

The categories listed above are commonly used in the study of geographic names in Taiwan. As the environment in Taiwan has been changed dramatically by urban and industrial developments over the last century, early geographic names may help us to comprehend the history and environmental change of an area. This is a unique value of geographic names in Taiwan.

3. Content and Functions of the GNIS

In order to better manage these geographic names, the MOI has created a comprehensive geographic names database and established the "Geographic Names Information Service (GNIS)" website. This openly accessible website provides a wide range of data and services. In terms of the database, GNIS contains more than 110,000 records of geographic names. Each record is composed of several fields, including the name, coordinates, type, description, and data sources. Users can query and plot the results on a map. With such a comprehensive database as the core, this website provides several useful functions as introduced below.

(1) Keyword Query: This function allows users to input keywords of geographic names and search the geographic names database. The query results can be listed as a table and shown on an interactive map. Users can select certain query results and read their backgrounds. In addition, users can export the query results into a .KML file that can be used in Google Earth or other GIS software such as ArcMap or Q-GIS. These functions allow users to further explore the locations or analyze spatial patterns of certain geographic names in combination with other GIS tools.

(2) Map Query: The main interface of this website is a map query system composed of two sets of maps, a base map and feature map. The default base map is a ‘General’ Map of Taiwan, the official digital map maintained by the Bureau of Surveying and Mapping. Users can switch the base map into aerial ortho-photos provided by the same agency as well. On top of the base map, users can choose to overlay a series of scanned historical maps dating back to 1904. As maps are a major source of geographic names, these comprehensive maps provide good sources for potential users who are searching for geographic names and studying environmental change of Taiwan.

(3) Administrative boundary query: The website provides options to query administrative boundaries at city/county, district/township, and village levels. The results are shown on the base map and/or feature maps, allowing users to explore the area of interest using maps from various times.

(4) Spatial Positioning: This website allows the user to import the coordinates of a specific location to show the existing maps. In addition, it also allows users to explore the geographic names and their surrounding areas of certain location.

(5) Digitizing: This function allows users to digitize a specific feature of interest derived from the map layers provided and to store the digital result as a .KML file. This feature of interest can be a point, line, or polygon. This function also allows users to digitize features from one map and save them as a main layer for another use, such as overlaying it on another map or for GIS analysis.

(6) Name Translation: This function provides the official English translations of geographic names in Taiwan. In addition, users can choose to translate the names by single input (for one-by-one search) or by batch input (for multiple searches, by uploading a list of place-names).

As introduced above, this website was created with GIS facility in mind. The database of geographic names is composed of coordinates that can be an input to different GIS tools. However, compared to other open GIS tools like Google Earth, the GNIS has three major advantages. First, it provides information about the meanings of geographic names rather than merely showing their locations. Second, the website provides a series of geo-referenced historical maps that allow users to compare the names of a place at different times and observe their transformations in relation to land-use changes. Third, the query functions make it possible to study the spatial pattern underlying a group of geographic names. For example, one can search for place names with the same keyword and explore their distributions. In this way, the relation between geographic names and other environmental characteristics, such as topographical features and distributions of ethnic groups, can be visualized better.

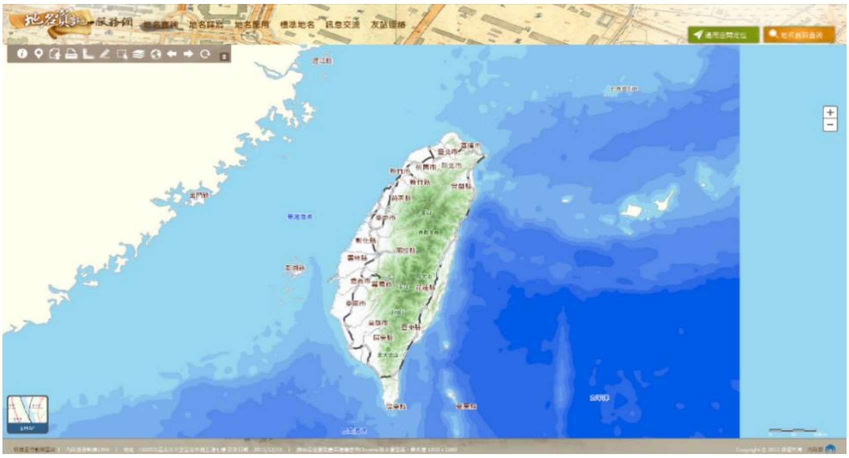

Figure 1: The home page of the GNIS provides six main functions, including keyword query, map query, administrative boundary query, spatial positioning, digitizing, and name translation

4. DISSEMINATION AND PROMOTION

4.1. Development of teaching modules

We developed ten teaching modules involving the application of the geographic names database. All 10 of the teaching modules are aimed at high school education in Taiwan. These modules were designed to cover different topics of the six categories of geographic names as mentioned in Section2. The specific topics are shown in Table1.

Each teaching module is composed of two parts. The first provides descriptions of the geographic names, and the second focuses on the applicability of the GNIS. With clear aims in mind, these modules provide examples of applying the GNIS in classes. Below, an example module is briefly introduced to demonstrate the relationships between a terrain features *Wo*, ethnic issues and geographic names.

The terrain feature of *Wo* (窩) was chosen for this module. The name *Wo* is a term originating from the Hakka dialect and refers to a narrow mountain valley. We queried the geographic names database to identify all names containing *Wo*. The result of this query is shown in Figure 2.

Table1 Topics of teaching modules

TOPICS	OUTLINE
Terrain	Names associated with terrain features
Plants / Animals	Names associated with local plants or animals.
Hydrology	Names associated with hydrological features
Industry	Names associated with industrial developments
History	Names associated with history issues
Ethnic	Names associated with different ethnic groups
Indigenous	Names originating from indigenous people
Politics	Names associated with political influences
Land development	Names associated with the development of land in early Taiwan
Koxinga	Names associated with Koxinga, a historical figure in Taiwan

	名稱	類別	標準地名	縣市	鄉鎮市區
定位	山豬窩	聚落	否	新竹縣	芎林鄉
定位	松樹窩	聚落	否	新竹縣	芎林鄉
定位	宋屋窩	聚落	否	新竹縣	芎林鄉
定位	烏龜窩	聚落	否	新竹縣	芎林鄉
定位	芎蕉窩	聚落	否	新竹縣	芎林鄉
定位	牛欄窩	聚落	否	新竹縣	芎林鄉
定位	牛角窩	聚落	否	新竹縣	芎林鄉
定位	燒炭窩	聚落	否	新竹縣	芎林鄉
定位	下窩子	聚落	否	新竹縣	芎林鄉
定位	桔子窩	聚落	否	新竹縣	芎林鄉
定位	茄苳窩	聚落	否	新竹縣	芎林鄉
定位	安屋窩	聚落	否	新竹縣	芎林鄉

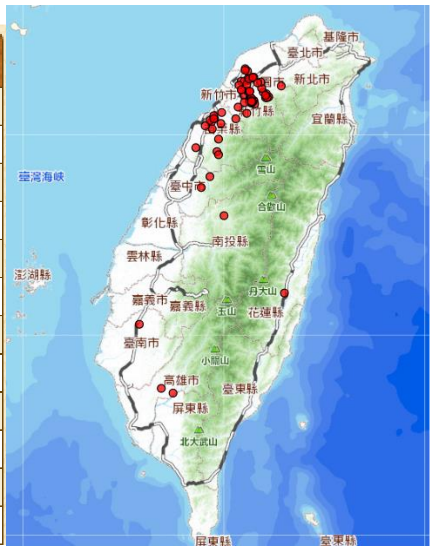

Figure 2: Wo distribution in Taiwan. The right map shows the locations of all geographic names with Wo. The left table shows the attributes of each of these locations, including its coordinates, geographic name, and administrative county and district name

As shown on the map, these name features appear mostly in Taoyuan, Hsinchu, and Miaoli Counties, where the majority of the population is ethnically Hakka. We further exported the results into a .KML file so that it could be displayed in 3D using Google Earth software (Figure 3). This example shows how a place name can be related to an ethnic background and a certain terrain feature.

Figure 3: The appearance of terrain with Wo (窩)

4.2. Organizing workshops

To promote the teaching modules, we organized eleven workshops in 2015 mainly targeting high school teachers; however, the workshops were open to anyone with interest. Each workshop lasted about 3 hours, during which each participant used a computer for hands-on experience. The content of the workshops included two parts: 1) background knowledge of geographic names, and 2) application of the GNIS website. At the end of the workshop, each participant was asked to complete a task described in a digital slideshow (in Microsoft PowerPoint) regarding how to use the geographic names in a teaching plan.

4.2.1. Teachers' feedback

The eleven workshops had a total of 368 participants. Among these participants, the high school teachers accounted for 75%, whereas the rest 25% included the non-teaching participants (11%), elementary school teachers (9%), and university students (5%). It is worth to note that the participated high school teachers had diverse backgrounds. While the majority of them were geography teachers, they also included history, math, civic education and English teachers.

The questionnaire results clearly showed that the high school teachers appreciated the way the GNIS website could be used in classes. In general, they agreed that the website could facilitate student learning about issues related to the usage of geographic names and solve geographic problems. More specifically, rich information, interesting topics and visualization functions were considered as the major advantages of using the GNIS in classroom. Most of the teachers expressed their willingness to use the website in their classes, given sufficient time and facilities. In summary, the teaching modules were viewed favorably by the teachers. They indicated that these modules provided inspiration for both teaching and learning. They also strongly recommended that relevant workshops could be organized regularly in future.

According to the evaluation questionnaires, all the participants gave the workshops an average satisfaction rating of 4.5 out of a maximum score of 5. Overall, the participants were most greatly impressed by the numerous historical maps and the query functions of the geographic names database. In addition, the interactivity of the historical mapping and the option of exporting query results to KML format were considered very useful.

4.2.2. Suggestions for the GNIS

Based on the feedback from the workshop participants, we developed suggestions for the future development and application of the GNIS website.

(1) The use of the GNIS website should not be limited to only geography classes, but open to the teaching of various subjects, such as history, biology, and geology. Geographic names can help students to learn about the early environment and development of a place, which is key to a wide range of knowledge, such as the development of hometowns, climate change, and human-environment interactions. Accordingly, the website functions should be extended to allow multi-disciplinary use, and relevant teaching modules and workshops specific to other subjects should be developed.

(2) The geographic names and their positions should be better integrated. The location of a particular geographic name is crucial to its application. However, because many of the place names in the database lack coordinates due to the inherent ambiguities of historical maps, they cannot be located with GIS. The major difficulty is that many place names cannot be pinpointed to an exact position. Still, for most applications and users, an approximate position or additional textual information will be helpful for users to refer the places names and to explore their spatial contexts.

(3) Digital audio files should be linked to the place names of the site so that users can be sure of the pronunciation. The pronunciation of geographic names is important and useful to their application because very often, a name may carry different meanings depending on its linguistic origin. Therefore, the pronunciation of the name may help to eliminate such ambiguity. Compared to the conventional maps or databases on chapter, it is easier to combine phonetic information (e.g. by recording the pronunciation in a digital audio format) with digital map databases nowadays.

(4) The GNIS could be combined with mobile devices to provide better accessibility to users. This design might facilitate outdoor teaching or other uses in various activities.

5. Conclusion

The importance of geographic information skills has been recognized and gradually included in textbooks or the national curriculum in many countries. Since geographic names are important components of geographic information, the promotion of the study of geographic names will enhance students' learning of geographic information. Although the existing high school education in Taiwan has long regarded map reading an essential skill, little attention has been given to the derivations of geographic names. However, through the development of the geographic names database and relevant websites, it is currently feasible for school teachers to highlight the origins of geographic names and to show the meanings of such names in a geographical and historical context.

Through the efforts of developing teaching modules and organizing workshops, we investigated the potential for application of the GNIS website specifically in high school education. According to the questionnaire results, the teachers who participated in workshops on the teaching materials provided positive feedback and felt encouraged to incorporate the website into their classes. Nevertheless, some suggestions for improvements are still provided as guidance for the future development of the website in terms of both information about place-names (i.e. better accuracy of locations, integration with audio information) and service functions (i.e. combination with mobile devices).

Last but not least, the participants of our workshops demonstrated that geographic names are attractive to not only high school teachers, but people with diverse backgrounds and professions. Therefore, how to create multiple functions of the GNIS and to promote it to the general public is an important issue for future research.

6. Acknowledgement

This research was supported by the Ministry of the Interior (MOI), Republic of China (Taiwan). The authors are very grateful to the MOI for providing the research grant and the data.

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SPATIAL ENABLEMENT IN A SMART WORLD

Spatial enablement is a concept implicit in the importance of location for developing the 'smart cities' and 'smart communities' concepts. Considering this, as well as the different systems, policies, institutional arrangements, technologies, environments, procedures, and strategies already in place, gives us the opportunity to examine how far we have progressed in spatially enabling 'smart city' and 'smart country' initiatives worldwide, in addition to what still needs to be done.

This book is divided into two parts, each part focussing on different aspects of applying spatial data or spatial technologies to deliver Spatial Enablement in a Smart World. The chapters are written by authors from twelve different countries across five continents and describe a combination of new developments and lessons learned in this journey towards achieving a spatially enabled smart world.

All chapters have gone through a full peer review process as part of the 15th Global Spatial Data Infrastructure Association (GSDI) Conference with the theme 'Spatial Enablement in Smart Homeland'.

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ISBN 978-0-9852444-5-3

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GSDI Global Spatial Data Infrastructure Association

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