Developing a Framework to Improve the Implementation of Geospatial Technology in the Planning and Delivery of Infrastructure for Residential Areas in Saudi Arabia: A Case Study of Riyadh City

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Abstract

Over the past five decades, Riyadh, the capital city of Saudi Arabia, has witnessed many organisational, economic, social and demographic transformations, all of which have contributed to its rapid growth. This growth, which exceeded the city's plans to meet the needs of a growing population, resulted in many neighbourhoods experiencing limited services and utilities. Along with governmental efforts to manage the spread of residential areas, several agencies accountable for providing residential services have sought to exploit the potential of geospatial technologies as a means for improving the planning, management and decision-making processes needed to address these issues. Government support has provided a major boost towards the improvement of geospatial technology usage in different areas. However, the use of these technologies in the context of residential infrastructure delivery is limited. This research investigates empirically how the implementation of geospatial technologies can be improved in the agencies concerned with the delivery of residential infrastructure, with the aim of developing strategies to enhance the exploitation of the available technologies in support of decision-making. To achieve the research objectives, the researcher carried out an extensive review of the literature, official reports and documentation, and conducted a Delphi study through three successive consultation rounds, involving a set of experts representing all concerned agencies. The results revealed that shortcomings in organisational, technical and human aspects are the primary reasons behind the limited use of geospatial technology tools in the planning process for residential infrastructure delivery. This in turn assisted in the development of consensus-based strategies for addressing these issues. The research contributes to the existing body of knowledge in the field of urban studies by offering a better understanding of how the employment of geospatial technology tools could be improved in the context of residential infrastructure delivery in rapidly growing cities in general, and the city of Riyadh in particular. It also offers a practical contribution to decision makers in the agencies concerned with residential infrastructure delivery, who work to improve the activities of these technologies to achieve the best use of their implementation. The research results are expected to help researchers to conduct further studies on the development of the use of geospatial technologies in the context of Saudi Arabia.

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List of Abbreviations and Acronyms

ADA	Arriyadh Development Authority
AMA	Agency of Municipalities Affairs
CSD	Central Survey Directorate
DSS	Decision Support Systems
GAS	General Authority for Statistics
GCS	General Commission for Survey
GDCD	General Directorate of Civil Defense
GDE	General Directorate of Education
GIS	Geographic Information Systems
GISTIC	GIS Technology Innovation Centre
GPS	Global Positioning Systems
HCDA	High Commission for the Development of Arriyadh
HTML	Hyper Text Markup Language
ICT	Information and Communication Technologies
KACST	King Abdulaziz City for Science and Technology
KSA	Kingdom of Saudi Arabia
MOMRA	Ministry of Municipal and Rural Affairs
NCGIS	National Committee for Geographic Information Systems
NGO	Non-Governmental Organisation
NPS	National Population Census
NSDI	National Spatial Data Infrastructure
NWC	National Water Company
OECD	The Organisation for Economic Co-Operation and Development
PHP	Hypertext Preprocessor
PPGIS	Public Participation Geographic Information Systems
RS	Remote Sensing
SDI	Spatial Data Infrastructure
SEC	Saudi Electricity Company
SGS	Saudi Geological Survey
SP	Saudi Post
STC	Saudi Telecom Company
TUGI	The Urban Governance Initiative
VRML	Virtual Reality Modeling Language
XML	Extensible Markup Language

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Declaration

I declare that the work contained in this thesis has not been submitted for any other award and that it is all my own work.

I declare that the total thesis word count is 66,044 words, excluding appendices and academic references.

Name: Mohammed Hassan Alqarni

Signature:

Date:

Chapter 1: Research Introduction

1.1 Research Background

The rapid increase in urban growth is a major issue in many cities. It results from the economic, political, environmental, demographic, cultural and social transformations in urban areas. These transformations help influence the ability of urban areas to meet their residents' needs in terms of infrastructure and service. Although patterns in this growth vary from one urban area to the next, it often results in the expansion of residential areas.

Urban infrastructure and public facilities are essential elements to consider when developing these areas. Shortcomings in basic infrastructure resulting from expansion can be a major challenge posing a catalyst for worsening housing conditions and a direct threat to the delivery of adequate living conditions for residents. Reducing the burden on the urban infrastructure represents a salient issue for governments that are typically responsible for the delivery of these services. Therefore, their responsibilities, particularly when facing the pressure of rapid urban growth, have become more difficult. This requires undertaking a better approach to improving institutional capacity, coordination, planning and funding to ensure coordinated delivery of such infrastructure and services able to keep up with this growth and limit any adverse effects.

Although government structures differ between countries and cities, the integration and participation of stakeholders in decision-making processes has emerged as an important aspect of infrastructure delivery issues in many countries. The capacity of governments to improve urban governance, the reconfiguration of authorities between the local and national levels, and the development of practical and effective tools to support coordination and information-sharing between all stakeholders involved in planning and decision-making, have become one of the major topics that have gained increasing attention when considering how to deal with such issues (Schübeler, 1996; Shah, 2006; McFarlane and Rutherford, 2008; Omar, 2009). This involves a complex set of

relationships between the various stakeholders benefiting from relevant decisions and actions.

The continuing development of Information and Communication Technologies (ICTs) has responded to the needs and aspirations of governments who aim to enhance these trends. The literature on this topic suggests that the use of these technologies has considerable potential to assist with decision-making and to improve the flow of information required to support these tasks in a positive manner, which justifies the growing interest in developing the use of ICT (Lee et al., 2008; Yigitcanlar, 2008; Ahmed et al., 2013).

A wide variety of ICT tools are currently used, of which geospatial technologies are some of the most common. The wide range of tools available includes geographic information systems (GIS), satellite and airborne remote sensing (RS), and global positioning systems (GPS). What distinguishes these technologies from other forms of ICT is their ability to manage and link different datasets that are represented spatially, and to easily and reliably allow concurrent access by multiple users. This growing use has provided an impetus to the continued development of their use in the context of infrastructure delivery, especially with regard to developments in web technology. However, the existence of these tools and data is not sufficient to achieve the full benefits of their implementation. Similarly, the opportunities and challenges involved in the implementation of these technologies differ from one place to another; it may therefore be argued that there is no specific strategy that could address all relevant issues and ensure successful implementation.

In Saudi Arabia, the government is clearly aiming to enhance the efficiency and performance of government agencies in the management of many service projects, and infrastructure and development plans and programmes. In addition to improving public information infrastructure, it aims to increase the efficiency of spatial data services to enable better decision-making and to facilitate coordination between different authorities.

This support has had a major role in disseminating geospatial technologies and contributed to the development of high-quality spatial data produced by different agencies.

Because of the importance of such technologies in this field, several government and private sector agencies concerned with residential infrastructure delivery depend on their large-scale use, and they are advancing rapidly. However, the implementation of geospatial technology tools faces a number of issues affecting their utilisation in the context of delivering those services. This research therefore seeks to explore the reasons behind this and identify how the agencies might achieve the desired benefits of using these tools.

1.2 Statement of the Research Problem

Cities in Saudi Arabia have undergone rapid changes in their patterns of growth in a short space of time. This growth is associated with the economic boom that followed the export of oil, and helped bring about a number of social, economic and political transitions. This led to restructuring in the functions of urban areas.

The capital city of Riyadh has witnessed accelerated changes associated with its transformation into the country's political, administrative and economic centre. This has had a huge effect on its growth and has led to rapid development. The growth in population rates has also increased, and it has become the largest urban agglomeration in Saudi Arabia in terms of area and population. As a consequence of this rapid growth, the city has faced major challenges in terms of controlling its spatial expansion and the continuing increase in the establishment of residential areas to meet the demands of that growth.

Accordingly, the government has adopted numerous urban planning policies in an attempt to deal with the growing spread of residential areas. This included the adoption of urban growth boundaries within the specified time frames to limit urban development

outside the city boundaries, and to coordinate the provision of urban infrastructure, services and utilities for reducing the associated high costs of delivery. However, the multiplicity of agencies responsible for urban infrastructure provision, weaknesses in coordination and participation, inadequate data and inaccuracy in the information available have made it difficult to address decision-making issues. This in turn has resulted in the city's current spatial pattern growth not being accompanied by the requisite urban infrastructure, in spite of the enormous government investment on its provision. Therefore, many residential neighbourhoods lack some of the basic services and utilities.

The majority of these agencies have thus sought to exploit the potential of geospatial technologies to improve the planning processes and decision-making in order to meet the requirements of infrastructure in residential areas. This has been accompanied by government support in the use of such technologies in an attempt to improve the performance of public agencies and the level of coordination and service delivery. However, these efforts have so far, been inadequate in achieving such goals. At the present time, each agency has their own independent implementation processes due to the absence of strategies and standards that organise implementation of their activities, along with a lack of coordination between agencies at various levels of government (Al-Ankary, 1991; Kubbara, 2002; Al-Shahrani, 2002; Algarni, 2006; Alshehri, 2007; Al-Ramadan, 2009; Alsultan and Rahman, 2015). This contributed to a significant degree of duplication and redundancy of efforts, difficulty in the exchange of data and financial wastage, which in turn limited the employment of these technologies, compared with the development of their use in many of the agencies, in coordinating efforts related to infrastructure delivery in urban areas, especially in the context of residential neighbourhoods. This research therefore explores the critical issues and challenges facing the implementation of these technologies, with the objective of improving the exploitation of their potential to support decision-making in the planning of residential infrastructure delivery.

1.3 Research Aim and Objectives

The research seeks to identify the factors that limit the use of geospatial technologies in the context of residential infrastructure delivery. It highlights the challenges affecting the exploitation of the available technologies in the agencies concerned with the delivery of infrastructure, and the extent to which they utilise these technologies to provide services to keep pace with Riyadh's rapid growth. The main aim is to develop strategies for improving the implementation of geospatial technologies, in supporting decision-making in the planning of residential infrastructure delivery.

To achieve the main aim, the following research objectives were formulated:

Objective 1. To critically review concepts of urban growth and the measures being undertaken to address its negative effects on infrastructure in residential areas.

Objective 2. To identify the role of geospatial technologies in improving decision-making and planning for infrastructure delivery.

Objective 3. To consider the organisational context of residential infrastructure provision and the extent of the contribution of geospatial technologies for relevant decision-making in the case of Riyadh.

Objective 4. To explore the factors influencing the implementation of geospatial technologies within the agencies responsible for residential infrastructure delivery in Riyadh city.

Objective 5. To provide insights and guidance into how to improve the exploitation of geospatial tools to support residential infrastructure delivery in the context of Riyadh city.

1.4 Scope of the Research

Geospatial technologies have gained increasing importance in various fields because of their ability to handle, manage, analyse and facilitate access to spatial information. Developments in ICT in general and in geospatial technologies in particular in recent

decades have led to various types of uses that can be exploited in different contexts. In the Saudi context, these technologies are widely used by many public and private sector agencies to support their daily tasks. This study looks at agencies responsible for urban infrastructure in sectors that have benefited from and adopted the use of these technologies as tools to support the planning and implementation of various projects. This made it difficult to examine all aspects related to the use of such technologies within the scope of a single research study. Therefore, this research only focuses on improving the implementation of geospatial technologies in the agencies concerned with the planning of residential infrastructure delivery in the city of Riyadh in order to enhance their capability to deliver services to keep pace with the city's growth.

1.5 Significance of the Research

Geospatial technologies have created new opportunities for involvement in spatial decision-making, and as a channel for accessing information they are becoming more frequent in many fields. Therefore, they have gained considerable attention from both researchers and practitioners. In the Saudi context, many studies, particularly in the field of urban studies, have examined the use of geospatial technology tools. The review of the available literature indicates that the majority of the key themes in these studies revolve around issues related to spatial data, or refer to the use of specific geospatial tools and applications in different contexts. However, a small number of academic studies have investigated the use and benefits of their implementation in the context of residential infrastructure delivery.

The significance of this research study lies in highlighting the organisational and technical issues surrounding the implementation of geospatial activities in the agencies responsible for delivering those services. In addition, it seeks to explore the factors behind the repeat of effort and lack of coordination and cooperation between these agencies. Furthermore, it intends to identify deficiencies that influence existing uses, and

understand the reasons that have limited the extent to which such tools can be relied on to enhance decision-making processes.

The principal outcomes from this research will consist of a set of appropriate measures for the improvement of geospatial activities in terms of their adoption and use in the context of residential infrastructure delivery. These measures will help relevant agencies to understand the challenges facing the implementation of these technologies, avoid the duplication of effort, and reduce the associated implementation costs. Furthermore, the outcomes of the research will assist the responsible agencies to improve collaboration, integration and citizen participation, provide services electronically, and facilitate the performance of their daily tasks, decision-making, and planning. The results will also help address issues related to the collection, management, exchange, access and flow of geospatial data and information between all stakeholders, which has significant implications for achieving the benefits of geospatial implementation. Moreover, this research will be of benefit to both academics and practitioners wishing to conduct further research in this field.

1.6 The Structure of the Thesis

This research study consists of eight chapters, followed by references and appendices. A brief description of the chapters is given below:

Chapter 1 introduces the background to the research. In addition, it sets out the description of the problem, aims and objectives, followed by a description of the scope of this research. The chapter also provides a summary of the research structure and the content of the following chapters.

Chapters 2 and 3 cover the literature review. Chapter 2 includes a review of the literature on urban growth; this includes an explanation of key concepts, patterns and causes associated with this phenomenon. It then describes its impacts on infrastructure and basic services in urban areas in general and residential neighbourhoods in particular. The chapter also discusses the issues influencing the provision of residential

infrastructure and highlights the dimensions of urban governance and its role in improving decision-making to address the delivery of these services. Chapter 3 provides an inclusive view of the importance of ICTs as tools for supporting those decisions, and describes the potential of geospatial technologies in this context. The chapter also outlines the challenges and factors that limit their implementation in relevant tasks.

Chapter 4 presents the methodology used in this research. It provides an overview of philosophical paradigms, and explains the necessary approaches and strategies required to carry out the research. It also discusses the choice of the research population, describes the methods used to obtain information and for data collection, and the data analysis procedures used. In addition, the chapter introduces the ethical considerations and summarises the limitations of this research.

Chapter 5 provides an in-depth background to urban growth and development in the city of Riyadh, and presents a detailed explanation of the institutional arrangements, with a focus on systems and policies related to residential infrastructure delivery and the roles of relevant agencies in decision-making, policy development and implementation. The chapter presents an overview of the development of geospatial technologies, and highlights governmental efforts to promote the efficient use of such technologies, followed by a description of the current use of these technologies in the context of residential infrastructure delivery.

Chapter 6 explores the status of the implementation of geospatial technologies in the agencies responsible for residential infrastructure delivery, and identifies the factors affecting the adoption and use of the available tools of these technologies in the context of residential infrastructure delivery.

Chapter 7 presents a number of strategies aimed at improving the exploitation of these technologies in the planning of residential infrastructure delivery based on the results reached in Chapter 6. It also includes a discussion of the results of the research.

Finally, Chapter 8 summarises the main findings of the research and outlines the research contributions. It also summarises the research limitations, followed by recommendations and suggestions for further research.

1.7 Summary

This chapter has presented an introduction to the research study. It has given an overview of the research study and presented a problem description. The research aims and objectives, the research scope, and the significance of the research were also introduced. The chapter concluded with the structure of the thesis in terms of the number of chapters and their content.

Chapter 2: Urban Growth and its Implications for Infrastructure in Urban Areas

2.1 Introduction

According to the UN (2011), the majority of the world's population now reside in urban areas which will grow at an unprecedented rate in the next 40 years to 70 per cent of the global population by 2050. Although the standards distinguishing urban areas from suburban or rural areas are different from country to country, urban growth in developing countries is high compared to developed countries (Anjaneyulu et al., 2004; Michelangeli, 2015).

The drivers of urban growth and its impacts differ from one area to another and require proper planning and coordination among stakeholders at various levels in order to reduce the negative effects. Adequate urban infrastructure is a critical element in achieving balanced urban growth. Therefore, it has become imperative to create appropriate policies and institutional arrangements able to cope with this growth.

This chapter critically reviews literature on the concept of urban growth and the importance of urban governance in the context of residential infrastructure delivery. The first part examines the concept of urban growth and understand the modern manifestations of this in urban areas. It critically analyses the concept and components of infrastructure, and the factors affecting its provision in order to explain how rapid urban growth affects urban infrastructure and services in residential areas. The second part aims to critically review the definitions and key features of urban governance and its roles for addressing the issues related to delivery of infrastructure of residential areas.

2.2 The Concept of Urban Growth

Historically, the first cities emerged as early as 5,500 years ago, resulting from a number of interrelated factors such as space, population, social organisation, economic, religious and political factors that played an integral role in the formation and growth of urban communities (Paddison, 2000; Frey and Zimmer, 2001). However, the volume of surplus products imposed a ceiling upon growth in these communities (Wheatley, 1971, cited in Clark, 1998). Meanwhile, Paddison (2000) suggests that the real change occurred with the industrial revolution in the nineteenth century. This in turn made it possible for large numbers of people to live in urban centres and resulted in a change in population distribution and urban living patterns.

Urban growth is a global issue, has been the subject for acute debate and has attracted considerable attention of researchers in contemporary urban studies. The majority of these studies focused on aspects related to managing, measuring, monitoring urban growth and analysing its patterns. Furthermore, several studies discussed this phenomenon in different contexts, whether demographically, ecologically, economically, organisationally, socially and behaviourally.

In the literature, there are different definitions of urban growth. According to the definition provided by Han et al., (2009, p.139), "urban growth is a complicated process involving the spatio-temporal changes of all socio-economic and physical components at different scales". In other words, this process includes a number of variables such as the immigration of population to urban areas, urban sprawl, loss of agricultural land, climate change and increased air and water pollution. It also denotes the rise in populations in urban areas often linked to various demographic and socio-economic activities that involve spatial interactions, which bring about various changes, such as change in land use and spatial sprawl or expansion (Clark, 1982; Bhatta, 2010; Azari and Reveshty, 2013). In addition, the term urban growth can be defined as "a spatial and demographic process and refers to the increased importance of towns and cities as concentrations of

population within a particular economy or society" (Clark 1982 cited in Abdou Azaz, 2004, p.1). Furthermore, it can be loosely described as "a result of physical and human impacts" (Azari and Reveshty, 2013, p.993).

Although there are clear definitions of urban growth, Bhatta (2010) indicates the terms urban growth, urban sprawl and urban expansion are sometimes used as synonymous terms, and argues that urban expansion is one of the urban growth forms, and urban sprawl is considered one of its characteristics. Meanwhile, Ujoh et al. (2010) claim that urban sprawl is a direct consequence of urban growth and expansion. While, Zeng et al. (2014, p.2) state that "urban sprawl can be interpreted as a specific form of urban expansion or urban growth, and these expressions are interchangeable with each other in most cases". From the above, it can be noted that the concept of urban growth has been interpreted in different ways within the literature. This in turn has led to the emergence of many characterisations that describe this phenomenon, varying in developed and developing countries. Therefore, urban growth characterisations can be interpreted both positively and negatively.

In some situations, urban growth is described as one of the undesired trends facing urban areas and brings with it several environmental, health and socio-economic problems (Han et al., 2009). This can be noted in descriptions used by researchers to express urban growth, and associated it with the rate at which urban issues increase, such as urban infrastructure, demand for residential accommodation, increased height and density of buildings, overcrowding, unemployment and poverty, increased pollution, water overconsumption and increased racial and economic disparity (Narayana, 2008; Castro et al., 2009; Teriman et al., 2009; Liu and Feng, 2012; Yucel et al., 2016).

Conversely, a second group of researchers (e.g. Tolley and Thomas, 1987; Barnes et al., 2001; Mendez de Martinez, 2007; Antoni et al., 2008) argue that urban growth plays a significant role in promoting economic and social development, as well as improving service quality. However, Bhatta (2010) argues that this growth can be economically efficient, but may lead to uncontrolled urban growth. Similarly, Fodor (1998) claims that

environmental and social costs on urban areas may be even higher in the long run. Therefore, the challenge lies in how to take advantage of the potential benefits of urban growth and the ability to reduce negative impacts.

2.2.1 Causes of Urban Growth

Several issues and factors have contributed to the formation of urban growth. According to the relevant literature, the causes associated with urban growth are diverse and complex (Pumain et al., 1997; Ewald et al., 2006; Cuadrado-Roura and Güell, 2008). However, a growing population and economy can be considered the main causes behind the growth in urban areas (Brockerhoff, 1999; Fodor, 1999; Lu et al., 2013).

In urban areas, the phenomenon of population growth is often a result of the natural rate of population increase/decrease. An expanding in-migration is also other key factor behind the change in population rates resulting from the flow of people into urban areas from both intranational (rural to urban and other urban communities of the country) and international (labour migration, refugees and undocumented migrants). In addition, the growing population is largely attributed to the availability of a number of pull factors towards urban areas via a variety of infrastructural facilities, services and social amenities (Ali and Varshney, 2012).

Economic factors also play a significant role in contributing to the growth in urban areas. Ioannides and Rossi-Hansberg (2010) claim that the spatial distribution of economic activity, concentration of investments in urban areas, emergence of industrialisation, increase in job opportunities, employment and incomes are considered factors closely linked to the growth of urban areas. On the other hand, a number of studies indicated that administrative reclassification (rural to urban) has exacerbated urban growth as a result of its role in motivating population and migration growth (Mazumdar, 1987; Nefedova and Treivish, 2003; Cohen, 2006; Mitra and Murayama, 2009; Chandrasekhar and Sharma, 2015; Sugiyarto, 2015). Bhatta (2010), however, offers a different perspective and considers that urban growth causes are similar and interlinked with those of sprawl, and argues that there are twenty-five factors responsible for urban growth which include many social, economic, and political causes (see Table 2-1).

Table 2-1: The primary causes of urban growth which may result in either compact and/or sprawled growth

Causes of Urban Growth	Compact Growth	Sprawled Growth
Population growth	●	●
Independence of decision		●
Economic growth	●	●
Industrialisation	●	●
Speculation		●
Expectations of land appreciation		●
Land hunger attitude		●
Legal disputes		●
Physical geography		●
Development and property tax		●
Living and property cost		●
Lack of affordable housing		●
Demand of more living space	●	●
Public regulation		●
Transportation	●	●
Road width		●
Single-family home		●
Nucleus family	●	●
Credit and capital market		●
Government developmental policies		●
Lack of proper planning policies		●
Failure to enforce planning policies		●
Country-living desire		●
Housing investment		●
Large lot size		●

Source: Bhatta (2010, p.18)

2.2.2 Urban Growth Issues

Current evidence suggests that in many countries, the rates of urban growth are projected to continue for decades to come (Habitat, 2008). Given the trend of increasing urban growth throughout the world, many urban areas face a range of issues associated with this growth. These issues contribute to changes in the economic, social and environmental systems of urban areas (Starke, 2012). Although urban growth may have been linked to a number of positive impacts such as increase in economic production,

work opportunities, improvement in basic services and quality of life, in many instances, this growth is uncontrolled or uncoordinated generating a diverse range of issues that are difficult to address.

The increase in population in urban areas poses many issues. It often creates rapid changes in the pace of growth and sprawl of urban areas that creates many spatial issues. In this way, urban areas are continually growing and in many instances, this growth forms continuous urban development with close surrounding rural areas, which is often at the expense of agricultural land (Luo and Wei, 2009; Asare-Akuffo, 2014). Similarly, the rapid pace of urban growth also generates a number of issues related to unplanned expansion, transportation problems, changes in land use and its high price, and lack of areas suitable for accommodating future residential growth (Hartgen and Curley, 1999; UNFPA, 2007; Maconachie, 2012; Rui, 2013). This in turn creates many issues linked to the spread of slums areas (Gizewski and Homer-Dixon, 1995; El-Batran, 2008). It may also play part in increasing the spread of individual housing in unstructured patterns whether planned or unplanned, with or without public utilities within or on the periphery of urban areas (Lhomme et al., 2009). Although there are differences in growth rates between countries, the spread of informal housing is a prominent feature distinguishing urban growth in many developing countries (Souza, 2009). This in turn poses challenges for the government's capacity to provide comparable progress in urban services and infrastructure.

According to Mendez de Martinez (2007), a number of social factors also arise as a result of rapid urban growth. Gizewski and Homer-Dixon (1995) claim that urban growth contributes to increasing the chances of social degradation resulting in high rates of unemployment and soaring poverty. While, Paddison (2000) suggests that it is considered an important factor in bringing about a number of social changes such as creating a division in social stratification and political consequences.

Furthermore, rapid urban growth often produces a variety of environmental issues. According to Newman (2006), the pace of growth in urban areas has outstripped the capacity to reduce overexploitation of natural resources, ecosystem destruction, environmental deterioration and pollution. Kahn (2006) points out that this growth is one

of the contributing factor that exacerbates the risk of climate change by generating greenhouse gases and increasing energy consumption. It is also associated with the main causes of water pollution and waste production (El-Araby, 2002). Although technological advances provide opportunities to enhance urban environmental quality and its sustainability, urban growth still plays a major role in increasing levels of air pollutants resulting from rapid growth of industrial activities and auto engines.

2.3 The Urban Infrastructure

Urban infrastructure is seen as significant in shaping the spatial form of urban areas and improving and developing several economic, social and environmental aspects (Enakrire and Onyenania, 2007; Lee et al., 2008; Todes, 2012). It is essential for any urban development, which creates challenges for many countries especially in areas experiencing rapid urban growth (Mehdi Azizi, 1995).

There are various definitions of infrastructure which often depend on the context (Wenban-Smith, 2006). According to Zimmerman (2009), infrastructure, as a general term, is a relatively new concept in its new meaning because, before the 1980s, the term only had a wide definition in the context denoting military installations. It typically refers to basic physical and organisational structures and the institutional systems needed to support social and economic activities; it also includes many dimensions including physical, economic and social, as well as political, for the operation of a society (Oyedele, 2012). Meanwhile, Sulivan and Sheffrin (2003) claim that infrastructure denotes the essential services and products or facilities required for an economy to work appropriately. Furthermore, Jimenez (1994) argues that infrastructure is a foundation component for the development. Hirschman (1958, p.83) mentions that infrastructure broadly "includes all public services from law and order through education and public health to transportation, communications, power and water supply, as well as such agricultural overhead capital as irrigation and drainage systems". In addition, Tarr, (1984, p.4) defines urban infrastructure as "the sinews of the city: its road, bridge and transit networks; its water and sewer lines, and waste disposal facilities; its power systems; its public buildings; and its parks and recreation areas". According to the relevant literature, infrastructure can be divided into two main types: soft and hard infrastructure (Hellinget

al. 2010; Kgamanyane, 2015). Soft infrastructure includes the rules and regulations that govern a wide range of intangible structures such as the economics, education, health, judiciary, security and legal frameworks as well as other social, recreation, and cultural services (Kumar, 2005; Lin, 2010). Whereas hard infrastructure, refers to a number of essential components of urban life such as roads, buildings, energy, water supply, sewage and waste disposal (see Table 2-2).

Table 2-2: Examples of different types of infrastructures

Hard infrastructure		**Soft infrastructure**	
Utilities	Electrical power	**Institutional Infrastructure**	The government system
			Public administration
	Telecommunication systems		The legal system
			The financial system
	Wireless communication		Emergency service
			Human resources
	Gas supply	**Social and Cultural Infrastructure**	The health care system
	Flood control systems		The educational and research system
			Living standard
	Drinking water supply		Social welfare system
	Storm drains		Social relationships
	Sewerage		
	Irrigation systems		
Buildings	Residential		
	Commercial		
	Public service		
	Leisure/entertainment		
Transportation	Airports		
	Railways		
	Seaports		
	Bridges		
	Paved roads		
	Street lighting		
	Pavements		
	Traffic control equipment		
	Bus stations		
	Car parks		
	Ferries		
	Underground stations		
	Tram lines		
Other	Monuments, landmarks		
	Parks/ Open spaces		
	Children's playgrounds		
	Playing fields		

Source: The author based on Wenban-Smith (2009) and Oraegbune (2015)

In residential areas, infrastructure can refer to various facilities, basic urban services located in the residential areas and not the ones which are used by the residents daily such as a public transportation services. This infrastructure includes, but is not limited to sports pitches, play space, lakes, parks, shops, post offices, community centres, places of worship, library, sports centre, car parks, transport stations, roads, water supply, mains drainage, broadband, electricity, telephone systems, schools and colleges, health centre, municipality office, cemetery, police station, fire station, power units and recycling facilities (Mayo and Angel, 1993; Taylor, 2011; Nigam and Devadas, 2014).

Generally speaking, rapid urban growth forms a tremendous challenge to agencies responsible for the provision of essential infrastructure services especially in residential areas. The provision of adequate infrastructure is considered a long process that may involve a multitude of stakeholders, however, governments traditionally have primary responsibility for managing this process, although the private sector may also be involved in some parts of the processes related to its provision (Mehdi Azizi, 1995; Wu, 1999). Therefore, local governments serve as direct representatives for ensuring the quality and efficiency of infrastructure on behalf of central government, whether as a provider or as a partner in their delivery (Bennett et al., 1999; Au-Yeung et al., 2010). However, these processes are influenced on an ongoing basis by several economic, social, cultural and environmental processes (Toutain, 2006). In addition, the decisions related to their provision are affected by many formal and informal stakeholders such as government regulatory agencies, non-governmental organisations, private sectors and the communities who receive the services (Stern and Holder, 1999; Tewdwr-Jones and McNeill, 2000; Rotmans et al., 2000; Davison, 2001; Bobylev and Jefferso, 2014).

According to Yang (2014), identifying the stakeholders and their interests has influence on the appropriate decision making related to urban development. Many stakeholder theories, from a broad range of research fields, have contributed to the multiplicity of definitions and meanings related to this theory (Friedman and Miles, 2002;

Miles, 2011). However, most of these definitions assume that stakeholders are a wide range of individuals and groups who can be identified by management, and that their interests can be taken into consideration in the decision-making process (Buchholz and Rosenthal, 2005). In this context, Bett (2014) claims that the stakeholder theory was originally detailed by Freeman (1984) who defined this concept as any individual or group that is affected, and can affect the organisational achievement of an objective. However, El-Gohary et al. (2006) classified infrastructure stakeholders into three groups, namely the interested, the impacted, and the responsible. The interested stakeholder is an individual or an organisation not directly affected by the project, but who would like to take part and provide his or her opinions in the infrastructure development process. The impacted stakeholder is described as an individual or organisation directly or indirectly affected by the process of developing infrastructure. Meanwhile, a responsible stakeholder encompasses any entity that holds a level of liability and responsibility in the infrastructure development process.

On this basis, this research will use the term stakeholders to refer to all responsible entities and interested parties who have input or affect each other in decision-making activities related to urban residential infrastructure provision as well as those who will benefit from their provision. This includes the public sector, private sector, the third sector and residents of residential areas as individuals, or their representatives involved in residential infrastructure development. These four classes of stakeholders play crucial roles which affect the decision making processes of the residential infrastructure delivery. Thus, there is a need to clarify their roles and responsibilities.

The first class of stakeholders involved in the residential infrastructure delivery processes are the public sector and national government authorities, along with their local city authorities who operate in an environment determined by the framework of the national government. They play a central role in the promulgation of rules and regulations, general policy, procedures and the involvement of other sectors, as well as

managing processes associated with providing residential infrastructure. They are also considered directly responsible for the citizens for the implementation, operation and maintenance of public services, including delivery ways and the trade-offs between spending on these services and setting user fees and prices (Shah, 2005; Abdel Aziz, 2007). In addition, they have a direct relationship with the regulation of the infrastructure market, such as ownership of infrastructure networks, pricing mechanisms, standards and implementation specifications, along with defining the financing mechanisms and the ownership of infrastructure companies (Razaghi and Finger, 2013).

The second class of stakeholders are the private sector which includes statutory undertakers providing infrastructure, and firms working in the development and operation of residential infrastructure, who may be in contract with the public sector for its implementation. The role of the private sector lies in its involvement with the public sector in the work of designing, constructing, and maintaining urban infrastructural plans, which makes a significant contribution to the improvement of the operational efficiency and, therefore, reduces the expenses in the public sector (Mehdi Azizi, 1995; Kumar and Prasad, 2004; Koppenjan and Enserink, 2009). It can sometimes influence the public sector through its ability to provide technical and management skills and urban infrastructure financing (Schübeler, 1996; Wu, 2010; Chakrabarti, 2014).

The third class of stakeholders are the third sector organisations that have an important role in effectively promoting decision making engagement related to delivering public services (Brandsen and Pestoff, 2006; Brandsen and van Hout, 2008). They also have a key role in promoting urban governance and the contribution in response to citizens' needs (Pestoff, 2007; Bifulco and Centemeri, 2008). In spite of the difficulty defining the third sector, Westall, (2000) (cited in Clift, 2008) defined it as sectors and organisations which are seen as not aiming for profit. The third sector has a number of names, which include the civil society, the social economy, the (private) non-profit sector, or the voluntary sector (Pestoff and Brandsen, 2009).

Finally, the residents being the services recipients, acting individually or as representatives such as neighbourhood councils, have a crucial role in influencing policies and decisions of the bodies responsible for the delivery of residential infrastructure. This is achieved through discussing their demands and actual needs, which can help bring an increased quality in the delivery of services.

Thus, the responsibilities of local governments, especially under the pressures of rapid urban growth and continued spatial expansion in urban areas, have become increasingly intertwined and a complex undertaking to address economic, social and environmental issues, as well as meeting the local community's needs for urban infrastructure (Rotmans et al., 2000; Au-Yeung et al., 2010). Accordingly, it can be said that the traditional roles of local governments in managing urban areas are no longer sufficient to meet the residents' needs and it is necessary to strengthen their capacity, especially in the fields of urban governance. Therefore, many governments relied on sets of policies and procedures to deal with these changes, such as privatisation of government departments, providing better incentives into investment choices and improvement of the legal and regulatory framework, planning and management systems, adequately financed, increasing the administrative capacity and improving operational tools (Jimenez, 1994).

However, shortcomings in the organisational environment, particularly responsibility overlap and the relationship between various stakeholders and participation in decision-making are still major challenges in addressing such issues. The reasons for this may be traced to a number of factors, including strategies and public sector policies, regulations and legislations, procedures and financial aspects related to the coordination, management and governance of these processes. Thus, there has become an increasing need to search for appropriate ways to enable joint working arrangements between stakeholders for participative decision making. This requires the improvement of urban governance as a key aspect to face the challenges of infrastructure issues (Wilson, 2000; Ichimura, 2003; Teets, 2008). The reasons for this will be discussed in more detail in the following section.

2.4 Governance of Urban Infrastructure

Governance is perceived as critical for the efficient delivery and management of urban infrastructure and services (Otegbulu, 2013). According to Makara (2010), there is an increasing trend towards governance in urban authorities. Gupta et al. (2015) argue that this started in the 1960s as a result of the strong tendency towards enhancing public participation, bringing together various stakeholders in processes related to decision-making. Such relationships have proliferated in different domains and have introduced new types of institutional arrangements and cooperation and interaction of stakeholders, which have shaped the driving forces in a shift to what is referred to as governance (Blanco, 2013; Kuokkanen, 2016). Harpham and Boateng (1997), argue that this prompted governments to increase their interest in governance as an appropriate approach for the improvement of urban services delivery, which will be highlighted in the next sections.

2.4.1 The Definition and Scope of Governance

The concept of governance is multidimensional and has been applied to many issues and in many different contexts. Therefore, the term governance has been given different definitions (Farazmand, 2004). According to Bevir (2011), the term governance does not have a specific meaning; at the most general level, it refers to the concerns and theories that relate to the nature of patterns of rule and social coordination. However, the concept of governance is often associated with the concept of government. Gupta et al. (2015) refer that this has coincided with the rise of civil society organisations, non-governmental organisations and corporations that do not belong to state institutions for participating in governance processes, which in turn led to the expansion of government to governance. Osborne and Gaebler (1992) indicate that governance is about a reinvented form of government which includes new forms of regulation and management tools. Although they cover much of the same ground there are subtle but significant differences and the two should not be confused (Saunier and Meganck, 2009). Thus, numerous studies have revealed that the concept of governance is more than just the government (i.e. Hu and

Chan, 2002; Devas, 2004; Edgar et al., 2006; Hildebrand et al., 2013). However, according to Söderbaum (2004) governance is less significant than government in sociopolitical and economic-political processes. Further, it still has the regulatory powers, the fiscal responsibility and political legitimacy that creates the structures of collective action (Saunier and Meganck, 2009). In other words, the difference between the concepts of governance and government in the level of monopoly over decisions regarding the regulation of societies.

A considerable amount of literature, in various disciplines, has been published on the concept of governance and how it should be defined. The governance concept has been more salient within the context of discussing the global environmental challenges from a social science perspective (Bobylev and Jefferson, 2014). Peter (2005) considered that the concept of governance is made up of various elements that include the process of choosing and monitoring the government, self-organisation and interaction between differing legislatures and administrations and the judiciary, the capability of the governing system to formulate and implement laws and policies, and the mechanism, that explains the intervention between governments and citizens. Leftwich (1993) points out that governance means a set of systems and institutional arrangements, and political and socioeconomic relations. Smith (2007) adds that the concept of governance refers to the capability of governments to create sound policies that govern their economic and social capitals. In addition, Edgar et al. (2006) suggest that governance has ideal ways of directly engaging different societal sectors, which are linked with democracy, whereby societies or organisations make their own important decisions and can be applied in global, national, institutional and community contexts. In another study, Meehan (2003) finds that the concept of governance merges a number of concepts which include the following: fragmentation or sharing of public power; arrangements encouraging policies that offer greater involvement; formulated and implemented away from centralised government; aiming to increase the reliance on partnerships and dialogue. Whereas, Hirst (2000) classifies five aspects of the use of governance to including: formation of an effective political framework in the side of the economy, holding agreements, cooperation with

different international agencies to tackle global issues, contributes to improve the accountability and transparency, working towards the privatisation of the public sector, and enhancing collaborative activities involving various stakeholders. Therefore, it could be conceived that governance refers to the formation of new political frameworks and shifts in government management approaches from top-down to the bottom-up approach by full participation of all sectors of society - economic, social and political.

In addition, the term of governance is used in the context connected to decentralisation and the move towards a shift from government to governance through a collaborative approach between state institutions, non-governmental actors and institutions as well as civil society. This is being facilitated by addressing problems at community level, enhancing efficiency, credibility and accountability, the rule of law and empowerment in these institutions, and all groups of civil society, in full participation in the governance process in order to achieve effective implementation (Kim, 2010; Shafiei, 2011). However, due to changes affecting the role of government and lack of any consensus and viewpoints among many actors and stakeholders on the restructuring of policies by which it should work, defining governance is becoming more diverse and not a straightforward task. As a result, many organisations seek toward improve define governance in order to build a sound model that could contribute to the decision-making processes.

According to Chhotray and Stoker (2009), governance theory relates to the practice of collective decision-making within environments where there is a multitude of actors. Therefore, it provides an understanding of how to determine the role of the state in society and to restructure the situation in which official authority and various actors converge. Voegelin et al. (2003) claim that the problem involved in the theory of governance is the difficulty of defining the power for decision-making and implementation. The emergence of a network of relations between the state and other actors may create difficulties to direct the collective work. From the institutional perspective, the formation of this network tends to produce institutions and in turn, imposes challenges on how to connect

the public sector with other actors and the nature of the interaction between them (Peters, 2011). In this regard, Edelenbos and Klijn (2006) indicate that the governance and network theories have focused on the changing nature of the decision-making process and have different perceptions and ideas which helped to provide solutions to the complex interaction between government and other actors in the decision-making process. The main concern, however, lies in the state's ability to manage this network successfully. Therefore, a number of critiques on network governance have emerged, linked to the continued dominance and steering of the state and inequalities in power within the network, as well as the impact of the institutional context of these networks and the constraints that may result in the decision-making (Van Bortel and Mullins, 2009). This, in turn, led to the importance in giving these networks institutional expression through granting them more independence and interdependence within a clear set of rules.

Lawrence and Shadnam (2008) suggest that the development of institutional theory has contributed to providing a range of interpretations regarding the formation of relationships, procedures, institutional contexts and organisational structures, as well as the factors that guide institutional changes. Based on this perspective, institutionalising these types of relationships between actors is fundamental to make governance efficient (Chhotray and Stoker 2009). This means defining the rights and duties of these actors prior to linking them with more formal actors in the public sector and formation of more routine and predictable patterns of interaction (Haus and Heinelt, 2006; Peters, 2011). However, these relationships may face a challenge in the development of its own internal culture and manner of functioning (Boin and Goodin, 2007). It also needs legitimacy to play its role in governance and secure a place in the decision-making process, which is considered by the new institutionalism an essential objective to ensure its survival (Meyer and Rowan, 1977; Peters, 2011).

2.4.2 Urban Governance and Delivery of Infrastructure

Urban governance is seen as being an effective approach for enabling societies to participate in identifying real urban problems and ascertain the interventions that are best

suited to address these problems (Tibaijuka et al., 2005). It is considered a requirement to reduce urban contemporary challenges, such as exacerbating urban growth, social inequality, meeting the local demands for service provision and environmental stress, especially in the developing world (Van Ewijk, 2008; Lange, 2010; Verrest et al., 2013). According to Wang et al. (2009), the literature on urban governance provides different definitions and assumptions of urban governance, due to the complexity of its interactions between the multi-levels; this makes it difficult to clearly determine its notions. It tends to focus mostly on the working arrangements and processes of integration amongst different actors at different scales in urban areas including, governmental agencies, political parties, the private sector, trade unions, trade associations, NGOs, and civil society. Hydén (1998) indicates that urban governance is the relationship that links various institutions of local, state, civil society and the private sector. This determines what happens within the city in order to contribute to decision-making, stabilisation and welfare by transparency of all financially processes, revenue sources, expenditures and the administration as well as delivery of services, with contributions from government, the private sector and communities in the urban economy (Devas, 2004; Abdulrashid et al., 2009). While, Hendricks (2013, p.555) defines urban governance as "the more or less institutionalised working arrangements that shape productive and corrective capacities in dealing with urban steering issues involving multiple governmental and nongovernmental actors".

According to Ashwini (2015), the theories in urban governance are explanations of two major phenomena aimed at the subjects related to the management of cities and decision-making on urban issues. Therefore, they can be seen as an activity that regulates the relationships related to how decisions are made by and through government, and thus, the way in which governance processes are structured can have a significant impact on the adopted decisions. This suggests the need for similar policies at all levels of the state which are dependent on the actions of other actors. Therefore, urban governance focuses on regulations, plans, governance and management to find appropriate ways to address

such issues (Ashwini 2015). In this respect, a large body of evidence suggests that urban governance plays an important role in addressing issues of urban infrastructure along with financial challenges and technical concerns (Jones et al., 2014). Similarly, the literature also indicates that many urban areas sought to improve the governance, and adopted more effective management practices to give the stakeholders a greater role in decision-making aimed at enhancing infrastructure delivery (Bontenbal, 2009; Vaidya, 2009; Freire and Stren, 2001). However, the majority of available studies do not allow for the drawing of conclusions about the nature of the main challenges of urban governance and the most important lessons learned in the context of services delivery (Jones et al., 2014). As a consequence, it is very difficult to generalise their results even though they are consistent with many principles.

On the other hand, a number of international organisations have made a contribution in shaping the definitions of governance and developing its practices. However, they showed significant differences in their views about its concepts. In a 1994 report, the World Bank explained that governance denotes the way in which the power is used in the management of social and economic resources of any nation (The World Bank, 2000). Governance was also defined by the United Nations Development Programme as a set of exercises of political, administrative and economic authority to manage a country's affairs, which comprises various processes that meet all citizens' obligations and reconciles their dissimilarities (UNDP, 1997). Furthermore, the Organisation for Economic Co-operation and Development indicates that the concept of governance denotes the government's exercise of control on public life in a society in relation to the management of its resources in the field of economic and social development (OECD, 1995).

In the same vein, a number of international organisations have paid attention to urban governance and have adopted several initiatives to introduce and popularise the concepts and broad methods and forms on this matter. The World Bank published good governance classifications, using more than a hundred indicators to tackle the six main features associated with good governance, "voice, and accountability; political stability and

absence of violence; government effectiveness; regulatory quality; rule of law; and control of corruption" at urban and local levels in 209 countries (Shafiei, 2011, p.19). The Urban Governance Initiative (TUGI) of the United Nations Development Programme (UNDP) has also adopted nine principles of good urban governance, which include: participation, equity, rule of law, effectiveness and efficiency, transparency, consensus orientation, responsiveness, accountability and strategic vision (TUGI, 2003).

Similarly, The UN-Habitat (1996) (cited in Kennedy et al., 2011, p.10) proposed a definition for urban governance as "the sum of the many ways individuals and institutions, public and private, plan and manage the common affairs of the city. It is a continuing process through which conflicting or diverse interests may be accommodated and cooperative action can be taken. It includes formal institutions as well as informal arrangements and the social capital of citizens". The UN-Habitat also launched the Global Campaign on Urban Governance in 1999 with the objective of improving the quality of life and fighting against poverty by developing urban governance (Lange, 2009). The campaign also included developing urban governance indices to contribute to synthesising complex concepts of urban governance and to demonstrate the importance of urban governance in achieving development goals at global and local levels, as well as measuring the quality of governance mechanisms, institutions and processes (UN-Habitat, 2004). In 2001, the campaign identified a number of norms and principles, which included participation, equity, inclusion, accountability, decentralisation, responsiveness to civil society, efficiency of service delivery, sustainability and security (Devas, 2004).

Against this background, there is an emphasis on the role of urban governance which has taken all of these complex issues into account. Achieving urban governance, as proposed by The Global Campaign on Urban Governance, has many of the important characteristics which seek to improve organisational aspects and activate stakeholders' roles in the various practices related to decision-making in an organised way. However, these dimensions require appropriate mechanisms to generate motivation, and incentives that encourage all stakeholders to function in a collective manner. According to its

approaches, four core dimensions are adopted which are; participation, accountability, effectiveness, and equity (UN-Habitat, 2004; Moretto, 2007; Lewis and Ogra, 2010); which are explained in the following.

The first dimension is participation, which is increasingly considered a critical tool for improving decisions and tackling urban problems. In the context of urban infrastructure services, there are various forms of stakeholder participation in infrastructure service management including decision making, planning, needs assessment, monitoring, implementation and operation, evaluation and maintenance between communities and government authorities (Schübeler, 1996). These can yield important benefits for users and government alike. However, the challenge is in how to create appropriate policies and instruments to identify and ensuring involve all stakeholders (Kyessi, 2001). In practice, participation requires a shift of change in organisational culture as the public sector requires clear objectives built on formal systems through precise criteria. Shah (2005) indicates that there is a number of ways for stakeholder participation, such as through neighbourhood councils, committees, grievance systems and non-government organisations. However, these might face a number of problems, due to the influence of local elites in decision making for their own gains rather than for the greater good of the community.

On the other hand, the establishment of mechanisms to ensure accountability and transparency is important aspect to promote urban governance in relation to urban infrastructure delivery planning. It has important roles in contribute to explaining of plans, actions and outcomes as well as providing evidence of performance for stakeholders. Accountability is defined as "a pro-active process by which public officials inform about and justify their plans of action, their behaviour and results and are sanctioned accordingly" (Ackerman, 2005, p1). It is also concerned with the obligation towards individuals or entities to provide information and take whole responsibility for their decisions (Cruz and Marques, 2013). Accountability also has a role in encouraging participation and reducing the possible occurrences of corruption, fraud and nepotism as

well as contributing towards the promotion of transparency, which in turn strengthens confidence in the public sector (Ashenafi, 2013). Shah (2006) indicates that accountability ensures that organisational choices of the decision maker are based on a consensus by residents and thus limits risk tolerance.

There are three essential aspects of accountability: political accountability which requires an active role by the public in the scrutiny of governmental activities and take action on negligent or abusive government officials; second, public accountability which tends to concentrate on monitoring and controlling practices of the public sector by which people can verify the quality of public services; and third, legal accountability which means that citizens can make the public sector responsible for its actions through the law (Brautigam,1991, cited in Kim, 2010). While UN (2007) refers to two other aspects with regards to accountability, which are financial accountability, involving the use of authority to report on the intended and actual use of resources and administrative accountability, involving internal governmental controls such as civil service structures, professional standards, administrative reviews, and oversights. All of these dimensions of accountability contribute towards building trust in the public sector and having an essential role in minimising the bureaucracies and centralisation systems of infrastructure service delivery (Bardhan and Mookherjee, 2006; Ossio et al., 2008).

While, transparency has proven its importance as a means of improving public trust in the government and increasing its responsiveness to its citizens' needs, anti-corruption benefits and creating equality (Bertot et al., 2010; He and Tang, 2012). Transparency refers to visible procedures of public decision-making which give citizens direct access to information regarding how government works in the policy-making process (Kim, 2010). It also refers to a set of clear processes and procedures enabling access to public information (UN.2007). In this context, Stirton and Lodge (2001, p.477) state that there are four transparency mechanisms contributing to the boost of effective response regarding the architecture of public services, which include: (1) voice "to promote the exercise of individual contributions to and redress from the provision of public services";

(2) choice "includes all types of possibilities through which users can exercise ‘exit’, mostly by selecting other providers, but also in terms of choosing different types of political leadership" (3) information "facilitates the quality of user knowledge, enhancing in particular the exercise of voice and choice"; (4) representation "aims to provide an institutionalised interest for the service user in regulatory and wider policy decision-making, in order to compensate for the potential over-representation of competing interests".

The third dimension is effectiveness, usually related to organisational aspects which "measure the existing mechanisms and the socio political environment for institutional efficiency in financial management and planning, delivery of services and response to civil society concerns" (Cobbinah and Erdiaw-Kwasie, 2016, p.89). In addition, it measures extent responsiveness to needs and public contentment towards public services, as well as capacity achievements (Shafiei, 2011). Boyne (2003) claims that the interpretations of effectiveness tend to concentrate on the success or failure of organisations in their contribution towards service provision. In other words, it refers to the extent of the achievement of organisation objectives. Therefore, it requires an understanding of the development of the urban structure with time, the relations between processes in society and the conditions for the behaviour of stakeholders (Dijst and Schenkel, 2002). In addition, the efficiency concept is associated with the effective predictability of the financial planning and management, high responsiveness to citizen requirements, and service delivery (UN-Habitat, 2004). The conventional notion of efficiency means the ability to work well and produce positive results with the available potential in the most effective ways. In short, it refers to getting the maximum public services at the lowest possible cost. In this context, Rashid et al. (2009) indicate that the efficiency aims to ensure that resources available to the public sector are being used in the optimum way to deliver better public services, which are consistent with citizen priorities. It can also be evaluated by examining the costs of production and the degree of competition in service production (Shah, 2005).

Finally, equity and a balanced spatial distribution when delivering infrastructure is an important aspect to achieve urban governance. In general, equity indicates unbiased and inclusive access of all stakeholders in the basic necessities of urban life and the decision making processes (OECD, 2000, cited in Kraas et al., 2014). It is also considered one of the means that can be used to measure performance of the public sector with regards to spatial distribution of urban infrastructure (Savas, 1978). Equity issues relate to the degree of access to public services, the users fee, and the negative effects that may be associated with its development (Fox, 1994; Sliuzas, 2003). Thus, equity should include sustainable management of urban areas and "must attempt to balance the social, economic and environmental needs of present and future generations and develop long-term strategic vision" (UN-Habitat, 2004, p.21).

However, there has been extensive research discussing different approaches to tackling governance and urban infrastructure planning issues. Rotmans et al. (1998) indicate that there are many approaches to addressing interrelated problems of urban infrastructure planning which focus on integrated approaches through the interdisciplinary process aimed at combining the interpretation and communication of knowledge gathered to benefit from them in decision-making. Meanwhile, Hansman et al. (2006) point out that there is no comprehensive theory for the practice and management of infrastructure, and a lack of methods to develop, evaluate, and evolve it in future. However, the authors put forth four elements that create an integrated approach to the study of infrastructural planning. The first element involves comparing and analysing the infrastructure systems, including case studies of the market, demand, political, financial, operational, technical, regulatory, and others, to develop knowledge on the infrastructure systems. The second element is the development of integrated infrastructural models, which will help in comprehending and recognising the links between the private initiatives, governance, regulations, and technical changes. The third element is the methodology formulation that will support the effective improvement of infrastructure and improves the techniques to provide better communication between the

stakeholders and multiple decision-makers. The last element is the evaluation and testing of the applications (Hansman et al., 2006).

Yang (2001) claims that there are various initiatives which aim to enhance the development of urban infrastructure such as privatisation of public services, expansion of semi-public institutions and joint production between private and government sectors. In addition, governments must stimulate and support such policies and allow these sectors a greater role in urban infrastructure management as well as finding a balance between private and public sector responsibilities (Rondinelli and Kasarda, 1993; Birkinshaw, 2013). In other studies, there is reference to the importance of urban infrastructure investment through public-private partnerships (Mattingly, 2001; Ottesen, 2011). These studies suggest that they are important to revise government policies or creating new ones that would respond to the needs of urban infrastructure investment to improve the provision of public services. This is likely to be more efficient than if infrastructure investments are financed from general funds (Bahl and Linn, 1992; Mattingly, 2001).

Meanwhile, Lee et al., (2008) recognise that technological advances offer promising opportunities for improvement in the planning and operation of physical urban infrastructure. Indications from the available literature suggest that these technologies have significant potential for contributing to improving urban governance, providing a set of tools to enhance participatory methods supporting the decisions to be taken (McCall, 2003; Sliuzas, 2003, Shin, 2009). They also offer electronic platforms that can be utilised for encouraging interaction and to strengthen the relations between various stakeholders. In addition, the use of technology opens new ways toward participation and the creation of a coherent vision for expressing their views and collective decision-making in the places where they live (Hanzl, 2007). Furthermore, the available literature demonstrates the significant effect of using technologies on decision-making practices related to urban infrastructure planning, where coordination, obtaining and sharing information, and enhancing integration among all government agencies can be facilitated (Lui and Tan, 2001; Yigitcanlar et al., 2008). Moreover, they can support information

flows, procedures, roles, obligations, rights, analysis, display and interpretation of data from different sources to establish a platform for the exchange of ideas to support the work of governments (Kumar and Van Dissel, 1996). According to Geertman and Stillwell (2009), many governments increasingly rely on information technology to enhance democratic decision making in infrastructure projects. Au-Yeung et al. (2010) suggest that the use of urban modelling tools to support those involved in planning tasks and urban governance has proven successful in handling the ever-increasing complexity of urban infrastructure planning tasks. Focusing on the development of integrated support systems has enabled the engagement of different sectors in the decision making process and can promote accountability and transparency.

In this context, Hanzl (2007) points out that there are a number of systems and applications which offer possibilities relating to accessibility and exchange of urban data such as Geographic Information Systems (i.e. GIS in the network (PPGIS), Planning Support Systems) and other software based on the web (i.e. flash technology, VRML, XML, Multimedia, HTML and PHP) as well as collaborative software (i.e. email or Internet communicators). However, use of information technology requires an integrated technological infrastructure than will provide a communication platform that includes a set of tools, applications and relevant data which have the potential to connect and absorb needs and preferences (Daghistani, 2007; Wang et al., 2011). Also, the success of these systems and applications requires a consistent and reliable planning support database to enable strong and well-grounded decisions to be made (Tregoning et al., 2002; Cheng and Masser, 2003; Haywood, 2005; Joshi et al., 2006 cited in Au-Yeung et al. 2010). Additionally, they may not be widely used because of a number of complex issues facing effective participation such as, accepting the use of technology from citizens, the politics of authorities in dealing with the transfer and exchange of data, a lack of financial resources and many technical factors.

Therefore, it is important to recognise that the use of such technologies is by no means a panacea to the relevant issues of urban infrastructure delivery. Despite their

potential to improve urban governance and enhance participatory methods supporting the decisions making process, their effectiveness, however, lies fundamentally in the nature of relationships that link relevant actors at multiple levels of horizontal and vertical governance systems. There is also a need to consider the institutional structures and processes that enhance decision-making. This is considered important for creating an appropriate organisational environment for these relationships able to support participation, and organise accountability and responsibility as well as interaction of urban actors to coordinate and align their plans and programmes for infrastructure development at national, local and neighbourhood levels (Morphet, 2013; Gupta et al., 2015). Along with this, Gyogluu (2006) emphasises the importance of decentralised infrastructure planning and development for providing more opportunities to promote integration and participation between formal and informal institutions as well as facilitating residents to decide for themselves the infrastructure they need and to contribute to the formulation of the plans needed for improvements. Likewise, a number of studies argue that the support of capacity building for urban governance and planning is critical to support collective action and the ability to coordinate infrastructure delivery, thus ensuring efficiency in service provision and more appropriate decisions (Williams, 1999; Otegbulu, 2003; Rumbach, 2016).

2.5 Summary

This chapter has provided a broad review of the literature about urban growth and the importance of urban governance in the context of planning for urban infrastructure in residential areas. The first part highlighted a number of definitions and concepts of urban growth, along with the causes associated with this phenomena. It is apparent that the concept of urban growth has generated divergent viewpoints between researchers which led for the emergence of many varying definitions. Most of these definitions have concentrated on explaining the associated reasons of this growth. In many cases, urban areas are prone to this growth, which it is projected to continue for decades to come. This has caused concern for many governments and existing communities. Changes in

economic, social, political and organisational circumstances have influences upon the urban growth to a substantial degree which may reflect negatively or positively on the population of urban areas. However, the population increase and expanding in-migration are considered major influences, which may drive the creation of many issues which pose a direct threat to urban environmental quality and the well-being of the urban population. Integration of urban infrastructure is a critical element to achieving balanced urban growth and reducing adverse effects of urban growth, which in turn has a significant effect on decisions about where to live, and consequently on population growth in urban areas. Therefore, it is important to take into consideration the projected urban growth scenarios and take proactive steps of likely impacts on urban areas through the creation of appropriate policies, institutional arrangements and improving operational tools be able to cope with this growth.

In response to this, the need emerged for active participation in decision-making, consensus and the sharing of powers and responsibilities between various relevant stakeholders to promote sustainable urban growth and meet the population's needs for urban infrastructure in an appropriate way. Urban governance has gained increasing attention from researchers and practitioners, whereby those aspects are taken into account. Therefore, the concept of urban governance and its importance in addressing the issues related to improving the decision-making processes and creating a structured coordination and integration between actors to deliver infrastructure has been discussed. The literature on urban governance shows that there is still a gap between the appropriate policies and institutional arrangements and the attitudes of the actors in this context, on the one hand, and the reality of actual practice, on the other. It also shows that the ICT has the potential to provide promising opportunities for improvement in the handling of these aspects. This leads us to the discussion of the use of ICT with an emphasis on geospatial technology for improving the processes of planning in the delivery of residential infrastructure in the next chapter.

Chapter 3: The Use of Geospatial Technologies in Residential Infrastructure Planning and Delivery

3.1 Introduction

Information and communication technologies (ICT) play a positive role in contributing to enhancing the efficiency and effectiveness of urban governance by offering a wide range of tools for promoting and facilitating the collaboration, interaction and supporting the practices of teamwork and involvement in the decision making process (Relhan et al., 2011). Geospatial technology tools are one of the most rapidly developing fields within ICT and are seen as a promising and effective means of bringing about positive change in the realms of urban governance and improvement in the planning and delivery of infrastructure services to residents (Lewis and Ogra, 2010). However, it is still at a rudimentary stage of development (Njoh, 2012).

This chapter provides an overview of ICT in general with geospatial technologies in particular, and their significance in the context of infrastructure delivery. It aims to disclose the importance of these technologies for tackling issues related to making decision, and their contribution to increase the level of integration and coordination between various stakeholders. The chapter begins with a discussion of the theory on the use of ICT. It then presents background information about geospatial technology including key technical components and its modern uses; as well as discussing challenges and critical factors affecting their implementation.

3.2 The Use of ICT in Urban Governance

Around the world, governments endeavour to integrate and fully exploit the capabilities of ICT in relation to urban development projects, business and community sectors as well as citizens (Gupta et al., 2008; Chourabi et al., 2012). According to Okot-Uma (2000), ICT has potential to bring positive changes to the processes of governance and make it function better than at present. In this respect, a number of studies have singled out the benefits and advantages of the use of ICT in bettering the accountability, transparency and efficiency. Studies have also indicated its potential for enhancing methods of communication collaboration, participation, interaction, and the assigning of responsibilities and duties among all stakeholders and other actors, such as citizens, non-governmental organisation, businesses, public sectors, and investors by overcoming geographical distance, promoting ideological variety, opening citizens to more varieties of viewpoints, and promoting joint deliberation (Edwards, 2002; Ebrahim and Irani, 2005; Pani and Mishra, 2009; Goldfinch et al., 2011; Hsieh et al., 2011; Chang et al., 2012; Mergel and Bretschneider, 2013). However, issues such as inequalities in the access to and use of ICT, as well as the digital divide, especially in disadvantaged communities, can reduce the benefits they provide (Hsieh et al., 2011). Therefore, their impact is still unclear (Odendaal, 2003; Chourabi et al., 2012).

ICT is heavily involved in the governance of urban areas, where they are used as tools to achieve a more sustainable urban context through the participation of different stakeholders. The current literature indicates that there are several concepts, within a variety of disciplines which has led to difficulty in finding a consensus with regard to its definition. Despite this, there are studies that indicate ICT in governance practice is more than just the act of automation and computerisation, and includes a set of devices and technical infrastructure that defines and assesses the practice and administration of governments and facilitates collection, storage, processing, transmission and display of

information which can be utilised to support various areas (Cecchini and Scott, 2003; Saxena, 2005; Tongia et al., 2005; Sheridan and Riley, 2006).

However, there are overlapping terms and synonyms such as, 'digital government', 'cyber government', 'virtual government' and 'e-government', these terms differ from one place to another (Misuraca et al., 2010; Nijkamp and Cohen-Blankshtain, 2013). Nevertheless, these terms represent concepts aimed at facilitating the interaction between government agencies and other actors, using all forms of electronic communication, thus promoting more efficient working to achieve better governance (Lee et al., 2005; Saxena, 2005). Therefore, it could be said that the objective of using ICT in governance is more than just a website to provide government services online, but is a process to support the governance of all parties in society, government, citizens and businesses (Perumal et al., 2007).

There have been many discussions in the literature about the role ICT plays in the improvement of urban governance, which received substantial attention from researchers in this field (i.e. Okot-Uma, 2000; Fleming, 2002; Acconcia and Monte, 2003; Sein and Harindranath, 2004; Bankole and Osei-Bryson, 2014). Meanwhile, a considerable body of literature, in the context of smart cities, documents the importance of ICT as the main element for the governance and management of urban areas (i.e. Hansen et al., 2001; Odendaal, 2003; Bifulco and Centemeri, 2008; Paskaleva, 2009; Chourabi et al., 2012).

Pani and Mishra (2009) claim that the use of ICT is a vehicle for good governance and has a key role in supporting the organisational capacity and managerial competence of the power exercise. It may also contribute to a rise in reliability, accountability, transparency, efficiency, equality and facilitates stakeholders' participation arrangements. Therefore, it can be described as supports tools legitimise decision making and efficient implementation, due to possibility to use it in the discussion of decisions and alternatives, thus stimulating stakeholders to establish democratic interactions. In addition, the success of the use of such technologies are intimately linked to the

methodology used, existence of political will, overcoming administrative challenges, restrictions imposed by the regulations and administrative policies in both government and relevant organisations (Bhogle, 2008; Pani and Mishra, 2009).

Indications from the available literature suggest that the advantages offered by the practice of ICT in urban governance are multiple. For example, Beck et al. (2004) and Gichoya, (2005) have outlined some of the potential benefits which include promoting democratic interaction between governments and citizens; introducing modern management techniques in urban governance processes; raising the quality of service delivery; improving decision making by participation, coordination and collaboration; reducing corruption and increasing accountability by improving access to information and increasing government capacity.

On the down side, the literature shows that there are a set of issues and challenges limit the successful use of ICT in urban governance, such as, political, economic and cultural issues, accessibility, technical competence, information and data issues, security aspects, privacy, democratic access, the digital divide, ICT infrastructure, raise trust rate and awareness among people to resist change, hardware and software availability and usability (Bélanger and Carter, 2008; Dawes, 2008; Nijkamp and Cohen-Blankshtain, 2013; Silva, 2013; Venkatesh et al., 2014). There are also a number of sources that provide approaches to tackle these issues and challenges. This could be through; promoting policies for adopting and using ICT among the population and engaging the private sector in these policies; establishing the necessary information infrastructure; developing human resources to operate the information infrastructure; addresses socio-cultural aspects and raises awareness levels; choosing appropriate technology and providing adequate financial resources to implement the processes (Edwards, 2002; van den Berg and van Winden, 2002; Akinsola et al., 2005; Kalsi et al., 2008; Pani and Mishra, 2009).

3.3 Geospatial Technologies and Residential Infrastructure Delivery

Widespread use of geospatial technologies has emerged to improve urban governance; this has been largely linked to the recent developments in the ICT domain (Pfeffer et al., 2015). A large amount of literature indicates that the use of these technologies in urban areas goes beyond the mere function of mapping and spatial data generation, where they can play an important role in addressing many issues facing urban areas (Jensen et al., 2005; Rinner, 2006; Hanzl, 2007; Lin, 2013; Baud et al., 2015). They can also bring about positive change in improving interactions between stakeholders, and enabling their participation to support decision-making. Thus, geospatial technologies are seen as one of the main transformations in this field (Jensen et al., 2005; Eräranta et al., 2016).

The rapid development of geospatial technology tools and their capability to improve decision-making have contributed to increasing their use within entities responsible for urban infrastructure (Matapurkar, 2006; Lewis and Ogra, 2010; Mockert, 2010). Integration of these tools represents one of the developments in this area, frequently used to help with mapping, spatial knowledge production, availability, facilitating access and exchange and performing analytical tasks (Pfeffer et al., 2013). Therefore, many geospatial technology tools are used in management, planning, organising, coordinating, monitoring and simulating urban development as well as addressing issues of urban infrastructure resulting from urban expansion. The tools can provide data required by decision makers to facilitate understanding of the local context, identify needs and priorities and facilitate decision-making, draw up policies, planning, and service management in both developed and developing countries (Sliuzas, 2004; Hahn et al., 2009). They can also be used to develop a number of systems and applications, in different contexts, to make decision-making activities more efficient, for example, Planning Support Systems (PSS), Spatial Decision Support Systems (SDSS), Participatory

Planning Support Systems (P-PSS) and Participatory Geographic Information Systems (PGIS) (Geertman and Stillwell 2004; Aditya 2010; Coutinho-Rodrigues et al. 2011).

Generally speaking, Geographical Information Systems (GIS), Remote Sensing (RS) and Global Positioning Systems (GPS) can be considered as three of the most important geospatial tools for generating a variety of data that is relevant within the context of infrastructure provision (Tiwari, 2005). GPS is deemed beneficial for the collection and production of spatial data (Shen et al., 2001). This tool has been used for supporting activities related to surveying and mapping since the late 1970s (Bossler et al., 2004). GPS is a system that depends on satellites to obtain an exact position using radio signals. The development of this technology has attracted considerable attention in both the public and private sectors and has become one of the most used tools in geodetic works, where benefits that can be gained outweigh the traditional methods in terms of accuracy and cost savings (Warner and Johnston, 2003). In addition, it is considered a useful tool for detailed mapping and providing the necessary data for various activities related to infrastructure provision that require high-accuracy data. The accuracy of standard GPS measurements is now within 1 to 3 metres, which is acceptable for most types of survey (Rahman, 2007; Wagtendonk et al., 2009).

Remote sensing is the science of acquiring and extracting information regarding an object and area acquired from aerial images or satellites (Campbell and Wynne, 2011). It comprises a wide range of techniques, which permit the analysis of information of the Earth’s surface and is acquired using a variety of satellites and aerial photography methods (Paudyal, 2014). Remote sensing has great potential to provide qualitative and quantitative information about an area on the Earth’s surface without being in direct physical contact (Light and Jensen, 2001). According to Green et al. (2005) remote sensing is rapidly evolving in various fields. The data produced by remote sensors is considered to be a major driver in the development of geospatial technologies and can be used in many fields such as, mapping, assessing, monitoring and management (Bossler et

al., 2004; Gatrell and Jensen, 2008). Remote sensing is also used as a tool to generate detailed and specialised maps, while it has great potential for measuring and managing urban expansion. (Rahman, 2007). In the context of infrastructure delivery, remote sensing provides an opportunity to produce and record the data in accurate digital maps making it possible to improve the decision making used for planning urban infrastructure needs and forecasting the need for public services (Cowen and Jensen, 1998). Although remote sensing is a more effective technique than alternative field-survey methods, and a more accurate means of analysing the imagery or spatial data for supporting decision-making, it is, however, comparatively under-used in local governments due to the fact that the acquisition of image processing and data involves high costs (Gilfoyle and Thorpe, 2016).

GIS is one of the most rapidly evolving geospatial technology tools due to its high potential in dealing with various layers of geo-information (Bradshaw and Muller, 1998). The deployment of GIS has attracted significant attention in various fields due to its ability to manage and analyse spatially diverse and distributed data (Wu et al., 2008). Great progress has been made during recent years in the development of handling spatial and meta data through advances in positioning, data dissemination and its sharing as well as data acquisition technologies. Therefore, there is no longer a static concept and definition of GIS because of the multiplicity of fields, its uses and applications.

GIS was first introduced in 1960s, while the 1970s saw tremendous developments and wide usage, in particular, within different government organisations (Kazmi and Usery, 2001; Li et al., 2002; Lazdans and Nitcis, 2008; Mukherjee, 2009; Mohamad et al., 2013; Rj Zimmer, 2013). In light of the diversity of science which covers geographic information and the spread of its uses, many definitions appeared depending on the scientific backgrounds of its users or according to the diversity of the area of its application leading to a diversity in the formula of definitions. Thus, it became difficult to find appropriate definitions which would be acceptable to all. However, in order to

distinguish GIS from other specialised systems, studies by Cowen (1988), and Bahaire and Elliott-White (1999) suggest that definitions of GIS in the literature into one of the five categories outlined in Table 3-1.

Table 3-1: Definitions of geographical information systems

Categories	Definition
Process	"any manual or computer based set of procedures used to store and manipulate geographically referenced data" (Aronoff, 1989, p.39).
Application	"Urban systems, planning and evaluation systems, cadastral information system, management command and control systems, arketing information system and citizen scientific systems etc". (Pavlidis, 1982, cited in Cowen, 1988, p.1551).
Toolbox	"a powerful set of tools for collecting, storing, retrieving, transforming, and displaying spatial data for the real world" (Burroughs, 1986, p.6).
Database	"automated systems for the capture, storage, retrieval, analysis, and display of spatial data" (Clarke, 1995, p. 13)
Decision support	"a decision support system involving the integration of spatially referenced data in a problem solving environment" (Cowen 1988, p.1554).

Source: Cowen (1988); Bahaire and Elliott-White (1999)

The range of definitions presented above, illustrate that GIS definitions include many interpretations; perhaps the most important of these definitions involves aspects of linking data to a spatially referenced base map. In other words, "to link multiple sets of geospatial data and graphically display that information as maps with potentially many different layers of information" (Zhang, 2004, p.27). Therefore, it could be said that geographical information systems were designed as a means of improving the handling capability of information regarding spatial locations. Although, there is multiplicity of GIS interpretations and forms, there is some consensus that they consist of five essential elements; (1) data; (2) hardware; (3) software; (4) procedures and (5) users (Bolstad, 2005). They also provide technical functionality such as: querying, storage, output, integrating and manipulating spatial data (Salma, 2000).

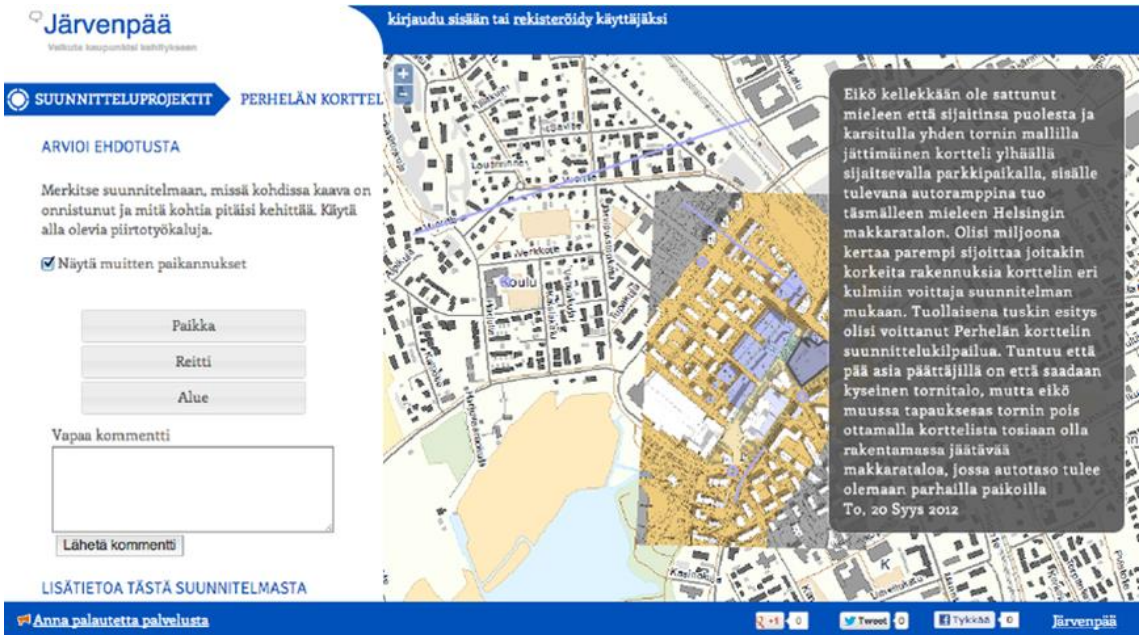

Figure 3-1 Example of application for online planning developed to support and enable map-based synchronous discussions in Järvenpää city, Finland

Source: Czepkiewicz and Snabb (2013.p.42)

Generally speaking, GIS is distinct from other information systems because of its strong capability to organise, store and manipulate different sets of data in different layers into a single map along with its ability to analyse, modify, modernise and convert such data based on its spatial characteristics (Cox, 2007; Azzam and Robinson, 2013). Furthermore, GIS has the ability to integrate, interact and link with multiple and heterogeneous systems such as internet-based applications to help with managerial functions and make spatial resolution more explicit as well as improve communication with the public (Budić, 1994; Clifford et al., 2010; Goodchild, 2011). Moreover, these systems offer different benefits which are difficult to measure, and depend on the kind of applications used and the geographic information stored in databases (Zhao, 2002). Several studies have revealed that there are a set of benefits and advantages offered by these systems such as automated cartography, improvement of organisational efficiency and effectiveness, cost reduction, tracking and monitoring, improved support, decision making and customer service, policy formulation, display of different types of spatial analysis, updating, providing and production of data and maps at different scales (Budić, 1994; Olba and Al-Ramadan, 2006).

A large number of studies point to the growing value of GIS applications to provide solutions which can support infrastructure planning in an efficient manner, and achieve the necessary requirements for an effective urban governance (Webster, 1994; Lewis and Ogra, 2010; Perez-Ramos, 2016). This can be attained through improving public access to information and to communicate with others, as well as offering better opportunities for public participation with regard to decision making (Haque, 2001; McCall, 2003; Olowu, 2003; Sliuzas, 2003; Crampton, 2004; Cinderby and Forrester, 2005; Singh, 2005; Baud et al., 2008; Kam, 2008; Pfeffer et al., 2011; Mukherjee and Ghose, 2013; Tiwari and Jain, 2013). GIS is also considered an integrated system which has the ability to combine different data types able to facilitate linking them together, analysing, supporting group-based decision making and providing a degree of standardisation in the spatial representation, as illustrated in Figure 3-1 with a case study in Finland. Additionally, they present opportunities for drawing out and incorporating local knowledge for a better understanding of the local context, through exploiting the geographical dimensions (Pior and Shimizu, 2001; Ferreira and Duarte, 2005; Pfeffer et al., 2011). Furthermore, they also have capability to integrate with other ICT which enhance administrative affairs for the integration of the work of different government departments and agencies involved in infrastructure planning, regulation and provision as well as responding to urban changes.The main characteristics of GIS provide a number of useful contributions towards inclusive urban management can became an indispensable tool to enhance the local needs and priorities of urban development practice.

Against this background, geospatial technology tools are characterised as being able to understand location-based issues by adding accurate and reliable locations to existing information, and provide effective methods of organising this information from different sources (Steudler and Rajabifard, 2012). They also have a set different of choices to gather and control the data access and its use. Furthermore, these applications are often employed in an integrated fashion, for example combining existing data from fieldwork, data from remote sensing images as well as GPS data, with web-based databases, in a

single uses environment, as illustrated in Figure 3-2 showing the geo-portal of Charleston County Government, US. Therefore, they are an important innovation and a paradigm shift in urban governance systems, and effective tools introduce completely new ways for facilitating and supporting decision-making through collective work (Bwalya, 2009).

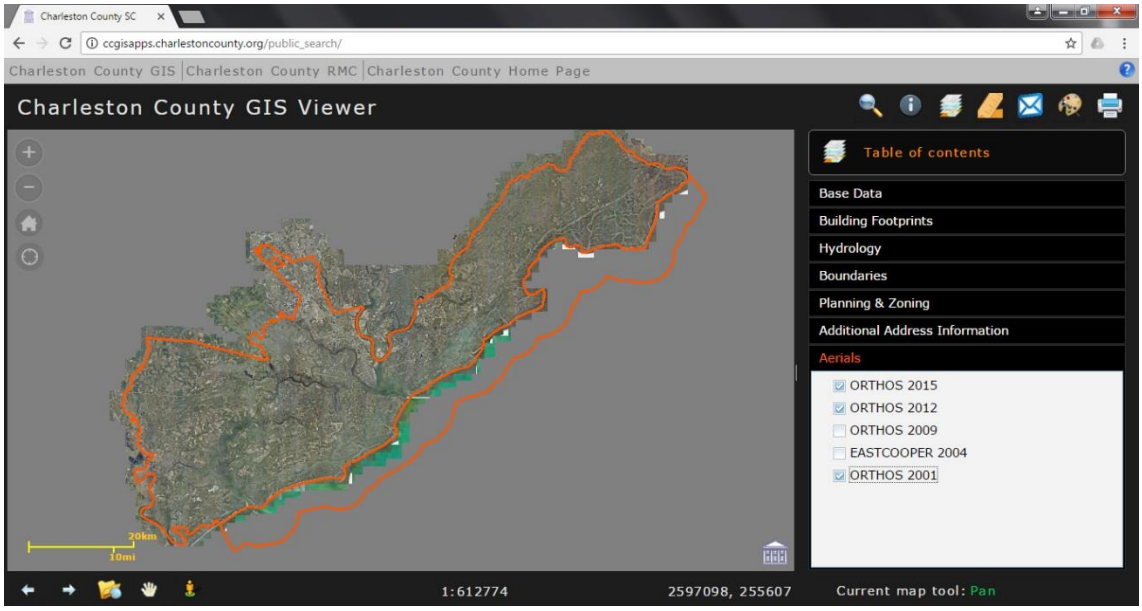

Figure 3-2 A screenshot of the of geo-portal of Charleston city in the USA showing the use of imagery and GIS for monitoring urban growth for use by planners to support decisions related to link transportation, infrastructure and land use planning

Source: Esri (2006); Charleston County Government (2017)

With the increased availability of the Internet, web-based geospatial technological development has contributed to allowing various applications and mapping software to access the data and support infrastructure planning and delivery (Aditya, 2010; Kintu, 2015). Dragićević and Balram (2004) point to a number of benefits of web-based geospatial tools in the planning process, including the ability to make data available before, during and after the planning process, in addition to enhancing participants' interactions and simplification of the decision making process. Aditya (2010) also claims that such development provides citizens with the means to identify and discuss neighbourhood problems, and express their needs and concerns for improving decisions related to infrastructure planning processes. Kleinhans et al. (2015) suggest that many contemporary technologies such as Google Maps, volunteered geographic information (VGI), social media and various smartphones applications have provided opportunities to generate spatial information, as illustrated in Figure 3-3. This information has created the

opportunities for decision makers to set proper plans and strategies for effective planning and urban management, as well as for improving urban governance (McCall and Dunn, 2012).

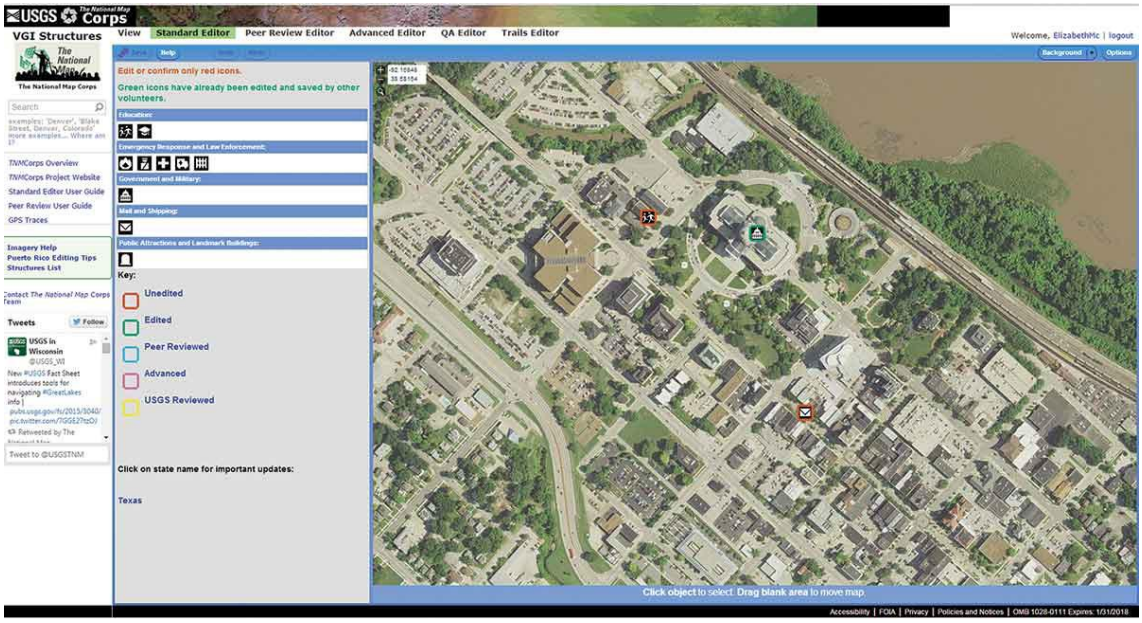

Figure 3-3 Example of web-mapping interface with editor tabs for 'The National Map Corps', which uses volunteer citizens to help the geospatial information office of the U.S. Geological Survey (USGS) provide spatial data to update the national map

Source: McCartney et al. (2015. p55)

A new way to support e-governance initiatives in its tasks related to service delivery and organising the contributions of various stakeholders has also opened up (Thurston et al., 2003; Greene, 2001 cited in Nedovic-Budic, 2010). In addition, many researchers have argued that these technologies play a significant role in the context of smart cities, due to their ability to facilitate the operations of managing infrastructure projects and making their components and services more intelligent, interconnected, and efficient (Al-Hader et al., 2009; Hennig, 2014; Li et al., 2015).

Similarly, geospatial tools provide the means to improve the tasks and responsibilities for infrastructure delivery. Such technologies could be employed to provide the information needed to achieve a better understanding of the spatial distribution of infrastructure (Ayeni, 1997: Rahman et al., 2011). According to Patnaik (2013) these technologies can help decision makers design polices related to providing infrastructure needs resulting from urban expansion and support the ability to predict

expansion in addition to evaluate and measure accessibility to spatially distributed services and utilities. They can also be used to identify the extent of coverage of existing infrastructure by analysing the disparities in the areas covered by the infrastructure and those areas not served (Nedovic-Budic, 2010). This in turn contributes to improving the spatial analysis and hence link during the process of planning and spatial distribution of infrastructure, as illustrated in Figure 3-4 with a web map portal for neighbourhood improvment in Indonesia. Thus, they are important tools for achieving equality in distribution of these services and facilities within residential neighbourhoods and disadvantaged areas.

Figure 3-4 Example of the web map portal designed to facilitate providing data related to the needs and concerns of infrastructure improvements in neighbourhoods in Pandeyan, Indonesia

Source: Aditya (2010.p.138)

Furthermore, geospatial tools provide an insight into finding more effective ways for delivering urban infrastructure in terms of costs and the possibility of different alternatives for implementation (Coutinho-Rodrigues et al., 2011). The geospatial tools also provide information needed for testing infrastructure network extensions, which assist in making decisions during the planning process and identifying whether there is a

need for expansion and estimate the expected cost involved in infrastructure development prior to the implementation (Biermann, 2003; Gebetsroither-Geringer and Loibl, 2015).

However, the use of geospatial technologies is not without shortcomings, as they require significant financed and technological investment. At the same time, these technologies may not be accepted by various users due to the lack of necessary skills needed and issues related to accessibility. Additionally, performance depends greatly on spatial data availability and is also associated with a number of organisational factors, which will be discussed in the following section.

3.4 Factors Influencing Use of Geospatial Technology

The above discussion of the literature review highlighted the importance of geospatial technologies as tools able to improve decision making when planning for residential infrastructure delivery. This is due to their capability for underpinning location-based information and enhancing communication, and sharing and coordinating data exchange among different stakeholders for better decision making (Rajabifard, 2012). In addition, they have the ability to integrate with other types of ICT, including technologies and applications on the Internet, different databases and software applications, where their use in the context of e-Government initiatives is important. However, the use of such technologies requires an integrated technological infrastructure providing a communication platform that includes a set of tools, applications and relevant data. Therefore, it is important to recognise that these technologies may not be widely used due to not meeting the necessary requirements, where the successful implementation depends on the ability to overcome both technical and non-technical factors. This will be discussed in the following sections.

3.4.1 Non-Technical Factors

Organisational aspects, especially those related to public agencies responsible for provision of infrastructure, are considered critical elements for the success of geospatial technology implementation. The continuous development of these technologies requires

the reorganisation of administrative structures and tasks and direct resources that assimilate their actual needs and achieve optimum efficiency. Jackson et al. (2009) stress the importance of leadership that understands change and can create an organisational culture capable of adapting to the changes associated with their use. According to a number of studies, as reviewed by Stea and Harindranath (2006), the nature and characteristics of organisations often affect the manner in which they tend to use technology; such as hierarchical structures, internal political tension, bureaucracy, legal and public policies, power disparities and coordination. Therefore, the desire to introduce geospatial technologies, and the acceptance of their use in performing various daily duties, enhance cooperation opportunities and engage stakeholders in the decision making process, would be a driving force and have significant impact on obtaining the benefits of implementation.

In addition to this, the existence of geospatial strategies plays a critical role moving towards the adoption and use of geospatial tools (Jacoby et al., 2002). This includes setting a clear vision and the objectives of what can be achieved using geospatial technology, identifying financial resources, policies of cooperation with different agencies, and the needs of users and other stakeholders whilst involving them in all stages of the implementation to improve levels of interaction and participation (Campbell, 1992; Anumba et al., 2006; Fegeas, 2007).

On the other hand, Spatial data and information is crucial to exploit the opportunities offered by geospatial technologies to improve decision making. It is also considered the basis of all works that involve the use of geospatial tools (De Bakker et al., 2004). Many issues that limit the utilisation of these technologies can be attributed to inadequate spatial data and information and its long-term management. With the fast development in spatial data collection and communication technologies, the establishment of spatial data infrastructure (SDI) has become an important aspect in the way the spatial data are used (Rajabifard and Williamson, 2001). It provides new forms of collaboration and partnerships between various spatial data producers and users, support for interactions

and activities related to the exchange and sharing of spatial data at societal and organisational level, and the access and transfer of data and information acquired from a variety of sources (Rajabifard et al., 2002; De Rink, 2004; Granell et al., 2007). SDI is crucial for avoiding the duplication of efforts and waste of resources in spatial data production, costs for maintaining spatial data can be reduced, and a common framework for collection of data provided. It also promotes interoperability along with addressing issues related to integration of spatial data from multiple sources and formats (Hadi et al., 2012). It is important to facilitate access to spatial data or information, whilst addressing legal and security issues, including preserving the privacy of stakeholders contributing to the provision of geospatial data and information (Barndt, 1998). In addition to this, it is fundamental to ensure spatial data accuracy, quality and accessibility which have always been a problem within different sectors (Napier, 2003; Stratton, 2009). However, Rajabifard and Williamson, (2001, p.4) indicate that there are six key factors that should be considered to achieve the advantages of an SDI and drive its development. These factors include "awareness of use of Geographic Information and SDIs; cooperation between the various stakeholders; involvement of the politicians concerned; knowledge about the type, location, quality and ownership of datasets; accessibility of datasets; and the successful widespread use of the datasets".

The cost associated with implementation of geospatial technologies is also one of factors that have a negative influence on their use. Although the implementation of these technologies may be an appropriate technological solution for improving the performance of tasks related to service delivery, there are many costs involved that require financial resources to implement the necessary technology including, geospatial tools, hardware and software acquisition, training, collection and upgrade of geospatial information data and its management, system maintenance (Foresman et al., 1999; Johnson, 2013; Jackson et al., 2009). Thus, it is necessary to calculate the costs and benefits associated with geospatial activities before starting the implementation phases in order to reduce the constraints in funding when the results and benefits may take time to emerge. One of the

important measures in this regard, pointed out by Carpenter and Snell, (2013), is the significance of the exploitation of technological developments which contribute to reducing costs and increasing efficiencies. This includes, for example, use of and reliance on the cloud for hosting and serving information, open source software and web-based geospatial technology and mobile phones that have GPS and navigation functions to generate spatial data.

Moreover, lack of awareness about the potential of the geospatial technology tools is also among the factors that affect the implementation of these technologies. According to Tsou (2008) increasing awareness about the benefits of geospatial technology is critical to expand the level of their use. The lack of awareness may also influence the dissemination of information to the public and the sharing of spatial data, as well as the selection of appropriate geospatial tools that meet the work requirements, all of which may lead to limiting the benefits and potential (Hadi et al., 2012; Johnson, 2013).

Similarly, responding to the needs of a geospatial workforce is a vital component to ensure the competence of implementation, where the use of these technologies requires a team of staff with the necessary qualifications and skills. In spite of advancements in geospatial technologies there is, however, a shortage of qualified employees and staff with managerial skills in the geospatial field (Annulis et al., 2004; DiSera, 2011). Therefore, providing appropriate training, raising qualifications and skills, identifying staff roles, responsibilities and work patterns, along with providing incentives can influence achieving optimal benefits from their implementation (Gaudet and Annulis, 2001; Green et al., 2001; Anumba et al., 2006; Johnson, 2013). Additionally, setting a clear professional identity for geospatial professionals is vital to encourage and develop their use (Róiste, 2014).

3.4.2 Technical Factors

There is growing recognition that geospatial technologies have tremendous potential that can be harnessed to improve infrastructure provision in urban areas and help to

overcome issues related to their delivery (Singh and Ogra, 2011; Roche et al., 2012). The adoption and use of geospatial technology tools requires the provision of a suitable technological infrastructure and tools that assist in increasing the participation between service providers and citizens, as well as the effective production and handling of geospatial data and information. This infrastructure involves many geospatial tools such as, GPS, digital devices, remote sensing applications and reference stations, as well as other peripheral devices, communication networks necessary to conduct spatial data collections along with related software used for creating, viewing, managing, analysing and converting data into a digital format (Voženílek, 2005; DiBiase et al., 2010).

With the growth in the use of geospatial technology based on web, taking advantage of these technologies in the context of service delivery has become limitless. Zhao et al. (2007) argue that these developments hold many advantages including enabling the sharing of computational resources between the organisations, facilitating maintenance and updating existing systems. New opportunities have emerged that will improve the gathering, displaying, processing, analysing, exchanging, transferring, storing and retrieving spatial data compared to traditional methods. In addition, these developments provide considerable potential, at lower cost, for improving multi-level participation in decision-making processes, tools that are more accessible to a broader range of users, as well as non-specialist. Therefore, keeping abreast of rapid technological developments is key when creating shared platforms based on geospatial technologies that can be used as a shared space between different agencies to support the requirements of spatial data and information exchange, decision-making, and technical support.

Developments in ICT have also made it possible to improve different uses of geospatial technology tools. There are various types of ICT infrastructure that serve different geospatial activities and the processing of spatial data. This includes a set of tools such as, computer hardware, networks, servers that host and provide protection for system components, geospatial applications and system interoperability of geospatial databases are necessary to achieve the best use of geospatial technologies (Al-Hader et

al., 2009). In addition, a wide range of software, programming tools, data transfer protocols, standards, technologies and the infrastructure of the Internet that enable spatial information sharing and interoperability of services must be available to maximise the benefits of implementing geospatial technologies (Lake and Farley, 2009). This also involves wireless networking infrastructures which may be useful in a multi-stakeholder environment to facilitate the transmission of large datasets by different geospatial applications and overcome the high cost of providing the required technological infrastructure (van Manen et al., 2009). However, factors such as the digital divide, Internet and access issues are challenges that should be taken into account, since they may hinder the potential of geospatial technology to achieve appropriate levels of participation and providing and sharing data between all stakeholders.

In addition, geospatial technologies are constantly developing (Lachman et al., 2002). Pearlman and Coote (2014) point out that both geospatial data and physical infrastructure depreciate over time. Therefore, upgrading and maintaining the necessary technological infrastructure in parallel with updating the spatial databases are crucial to ensure efficient implementation and to exploit the opportunities offered by these technologies.

3.5 Summary

This chapter presented an inclusive view of the importance of ICT and geospatial technologies as an effective tool for supporting tasks related to residential infrastructure. The roles that geospatial technologies play in the context of infrastructure delivery are varied. It was noted that there are clear implications on encouraging the relevant actors to participate, organise collective action, exchange data and information, and improve both decision making and the process of service delivery in innovative ways. There is no doubt that the rapid developments in various technologies have contributed to improving geospatial uses and the availability of geospatial data in different contexts. However, the emerging conclusion alludes to a number of obstacles that minimise the use of geospatial

technologies. A number of factors were attributed to both technical and nontechnical issues such as, organisational aspects, accessibility, technical competence, information and data issues, security aspects, privacy, democratic access, the digital divide, distribution of e-infrastructure, hardware and software availability and usability. Therefore, the challenges in implementation not only lie in the availability of the tools, but in the development of strategies to meet the needs of coordination, partnership, interoperability and access of stakeholders to obtain full potential.

Chapter 4: Research Methodology

4.1 Introduction

The previous chapters critically reviewed the effects of rapid urban growth specifically the shortage of residential infrastructure associated with the continued increase in the spread of residential areas. In addition, they justified the importance of urban governance as a key element to address these issues. They also illustrated how geospatial technology can offer promising opportunities for promoting the integration of between stakeholders and providing data thereby improving the decision making process related to the delivery of infrastructure and services for residential areas.

This chapter presents in detail the methodology undertaken in this research, and how it seeks to achieve the research aim and objectives. It provides an overview of the philosophical paradigms, and explains the necessary approaches and strategies required to carry out the research. The chapter also outlines the choice of the research population, illustrates methods for information and data collection, and the approach that will be used for the data analysis. Finally, it highlights difficulties and limitations that faced the researcher during the data collection period, followed by ethical considerations taken into account at the time of carrying out this research.

4.2 Research Philosophy

A research philosophy is an expression of the ways to achieve development of knowledge through the adoption of assumptions which underpin the methods and research strategy in order to enable researchers to see the relations between its parts for analysed (Saunders et al. 2011). Therefore, understanding of the research philosophy is essential underpinning to guide the study through clarifying the research strategy, the choice of information and data collection techniques required to conduct the investigation as well as the method of analysis used to answer the research questions (Easterby-Smith et al., 1997; Hafeez-Baig et al., 2006).

Research philosophies can be distinguished in different ways, usually associated with a research paradigm which has fundamental assumptions about how to research (Daymon and Holloway, 2002). However, there is no consensus about classification of research philosophies which share critical assumptions (Mkansi and Acheampong, 2012). Thus, Somekh and Lewin (2005, p.275) argue that research philosophies "are useful conceptual tools but they should not drive practice decisions". While Holden and Lynch (2004) claim that during the research work selecting a philosophical stance is not necessary for the proper utilisation of research methodology and could be better investigated in the research problem using a method from an alternative philosophical stance to enhance confidence in research results.

Wilson (2001) indicates that ontology, epistemology, axiology and methodology are the assumptions relevant to the research philosophy used by researchers to clearly define their philosophical position and how they gain knowledge. Specifically, ontology can be defined as the study of being (Crotty, 1998). According to Lawson (2004, p.1) "the word being has two senses: (1) Something that is, or exists; an entity a thing; (2) What it is to be or to exist; what all the things that are have in common". Ontology is the philosophical study concerned with the nature of reality and what can be known about it (Ritchie, 2003). It is associated with "philosophical questions relating to the nature of being and purpose of existence" (Somekh and Lewin, 2005, p.347). Whereas, epistemology as described by Vanderstoep and Johnson (2008) is the philosophical study of knowledge; beliefs about the nature of knowledge and knowing. Ormston et al., (2014, p.6) describe epistemology as the philosophy that is "concerned with ways of knowing and learning about the world and focuses on issues such as how we can learn about reality and what forms the basis of our knowledge". According to Guba and Lincoln, (1994, p.108) the key questions to epistemology are: "What is the nature of the relationship between the knower or would-be knower and what can be known?". Methodology refers to a model behind the research process in the context of a specific paradigm (Wahyuni, 2012). It is the ways in which knowledge is acquired in the particular field of study (Goudarzi et al., 2011). While, axiology is the philosophical discipline that studies judgments about value (Saunders et

al., 2009). It denotes philosophical questions relating to the nature of values (Somekh and Lewin, 2005). Table 4-1 shows a summary of the philosophical assumptions characteristics and differences of the four research paradigms.

Table 4-1: Comparison of research philosophies

Philosophical Assumptions	Research Paradigms			
	Positivism	Postpositivism	Interpretivism/ constructivism	Pragmatism
Ontology	External, objective and independent of social actors	Objective. Exist independently of human thoughts and beliefs or knowledge of their existence, but is interpreted through social conditioning (critical realist)	Socially constructed, subjective, may change, multiple	External, multiple, view chosen to best achieve an answer to the research question
Epistemology	Only observable phenomena can provide credible data, facts. Focus on causality and law-like generalisations, reducing phenomena to simplest elements	Only observable phenomena can provide credible data, facts. Focus on explaining within a context or contexts	Subjective meanings and social phenomena. Focus upon the details of situation, the reality behind these details, subjective meanings and motivating actions	Either or both Observable phenomena and subjective meanings can provide acceptable knowledge dependent upon the research question. Focus on practical applied research, integrating different perspectives to help interpret the data
Axiology	Research is undertaken in a value-free way, the researcher is independent of the data and maintains an objective stance	Research is value laden; the researcher is biased by world views, cultural experiences and upbringing	Research is value bond, the researcher is part of what is being researched, cannot be separated and so will be subjective	Values play a large role in interpreting the results, the researcher adopting both objective and subjective points of view
Methodology	Highly structured, large samples, measurement, quantitative, but can use qualitative	Mixed or multiple method designs, quantitative and qualitative	Small samples, in-depth investigations, qualitative	Methods chosen must fit the subject matter, quantitative or qualitative

Source: Guba and Lincoln (2005), Hallebone and Priest (2009), Saunders et al. (2009, p.119) cited in Wahyuni (2012, p.2)

As stated in chapter one, this research seeks to improve the implementation of geospatial technology as tools for supporting the process of making decisions related to residential infrastructure delivery planning. This requires a clear understanding of the nature of the issues and factors affecting the adoption and utilisation of their tools within relevant agencies and how they can improve the current situation. In view of this, the research adopts the epistemological position of pragmatism, which takes into account the variety of forms of knowledge to reveal the reality of the current use of geospatial technology identifying factors that may influence their use and ways this could be improved.

Such an approach allows the researcher to use the methods available to understand and deal with the research problems (Kalolo, 2015). In addition, it offers the researcher the freedom to select methods, procedures and techniques, which suit the needs and objectives of their research (Creswell, 2003). Therefore, this approach tends to rely on different forms of data collection, whether qualitative methods or a combination of both qualitative and quantitative methods, to provide the best understanding of social reality (Wahyuni, 2012). It also enables the researcher to offer further interpretations in terms of concepts and guidelines in the literature thus helping to arrive at conclusions on the subject being studied. This in turn would help to identify and understand issues confronting relevant agencies, and further provide recommendations on how these issues could be resolved.

4.3 Research Approach

There are multiple approaches that can be used as the path in knowledge building, depending on the philosophical ideas which guide the research stages in different ways (Alassaf, 2007). Research approaches are defined as research procedures that cover a set of steps from assumptions to detailed methods of data collection and interpretation depending on the nature of the research problem for a specific topic of study (Creswell, 2009).

There are two basic approaches to research: a deductive approach or an inductive approach (Saunders et al., 2007). The distinction between inductive and deductive approaches has been widely discussed by many authors (e.g., Hyde, 2000; Swanson and Holton, 2005). According to Hyde (2000) the inductive research approach is used for the purpose of generating a theory from empirical evidence. It is a process that begins with the observation of particular instances and aims at establishing the generalisations about the phenomenon being observed or investigated. In other words, it seeks to develop the theory based on empirical evidence (Dubois and Gadde, 2002). What distinguishes this approach is its flexibility (Crowther and Lancaster, 2009). It is not constrained by a preconceived model or specific structure and does not require a pre-determined theory or hypotheses. However, the results to emerge from the inductive research may not be generalised with similar subjects in different circumstances (Badewi, 2016). Meanwhile, the deductive research approach is the opposite and aims to test a theory and see whether the theory applies to particular instances (Hyde, 2000). It is a useful approach if the aim is to test a theory and assess its validity in a different situation or to compare specific categories at different time periods (Elo and Kyngäs, 2008). In addition, the deductive approach is usually associated with the Positivist and Objectivist paradigms (Bryman and Bell, 2011).

There is some disagreement among researchers as to the methods used when conducting research and the way that data is collected. Therefore, researchers often refer to the two main types of data generation methods used, quantitative methods which often employs a deductive approach and qualitative methods for the inductive approach (Snape and Spencer, 2003). However, Trochim (2006 cited in Soiferman, 2010, p.12) indicates that researchers should "dispel the notion that quantitative research is always confirmatory and deductive, or that qualitative research is always exploratory and inductive". Overall, the main differences between deductive and inductive approaches can be seen in the following table.

Table 4-2: The difference between the inductive and deductive approaches

Deductive approach	Inductive approach
- Scientific principles. - Moving from theory to data. - The need to explain causal relationships between variables - The collection of quantitative data. - The application of controls to ensure validity of data. - The operationalisation of concepts to ensure clarity of definition - A highly structured approach. - Researcher independence of what is being researched. - The necessity to select samples of sufficient size in order to generalise conclusions.	- Gaining an understanding of the meanings humans attach to events. - The collection of qualitative data. - A more flexible structure to permit changes of research emphasis as the research progresses. - A realisation that the researcher is part of the research process. - Less concern with the need to generalise.

Source: Saunders et al., (2011, p127)

As such, this research is viewed within the hybrid process of both a deductive and inductive approach, the deductive method is used to tease out the factors affecting geospatial technologies implementation in the theoretical part of the research, while the qualitative data analysis, derived from a particular context and in absence of any sort of theory has led the research to generate a number of concepts and theories and is thus inductive.

4.4 Research Strategy

Determining a research strategy is considered to be an important element in determining a general orientation to the conduct of research (Bryman, 2008). Research strategy is a consistent set of methods, techniques and procedures aiming to collect and

interpret the research material (Verschuren, 2003). According to Yin, (2014) the selection of the research method to be used relies on three major considerations: (1) the type of issue being investigated, (2) the limit to which the researcher can control the events of the actual research activities, (3) the focusing on recent instead of historical or past events. His discussion of research strategies indicates that the research works are based on one of five major research strategies: case study, experiment, surveys, history and archival analysis. The table below provides a summary of the relevant situations for different research strategies.

Table 4-3: Situations of different research strategies

Research Strategy	The Type of Question	Control of Behavioral Events	Focus on Contemporary Events
Experiment	How, why?	Yes	Yes
Survey	Who, what, where, how much and how many?	No	Yes
Archival analysis	Who, what, where, how much and how many?	No	Yes/No
History	How, why?	No	No
Case study	How and why?	No	Yes

Source: Yin (2014, p.5)

Taking into consideration the information presented in the table above, the case study is deemed the most appropriate strategy for this research. This strategy is ideal when undertaking an investigation of a contemporary phenomenon and its associated contexts, as it has the potential to provide an in-depth understanding and a richer, more detailed picture of current events (Schell, 1992). Yin (2003) suggests that the case study is more suitable for providing rich and contextual data that can help to describe a phenomenon within its context. In addition, it enables the researcher to gather data using multiple

sources of evidence which reflects positively on the research findings and ensures conclusions are more accurate and convincing (Dhanda, 2013; Yin, 2014). Furthermore, a case study strategy is well suited for understanding the interactions between organisational contexts and innovations related to information technology (Darke et al., 1998). Therefore, this strategy is suitable for the purpose of this research, as it will assist in investigating the present situation, diagnosing and gaining a comprehensive understanding of the complex issues related to the use of geospatial technologies by concentrating on the use of these technologies in the context of infrastructure delivery in residential areas. The city of Riyadh is chosen as a case study since it is experiencing rapid urban growth and expansion in the development of residential areas. This has created many infrastructure issues as is the case in most of Saudi's large cities, but Riyadh is likely to witness growth at a faster pace than other, as stated in section 5-2. The organisational and managerial structures, and arrangements related to infrastructure delivery in these cities also have similar characteristics, but there may be some minor differences which can be attributed to the extent of development of geospatial activities in the relevant agencies, which does not affect the main focus of this research. The next section will describe the procedures for the research design which will be used to collect the data, along with the techniques which will be applied for data analysis.

4.5 Research Design

This section presents the research design used for carrying out the present research. It describes the phases carried out by the researcher to achieve the research objectives. The research phases began with a review of the relevant literature to determine the dimensions and area of the research. The second phase is focused on the development of the research methodology which identified the research strategy and methods that could be used to collect and analyse the targeted data to meet the research objectives. The third phase included a discussion of the results reached during the research process along with the development of the strategies. It also involved identifying how the results meet the stated research objectives. Figure 4-1 shows the process undertaken in the research, and

describes the stages of research development from setting out the problem to the conclusion and recommendations. These processes will be explained in detail in the following subsections.

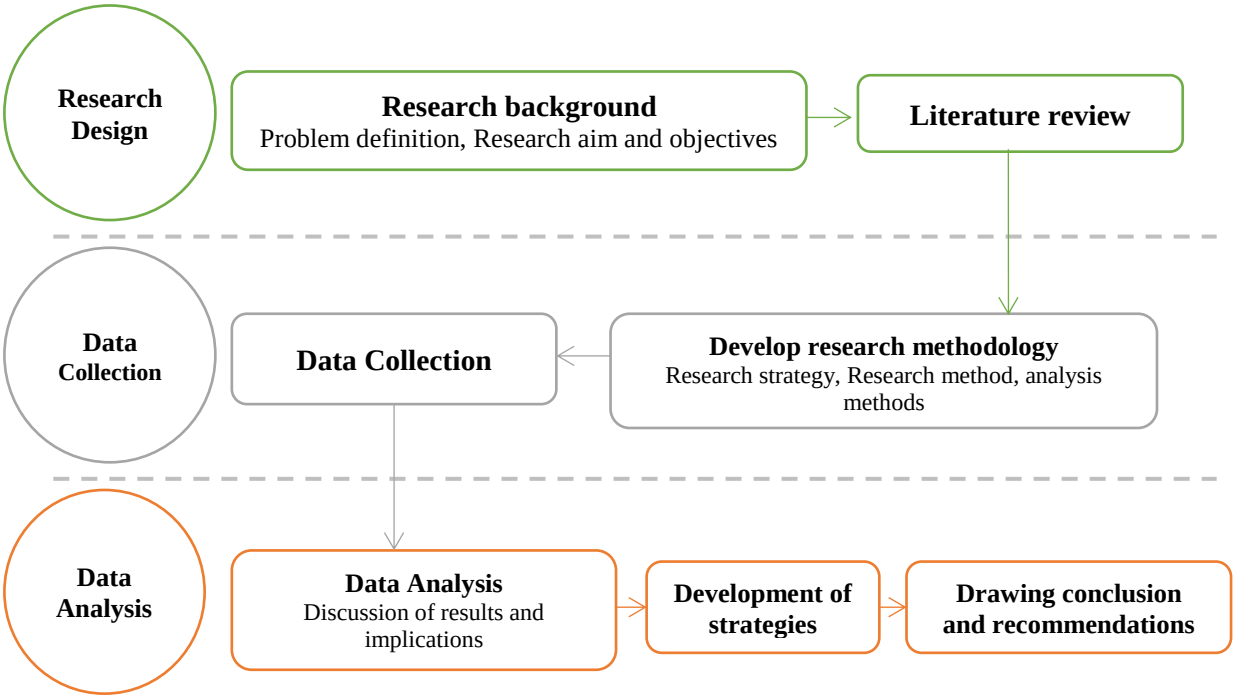

Figure 4-1 Research Design

4.5.1 The Literature Review

The literature review is an essential part of the research process (Cronin et al., 2008). It contributes to helping researchers to find out about the relevant available research and create a greater understanding with regards to a specific topic or issue. According to Blaxter (2010. p 124) "a literature review is a critical summary and assessment of the range of existing materials dealing with knowledge and understanding in a given field". It aims to provide an insight into previous work in the area of research to identify the critical issues that need to be investigated.

In this research, the process of conducting the literature review involved searching for relevant literature in a wide range of resources that that serves the research objectives. These resources included previous research presented in books, dissertations, government documents, refereed academic journals and professional journals available in libraries, electronic publications and relevant governmental agencies.

This stage reported in Chapter two and three began with a comprehensive review of the literature in the area of urban growth and its impact on urban infrastructure and services in residential areas, as well as urban governance. In addition, the importance of geospatial technologies and their role in making decisions for the purpose of addressing the issues of residential infrastructure delivery, and the issues related to their implementation were also considered.

Meanwhile, a wide range of literature was reviewed in Chapter five aimed at gaining a deeper understanding of the roles of various agencies that provide infrastructure services, and the current use of geospatial technologies. This included an explanation of the phases and patterns of urban growth and the development and analysis of their impacts on the residential infrastructure services by: (a) interpreting the factors that contributed to the city's growth, (b) describing the organisational processes, urban planning systems and development programmes that played a role in shaping the city and residential areas, and (c) identifying the consequences of urban growth, associated challenges, and its influence on the integration of residential infrastructure. It also included the existing systems, tasks, responsibilities, activities and mechanisms for decision making related to residential infrastructure delivery.

The review also provided an explanation of the institutional arrangements in the city of Riyadh, which started with a description of the current status of administrative systems and structures focusing on the transformations and reforms in local administration and decision making processes. The role of stakeholders in policy making and implementation in the context of residential infrastructure delivery was also considered. In addition, the review included highlighting the issues related to centralised and duplicated systems, as well as financial arrangements related to delivering residential infrastructure. Furthermore, it provided a clear description of the land planning system and infrastructure requirement for the adoption of residential schemes along with the responsibilities of the concerned agencies.

Moreover, the geospatial technology activities in relevant agencies, and issues associated with their implementation, paying particular attention to the extent to which it is used in the context of residential infrastructure delivery, were discussed. This included

provision of an overview of the development of geospatial technologies use in the agencies concerned with residential infrastructure delivery. The governmental efforts to promote efficient use of these technologies and relevant policies and strategies were also described. In addition, the issues of geospatial technologies implementation such as duplication of activities and other issues related to the spatial data were pointed out.

This review contributed to obtaining an in-depth understanding, forming a comprehensive picture and creating a better understanding of the relevant concepts and issues under research. It also led to a refinement of the main elements of the research and its aims and objectives.

4.5.2 Direct Observation

Direct observation is a method of information collection in which the researcher listens to and watches events, people and conversations in their usual environment at first-hand (Cassell and Symon, 2004). One of the advantages of this method is that it enables the observer to see and discover naturally occurring events without becoming involved in the situation under assessment (Mayoux, 2001). This in turn enables the researcher to obtain a true picture of the actual practices of the subject under study. Robson (2002) suggests that the data from direct observation can usefully complement information obtained by other data collecting techniques. However, this method is time-consuming and, therefore, often costly (Johansson, 2004). "Data gathered by this method may consist of detailed descriptions of a subject’s activities, behaviors, actions, and interpersonal actions" (Patton, 1990, cited in Walters, 2001, p.187).

In this research, direct observation, during meetings of the regional council, was used to explore the extent of reliance on the output of geospatial technologies to support decision-makers responsible for infrastructure delivery in the city of Riyadh. During the data collection phase, the researcher attended a formal meeting of the regional council, which include the majority of decision-makers from the agencies responsible for public infrastructure delivery. The researcher also attended committees meetings that preceded the Council meeting and reviewed the minutes from the previous Council meetings, which all are not open to non-Council members. Notes taken during the observation were

beneficial in highlighting the level of employment of these technologies in supporting the decisions taken. They also highlighted understanding of the extent of the Council's influence on coordination and integration between relevant agencies, which thereby enhanced the data collected during the research

4.5.3 The Delphi Technique

This research study aims to improve the implementation of geospatial technologies to support service delivery in residential areas. The development of strategies aimed at enhancing the use of available geospatial tools by relevant agencies is complicated, especially in the context of bureaucratic agencies that suffer from a lack of coordination and cooperation. Geospatial activities and the objectives informing their implementation may differ from one agency to another. However, the processes of implementation of these technologies in different situations includes many common elements, and thus, dealing with them in a coordinated and holistic manner is essential. In particular, it is difficult to determine the most suitable strategies for addressing these issues without engaging with relevant agencies, especially when the solutions are associated with more than one agency. This requires a coordinated approach, involving defined visions and strategies built on consensus and mutual acceptance among the relevant agencies in order to minimise redundancy and incompatibilities in the data and systems, as well as ensuring commitment to implementation. Therefore, the Delphi technique was used to obtain information about the issues influencing the implementation of these technologies. The objective was to secure the participation of responsible agencies to the maximum possible extent and to achieve a consensus of opinions among them on strategies that could improve their utilisation through a continuous process of interaction and feedback.

Delphi has been used in a wide variety of research areas as an efficient, inclusive, systematic and structured approach that enables a group of individuals to deal with extremely complex problems (Mukherjee et al., 2015). The Delphi technique is a method of collecting and exchanging the individual views of a group of experts to reach a reliable consensus or judgement on a particular issue (Williams and Webb, 1994). It is used to

assist in pooling experts' knowledge in a specific field of research to develop a collective opinion, a more accurate and informed judgement than is obtainable from one individual, through a series of consultations, which are repeated until a consensus is reached (Guzys et al., 2015). Delphi was first developed in the 1950s by the Rand Corporation, as a structured process for collecting and analysing collective opinions to obtain a reliable consensus among a group of experts (Robertson et al., 2000). It relies on iterative feedback to achieve a consensus for solving complex issues. The principal strength of this technique lies in its ability to synthesize diverse opinions.

Many researchers have adopted the Delphi technique as a research method, and it is now widely used in various research disciplines (Gupta and Clarke, 1996). According to Hasson and Keeney (2011), there are ten main categories of Delphi, each one has different characteristics in terms of sampling approach, the number of rounds, the level of anonymity and feedback given, the inclusion criteria and method of analysis (see Table 4-4). In this research, Decision Delphi was used to reach collaborative decisions amongst a group of experts from all relevant agencies concerning strategies and guidance that would help to improve the implementation of geospatial technologies. This method is characterised by anonymity, controlled feedback, iteration, statistical group response and stability in responses among the experts involved in the study (Hanafin, 2004). It also involves a number of benefits, including the ability to include many opinions from different geographical locations, the freedom of individuals to express their opinions without being influenced by others, and allowing individuals to participate at their convenient time (Whitehead and Elliott, 2007). In addition, Delphi is a suitable method to use when the empirical evidence associated with a specific problem is limited or when the questions may have no definitive answers (Skulmoski et al., 2007). On the other hand, the main limitations of the Delphi technique are represented in the participant selection bias and the decline in response rates resulting from the process of repeated rounds. These limitations diminish the degree of accuracy and level of generalisability of the results (Jackson, 2001; Hsu and Sandford, 2007; Addington et al., 2013).

Table 4-4: Types of Delphi designs

Design type	Aim	Target panellists	Administration	Number of rounds	Round 1 design
Classical	To elicit opinion and gain Consensus	Experts selected based on aims of research	Traditionally postal	Employs three or more rounds	Open qualitative first round, to allow panellists to record responses
Modified	Aim varies according to project design, from predicting future events to achieving consensus	Experts selected based on aims of research	Varies, postal, online etc.	May employ fewer than 3 rounds	Panellists provided with pre-selected items, drawn from various sources, within which they are asked to consider their responses
Decision	To structure decision-making and create the future in reality rather than predicting it	Decision makers, selected according to hierarchical position and level of expertise	Varies	Varies	Can adopt similar process to classical Delphi
Policy	To generate opposing views on policy and potential resolutions	Policy makers selected to obtain divergent opinions	Can adopt a number of formats including bringing participants together in a group meeting	Varies	Can adopt similar process to classical Delphi
Real time/consensus conference	To elicit opinion and gain Consensus	Experts selected based on aims of research	Use of computer technology that panellists use in the same room to achieve consensus in real time rather than post	Varies	Can adopt similar process to classical Delphi
e-Delphi	Aim can vary depending on the nature of the research	Expert selection can vary depending on the aim of the research	Administration of Delphi via email or online web survey	Varies	Can adopt similar process to classical Delphi
Technological	Aim varies according to project design, from predicting future events to achieving consensus	Experts selected based on aims of research	Use of hand-held keypads allowing responses to be recorded and instant feedback provided	Varies	Can adopt similar process to classical Delphi
Online	Aim varies according to project design, from predicting future events to achieving consensus	Experts selected based on aims of research	Implementation of the technique on any online instrument such as a chat room, or forum	Varies	Can adopt similar process to classical Delphi
Argument	To develop relevant arguments and expose underlying reasons for different opinions on a specific single issue	Panellists should represent the research issue from different perspectives	Varies	Varies	Can adopt similar process to modified Delphi i.e. first round involves expert interviews
Disaggregative policy	Constructs future scenarios in which panellists are asked about their probable and the preferable future	Expert selection can vary depending on the aim of the research	Varies	Varies	Adoption of modified format using cluster analysis

Source: Hasson and Keeney (2011, p.1697)

In the literature, Delphi often involves the collection of qualitative and quantitative data (Hasson et al., 2000; Skulmoski et al., 2007). It consists of a series of rounds, usually

three or four, interspersed with feedback and re-voting derived from the participant experts. It can be conducted using questionnaires and face-to-face or telephone interviews (Saleh et al., 2008). In this research, both qualitative and quantitative were used for data collection in order to facilitate a more in-depth discussion and exploration and to achieve consistency in the issues under investigation (Hartman 1981). A series of three consecutive rounds was used, in which qualitative data was collected in the first round and quantitative data in subsequent rounds (see Figure 4-2). The sample used in the Delphi method is based on a panel of selected experts that represent all responsible agencies to help provide a robust view on the topic being studied, which is discussed in the following sub-sections.

4.5.3.1 The Selection of the Delphi Participants

The selection of the panel of experts is a critical component of the Delphi process. Many authors in the literature have discussed the importance of the panel selection process as an essential if successful and credible results are to be obtained from a Delphi study (for example Chan et al., 2001; Stitt-Gohdes and Crews, 2004; Franklin and Hart, 2007). Therefore, the expert panel is not intended to be representative of the population for statistical purposes, they must, however, have experience and/or knowledge of the subject being studied.

According to literature on the Delphi method, there are no clear criteria to determine the number of experts required to form a Delphi panel. Rowe and Wright (1999) indicate that the size of a Delphi panel may range from a low of three participants to a high of 80, while Lilja et al. (2011) suggest that the size of a Delphi panel should have at least 10 participants in order to generate reliable results. Therefore, the willingness and ability of the expert panel members to express an opinion on the topics to be discussed are important, whereas quantity is not.

The key aspects of panel selection suggested by Stitt-Gohdes and Crews (2004) include experts' qualifications, size and participant commitment. According to Adler and Ziglio (1996), the four criteria requirements for expertise are knowledge and experience of the issues under study, capacity and willingness to participate in the study, sufficient

time to participate and effective communication skills. Hasson et al. (2000) argue that purposive sampling or criterion sampling are often used for the selection of the sample of experts in many Delphi studies. In this research, purposive sampling (expert sampling) was used to select a panel composed of heterogeneous experts who have a direct relationship with the subject under study and are best able to provide information and advice on the basis of their expertise. The expert panel was selected based on their positions as decision-makers and department managers who are involved with geospatial technologies. The selection aimed to represent all agencies concerned with the delivery of residential infrastructure and included other government agencies that provide the support for working on these technologies, outlined in Chapter five (see Table 4-5).

Table 4-5: The Delphi panel members

No	Organisation or Agency	Type of Service
1	Riyadh Municipality	Municipal Services
2	The General Department of Education	Schools and other Education Services
3	Saudi Post	Postal Services
4	General Directorate of Health Affairs	Health Services
5	The Branch of Ministry of Islamic Affairs	Places of Worship Services
6	General Directorate of Civil Defence	Fire Fighting
7	Public Security Department	Public Security
8	Saudi Telecom Company	Landline and Internet Services Provider
9	National Water Company – Riyadh	Water Supply and Sanitation Services Provider
10	Saudi Electricity Company – Riyadh	Electrical Power Services Provider
11	The High Commission for the Development of Riyadh	The Body Responsible for the Development of Riyadh
12	The National Committee for Geographic Information Systems	Organising GIS Activities
13	E-Government Programme (YESSER)	Developing E-Government Services in Government Agencies

Source: The author

This is in order to obtain a balanced combination of views on the issues being discussed. In addition, these individuals are able to influence the issues directly involved in this research. They have also participated in most stages of the implementation process of these technologies, providing them with substantial knowledge and experience with regard to the issues associated with their use.

In total, 24 experts were invited to participate in an expert panel, and were individually provided with an overview of the main objectives of the research, as well as

what was expected from them over the course of the study. Experts were also provided with the rationale behind their inclusion in this study, and were ensured that their anonymity and confidentiality would be maintained during the research process.

A total of 20 experts agreed to participate in the Delphi panel and were willing to share their experiences and thoughts on the research topic. However, only 18 experts continued to the end of the study. Specifically, the Delphi panel comprised ten decision-makers, eight department managers involved in the use of geospatial technologies in the agencies that provide residential infrastructure, and two officials representing the national committee for geographic information systems and the e-government programme.

4.5.3.2 Data Collection and Analysis Process

Following the expert panel selection process, a number of questions were developed based on extensive review of the relevant literature in preparation for starting the data collection phase. Before starting data collection process, a pilot study was conducted with the purpose of refining the questions that developed and soliciting suggestions for improvement. Following the completion of the pilot study, the consultations were undertaken with the experts. This included three rounds of data collection, each with particular objectives rounds (see Figure 4.2).

Delphi preparation	- Selection of a panel of participating experts. - Development of the first-round questions. - Conduct the pilot study. - Arrangement for conducting the first round
Round 1 **(An exploration phase)** **Face to face semi-structured interview** **(Sample size: 20)**	**Objective**: To explore the current issues affecting the utilisation of the available geospatial technology tools, and how they can be addressed.
Round 2 **(An evaluation phase)** **A structured questionnaire** **(Sample size: 18)**	**Objective**: To inform a panel of experts of the results from Round1 and obtain their opinions regarding the importance of each strategy on a Likert scale of 1 to 5, along with comments, amendments and suggestions to be included for discussion in the following round.
Round 3 **(An evaluation phase)** **A structured questionnaire** **(Sample size: 18)**	**Objective**: To inform a panel of experts of the results from Round 2 and give them the opportunity to reconsider their ratings based on the main average results to form their final decisions with space for comments.

Figure 4-2 A summary of the Delphi process used in the present research

The first round sought to explore the key issues affecting the utilisation of the available geospatial technology tools in the agencies responsible for planning the delivery of residential infrastructure. It also aimed to identify the reasons causing these issues and how they could be addressed. In this round, semi-structured interviews were used to collect data (see Appendix F). The interview process was initiated by providing the participating experts with supporting documents about the research, including a participant information sheet and a consent form (see appendices B and C). At the beginning of the interview, the researcher introduced himself, to each expert and brief description of the research and its aims of the research. The researcher also explained the reasons for the selection of each expert, and the role required when participating in the research, along with aspects related to confidentiality and research ethics. Each expert was interviewed once in his workplace; the length of the interviews ranged from 40 minutes to 65 minutes. The main interview topics focused on covering the areas related to both the technical and non-technical factors associated with geospatial technologies' implementation in order to guide the interview. On this basis, a set of open questions were formulated with the aim of giving the panel of experts an opportunity to talk with more freedom (see Table 4-5).

During the interviews, each expert was asked to offer information on existing use of geospatial technology tools, and whether they believed that these technologies improved work performance. They were then asked to express their opinions on a number of non-technical aspects with the aim of exploring the primary drivers for the implementation of geospatial technologies and how the organisational factors influence their implementation. In addition, the participating experts were asked to give their opinions on the level of support for using geospatial technologies as tools for the processes of residential infrastructure provision, financial issues, and to what extent the cost of geospatial tools and associated technologies has hindered their implementation and how these issues are being addressed. The researcher also asked the experts to identify the level of staff awareness, and their role in influencing geospatial activities. They were asked to elaborate on the existing approach for producing and sharing spatial data, and what aspects need to be improved. Each expert was asked to provide their opinions on

barriers that limit the coordination of geospatial activities with other relevant agencies, and how they can be overcome. In order to obtain the experts' opinions on technical issues, they were asked to highlight technological infrastructure issues that need to be addressed. However, the order and flow of the topics during the interviews did not remain as indicated, and some unplanned questions emerged from the answers given by experts. Questions that had already been answered during the interview were also avoided.

Table 4-6: Semi-structured interview guide

Topic areas	Questions
The current implementation of geospatial technologies	- How would you describe the existing responsibilities and functions of geospatial activities in the residential infrastructure delivery field? - How do geospatial technologies contributing to facilitating daily tasks?
Organisational aspects	- What are the primary drivers of the implementation of geospatial technologies in your organisation? - How would you describe the level of support for the adoption of geospatial technology as a tool for the processes of infrastructure provision?
The cost of implementing geospatial technologies	- To what extent does the cost of geospatial technologies influence their use in tasks related to residential infrastructure?
Geospatial technologies users	- What is your assessment of the roles of employees who use geospatial tools in influencing their implementation? - In relation to employees, what are the main issues that require attention? - How would you assess the level of qualification for employees working on the geospatial technologies?
The coordination of geospatial activities	- Has there been any coordination or collaboration in geospatial activities with other agencies? - What are the obstacles and challenges that limit such coordination? - What are the appropriate procedures that ensure effective coordination between relevant parties?
Geospatial data	- What is the level of availability of spatial data related to residential infrastructure? - What are the sources of spatial data and the data standards used? - What are strategies followed to update such data? - What approach is used for exchanging spatial data with other agencies? - What are the security concerns associated with spatial data exchanging? - Which aspects need to be improved in this context?
ICT infrastructure	- How does ICT infrastructure capability affect geospatial activities implementation and what are the issues that need to be addressed?

Thematic analysis was selected for the organisation and interpretation of the data collected. This analysis provides the opportunity for coding and categorising the data into themes that can reflect the views of the experts. The data analysis followed the process described by Miles and Huberman (1994) process, which consists of three linked stages: data reduction, data display, and conclusion drawing and verification (see Figure 4-3).

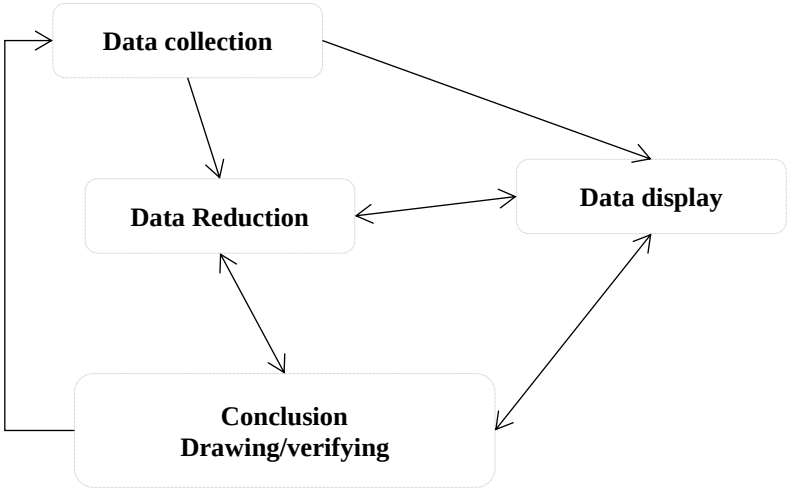

Figure 4-3 Component of data analysis

Source: Miles & Huberman (1994, p.12)

Before beginning the analysis process, the data from the interviews and observations were transcribed into Word documents and labelled according to their identity. The researcher then translated these documents word for word into English, primarily because the interviews were conducted in the interviewee's native language (Arabic). During the translation process the researcher made every effort to keep the original referential meaning of the words. A random sample of translated transcripts were also reviewed by two academicians competent in English language and examined for consistency to ensure that the translation had been carried out correctly and accurately.

After transcribing the interviews into English, the final version of translated transcripts was uploaded into NVivo software, which was chosen to facilitate the management of the data, and to help with arranging and coding themes as they emerged. This allowed for further systematic analysis and subsequent interpretation of the data. Once all of the transcripts have been imported into the software, the researcher began the

data reduction process by familiarising himself with the data. As a starting point, the data transcripts were read several times, to enable further exploration of the data and obtain a broader understanding of the thoughts and opinions of the participating experts. This was followed by searching the data in detail to discover recurring themes and identify quotes indicative of each theme (see Figure 4-4).

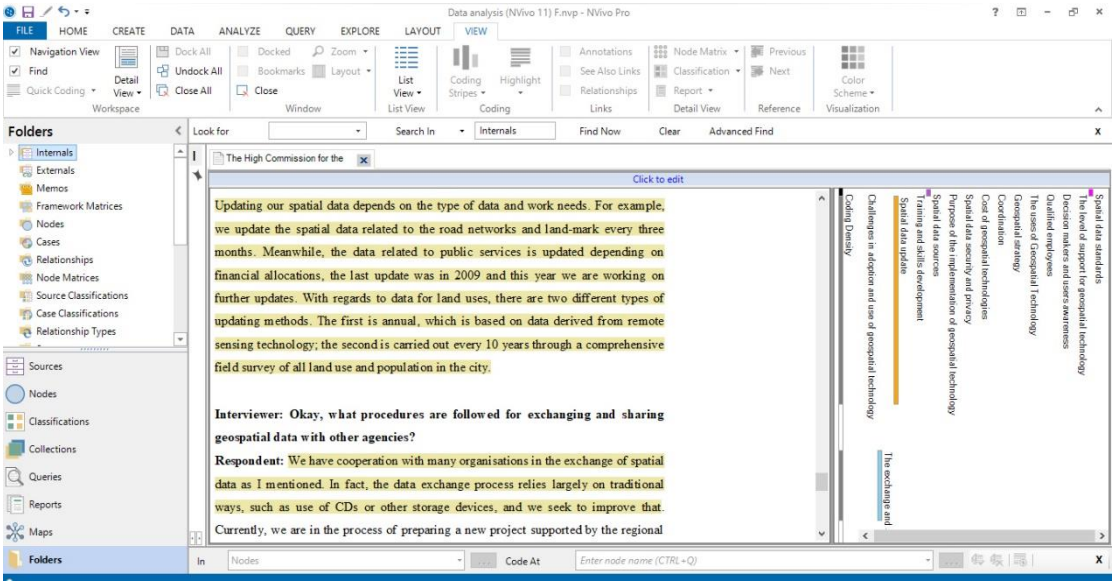

Figure 4-4 Screenshot shows sn example of coding in NVivo

The researcher examined these themes with a view to drawing up a list of key themes and sub-themes to clarify each theme and create codes (nodes) linked to the themes. Each theme was then investigated more closely through an iterative process to categorise and identify the differences, similarities, nuances in the coded data and to verify all the codes in each category.

This also included merging similar codes, reviewing the words or phrases that described the emergent themes, in addition making sure that the excerpts from the themes represented the whole text and were consistent with the overall theme of the category to obtain an accurate representation of the data. Repeating this procedure resulted in a list of themes. Throughout the coding phases, memoing was used for recording the notes, insights and ideas, as well as using the querying function tools to help in forming the final codes for building the themes. By the end of this process, the themes were displayed in a tree node to assist in revising and categorising all sub-themes under each key theme (see

Figure 4-5). This made the themes more specific and clearer, which resulted in a final list of themes and sub-themes.

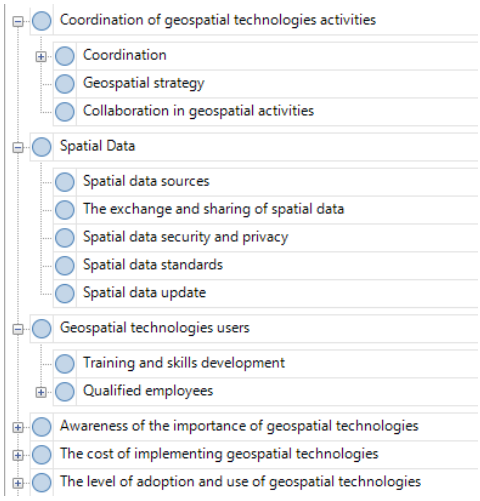

Figure 4-5 Screenshot Shows an example of themes and sub-themes coded in NVivo

The researcher was then able to display the verbatim quotations by theme in a concise and easy manner during the interpretation phase and draw conclusions in the final phase of the analysis process. Data analysed in this round provided valuable understanding about the issues affecting the use of geospatial technologies, and ways in which these issues could be addressed, this served as a basis for the following rounds.

The second round was based on the results obtained and analysed from the first round, along with a review of the relevant literature; a number of strategies were developed to address the issues raised. The purpose of the second round was to obtain expert opinions regarding the importance of each strategy and to add suggestions or further strategies based on their experiences. The questionnaire used as a tool to collect the data contained four main sections addressing the issues of organisational, technical and human aspects, along with issues related to spatial data (see Appendix G). Each expert was asked to rate these strategies based on their importance. A five-point Likert Scale was used to facilitate experts when indicating their level of importance of each item (see Table 4-7). The participants were also asked to give their comments and to state whether there were any additions, absent points or amendments that they would like included for discussion in the third round. The questionnaires were distributed in

electronic format using BOS (Bristol On-line Survey), and in hard copy form to those who did not provide an email address or who had asked for a printed version.

Table 4-7: The 5-point Likert scales and measurement of importance levels

Level of Measurement	Very Important	Important	Moderately Important	Slightly Important	Not Important
Likert Scale	5	4	3	2	1

In this round, the analysis of the data obtained was based on measures of central tendency (mean) to indicate the level of importance given to each item, where it gives equal weight to each of the responses. The level of dispersion (interquartile range IQR) was used to determine the level of consensus, which is considered acceptable as an objective means of measuring consensus in Delphi studies (Larreche and Moinpour 1983; Hsu and Sandford, 2007; Giannarou and Zervas, 2014). Although achieving consensus is the main aim of using the Delphi method, many different types of criteria have been used by researchers for determining when an exact level of consensus is reached due to the lack of a particular approach or firm rules to measure accurately (Fink et al., 1984; Holey et al., 2007; Pezaro and Clyne, 2015). For this research, the consensus was considered to be reached for each item receiving an IQR of less than 1 and greater than 0 (Heiko, 2012). On this basis, the consensus level was divided into three, the first high if the IQR was less or equal 0.5, medium, if it was between 0.5 and 1, and no consensus if the IQR was greater than 1. Similarly, the importance level of each item was determined as high if the mean value was more or equal to 4, and low if it was less than 4.

The third round aimed to achieve further consensus, and to validate and bridge the gap between the differences in opinions provided in the second round, in order to reach a final consensus and a common agreement on the strategies that should be undertaken to improve the exploitation of these technologies in the planning of residential infrastructure delivery. In this round, each expert received a questionnaire similar to those used in the second round, asking them to re-evaluate their answers for each item and provide further comments at the end of each theme (see Appendix I). The questionnaire included all items

from the previous round, even those that had already reached consensus, to give an equal chance and gain the highest possible consensus level (Keeney and Hasson, 2010). It also included a rating summary of the responses of each item obtained from the data analysis to help the experts form their final decisions and to consider the replies given by others. For this round, the same analysis procedures used in the second round were conducted.

After all of the participants' responses from the third round were received, an analysis determined that a fourth Delphi round would not be warranted, since a high consensus among experts had been reached for about 87 percent of all items, and with no significant revisions to their previous responses. Based on the analysis, a total of 59 of 68 items had reached consensus upon completion of the third round. Of these, 9 items reached consensus at IQR less or equal 0.5, and 50 items reached consensus at an IQR between 0.5 and 1.

4.6 Validity

Validity refers to the degree to which the empirical evidence and theoretical rationales that are supportive of the interpretations and that the modes in which the interpretations are used are appropriate (Moskal and Leydens, 2000). Research validity is generally classified into two broad categories: internal, which is "concerned with the question whether the method itself leads to desired results and forecasts" and external, which refers to the "similarity between a judgment about the future and its real value" (Van Zolingen and Klaassen, 2003. p 328).

Four types of evidence are commonly examined in which validity can be assessed; face, content, construct and criterion (Bellamy, 2005). The term content validity refers to the level to which the instrument covers the content that it is purported to measure (Yaghmaei, 2003). According to Hasson and Keeney (2011), many literature studies claim that the Delphi method provides evidence that supports face and content validity (e.g. Reid, 1988; Morgan et al., 2007; Huang et al., 2008). They argue that this claim relies on three assumptions. First is that the results originate from group opinions, and as

such, they are assumed to be more valid than a decision made by an individual. The second assumption is that the Delphi process is an outcome of expert opinions offering confirmative judgments (Spencer-Cooke, 1989; Cross, 1999). The third is based on that combining an open first qualitative round permits experts to generate scale items, and the continuation through a succession of rounds offers the opportunity to assess, review and judge appropriateness. However, a number of aspects such as, Delphi sample size and the level of expertise and agreement of the panel of experts may influence the validity of the study (Rowe et al., 1991). In addition, the large amounts of information from the first round could lead to bias from the outset (Hasson and Keeney, 2011).

In the present research study, different methods were employed to obtain data using closed and open questions and qualitative and quantitative analysis to verify the content validity. Furthermore, the feedback from the expert panel during the Delphi process, and based on their knowledge and expertise on the topic being studied, contributed to increase the content validity. The researcher also conducted a pilot study to determine the suitability of the interview questions and questionnaires and to confirm that they flow logically to verify the face validity (Alumran et al., 2012). Multiple sources of relevant literature were used in order to verify content validity, which in turn enhance the level of internal validity. However, the focus on a single case in this research study would likely affect the external validity, which makes it hard to generalise its results, it may be applicable in similar contexts and thus it would be possible to draw conclusions and recommendations. Furthermore, experts were given the opportunity to comment and the researcher avoided early closure on the ideas they raised to minimise bias (Chang et al., 2010).

Construct validity is the third type of validity, which "refers to the extent to which a study investigates what it claims to investigate, that is, to the extent to which a procedure leads to an accurate observation of reality" (Denzin and Lincoln, 1994 cited in Gibbert et al., 2008. p. 1466). According to Hasson and Keeney (2011), the Delphi method is assumed to achieve construct validity as the parameters are endorsed and defined by the

items granted by the expert panel. Austin (2015) adds that construct validity is determined by the researcher's endorsement of items given by an expert panel for inclusion in the following round. In this, Okoli and Pawlowski (2004) suggest that the researcher's interpretation and categorisation of the results from the first round should be fed back to the expert panel to undertake further checks. They also propose that since the responses in a Delphi study are not anonymous to the researcher, the construct validity of the items that are approved can be accepted.

The final type of validity is criterion-related, which is used to demonstrate the accuracy of a measure or procedure by comparing it with another valid external criterion already in existence (Bannigan and Watson, 2009). There are two types of criterion-related validity concurrent (same moment in time) and predictive (focusing on the future) (Lin, 2014; Chan, 2014). According to Hasson and Keeney (2011), concurrent validity is used to demonstrate the accuracy of a measure by comparing it with another measurement that has been previously considered to be valid. They indicate that the use of the Delphi technique in a research project is assumed to contribute to the concurrent validity due to the successive rounds and by achieving consensus from the expert panel, which is demonstrated by identifying and agreeing the components. Meanwhile, predictive validity refers to the degree to which the measures generated from an instrument can predict future concrete events (Dubrowski et al., 2010). It is tested by a future criterion, and thus, it has often been limited by the absence of an appropriate predefined criterion (Pearson and Bailey, 1980). As such, predictive validity is difficult to apply in the present research, as shaping the future results or predictive measures may not be accurate.

4.7 Challenges and Limitations

As mentioned above, the data collection phase included a number of interviews in the sectors responsible for delivering infrastructure in residential areas. In this respect, the researcher faced many difficulties arranging specific dates for conducting the interviews, especially with decision makers; this required the researcher to make frequent

visits to those agencies in order to organise suitable appointments. This is due to the congested professional schedule and daily tasks of the participants, as well as the numerous other reviewers wishing to meet with the same officials.

In addition, the researcher noted different degrees of reservation and exaggeration in some of the responses during the interviews in first round of the Delphi study. This was especially prevalent when the questions related to the level of support from top management regarding the adoption of geospatial technology, and the reasons behind the lack of coordination and participation with other agencies in their activities. Although some of the participants agreed to have the interviews recorded, others only approved of written notes being taken; this created difficulty for the researcher having to hand write all of the details from the dialogue. Moreover, some participants requested a paper copy of the questionnaire rather than an electronic version in subsequent rounds; this required the researcher to visit them again in their work place to deliver and collect the questionnaires.

The researcher also faced other challenges in this study represented in the translation of the interview questions and participants' answers from English to Arabic and vice versa, a concerted effort was made so that meanings were not changed (see Appendix F). Similarly, the original questionnaires for the second and third round were written in English and needed to be translated into Arabic then translated into Arabic because the participants' preference was to complete the questionnaire in Arabic. This was time consuming as it took time to ensure that the translation was interpreted correctly (see appendices G, H, I and J).

Another challenge facing the researcher was the fact that the secondary data that describes the development of geospatial technologies in agencies concerned with residential infrastructure delivery in the Saudi context was extremely limited. In addition, there was a shortage of modern published literature on topics related to the use of geospatial tools in the participation and coordination in decision making processes. At the same time, the researcher also faced difficulty in obtaining accurate and up-to-date

statistics on the current state of services and infrastructure available to residential areas in the context of Riyadh city. This in turn made tracking the development of residential infrastructure challenging, as there was insufficient literature available to explain this in more detail.

4.8 Ethical Considerations

Throughout all stages of the research, ethical issues have been considered and all necessary measures were taken to comply with the university's ethical requirements. In this regard, the researcher obtained ethical approval for the research from the University before beginning the fieldwork. As part of the process, the researcher prepared a Participant information sheet and a Consent form a brief introduction on the subject and objectives of the research was also included. It also included clarification of the reasons for the selection of participants, and the role required when agreeing to participate. The researcher informed all participants of his position as a PhD researcher and the purpose of the data collection, also explaining the methods for its storage and use. In addition, all participants were given full opportunity to ask questions about the research and what their participation would involve, all the necessary explanations were provided. In spite of the acceptance from all of the participants to participate in the research, a number of them expressed a preference for their names to be excluded from the consent form because of unwillingness to disclose their identity. The researcher also obtained approval to attend the regional council meeting from the relevant members of the council, and they were made aware of the researcher’s position and the purpose of the observation.

4.9 Summary

This chapter presented a detailed description of the appropriate methodology for conducting this research. It provided a description of the philosophical underpinnings and approach of the research and the justification for their selection. The chapter also discussed the research strategies, and provided justification for selecting the case study strategy to carry out this research and the rationale for the choice of the city of Riyadh as

a case for this research. In addition, it highlighted the research design and the various research phases followed in this research. Furthermore, the chapter identified the data sources and the chosen collection methods. This included a detailed description of the methods that were used to collect primary data using the Delphi technique in order to integrate the opinions of experts, who were involved in three different rounds, by conducting interviews and a questionnaire survey, along with direct observation through attending meetings. The participants were selected from agencies concerned with residential infrastructure delivery, and other relevant agencies, with respect to the use of geospatial technologies. They were chosen because of their potential to uncover challenges related to the implementation of these technologies. Meanwhile, secondary sources were gathered which included relevant literature and official documents. This chapter also discussed the methods adopted for analysing the data. Finally, an explanation of the limitations and challenges that faced the researcher along with the ethical considerations that guided the research were presented.

Chapter 5: Urban Growth and Policies of Residential Infrastructure Delivery in Riyadh City

5.1 Introduction

This chapter provides an in-depth view of the urban growth and development in the city of Riyadh, including a detailed explanation regarding the organisational context of residential infrastructure provision in order to identify the existing conditions and challenges in place. It will also describe the current status, and present an overview of the development and use of geospatial technologies.

The chapter begins with a brief overview of the Kingdom of Saudi Arabia, the background of the historical development of the city of Riyadh, and highlights the periods that witnessed the transformation of urban growth patterns. The background also includes an interpretation of the factors that contributed to population growth and the critical issues accompanying this growth. Furthermore, the chapter discusses the institutional evolution in the country, and the systems and policies for urban planning adopted to adjust the operations of urban growth and to meet the infrastructure requirements for residential areas. It also provides an overview of the current use of geospatial technology tools and their effect in the context of residential infrastructure delivery.

5.2 A Brief Overview of the Kingdom of Saudi Arabia

The Kingdom of Saudi Arabia lies in the southwest of the continent of Asia, between latitudes 18° and 35° north of the Equator, and longitudes 36° to 48° east of Greenwich. It occupies the bulk of the Arabian Peninsula, with a total land area estimated at more than around 2 million sq km. Saudi Arabia is surrounded by the Red Sea in the west, the Arabian Gulf, Qatar, Bahrain and the United Arab Emirates in the east. Along its northern frontier, from east to west are Kuwait, Iraq and Jordan; and Oman and Yemen to the south.

Figure 5-1: Map of the Kingdom of Saudi Arabia

Source: Clements (1988) cited in Al-Rasheed (2010. p xxiii)

The system of government in Saudi Arabia is a monarchy. The King is the head of state and also prime minister, and the crown prince is the deputy prime minister. The

executive authority is vested in the King, and assisted by the crown prince and the Council of Ministers in the performance of his duties. The Council of Ministers comprises ministers with portfolio, in addition to ministers of the state and the King's counsellors, who are appointed as members of the Council of Ministers by royal decree.

Saudi Arabia is divided into 13 administrative regions, each headed by a governor appointed by the central government. These regions consist of a number of governorates and centres, or sub-governorates, and have a capital or headquarters usually situated in the region's largest city, as shown in the following table (Table 5-1).

Table 5-1: Administrative divisions of the kingdom of saudi arabia

Region	Headquarter	Number of governorates	Number of centres	Area (Km2
Riyadh	Riyadh City	20	454	380,000
Makkah Al-Mokarramah	Makkah City	16	111	137,000
Al-Madinah Al-Monawarah	Al-Madinah City	8	90	150,000
Al-Qaseem	Buraydah City	12	153	73,000
Eastern Region	Dammam City	11	107	540,000
Aseer	Abha City	15	102	80,000
Tabouk	Tabouk City	6	73	136,000
Hail	Hail City	8	84	120,000
Northern Borders	Arar City	3	17	104,000
Jazan	Jazan City	16	31	13,000
Najran	Najran City	7	59	130,000
Al-Baha	Al-Baha City	9	35	12,000
Al-Jouf	Sikaka City	3	33	85,000

Source: SGS (2012)

Since the country's foundation in 1932, Saudi Arabia has experienced rapid development in various industrial, construction and commercial fields, and also achieved

significant expansion of public services and facilities across the country. This was as a result of an economic boom which was accompanied by the rapid rise of international oil prices. Prior to oil being discovered in 1938, the Saudi economy was primitive, was largely dependent on the pilgrimages to the Holy places, along with a number of small trading activities in areas of agriculture, raising of livestock, fishing and food production (Alam, 2015). Currently, Saudi Arabia is considered to be one of the largest oil producing countries, and an important member of OPEC. Therefore, the oil industry can be seen as the basis for contributing to the improvement of the country's income level, whilst having a significant impact on the rapid developments that have taken place. It has also played a major part in many social, economic and demographic transformations in just a few decades.

Similarly, during this period, most urban areas in Saudi Arabia experienced rapid urban growth and spatial expansion with the corresponding growth and development of urban infrastructure, utilities and services. These rapid developments have contributed to bring about cities unprecedented in size, which have also seen a rapid increase in population growth rates. However, the average gross density in Saudi cities is approximately 13.9 persons per square kilometre, which is considered moderately low (SGS, 2012). The striking feature in this growth is the population of the country has increased more than six times during the last 40 years. In general, the population of Saudi Arabia is characterised by the large family sizes and fast population growth. Added to this, the country has seen an influx of immigrants from different countries, especially after the economic boom. The population statistics indicates that the population grew from about 5,935,361 in 1974 (Ashwan et al., 2012) to 31,742,580 inhabitants according to the mid-year population estimates for 2016 of Saudi General Authority for Statistics (GAS). The recent estimates from the GAS also reveal that about 63% of the populations are Saudis, 37% are non-Saudi expatriates. Furthermore, the urban population of Saudi Arabia is around 83%, as per the World Bank statistics from 2010. According to the latest official population census, in 2010, there are four cities with a population of more than

one million. The city of Riyadh, the capital of the country, is home to more than 5.2 million people. While other cities such as Jeddah, which is an important commercial centre and transit place for millions of pilgrims to visit Holy places, has a population of more than 3.4 million; Makkah and Al-Madinah which are religious centres have populations exceeding 1.6, and 1.1 million respectively. These developments, in turn, created a challenge for the relevant agencies in achieving a balanced urban growth. They also contributed, along with the absence of appropriate urban planning measures and policies that guide urban expansion, to several urban problems in many Saudi cities, in particular, the city of Riyadh (Gamboa, 2008). Despite improvements in urban management and planning over a period of time, the city of Riyadh has problems which still persist, such as, random expansion, inadequate of urban infrastructure and increasing delivery costs, coupled with difficulties in coordination between responsible agencies to deal with such issues (Garba, 2004; Mubarak, 2004b). This will be discussed further in the following sections.

5.3 The Features of Urban Growth and Development of the City of Riyadh

Riyadh is the capital of the Kingdom of Saudi Arabia and its centre of administrative and political power. It is considered one of the fastest growing cities in the Middle East which is currently experiencing extensive population and urban prosperity (Garba, 2004; Susilawati and Al Surf, 2011). The city of Riyadh is located in the centre of the Arabian Peninsula, on the latitude 34-38◦ north, longitude 46-43◦ east, at an altitude of approximately 600 metres above sea level (ADA, 2011).

The history of human presence on the current site of the city of Riyadh goes back to the fifth century AD (Aljaser, 2002). According to historians, this area was inhabited in ancient times and was called the city of Hajar; the capital of Al-Yamamah region; where a number of Arabian tribes settled and was one of the main stations on the caravan route in the Arabian Peninsula (ADA, 2004). Like other ancient settlements in the Arabian

Peninsula, the city of Hajar consisted of a number of simple and specific activities due to the small population and the modest living conditions of that period (ADA, 2004).

In the eighth century, the city of Hajar faced a drought and water shortages, which led to poor agricultural production – the main source of living – and the level of trade exchange with residents in the nearby countryside. These conditions led to the city being divided into a number of small villages such as Al-oud, Al-Binya, Mekal, Al-Salia and Jabra (ADA, 2004). However, in the eighteenth century, some of the villages that remained in the city of Hajar such as the village of Mekal, Al-Oud and Muqrin began to develop and formed a small urban community and was named the city of Riyadh (Aljaser, 2002). By the year 1747, walls were built to surround the city in order to protect it from recurring attacks, as the city had faced many wars and political instability. During that period, the city did not witness any expansion in the urban growth scope and remained confined within the limits of its walls due to its proximity to the city of Al-Diriyah the political capital of the Saudi state at that time (Aljaser, 2002).

In 1825, the Saudi state faced a number of political changes, which resulted in the move of the capital city from Diriyah to Riyadh (Aljaser, 2002). During that period the Riyadh city witnessed the rebuilding of walls and gates as well as many residential neighbourhoods and facilities; such as the governance palace, roofed corridors, and commercial markets (ADA, 2004). However, in 1891 the city once more suffered from political instability, which contributed to the destruction of its walls and many public facilities (Aljaser, 2002). In 1902 the political stability returned to the city headed by the founder of the current Saudi state King Abdul Aziz bin Abdul Rahman bin Faisal Al Saud (Bonnenfant, 2014). The city did not experience any urban expansion in this period and remained limited within the walled borders of the city in an area not exceeding 0,05Km2, with a limited population estimated to be about 19,000 until the declaration of Riyadh as the capital city of Saudi Arabia in 1919 (Mubarak, 2004). This period is considered an important turning point in the history of urban growth of Riyadh, which witnessed a number of shifts in the population and urban growth pattern.

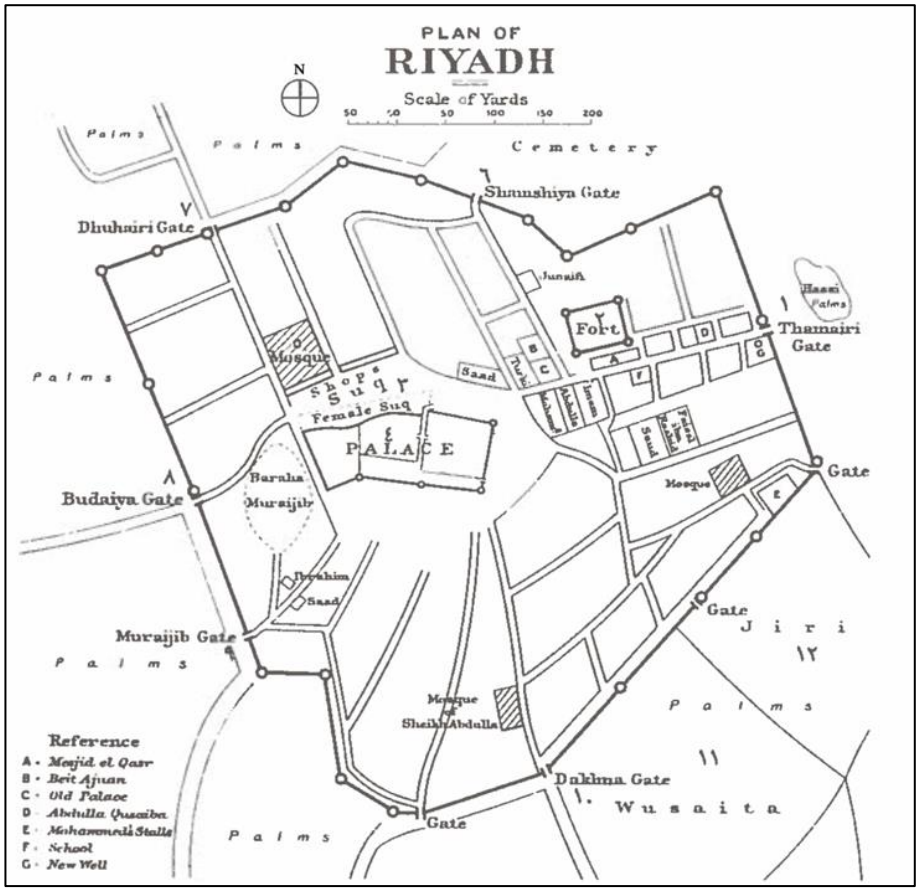

Figure 5-2: Plan of Riyadh in 1919

Source: Riyadh Municipality (2010a, p.34)

In order to study the features of urban growth and development in the city of Riyadh, it can be noted that there were two major phases which had prominent roles in the formation of the urban growth pattern. The initial phase ranges from the declaration of Riyadh as the capital city of Saudi Arabia in 1932 to the period before the oil boom in 1970, when the second phase started from the oil boom in 1970 until the present. Thus, the urban growth witnessed by the city during these two periods will be reviewed and discussed here in detail, based on published studies and research carried out by government agencies, researchers and academics in this field. The main purpose of this section is to provide a critical overview of the changes in the urban growth pattern for the city of Riyadh alongside an interpretation of the conditions that played a major role in the urban expansion. This is important so that we can understand how historical conditions and transitions have influenced the integration of infrastructure services in residential areas.

5.3.1 Pre-Oil Boom (1932-1970)

This period, saw the city of Riyadh enter a new phase of growth and prosperity after achieving its political stability being declared as the capital of the country. This played a fundamental part in the acceleration of urban growth witnessed by the city, where at the start of that period it was small in size and positioned within the borders of the surrounding walls.

The year 1938 is considered as the real beginning of the expansion and growth of the city outside the boundaries of its walls, where a number of royal palaces and administrative buildings were established north of the old city, at a distance of about 2 kilometres, in a suburb called Al-Murabba (Mubarak, 2004). The construction of these buildings had a great impact on the growth of the city towards the north, which was followed by the construction of many palaces and guest houses owned by the ruling family, as well as a limited number of dwellings (Al-Hathloul and Edadan, 1995). In spite of this expansion, the level of city planning and infrastructure provision at the beginning of this stage was limited. Riyadh Municipality's taskes established in 1941, were limited to carrying out services of cleaning, maintenance and lighting of roads and footpaths until 1953 when its functions were expanded to include design and asphalting the streets, the sewage network as well as flood water drains (ADA, 2004).

With the increasing population resulting from the stable political situation which characterised that period, there was an urgent need to expand beyond the confines of the city walls. Therefore, in 1945, the government distributed pieces of land for the citizens in an area adjacent to the old city for the purpose of housing, the area per household was no more than 64 m2 linked by corridors 8 metres wide in an area named the Manfuha neighbourhood (Aljaser, 2002). It also established further urban communities outside the old city walls such as Al-Nasryah, Al-Shimeisy in the west, Holat Al-Ahrar, Wadi Al-Batha in the east and in the south an isolated residential area called Ateeqah (ADA, 2004).

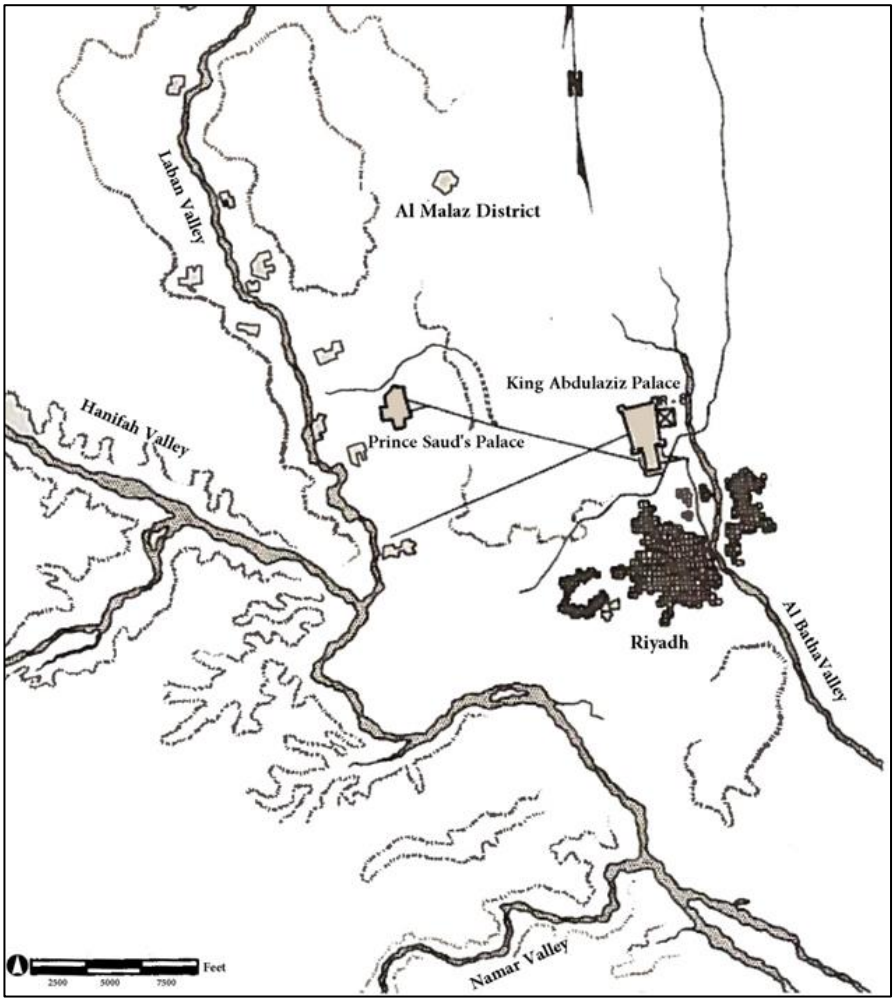

Figure 5-3: Showing the beginning of the first stages of building beyond the old city walls in 1953

Source: Daghestani (1985, p.70) cited in Riyadh Municipality (2010a, p.60)

In the 1950s and as a result of the activity of this urban expansion, the government demolished the city walls because of their decreasing role in the protection of housing, which allowed to spread outside the boundary of old city, and contributed significantly in the stimulation of its growth (Aljaser, 2002). This period also saw a number of changes which contributed to the rapid transformation of the city's urban growth patterns; the most prominent was in 1953 when the headquarters of the government agencies were transferred from the city of Jeddah to Riyadh, as the country's official capital. This resulted in an influx of employees, which required the construction of several facilities and new buildings to house the ministries' headquarters. The space surrounding the old city could no longer accommodate the increasing demands of an expanding population within its boundaries. As a consequence, the government established a new housing area

on 500 hectares land, located about four kilometres north-east of the old city called the Al-Malaz district (Mubarak, 2004). This district was planned according to the modern planning approaches of that period, at the time this was named the new Riyadh, and included a number of administrative and residential buildings, wide roads, facilities, services, a public park and a library (Al-Hathloul, 2010).

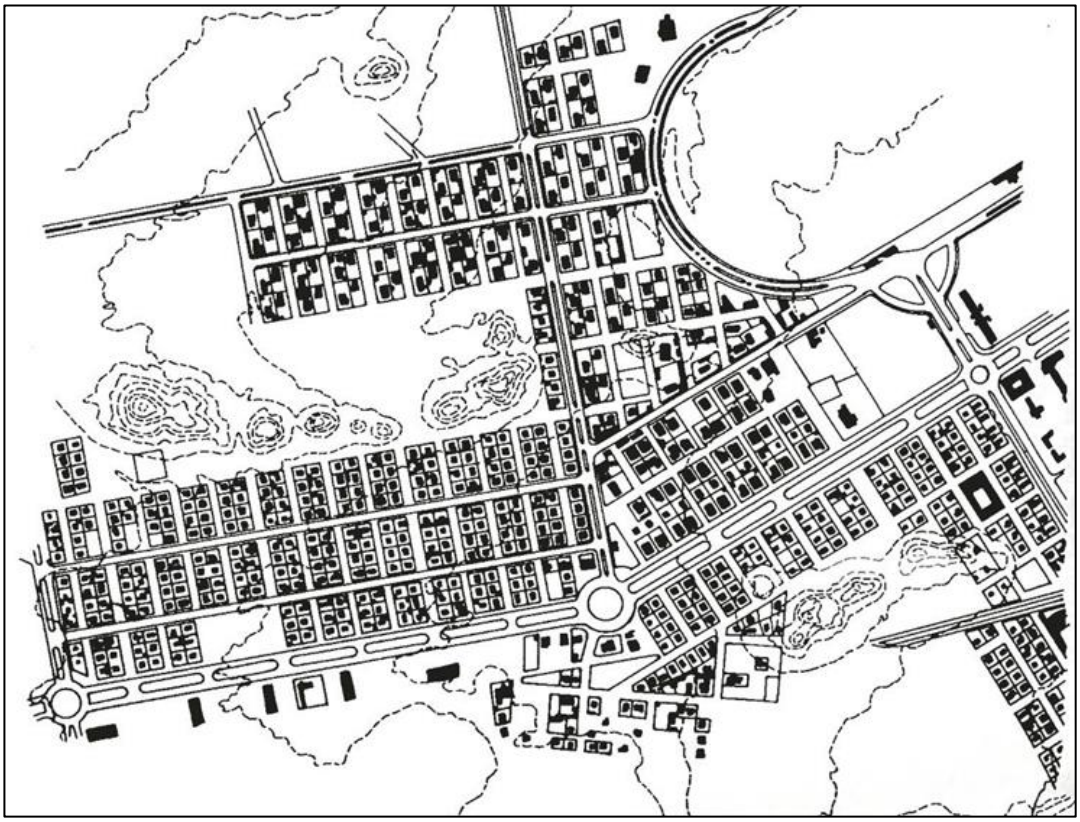

Figure 5-4: Al-Malaz District

Source: Al-Hathloul et al. (1975, p.39)

As a result of developmental programmes and plans established by the government, (see section 5.4 and 5.5) the city of Riyadh has seen developments in various aspects of urban infrastructure. These developments included many large projects in the transport and public services, which contributed to the expansion of the city and the growth of its population (see Figure 5-5).

Figure 5-5: The most prominent developments in urban infrastructure in the period between (1932-1970).

From the above it can be argued that the rapid urban growth of the city of Riyadh during this period resulted from a number of events which were vital in advancing the development of various economic, social, demographic and urban sectors. The most prominent of these events and shifts in the expansion of the city toward the desert began with political stability and the establishment of Riyadh as the capital of the state and the seat of government departments and institutions. In addition, the evolution of the country's economy, which accompanied this period, reflected directly in the development of various sectors in the city. On the other hand, the construction of facilities related to the ruling family outside the boundaries of the old city walls impacted the population in that period, since the walls of the city no longer prevented its expansion; this led to the start of movement in all directions, as there were no longer constraints limiting this expansion. Furthermore, the development of road networks and use of cars as an essential means of transportation had an important role in expansion beyond the old city. The high population immigration rate, whether from cities or neighbouring villages due to the development of services in the city and the provision of employment opportunities, also played a prominent role in stimulating the city's unprecedented and rapid growth. Accordingly, the size of the city has expanded within its walls from less than 3.5 km2 before 1950 to about 95 km2 in 1970, along with north- south axis with an area of 12 km and east-west axis with an area of 9 km, without a real plan to fit the requirements of this growth (Al-Oteibi et al., 1993; Al-Khaldi, 2005).

5.3.2 Post-Oil Boom (1970 to the Present)

During this period the city of Riyadh witnessed several rapid changes as a result of the rise in oil export prices and the rate of income in the country. These changes have reflected directly on the implementation of several developmental projects, and contributed to stimulation of the construction industry, which, in turn, have heavily influenced the pattern of the urban growth in the city (Bonnenfant, 2014). At the same time, the population continued to grow, experiencing an influx of immigrants, including foreign labourers due to the available job opportunities and services in the city. The

population has grown by approximately 20 per cent each year from 160,000 of the total in 1960 to 355,000 by 1970 (Al-Khalidi, 2005). However, as a result of the continued growth and lack of a defined city structure, a number urban problems have begun to emerge (Doxiadis, 1968 cited in Garba, 2004). These problems could not be effectively dealt with and so, the city has reached a critical stage, especially in issues related to the provision of housing, traffic congestion, public services and utilities for immigrant residents (Al-Khalidi, 2005). These issues have led the government to reconsider the pattern of the city's expansion, and it has definitely become crucial for there to be strict management of the city's urban growth with a plan that clearly directs the growth and offers solutions for the existing urban problems. Thus, the first attempts are being made to organise its rapid urban growth, as the government has assigned the Municipal Affairs agency to prepare a Master Plan, implemented by the Greek consulting firm Doxiadis (Alkhaldi, 2005). In 1973, the Council of Ministers adopted the implementation of the city's first Master Plan (Doxiadis Plan), which included a number of detailed and executive plans to guide the physical development up to the year 2000 (Mubarak, 2004). "The plan identified two planning goals; the need for a flexible structure to cope with any rate of development in the absence of any physical constraint, and the need for balanced, equitable and effective distribution of facilities and services" (Garba, 2004 p 601). By 1975, the Ministry for Municipal and Rural Affairs had been established, which granted responsibility for spatial planning at local, regional, and national levels, in addition to the management and provision of the infrastructure. This in turn contributed to improvements of urban management during that period. However, urban growth soon exceeded the planning efforts and limits of those plans that were adopted, which projected the city's population at 900,000 by 1985 and 1,050,000 and 1,400,000 by 1990 and 2000 (Al-Oteibi et al., 1993; Garba, 2004). The fast rate of population growth that characterised this period has played an essential role in the spatial expansion of the city and contributed to increase in demand for urban infrastructure (see Figure 5-8). In 1978, the old city centre started progressively to expand outside its old walls (Bonnenfant, 2014). A number of new urban axes were created from the city centre along with a network of supporting streets to

establish new residential neighbourhoods, which enabled it to expand rapidly (Riyadh Municipality, 2010a). An urban development came into being, which spread toward the north of the city on the road leading towards the airport, which later became the main growth axis of the city.

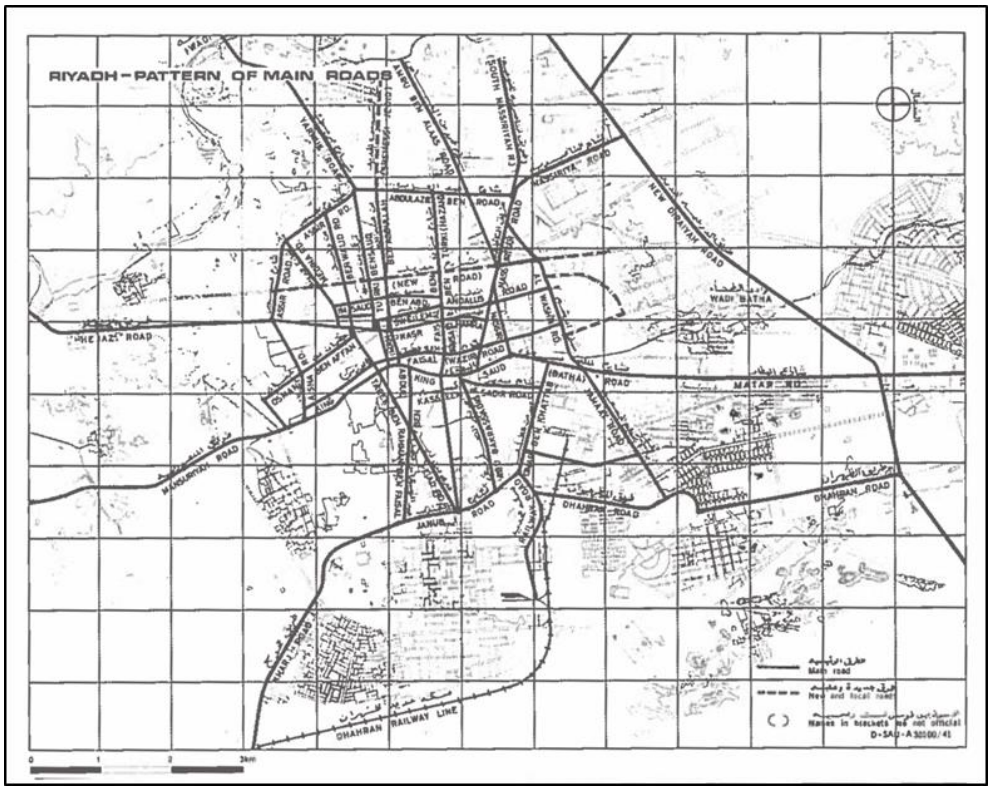

Figure 5-6: Plan of main roads 1968

Source: Doxiadis Associates (1970, p. 155) cited in Riyadh Municipality (2010b, p. 87)

The expansion of the city also continued to another axis east in the direction of the Al-Malaz neighbourhood, which attracted a large proportion of the population, especially public sector employees, because of its proximity to the area allocated to the ministries and government departments. The areas located on the axis of the road leading east to the city of Dammam have also flourished attracting a number of light industrial activities on two sides, currently called the first industrial zone. It also created a number of luxurious palaces and houses north-west in the area called the Al-Nasiriyah, which is characterised by spacious roads and parks. A number of residential neighbourhoods were established adjacent to Manfouha south of the old city as well as towards the south-west on the road leading to the Al Hijaz, such as the As-Suwaidi and the Al-Shifa.

To cope with the increasing growth of the population, the government followed an approach to solving the land and housing problem by direct construction, granting residential land for low-income citizens in different sites of the city (Garba, 2004). Bonnenfant (2014) suggests that the increased of the prices of land dedicated for housing in a radius of some 20 km from the centre of Riyadh has created an active and speculative real estate market, and caused a housing crisis, especially for recent migrants. Thus, the residential suburban development of the city has continued, which contributed also to the expansion of its spatial growth. The government also continued to grant residential land to citizens on different sites of the city, which later became a burden on the government in terms of meeting their infrastructure requirements. In addition, it established the Real Estate Development Fund (REDF) in 1974, which also played a prominent role in the accelerated pace of urban growth, through granting the citizens long-term interest free loans, to contribute to the construction of housing units. In this, the Fund issued 85,029 loans for housing at a value of SR 24,744,492,038 that contributed to the construction of 102,034 housing units in the city in the period between 1975 and 1990 (Real Estate Development Fund, 1991 cited in Al-Oteibi et al., 1993). These loans contributed to the expansion of the construction sector and the increase in the number of dwellings which made the city one of the largest construction sites in the world (Al-Oteibi et al., 1993). The Fund has also played a prominent role in resolving the growing housing crisis through a number of housing projects such as the Al Maather, Al-Kharj road and the Al Jazeera housing.

Moreover, the city has seen similar developments on the level of infrastructure services which also had an effect on the change in its urban growth pattern. One of the most prominent of these developments was in the transportation sector, with the opening of King Khaled International Airport in 1983, about 35 kilometres north of the city centre. In addition, an extensive network of ring highways were established around the city linking them with the axis of main and sub-roads in the city, which increased mobility and enabled the population of the city to expand rapidly (Al-Oteibi et al., 1993).

The urban growth in the city of Riyadh continued at an accelerated pace in all directions until it occupied an area estimated at more than 3115 Km2 (HCDR, 2014 cited in Abubakar and Aina, 2016). However, the direction of this growth is increasingly raised towards the north of the city. This may be due to the presence of the headquarters of a number of major projects and government services along with a lack of natural determinants that limit this growth, while the presence of industrial zones and the treatment sewage station in the south of city has contributed in limiting the growth towards this direction (see Figure: 5-7).

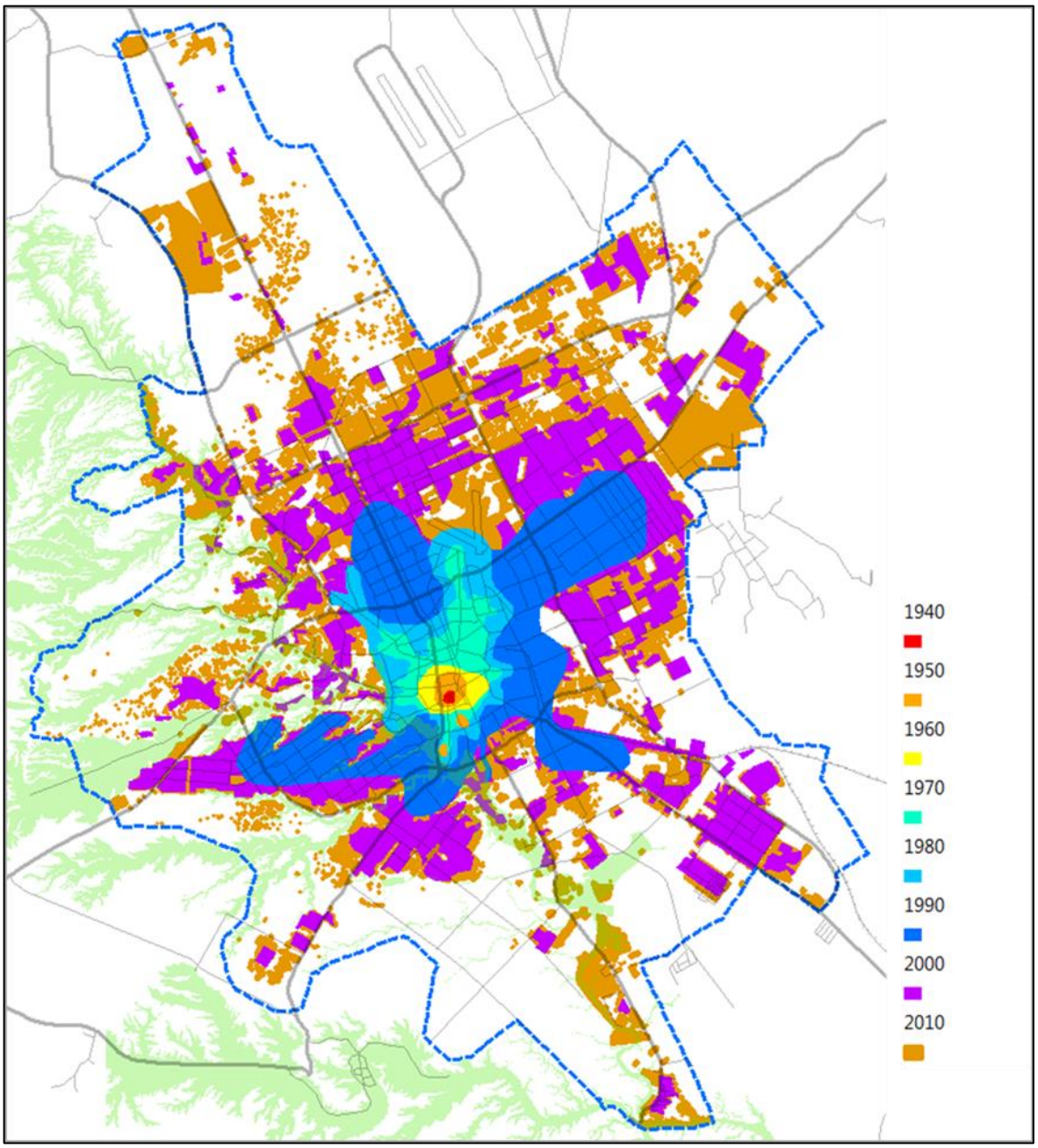

Figure: 5-7 Map of Riyadh's urban growth 1940 – 2010

Source: ADA (2015)

In addition, this growth expanded towards nearby towns such as Al-Diriyah, Iraq and Al-Ammariyah, which are currently located within the urban boundary of the city. All of these changes that accompanied the city's growth have contributed to the emergence of many issues and problems; these will be discussed in detail later in this chapter.

5.3.3 Population Growth and Structure

Over the past eight decades the city Riyadh has witnessed accelerated changes associated with its transformation as a political, administrative and economic centre of the country and has had a huge effect on its expansion, demographic characteristics and population growth rates. The concentration of power in Riyadh has attracted waves of newcomers to the city and expedited the rate of its population growth where it became the largest urban agglomeration of Saudi cities in terms of area and population. The striking feature of the population growth is that the population has dramatically increased approximately 150-fold since the unification of the country in 1932, which was 35,000 to more than 5.3 million people in 2010, constituting approximately 19% of the total population of the Kingdom of Saudi Arabia (Kahala,1964).

The continuing population growth, which has grown steadily since 1940, has coincided with several changes that had an unusual effect on its rates which was totally dependent on natural growth (Ashwan, 1990). The rapid growth of the Saudi economy, resulting from high oil revenues, is considered one of the most important factors which responsible for the abnormal population growth of the City of Riyadh, and was a direct reflection on the increase in population growth rates.

As a result of this economic growth, which has contributed mainly to improving living conditions and thereby the natural increase in population, there has been a clear rise in the average youth population, which led to an increase in the rates of family formation and fertility as well as the rise in household size averaging approximately 6.2 person/family (ADA, 2011). In addition, the improvement in the provision of health

services has also contributed dramatically to the natural increase in population and decreased mortality rates, especially in children.

The increasing rates of internal immigration to the city from other cities, rural areas and small villages of the Kingdom, and the external immigration represented by attracting expertise and manpower for the purpose of contributing to the implementation of development projects, have had a prominent role in the rising population (Ashwan, 1990). In this context, the transfer of government ministries and other government offices from Jeddah to Riyadh in 1953 and the increase in government spending on infrastructure development to enhance its position as a capital of the country, have played an important role in creating a demand for a labour force whilst stimulating migration has made Riyadh a centre for jobs in all sectors. As a consequence, this has created numerous employment opportunities thus becoming a magnet for job seekers and an attractive place to live due to the concentration of economic activities, governmental offices and services, the availability of educational, social, health and cultural service, as well as the foundations of modern life in the city.

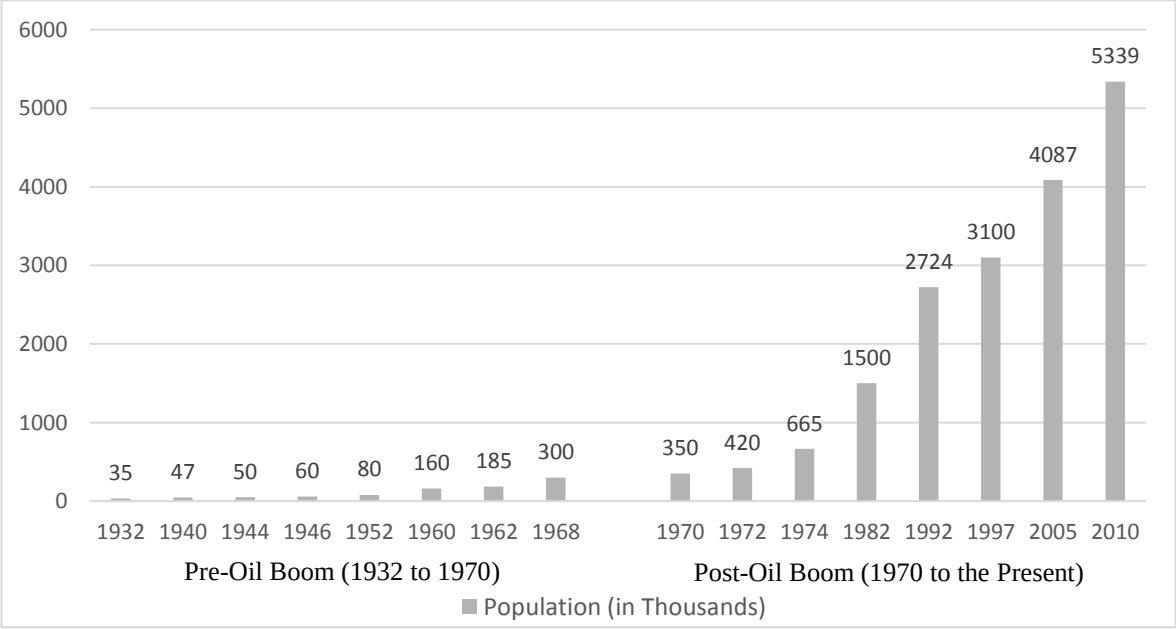

Figure 5-8: Population growth rate in Riyadh city 1932-2010

Source: Al -jetaili, (2009); (NPC, 2010); Riyadh Municipality (2016)

This rapid growth in population has created many of the issues represented in the creation of many new residential areas and pressure on public services and utilities. According to population estimates based on the results of the National Census of 2010, the high rate of population growth will continue and could be up to 7.3m by 2025. This growth will be accompanied a need for the provision of about 30,000 housing units per year, since the 35% of the population is under the age of 15, which will be a major contribution driver in the high demand for housing (ADA, 2001). Thus, there is a need to develop about 70% of the residential land in the city within the limits of its urban scope in an average ranging between 200-500 m2 for each housing unit, or the development about 30% of this land for residential units within multiple floor buildings to accommodate this expected population growth. Therefore, there will be increasing demand for services and utilities at neighbourhood level, presenting a challenge in planning and provision to keep pace with requirements (ADA, 2001).

5.3.4 Consequences of Urban Growth and Impact on Residential Infrastructure

The rapid urban growth in the city of Riyadh led to the creation of a major challenge to control the size of the increase of spatial expansion in the city, which escalated with the increase in population growth and ongoing expansion in the establishment of further residential neighbourhoods. Despite economic prosperity witnessed by the country, the provision of residential infrastructure and public services are still major issues in the city and a challenge for public sector agencies. The increase in demand for housing, which accompanied the unexpected population explosion, especially in the period 1976-1989, is considered as one of factors that played a significant role in the pressure on the infrastructure (Al-Khaldi, 2005). In addition, conventional urban planning practices and institutional challenges related to the roles of agencies involved in growth management and coordination of service delivery have similarly contributed to the acceleration of the development of residential neighbourhoods in an unorganised pattern, resulting in inadequate residential infrastructure (Al-jetaili, 2009). As a result of these issues, many

residential areas on the outskirts of the city appeared, where there was the availability of the main road networks linking Riyadh to neighbouring cities, and the shortage of affordable housing and the rise in land cost in the city were instrumental in growth of these areas (Mubarak, 2004). This in turn makes the agencies concerned with residential infrastructure delivery face difficulties to effectively perform the duties assigned to them, which exceeded their capabilities and potential to accommodate this expansion (Abubakar and Aina, 2016). Despite improvement in urban infrastructure delivery, the provision of adequate coverage that keeps pace with urban growth is still difficult to achieve (Garba, 2004).

To address the growing expansion of dispersed residential neighbourhoods, the government has adopted urban growth boundary policy (UGBP), which include three phased development limits: the first urban limit, the second urban limit, and the urban environs phase, in an attempt to focus the development on a specific geographical frame to control the urban growth and make the urban fabric more compact, as well as reducing costs of infrastructure delivery (Mubarak, 2004). However, the escalating development of residential land schemes are ongoing compared with other land uses (see Figure 5-9). This was accompanied by a lack of coordination and exchange of data, whether horizontal coordination among agencies was managing growth at local levels or vertical coordination between the local agencies and the central government agencies, as well as the different standards related to the infrastructure delivery and public services among these agencies (Garba, 2004). This in turn has contributed to an imbalance in determining the actual needs of the residential areas that have been developed within the city's urban boundary despite the considerable government support given to the infrastructure projects. In addition, the pattern of low population density in Riyadh has made it hard for the government to provide an adequate infrastructure for the residential areas, which is costly and often lead to budget exhaustion (Al-Hathloul and Mughal 2004 cited in Abubakar and Aina, 2016).

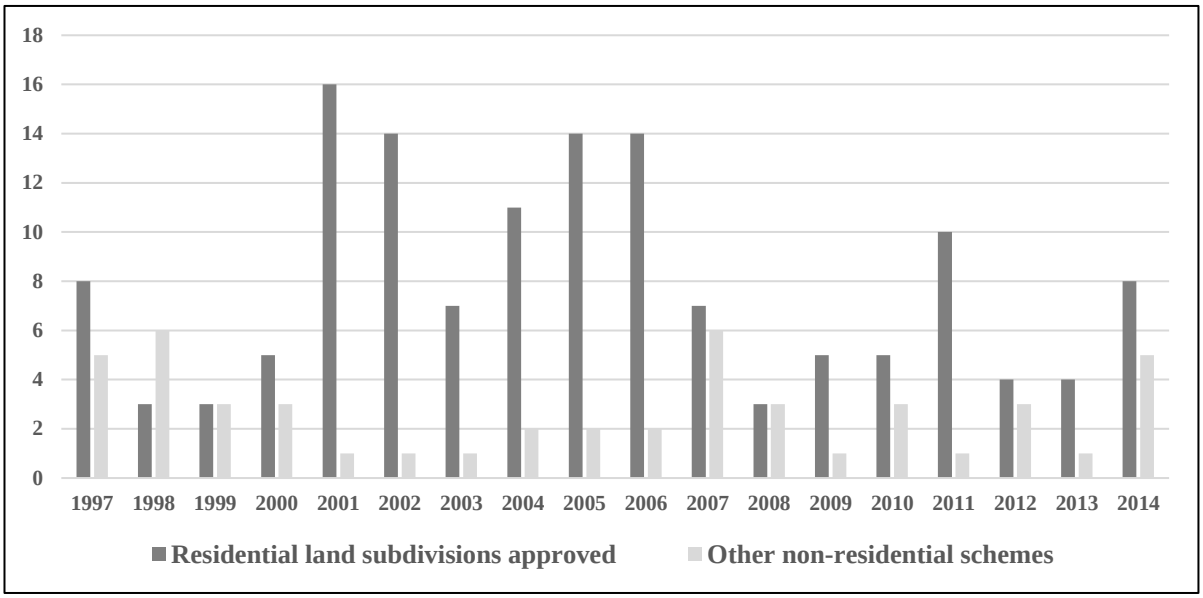

Figure 5-9: The number of approved residential schemes compared with other schemes in the period from 1997 to 2013

Source: Riyadh Municipality (2016)

In general, the developed area of the city has grown, exceeding 1.297 km2, and the number of residential areas, which exceeded 200 residential districts to include more than about 1.02 million residential units has also escalated (ADA,2015). Resulting from this growth, residential neighbourhoods suffer from deficiencies and unequal distribution of infrastructure and public services and utilities (ADA, 2010). In addition, there are many houses without roads, supply of water, health care and educational facilities (Al-Hathloul and Mughal, 2004 cited in Abubakar and Aina, 2016). On the other hand, a number of issues have emerged including a lack of government land for the establishment of facilities for public services due to the accelerated adoption of residential schemes without coordination with the sectors responsible for those services. This has contributed to increased numbers of governmental rented buildings, which constitute about 46% of the total number of governmental public services buildings (ADA, 2010). Furthermore, as a reflection of its rapid growth, the city has seen an increase in daily electricity consumption rates, which exceeded 11,500 megawatts per/ day. It also impacted the city's water resources, where the consumption of water is witnessing high rates, up to approximately 1.8 m m3 per day. Moreover, the current sewerage system serves only

about 51% of the city's population, which has led to the rise of ground water level pollution in addition to the harmful effect on public health. Also, the rainwater drainage and flood networks do not serve all areas of the city, leading to huge floods in the main streets, especially during the heavy rains periods in the previous years.

5.4 The Organisational Context of Residential Infrastructure Delivery

The previous section has highlighted the transformations that have had a significant contribution to the acceleration of the pace of urban growth and expansion in the development of residential areas and the influence it has had on its infrastructure efficiency. Due to the importance of the residential infrastructure role in achieving balanced urban growth and enhancing the quality of life for residents, the government has adopted various organisational measures, at different stages, in its quest to find suitable solutions to address the issues resulting from the rapid growth. A detailed description of these organisational frameworks and residential infrastructure delivery will be described in the following sub-sections.

5.4.1 An Overview of the Decision Making Process in the City of Riyadh

Since the establishment of the Kingdom of Saudi Arabia in 1932, the state has seen several developments in administrative systems which reflect a number of circumstances and the social, economic and political changes which the country experienced. These developments were aimed at improving government sectors' performance and ability to carry out its functions and meet the needs of citizens in an efficient way. When reviewing the stages of evolution in these systems, it can be noted that the developments have been gradually made to keep up with these requirements and provide the basic elements and functions of a modern country.

As with any newly established government, the early stages of administrative development started through the creation of a number of agencies, and their branches, for carrying out the major tasks of the state and meet the necessary requirements of public activities and services. A number of councils and committees which played an essential role in establishing administrative work in the state were also created. The government

legislations for organising and managing cities began in 1938 and issued the system of a capital municipality and municipalities. The system played an essential role in the organisation of the cities putting in place regulatory frameworks for local administration and municipalities in the absence of government agencies supervising the implementation of services. During that period, the government divided the state into three administrative regions (Najd, Al Ahsa and Asir). Each region associated with the administrative governor who has the authority to manage and supervise all region affairs. Generally speaking, this stage was characterised by its tendency towards decentralisation where the administrative governor had a distinguished place through direct association with the king qualifying him to act freely make all the decisions in the region.

In 1940 the government issued a system of governors and administrative councils, which was considered the first local legislation in the country aimed at organising local administration. This system defined the authorities, responsibilities and duties of the regional governors and their relationship with central government and various authorities. In accordance with this system the kingdom was divided into fourteen administrative regions. Each administrative region has a council that acts in the supervision of local affairs and consists of four to eight members, headed by the regional governor (Mohsen, 2000). The regions' governors have direct association with the Minister of Interior and also have responsibility for representing the central government and running all the administrative functions of the region. These functions have included work on the development of various economic, social, health and cultural aspects. In addition, they provide assistance to government officials in the collection of general revenues, submission of reports about the performance of the branches of government ministries in the region to the Minister of Interior. Although this system granted governors wide responsibilities within their region, it did not, however, allow to them interfere directly in the government agencies that work in the region, except in special cases when discussing important issues that need to coordination between those agencies and contact with higher authorities (Khashoggi, 2002).

The establishment of the Council of Ministers in 1954 is considered the beginning of formal organisation and the start of institutional work to keep pace with the rapid

development of the country and cope with its needs. The Council of Ministers became responsible for all the executive, administrative and financial authorities as well as the organisation of and co-ordination between government bodies. Accordingly, the council were given full control for monitoring the implementation of statutes, rules, and the creation and organisation of public services, as well as following up the implementation of development plans and the progress of the work of ministries and other governmental bodies. In spite of the increased number of ministries that accompanied these changes, the responsibilities of local administration remained subordinate to the Ministry of the Interior and their tasks were confined to coordination of activities undertaken by branches of central ministries in cities (Mandeli, 2011).

In general terms, the Council of Ministers had granted the ministries and government bodies wide powers and independence in working to implement the developmental programmes and projects through their local branches. This has caused increased centralisation of decision making at the local level. It also created some overlap and duplication of responsibilities granted to the regions' governors, where local branches could override the local governor and receive their orders directly from central ministries. In this context, Khashoggi (2002) indicated that there were a number of reasons that encouraged the government towards centralisation of the work as a method to improve relations between central and local authorities, the most important of which was to achieve a balance in providing the public services and implementing development programmes in all regions of the state. Furthermore, adoption of one administrative language ensured the standardisation and homogeneity of procedures at the various governmental levels. Moreover, addressing the issues of lack of the qualified cadres who have highly administrative qualifications and experience especially at the local levels.

With economic prosperity, which has resulted from the discovery of oil, there was a need to expand various governmental services and an urgent necessity to upgrade its performance to deal with the constraints resulting from rapid growth and meet urban problems to ensure balanced development in all areas. These issues drove the government to conduct a number of administrative reforms, resulting in the establishment of the Agency of Municipalities Affairs (AMA) in 1963, which was linked to the Interior

Ministry for the administration of municipalities' affairs throughout the kingdom. During this period the AMA became responsible for the administrative and financial supervision of municipal activities as well as guiding the urban planning processes of cities and communities and the development of municipal services (Gadou and Quasi, 2009). Additionally, the Council of Ministers in same year adopted the Provincial Regulation system as an alternative to the system of governors and administrative councils. The most prominent features of this system was giving the governor more powers, and the local councils, for the supervision of the performance of government agencies and all aspects related to the improvement of local services. The system included the formation of a local council comprising thirty members with the membership term limited to two years. They were headed by the governor and the members were residents of the region selected by nomination from the Minister of the Interior, as well as representatives of the various ministries. Although the system was aimed at giving the local administration additional powers without referring to the central government, it was however, not implemented (Aba-Namay, 1993). In 1974, and with the expeditious changes and the importance of the city of Riyadh as a headquarters of the central government and its main institutions, the Council of Ministers approved establishment of The High Commission for the Development of Arriyadh (HCDA) which was considered unique and not available in other cities during that period; where established later a similar commission in cities Makkah, Al-Madinah Al-Munawarah, Eastern Province and Hail. The HCDA is chaired by the governor of Riyadh and has adopted an independent annual budget to perform its tasks. In addition, the Council of Ministers granted the HCDA a high degree of flexibility in management and finance as well as a wide range of powers and functions for the implementation and supervision of a specific number of important development projects to enhance the position of the city of Riyadh as a capital of the country.

Not long after the creation of HCDA, the country experienced economic changes as a result of the high revenue from oil sales, which led to the rapid growth of cities. These changes necessitated the government to carry out a number of administrative reforms in order to improve the performance of public organisations facing the boom experienced by the country, and enhance administration and implementation of the developmental

plans of cities and villages. As result of these reforms, in 1975 the Agency of Municipal Affairs was separated from the Ministry of Interior and established the independent Ministry for Municipal and Rural Affairs (MOMRA). Accordingly, the responsibility and duties of MOMRA included; management of rural and urban areas, responsibility for urban planning and provision of roads, improving and beautifying the cities, and maintaining the health of the environment. By 1978 MOMRA had issued a system of municipalities and villages as an alternative to the system of capital municipality and municipalities which granted municipalities financial and administrative independence, with remain the issuing of decisions, regulations, legislation and financial remained allocations under its control. The system also stipulated the formation of municipal councils and identified their functions only on the supervision and control of municipal works. Although the wide powers granted to municipalities for carrying out their tasks compared with another government agencies at local level, it should be noted that the government systems still tended toward centralisation in decision making related to local issues. In other words, the roles of municipalities at local level diminished in aspects related to the enactment of legislation, the planning of development programmes and executing projects, and adoption of their budgets where it became necessary to gain MOMRA approval for taking any decisions.

Over time, the local agencies in the city of Riyadh have faced difficulties in meeting the various developmental programmes and projects of the central ministries as a result of rapid changes in the developmental, economic and social fields. This situation led to reconsideration by the central government to provide solutions which aim to facilitate the tasks of local government agencies in planning and implementing those projects and programmes, and supporting decision making at the local level. Therefore, the Council of Ministers granted the HCDA the authority for planning, coordination, supervision and implementation of basic projects in the city of Riyadh and in 1983 established the Arriyadh Development Authority (ADA) as an executive agency for the HCDA. In addition, it has reshaped the HCDA to include members from the public and private

sectors operating in the city, as well as from civil society, to be the unified leadership for the development works of the city (see Figure 5-10).

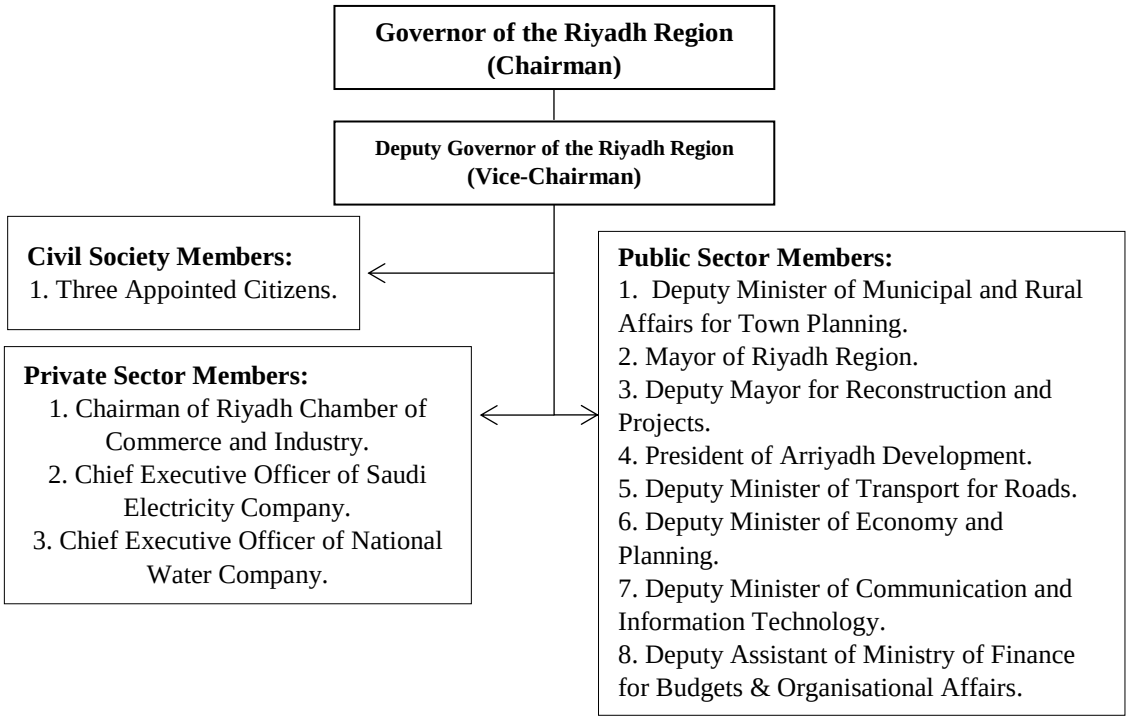

Figure 5-10 Organisational structure of the High Commission for the Development of Arriyadh

Source: The author based on (MOFA, 2013)

Thereby, the HCDA responsibilities have expanded to include inclusive planning of the city and preparation of developmental polices related to the future growth of the city, conducting studies, supervising a number of large infrastructure projects such as public transport projects, development of historical and cultural areas, and design and construction of some public buildings, as well as coordination between different agencies responsible for infrastructure provision in the city. It has also recently widened its scope beyond the city limits, with a strategic plan for the Riyadh region. This extended role of the HCDA came in order to facilitate and accelerate the procedures for adoption of developmental projects and programmes in the city, in addition to the lack of capacity suffered by the regional council, which does not have an executive department within its structure (Althabt, 2013).

The government has continued a process of administrative reform and issued the Provincial System in 1992 which was updated in 1993, as an alternative to Provincial

Regulation for the reorganisation of the local councils. The essential aim of the reorganisation was to promote development and provision of services as well as raise the efficiency of and to promote financial and administrative decentralisation of local agencies (Aba-Namay, 1993).

According to this system, the regions have been divided into three levels to include the provinces, governorates and centres. The councils are headed by the governors and heads of government in the provinces and include in its membership heads of the government's bodies in the region appointed in accordance with a decision by the Prime Minister on the recommendation of the Interior Minister. The councils' membership also includes a number of residents' not less than ten, with a membership term of four years which can be renewed, and are appointed by the Prime Minister on the recommendation of the governor, and on the approval of the Interior Ministry.

When considering the details of this system, it is worth noting that it did not differ a great deal from the previous one, but introduced some changes in roles and the prerogatives. The most prominent of these changes was to grant the Riyadh governor, as a representative of the central government in the region, greater powers and presidency of the regional council. In addition, the role also includes supervision of government units in its region, although there are no powers afforded in this aspect. Furthermore, those changes have identified responsibilities of the council of Riyadh in studying all developmental aspects that could improve the services standard in the region, in accordance with the general policy of the State including the incoming issues from local councils in governorates. These aspects have been identified in the article twenty-three of this system which included "(a) To define the needs of the region and propose the inclusion in the state's plan of development; (b) To specify useful projects in accordance with a scale of priorities and propose their endorsement in the state's annual budget; (c) To study plans for the organisation of cities and towns of the region and follow-up their implementation once they are endorsed; (d) To follow-up aspects related to the region vis-a-vis the plan of development while observing a balance and co-ordination in this matter" (The Provincial System, 1993). Accordingly, the nature and the scope of the responsibilities of the council, related to developmental issues, have become limited in

specific functions, which can be described to some extent as advisory and not executive, and remained without financial powers to implement its decisions.

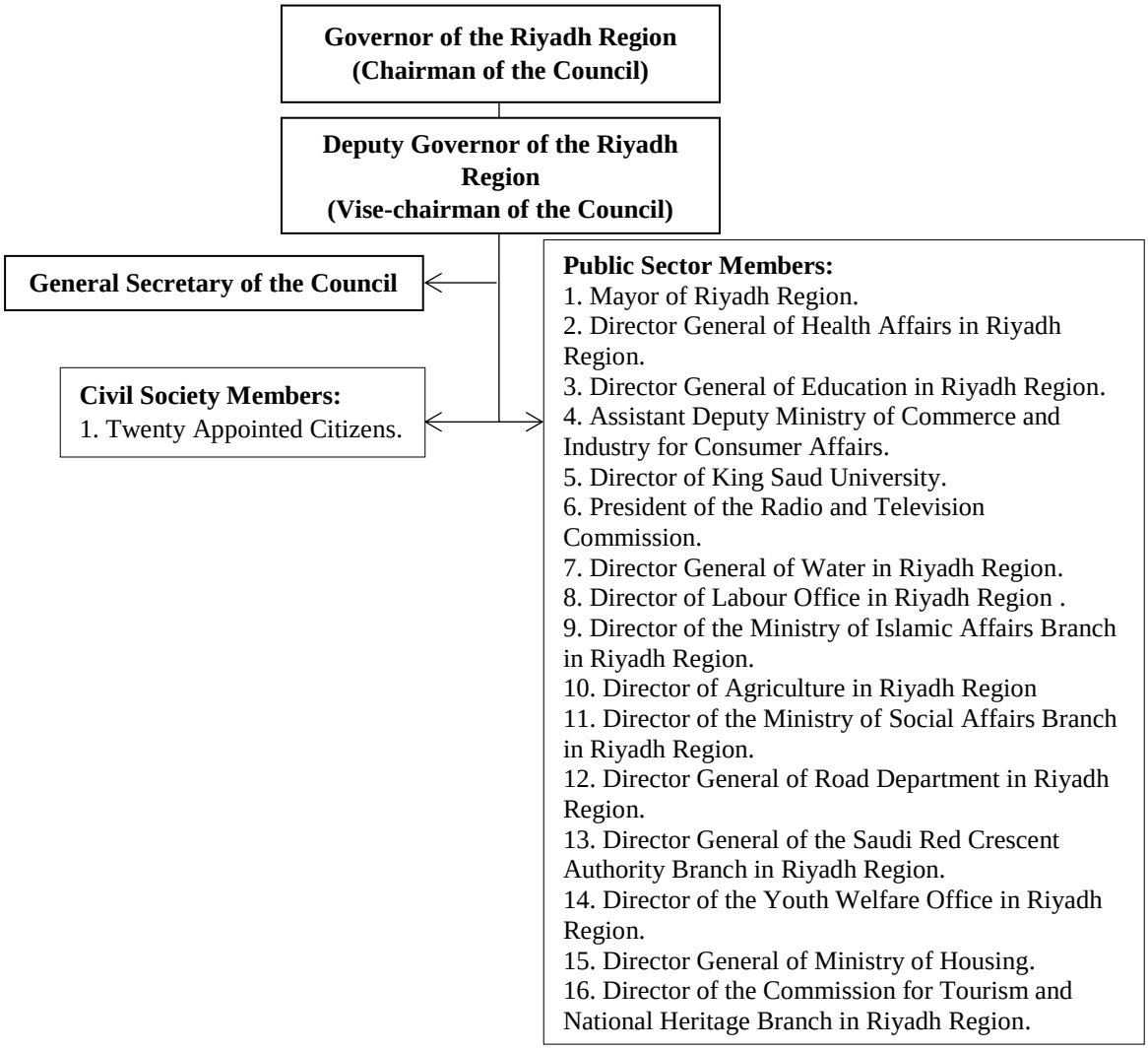

Figure 5-11 The current composition of the Riyadh Regional Council

Source: The author based on the minutes of Riyadh Regional Council meetings, (2015)

In spite of the important role that the regional council and the HCDA play in enhancing the coordination of providing those services and to increase their efficiency, however, the Council of Ministers issued a decision in 1989 obliging the coordination of all governmental agencies and public institutions with the MOMRA to establish the necessary executive development programmes according to the actual needs of the cities. The decision is aimed at enhancing the coordination of services provisions and dealing with the constraints resulting from rapid urban growth to ensure balanced development.

It is also aimed at reducing random distribution, shortage and duplication of public services provided (see Figure 5-12).

Stage 1	Conducting studies of actual residential infrastructure needs in residential areas by Municipalities through coordination with various agencies that provide the services based on standards identified by MOMRA
Responsible	**Municipalities**

↓

Stage 2	Reviewing the findings of the studies
Responsible	**MOMRA**

↓

Stage 3	Presentation of the findings of studies to the region's Council for endorsement and directing each sector to adopt the budgets required for implement.
Responsible	**Regional Council**

Figure 5-12 The work mechanism of the development priorities programme

Source: The author based on (MOMRA, 2004)

Additionally, and in an effort to strengthen decentralisation and raise the quality of service delivery and to increase their efficiency, the government, in 2002, privatised a number of service sectors including telecommunications and electricity, as well as water and sanitation. Furthermore, it also confirmed the importance of citizen participation in decision-making at the local level and announced elections for municipal councils in 2004. In spite of the importance of this step in improving the practises of management of development in the city, the municipal councils duties and responsibilities are only limited to taking decisions on some aspects associated with municipality tasks, which are mostly supervisory and managerial (Abdulaal, 2012). These aspects include adoption of budgets, monitoring the performance and organisational structures of the municipality and other activities related to improvement of municipal service provision. Furthermore, the prerogatives of the Municipal Council do not include coordination or even discussion on the city's urban issues directly with other agencies that are managed by central ministries or the private sector (MOMRA, 2015).

In view of this, many efforts and administrative reforms have been implemented by the government aiming to create more coordination to strengthen the capabilities of different agencies for achieving their objectives. It was also keen to give local government agencies more authority empowering them to carry out their tasks, thus reducing the control and constraints of central ministries and bodies. However, the trait of centralisation is perfectly clear in the relationship between central agencies and their local branches in the city with the exception of some powers given to the principalities and municipalities that are followed the Ministry of Interior and MOMRA. This is highlighted by the dependence of government on the central ministries and bodies in control of aspects related to planning, adoption of the budgets, monitoring performance, legislation and guidance, etc. Therefore, it can be said that there is no uniform policy followed by the government agencies and bodies for managing and organising the assigned works and duties to their associated local branches (see Figure 5-13).

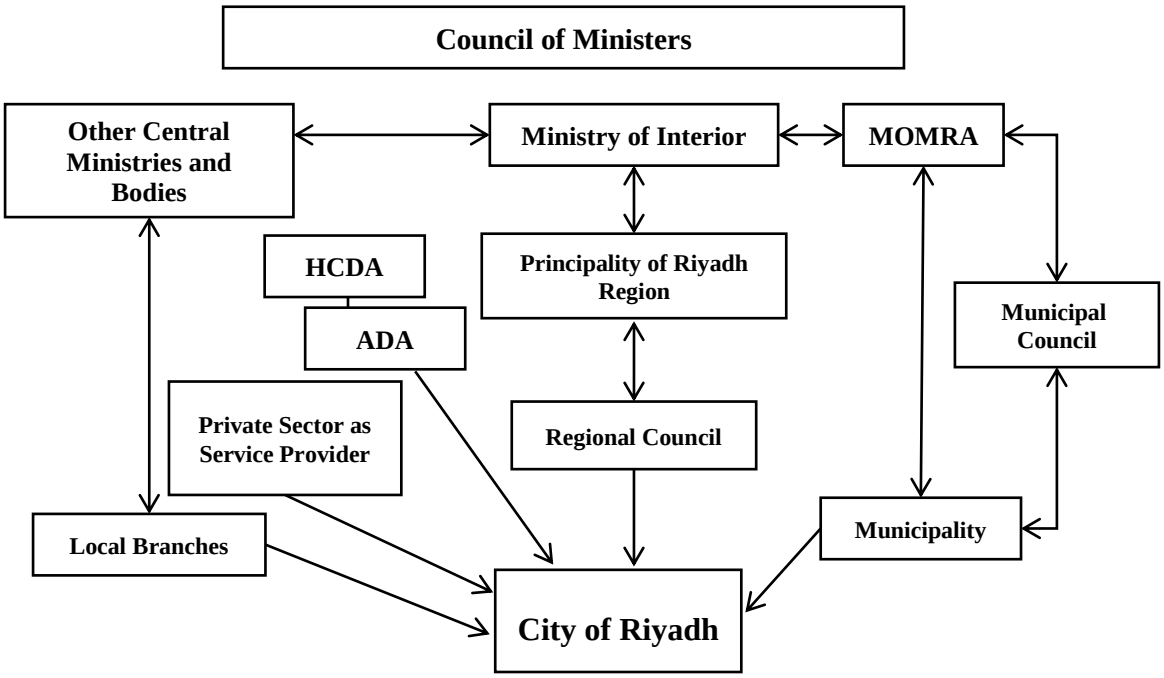

Figure 5-13: The Institutional framework for managing development in the city of Riyadh

Source: The author

The evolution of administrative arrangements regarding responsibilities of different authorities have contributed to some duplication and the multiplicity of local decision making mechanisms. This can be seen clearly through the fragmentation of

responsibilities of the local administration and multiplicity of authorities that are responsible for taking decisions within the city which created difficulties in coordination and managing urban issues. It can also be illustrated in some of the duties and tasks of the HCDA and the Riyadh regional council in aspects related to coordination between different sectors and studying and preparing developmental programmes and projects, as well as the disparity which may occur in decisions taken due to differences in the level of powers granted to their members. Furthermore, an absence of actual participation at neighbourhood level and in light of the multiplicity of those agencies concerned with local decision making, contributed to the widening of the gap between the decisions that are taken and meeting the needs of local service across the city.

5.4.2 Approach to Residential Infrastructure Delivery and the Agencies Concerned with its Implementation

In Saudi Arabia there is great dependence on government agencies regarding the provision of infrastructure services for residential neighbourhoods. As one of the objectives of the national development plans, several governmental agencies (under the umbrella of different ministries), along with private sectors such as the electricity company and telecommunications companies and also quasi government organisations such as the national water company, are involved in the planning and implementation of residential infrastructure (see Table 5-2). However, all of the main responsibilities lie with the government agencies in the implementation or follow-up of operations related to the delivery of physical infrastructure including, water distribution, sanitation, rainwater drainage, roads, electricity and telecommunications. Those responsibilities also include the provision of facilities and social services such as education and health care, police stations, civil defence and places of worship, recreational facilities, open spaces and footpaths.

In the city of Riyadh, there are two different types of processes for development of residential schemes. These processes differ in terms of the mechanism and course of the approval procedure. The first type is government residential schemes represented in the government lands that the municipality prepares and plans the plots ready for construction

and for the purpose of granting them to citizens to build homes. These types of schemes are adopted and the pieces of land are often distributed to citizens without any coordination among agencies that provide the infrastructure, where the services are delivered after houses have already been developed (Abdulaal, 1998).

The second type represents private schemes, where are located within sites allocated for residential use and are owned by individuals or land developers who develop these lands often for investment purpose.

Table 5-2: The role and responsibilities of the relevant agencies for planning and delivering residential infrastructure

No	Ministry	Organisation/ Agency	Role and responsibility relevant to infrastructure delivery
1	Ministry of Municipal and Rural Affairs	Riyadh Municipality	Adoption of residential land schemes and locations of public services and utilities; Permits for residential infrastructure projects; Development and maintenance of roads, pavements and lighting, rainwater drainage, public open space and waste management
2	Ministry of Education	The General Department of Education	Building and running schools
3	Ministry of the Interiors	General Directorate of Civil Defence	Police and Fire Station.
		Public Security Department	
4	Saudi Post	Riyadh Post	Post Offices
5	Ministry of Health	General Directorate of Health Affairs	Health Services
6	Ministry of Islamic Affairs	The Branch of Ministry of Islamic Affairs	Places of Worship
Private Sector			
7	The National Water Company		Water and sewerage service provider
8	Saudi Electricity Company		Electrical Power provider
9	Saudi Telecom Company		Telephone and Internet provider

Source: The author

The process of dividing these lands is subject to a number of planning criteria developed by MOMRA and the Riyadh Municipality. Alskait (2003, p.41) describes the approval process and requirements contained in guide for residential land subdivision issued by MOMRA, which includes seven main requirements: "1. Inspection of the site

and all related official documents; 2. Preparation of preliminary site plans; 3. Coordination with the Electricity Company; 4. Superimposition of the approved subdivision on the actual site; 5. Obtaining MOMRA approval of the superimposition; 6. Examination of the final subdivision by MOMRA; 7. Procedures of implementing the subdivision by the local municipality". In addition, land owners are required to prepare preliminary site plans. This should include the preparation of a land survey and studying of the relations between the proposed spatial subdivisions as well as the surrounding uses of the final site plan. Owners are also requested providing a minimum of 40% of the whole area of land for those services and facilities. These include roads, footpaths, open spaces, car parking and public services land such as health facilities, schools, post office and police station (see Table 5-3).

Table 5-3: Standards of public service provision of residential land division schemes

Type of Serves	**Public services (ratio/ area) required from a land total area**		**Service scope**
Roads, streets and footpaths	Maximum 25%		-
Primary school	2.4% / 10000m2		550m
Intermediate school	4%	12000m2	1200m
Secondary school		16000m2	
Primary health centre	Depending on the scope of service/2500m2		800m
Open space and parking	4%		-
Fire station	Depending on the scope of service/4000m2		1500m
Police station	Depending on the scope of service/2500m2		1200m
Places of worship (mosque)	2.4%		275m
Other government facilities	2%		-

Source: Riyadh Municipality (2016)

In addition, the adoption of this type of residential schemes also requires the provision of the infrastructure identified by the rules and policies of the urban growth boundary (see Figure 5-14). These are limited only to the construction of roads and the extension of water, sewage and electricity networks, while other utilities are left to the relevant agencies to implement services, which are often developed after plots of lands have been developed (Abdulaal, 1998). The municipality is entrusted to adopt these schemes if the subdivision plan meets requirements and administrative procedures followed in the approval. It is also charged with locating sites and allocating public facilities and utilities according to planning standards.

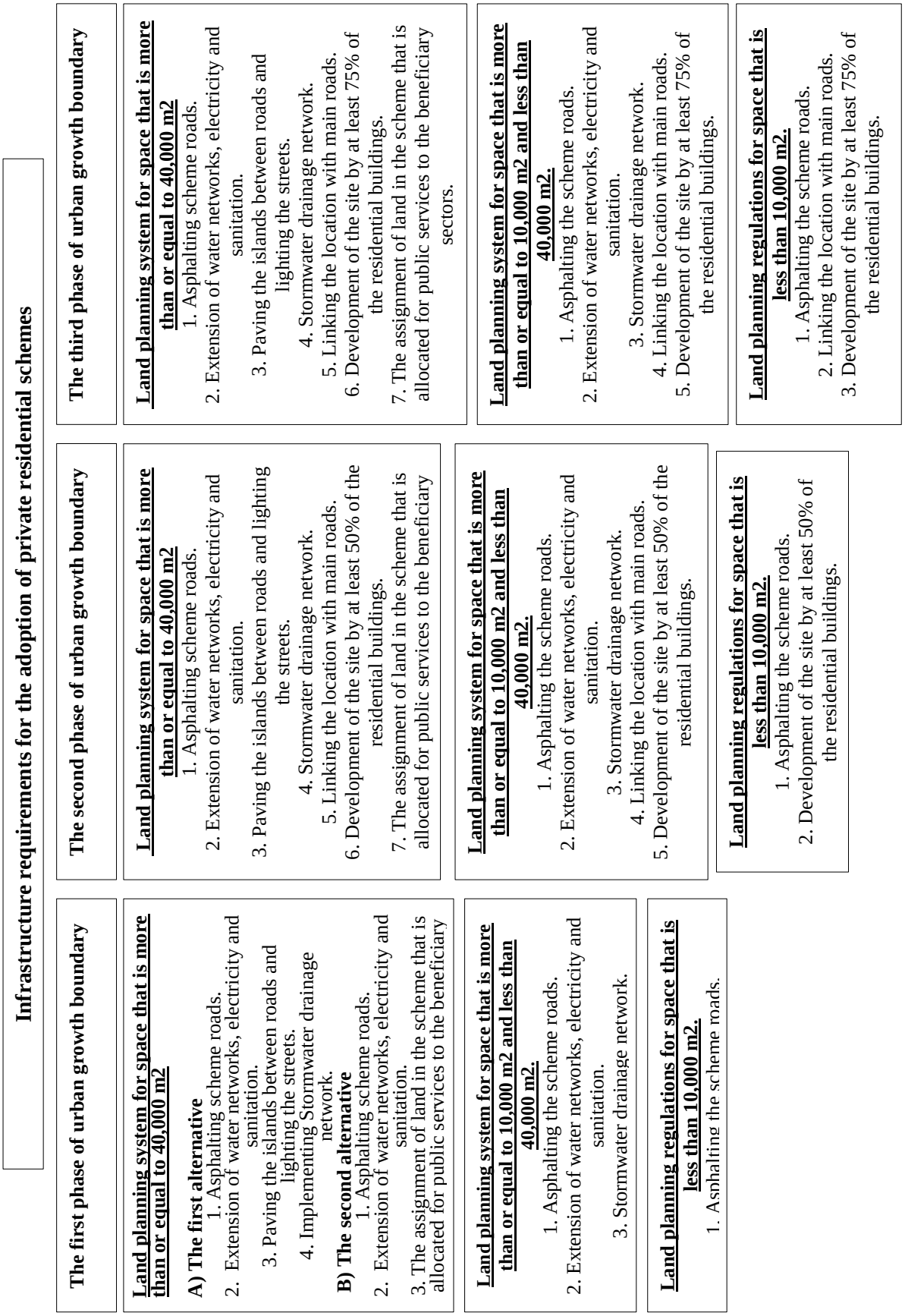

Figure 5-14: Land planning requirement within the phases of urban growth boundary in the city of Riyadh

Source: The author based on MOMRA (2015)

In addition, the municipality follows up on the achievement of the requirements for delivering the basic extension of physical infrastructure, (water, electricity, and telecommunications services) by the relevant agencies before final approval. Despite, the allocation of a high percentage of entire lands area to be developed to provide the services and not requiring their owners to provide public services, there is an absence in the coordination and participation of other relevant agencies to provide public services during the approval stages of residential schemes.

This in turn, contributes to many residential neighbourhoods being fragmented and incomplete infrastructures, as the municipality that oversees the planning is completely independent of other agencies that are in charge of implementing these services and infrastructures. As such, this kind of institutional multiplicity, fragmentation of residential infrastructure agency responsibilities and the centrality of the relationships among government ministries and their branches, which are still managed centrally, makes it difficult to integrate the processes of planning, financing and implementation of residential infrastructures. With the absence of participation and lack of information, especially in relation to the residential schemes being approved, proper planning in identifying needs and balanced distribution of infrastructure at city level can be difficult. Although most of these agencies employ geospatial technologies in different contexts, they are not exploited as tools to enhance coordination, facilitate access to information and involvement during the planning and approval process of the subdivision plans as well as providing infrastructure and services. This will be discussed in the following section.

5.5 An Overview of the Evolution of Using Geospatial Technologies in Saudi Arabia

The development of geospatial technologies has attracted many government agencies to adopt them in the management of many service projects, infrastructure and development plans and programs (Othman, 2003). These technologies have gained standing because of their positive role in providing support to decision makers and can

be used as a common platform to incorporate various database types, represented spatially, into one integrated system to facilitate informed decision-making. Saudi Arabia is one of the countries that has adopted the use of these technologies tools through a number of different governmental bodies (Kubbara, 2002; Alsultan and Rahman, 2015). In 1964, there were early attempts by some government sectors to use these technologies tools which were linked closely with mapping (Dawod, 2012). However, their evolution was rapid and coincided with developments in the field of space technology, communications and information technology in the country. These developments contributed to the multiplicity and diversity of the spatial data offered by many advanced monitoring and measurement devices. In addition, the development of computers and multiple geo programs played a vital role in facilitating the possibility of handling and processing the huge and diverse range of spatial and non-spatial information and storing it in several model and formats according to the users' needs. Currently, several government and private sectors with their various specialties depend on the use of this technology on a large scale (Kubbara, 2002).

Governmental support in this field had a major role in disseminating those technologies (Alshehri, 2007). Also, the agencies producing spatial data played a similar role in their broad dissemination. These agencies include the General Commission for Survey (GCS), Ministry of Municipal and Rural Affairs (MOMRA), General Authority for Statistics (GAS), Saudi Geological Survey (SGS), Saudi Post (SP), King Abdulaziz City for Science and Technology (KACST) and the High Commission for the Development of Riyadh (HCDR) (Algarni, 2006). However, the absence of strategies and legislation that support cooperation and integration did not keep pace with the great activity needed for implementation (Alshehri, 2007). As a result, there was an overlap in efforts, duplication and repeated implementation because of the multiplicity of government agencies and the disparity in their assigned tasks, and the ways of using these technologies. In addition, different versions of spatial data emerged, issued in accordance with different standards and specifications established by each agency without reference to local or international standards which had a negative effect on its quality, accuracy and

possibility of exchange (see Table 5-4). This in turn contributed to an increase in financial wastage associated with implementation and minimisation of benefits that could be provided.

Table 5-4: Duplicated spatial data in some government agencies

Spatial Dataset / **Organisations**	Geodetic	Road networks	Topography	Hydrology	Administrative boundaries	Utility information	Cadastral information	Geographical names	Transportation	Elevation and Bathymetry	Environment	Aerial or Satellite Imagery	Vegetation	Geology	Zip Codes	Population Census
MOMRA	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
GCS	■	■	■	■	■	■		■	■	■	■	■	■			■
KACST		■	■		■			■	■	■		■	■			
SGS	■	■	■	■	■			■				■	■	■		
SP		■						■	■						■	■
HCDR		■	■	■	■	■	■	■	■	■	■		■		■	■
GAS		■						■	■							■

Source: Alshehri (2011, p.5)

With growing awareness about the importance of unifying efforts various sectors showed a desire to establish unified policies and the mechanisms necessary as a base for all geospatial activities to support keeping pace with its evolution. The first initiative was in 1989, where the Council of Ministers issued a decision amalgamating all agencies involved in the field of surveying and mapping into one body called the Central Survey Department (CSD) linked to the Ministry of Defence and Aviation. This department was tasked with all surveying works for all governmental and non-governmental agencies. In addition, it was responsible for undertaking all work relating to geodetic, topographic and marine surveys, aerial photography and production of geographic information as well as all maps with a scale of 1: 25,000 and less. An exception to this decision was the production and updating of detailed cities' maps with scales greater than 1: 25,000 which was entrusted to MOMRA, also, the survey work related to oil and minerals remained in

the jurisdiction of the MPMR. In addition, KACST was given responsibilities for the administration of all tasks related to production of satellite images.

However, the activities of geospatial implementation and production of spatial data across various government projects were growing rapidly. Therefore, KACST took the initiative and proposed the creation of a national committee to unify efforts and eliminate duplication whilst rationalising costs via linking the concerned authorities together through a unified information network to exchange and share spatial data. In 2001 the Council of Ministers issued a decision mandating KACST to create a temporary committee unifying the general specifications and principles required to establish a national database for geographic information systems. The committee was composed of members representing the eleven governmental organisations involved in this area. The committee's main focus was on drawing strategies and plans, unifying efforts, specifications and public foundations in the field of GIS in accordance with specific regulations to serve all sectors and provide them with technical support. Meanwhile, its achievements were confined to categorising an inventory of all kinds of spatial data and set and integrate its national standards as well as determining a unified geodetic reference setting regulations and legislations relating to the exchange of data (Ashahrani and Molla, 2008).

The Council of Ministers supported this policy, and in 2006 issued a decision to convert the CSD to the General Commission for Survey (GCS). The GCS was given responsibility and tasked with all works assigned to CSD; developing GIS systems related to its work and modernisation requirements. In 2010, it was also given responsibility for chairing the National Committee for Geographic information systems (NCGIS), which was formerly a temporary committee and is now permanent. The NCGIS includes representation from thirteen government agencies in addition to three people from the public and private sectors that have the necessary expertise (see Figure 5-15). This decision gave the NCGIS responsibility for developing national policies and regulations in the field of GIS, to establish national spatial data infrastructure (NSDI) in the country

and submit their findings and recommendations to the Council of Ministers for consideration.

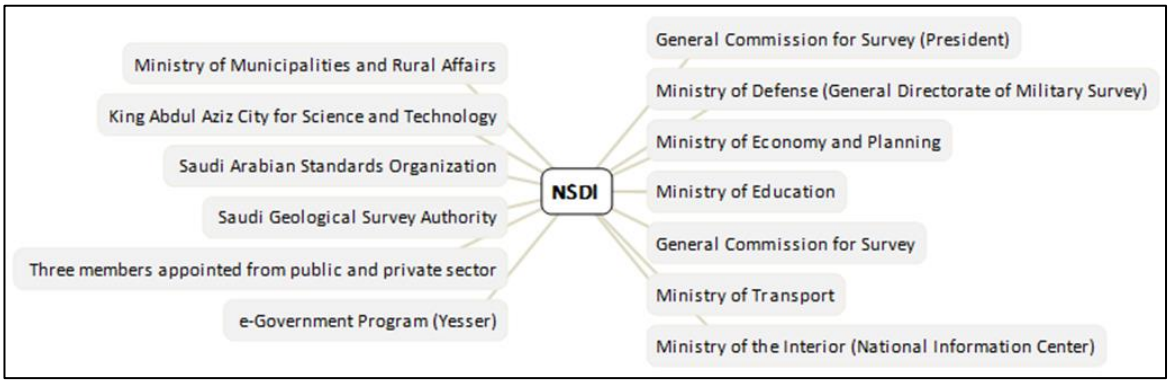

Figure 5-15: Members of National Committee for Geographic Information Systems

Source: The author based on NCGIS (2015)

There was also similar support in the field of scientific research and development in this area. In 2012, the GIS Technology Innovation Centre (GISTIC) was established as a research organisation with the aim of raising awareness and developing geospatial practices in the country. In addition, the government provided support for the Space Research Institute (SRI) at the KACST, which includes a number of centres that conduct studies, applied research and implement projects to support the development of applications in the fields of remote sensing and GIS, digital studies, aviation and satellite technologies.

Despite efforts to support the development, implementation and use of geospatial technologies, they did not however, help to create an integrated environment that supports compatibility among the various agencies where the issues continued and became more complicated. So far, the implementation of geospatial is carried out independently within different sectors. The majority of cooperation and coordination in geospatial activities is still in the early stages (Alsultan and Abdulrahman, 2015). The issues of repetition of projects among different agencies, accuracy and standards of spatial data are still on-going.

One of the most prominent examples of such duplication of efforts is the production of cities' base maps. In the city of Riyadh, the Municipality produced and updated the

city base maps; meanwhile, Saudi Post produced another map. Each map contained different spatial data standards and technical specifications. This difference shows clearly in the coding and numbering of buildings in the city, even though the Council of Ministers issued a decision in 2012 adopting a unified national postal code which was implemented by Saudi Post (see Figure 5-16).

Figure 5-16: Illustrates the difference in coding and numbering for buildings

Source: Alhsan (2011) and SP (2014)

Another example of duplication is the repetition in the creation of geodetic reference networks which is carried out without coordination between the GCS and MOMRA (Alshehri, 2011). Such issues reflect the dispersion and divergence of trends in implementation among sectors and the absence of governing regulations. It also directly contributes to the negative impact on the benefits gained from using these technologies, their development and the raise in implementation costs. This in turn limits their role as useful tools to support making decisions for implementation and coordination of development plans and programs among the various agencies.

5.6 Using Geospatial Technology in the Agencies Concerned with Residential Infrastructure Delivery

Geospatial technologies have received growing attention from the agencies that responsible for provide residential infrastructure, whether at central ministry level or their local branches. These agencies are exerting great efforts to take full advantage of the rapid developments of these technologies and employing them as support tools for planning and implementation, as well as decision making based on the vision of variables and

relationships associated with spatial location. In addition, they seek to exploit the high capabilities of these technologies in terms of monitoring, documentation and analysis and easy access to data. Moreover, to enhance their performance through the transformation of their services from traditional format into electronic format. Therefore, those agencies were the first to take the initiatives to use technology in a sophisticated way.

Despite the rapid technologies development, there remains a limited number of studies and research describing this development. Most studies have focused on the comprehensive description of experiences and the achievements made by the government agencies.

1986 represents the beginning of the modern use of these technology tools, where the Riyadh Development Authority (ADA) created the first urban information system. The purpose of this system was to create a unified system of urban information for the city in order to support coordination between the various bodies in the public and private sectors. Also, it was designed to contribute to the preparation of all urban studies related to the development of the city. Therefore, the ADA worked on producing base maps of the city updating them to include all metadata such as land uses, services networks, housing, environmental and economic information and public facilities. This information is also updated periodically, published and made available to different sectors.

Riyadh Municipality also had a desire to take full advantage of modern technology solutions and applied the best technologies in the geospatial field in order to improve the performance of its functions. In 2001, it launched a computer centre for the purpose of transferring from the primitive traditional system based on paper maps to a sophisticated and integrated digital system. However, this beginning was not encouraging to reliance of the use these technologies, therefore, a long-term plan was prepared to activate their daily use in all of its different departments.

In 2007, an advanced centre was set up for geographic information systems aimed at building a spatial database based on maps, digital spatial data, approved schemes and satellite images available in different departments and sections. The centre is currently

working on creating and developing many applications based on geospatial technologies to support facilitation of the task and functions of the Municipality's various departments. The geospatial applications include a survey reporting system, city planning, land division system, cartography, utility management, studies and designs and interactive maps. The centre also issues a permit system for the implementation of services, which aims to coordinate and organise and follow-up operations between different service providers.

Figure 5-17: Example of applications based on geospatial technologies in Riyadh Municipality

Source: Riyadh Municipility (2016)

In the field of physical infrastructure services, the Saudi Telecom Company (STC) adopted an ambitious plan to build a comprehensive spatial database to expand its services. In 2002, the STC commissioned a consulting company in collaboration with KACST to create the infrastructure for geographic information systems (Kartal et al., 2006). At that time, this project was considered to be one of the most significant projects in this field nationwide and was instrumental in the configuration of a comprehensive spatial database of the country's cities (Abdulaal, 2005). The project depended mainly on the use of satellite images and field surveys to create maps linked to spatial data. Based on the result of this project a number of applications were designed in the fields of planning and provision of information, business development and customer service, as well as maintenance activities.

In 2004, the Saudi Electricity Company (SEC) also started to create a centre for GIS centralised with the purpose of developing the use of geospatial tools to provide accurate,

comprehensive and unified information to support decision making (Albogami, 2006). The use of these tools led to the establishment of many applications that serve the company in the field of planning, as well as other services related to the reporting of emergencies and maintenance in addition to the management of field teams. Furthermore, the National Water Company (NWC) recently adopted the development of systems based on geospatial technologies in order to manage water and sanitation systems in addition to customer service.

The use of these technologies have also been introduced in other public service sectors. One of the most prominent sectors that adopted the use of geospatial technologies in an attempt to improve its service quality is Saudi Post, where these technologies employed in the implementation of the national address project in 2010. It also worked on urging other sectors to make use of the outcomes of the project through signing agreements with a number of government and private sectors to adopt its outcomes in their businesses. In addition, it made spatial data accessible to systems and applications developers via its website with the aim of facilitating the use of maps and spatial data from reliable sources.

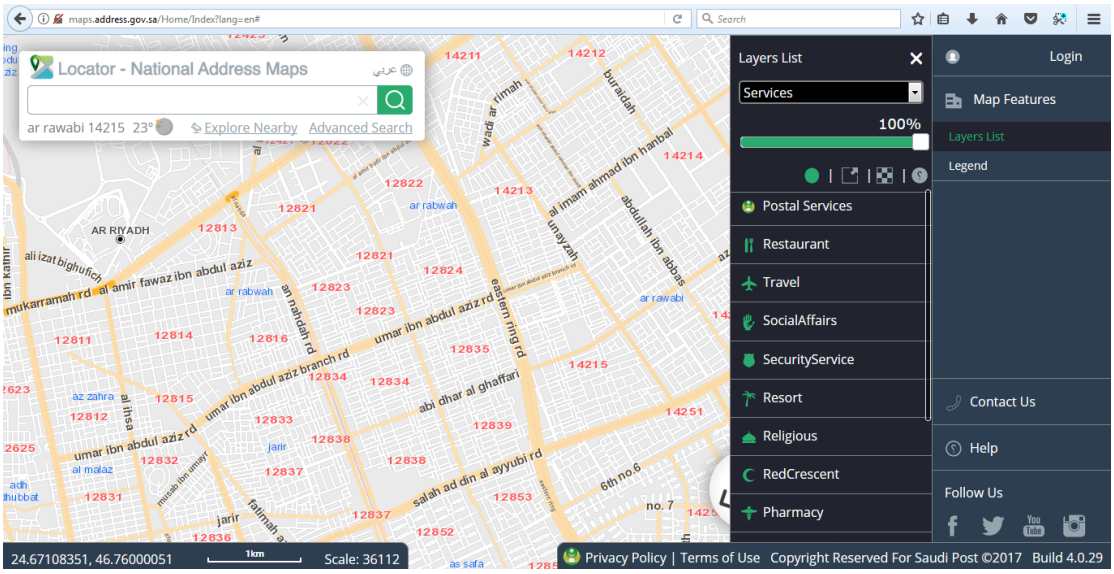

Figure 5-18: A Screenshot of the saudi locator, which provides a locator service using the postal addressing

Source: Saudi Post (2017)

The General Directorate of Civil Defence (GDCD) is another sector that employs this technology as an essential means of caring out daily tasks. It created a specialised

administration dedicated to linking maps with spatial data to enable civil defence teams to deal with communications of accidents swiftly and effectively. Moreover, it produced a number of spatial applications for smartphones which allowed citizens to take advantage from of them for the reporting of accidents. A "Makany" system is an example of geospatial uses in those sectors which were launched by the General Directorate of Education (GDE) to serve as a guide for locating schools. The system provides information on all educational facilities in all neighbourhoods according to their spatial locations.

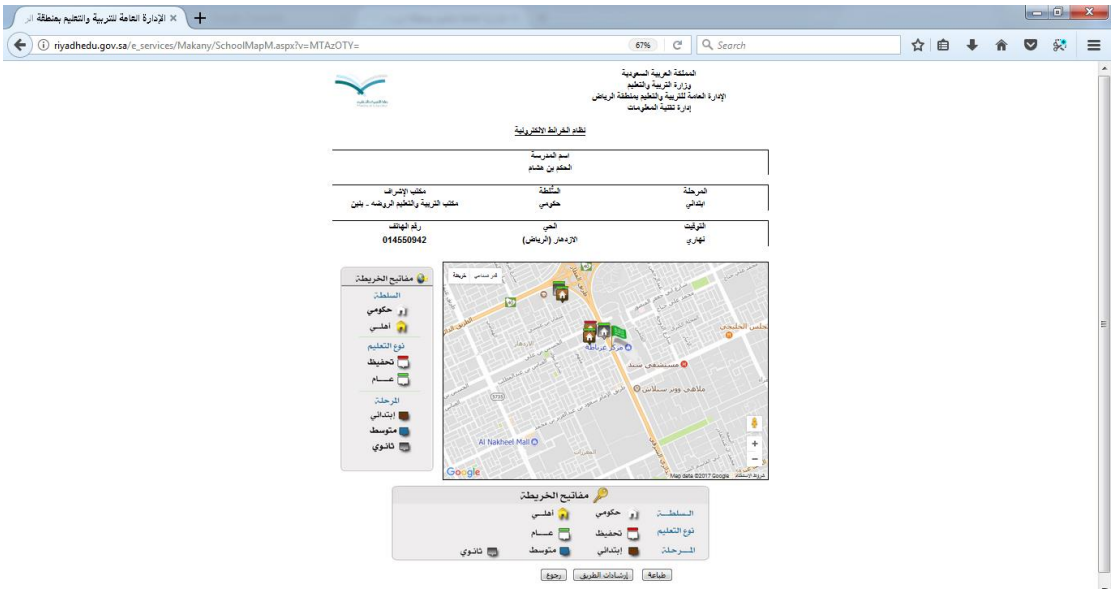

Figure 5-19: A Screenshot of the makany website showing information about the educational services in the city of Riyadh

Source: GDE (2016)

It is obvious that there is considerable activity in the field of implementation of geospatial technologies within the agencies that provide residential infrastructure. However, most of the implementation designed to manage spatial data, develop decision-making, and improve the quality of service delivery tools individually. This in turn limits the benefits gained from these technologies in the integration between stakeholders, whether service providers or citizens. There may be a number of obstacles and complexities that hinder the exploitation of the available geospatial technologies as support tools for overcoming issues of service shortages; this will be explored in the following chapter.

5.7 Summary

This chapter presented an in-depth background on urban growth in the city of Riyadh. A number of events, in a short period of time, had a significant impact on the accelerated pace of the urban growth of the city. Declaring Riyadh as the capital of Saudi Arabia, along with the high income rate played a major role in the acceleration of development in various economic, social, demographic and urban areas. The transfer of most of the headquarters of government institutions to the city of Riyadh was one of the main factors contributing to the high population growth rates. The government policy of granting residential land to citizens to address the housing crisis created a major challenge in service provision. As a consequence of this rapid expansion, issues of shortage and inequality in the distribution of residential infrastructure, services and utilities were raised. Accordingly, the government adopted numerous urban planning policies in an attempt to control the growing expansion of residential neighbourhoods. However, the balance between urban growth and infrastructure delivery to residential areas remains a challenge for public sector agencies at all levels. Fragmentation of responsibilities, the multiplicity of responsible authorities and centralised decision making have made it difficult to create integration in planning, financing and implementation of residential infrastructure. Lack of participation in decision-making between the concerned agencies and the population and the absence of information exchange also contributed to widening the gap between the decisions made and the actual needs of the services for those neighbourhoods. The government took the initiative to support the utilisation of the development in the field of telecommunications and information technology in order to overcome those obstacles and facilitate joint action among all sectors. One aspect of this support was to encourage the introduction of geospatial technologies in various public sector agencies to be used as a tool for decision making and spatial planning for the implementation of development programs and projects. The government has also introduced a number of policies and regulations that coincide with the evolution of its uses to support its development. However, the current geospatial implementations within

these agencies are limited to individual implementation rather than participation and collaboration with other agencies. This in turn reduced the benefits of its implementation in the support of integration in activities related to planning for the delivery of services. The reasons behind these limitations will be explored in the next chapter.

Chapter 6: Current Implementation of Geospatial Technologies in the Agencies Concerned with Residential Infrastructure

6.1 Introduction

The previous chapter provided an in-depth description of urban growth and development in the city of Riyadh and presented a detailed explanation of the organisational context for residential infrastructure provision and the uses of geospatial technology tools in this context. It also explained that, although there is widespread use of geospatial technology tools in many of the agencies concerned with residential infrastructure delivery, they have not been exploited to bring about positive changes in supporting and facilitating coordination between those agencies, and offering innovative solutions to achieve the desired integration.

The chapter explores the reasons behind limited exploitation of the benefits of implementing geospatial technology tools, and identifies the key issues affecting the utilisation of the available tools for enhancing coordination and active participation between the agencies concerned with the planning of service delivery. The results obtained from the data collected through semi-structured interviews with participating experts in the first Delphi round are included. The participants represented 13 agencies concerned with residential infrastructure delivery, and others that provide support in the use of geospatial technologies, as described in Chapter 4. Data were analysed using thematic analysis which produced a number of themes and provided the researcher with a deeper understanding of the current challenges.

6.2 The Current Implementation of Geospatial Technologies in the Agencies Concerned with Residential Infrastructure

This round of the Delphi study sought to elicit experts' views about the current status regarding the usage of geospatial technology tools and discover the key issues affecting the utilisation of the available tools in the planning process for delivering residential infrastructure. Semi-structured interviews were used as a tool for data collection. The reason for using the interview method was to enable the researcher to explore these issues closely and consider how they can be addressed through open discussions with the panel of experts which will assist in the creation of themes for the following rounds. The technical and non-technical factors gathered from the literature review formed themes from the interview questions to describe the current state of the implementation of geospatial technology tools in these agencies, as indicated in Chapter 4. The interviews have been analysed in NVivo using thematic analysis, as described in Chapter 4. Six key themes were identified from data analysis (see Table 6-1).

Table 6-1: Shows themes and sub-themes that emerged from the in-depth interviews

Theme	Sub-theme
Implementation	Individual / centralised implementation
	Disparity in the adoption / usage levels
	Support approach
Awareness	Decision makers' awareness
	Users' awareness
Costs	Providing ICT infrastructure
	Geospatial implementation
Users issues	Shortage of qualified specialists
	Retaining employees
	Training and skills development
	Motivation
Coordination	Geospatial strategies
	Coordination mechanisms
	Leadership
	Difference in priorities
	Interest in cooperation
Geospatial data	Exchange of data
	Standardisation
	Isolated databases
	Data quality and accuracy
	Data sources
	Data security and privacy

These themes have provided a deeper understanding of the current challenges and issues that limit the role of these technologies for improving ways of delivering services to residential areas, the themes were then used to develop the following rounds. The next sections highlight the results obtained in this round.

6.2.1 The Level of Adoption and Use of Geospatial Technologies

The previous chapter pointed to the evolution in the implementation of geospatial technologies in various agencies concerned with residential infrastructure delivery. It also indicated that there are different uses for geospatial technologies serving multiple activities and functions within those agencies. Although growing in their use, it was, however, obvious at an early stage of this study that the use of these tools in decision-making related to planning for residential infrastructure delivery is still limited.

In fact, the adoption and use of such technologies in the daily work activities and keeping pace with its developments requires a willingness to accept organisational and technological changes, which in itself poses a challenge, especially in the bureaucratic agencies. Although, the nature of functions related to residential infrastructure delivery are very similar, the integration and coordination of geospatial technology activities used is difficult to achieve in practice due to varying organisational structures in concerned agencies and the absence of relevant strategies. Therefore, the individual implementation of these technologies was the salient feature in such circumstances.

The effect of this is evident in the level of disparity in the adoption and use of geospatial technology tools from one organisation to another, as exploitation of these technologies has not been at the same pace. It was observed that a number of agencies continue to use a limited number of these tools in a traditional way, while others are using modern and sophisticated tools. For example, (PP1-1) said:

> *"...we depend only on open source maps (Google maps) to facilitate identifying all the locations of facilities and their coordinates...."*

(PP4-2) also adds:

"... in many cases, we use geospatial technology tools to identify the spatial coordinates of services' sites either already implemented or which need to be implemented by GPS devices..."

One of the reasons for this disparity is that a number of organisations focus fully on the implementation of this technology primarily at the level of the central ministries and in isolation from its agencies at city level. This point was raised by a number of experts; related to this, (PP3-2) said:

"…there is a need for the development of the uses of these technologies at the directorate level, which is equal to that in the Ministry."

Also, (PP3-1) said:

"…there is a specialist department at the ministry, which is using these technologies ...where they have available data and qualified specialists."

This also was evident from the reference to the limited support provided by some of the central organisations to their agencies at city level in the adoption and use of these tools within their tasks related to residential infrastructure delivery; as (PP2-2) said:

"...supporting the development of the use of these technologies is, in fact, not so great at the agency level."

(PP1-2) added:

"...there is support for using this technology, but, it is only limited to a few functions related to locating facilities purposes..."

This in turn reduced the attention given by some of these agencies for developing their use of geospatial technologies, and thus limited their use in a number of tasks. Therefore, the use of such tools remains at an early stage in some agencies, which may increase the difficulty in finding solutions for coordination and integration between them.

In relation to this (PP3-2) said:

"There is no reliance on the use of geospatial technology tools, particularly in operations related to the provision of services, except in aspects relating to calculating the distances between the service locations when conducting needs studies."

In addition, (PP2-2) added:

"...we use these tools in functions related to management of properties and facilities locations."

In contrast, a number of agencies seek to optimise the potential benefits offered by these technologies and use tools, which allow them to develop a number of applications to improve the performance of tasks related to the delivery of services, in both planning and implementation. Therefore, there were many modern devices and applications based on geospatial technologies used in these agencies to enhance their performance, for example, (RP3-1) and (RP3-2) said respectively:

"...we developed a number of systems based on these technologies for management and design of the infrastructure networks, such as underground cables and operating devices..."

"...we have a number of spatial applications that can be used by individuals whether on computer or smartphone devices.... We also offer a dedicated platform, which allows developers to develop software and applications based on spatial data available."

This is due to the support given by those charged with making decisions inside those agencies that encourage relevant departments to engage with continuous improvement in the use of those tools in order to improve and upgrade their performance. In connection with this, (CA1-2) said:

"...the support by the top management is high for development of using this technology as an essential tool for our work. We have an ambitious strategy to make use of this technology and cope with its rapid development, and we have invested significant sums in recent years to provide advanced geospatial tools, and this support is expected to increase in the next years."

Hence, it can be argued that the independent implementation of geospatial technologies and the disparity in its adoption and utilisation along with the support given according to the policies and directions of those agencies have made the integration of their activities to make participatory decisions difficult.

6.2.2 The Cost of Implementing Geospatial Technologies

In many organisations the cost involved in the use of geospatial technologies are still a big challenge in making decisions related to its implementation. Despite the decline in recent years in the prices of hardware and software related to these technologies, the costs associated with the provision of spatial data remain high. In addition to the spatial data costs, the implementation of these technologies encompasses other expenses, including maintenance, as well as providing qualified staff to run them, which then rise in line with the increase in the size of the data and purpose of its use. Sharing the costs of geospatial technologies implementation is an important factor in reducing the high costs of implementation. However, this is difficult to achieve in light of the financial and administrative independence of those agencies. This has contributed to the high costs of implementation and hampered the development of their uses, especially in the public sector agencies.

Data revealed that the high costs associated with the provision of ICT infrastructure and qualified technical cadres related to geospatial technologies limited the ability to keep pace with the evolution of the uses of these technologies and utilise them both at the level of the agency, or even to participate with other agencies in decision-making related to the delivery of services.

For example, (PP2-2) said:

> *"The costs associated with this technology are high as it requires the rehabilitation of the infrastructure necessary, whether technical tools or qualified staff to work on developing them; this directly affects the utilisation of this technology as required."*

In addition, the delay in approval of the necessary budgets has an adverse effect on the development of the implementation of those technologies which can take up to a year because of the governmental procedures. (CA1-2) said:

" ...financial costs to provide this technology is one of the most important challenges due to the government agencies associated in particular with specific budgets in this aspect, which make it difficult to keep pace with its continued developments."

Also, (PP 1-2) explained the importance of exploiting the potentials offered by these technologies by using cost-effective methods to overcome such obstacles and noted that,

"…there is a reliance on using open source maps through which service locations are identified and their data are added and this does not cost the department."

However, the reliance on such sources may not be as effective where some aspects, related to planning for the delivery of services, require a high level of data accuracy and reliability to make decisions.

On the other hand, some experts justified the high costs associated with the implementation of these technologies in terms of their benefits in the support of carrying out tasks, which is considered an important aspect to ensure the continuity of financial support for its development. In this respect (PR2-2) said:

"The costs of using geospatial technology are considered high, but in return it has a high payoff in facilitating work needs as well as the quality and level of residents' service."

6.2.3 Awareness of the Importance of Geospatial Technologies

The widespread growth of geospatial technologies in the agencies concerned with delivering infrastructure reflects the increasing awareness of its importance in contributing to improving the performance of their functions. However, there is a need to exert more efforts to take full advantage of all its potentials in the area of service delivery. Government initiatives to encourage the various agencies on the implementation of this technology must be accompanied by similar initiatives to create awareness and to develop sound fundamentals about how to obtain benefits from their use as tools for collective

decision-making in the implementation of development projects. The roles of the tools of these different technologies within the daily work tasks related to the services delivery in each agency may give a clear indication of the level of awareness about their importance. However, the absence of their role in the aspects of integration among the various relevant agencies demonstrates that there is a lack of awareness on how to utilise all the advantages that can be provided.

The views of the experts show that there is awareness about the importance of geospatial technologies in decision-making processes related to service delivery; however, few of them mentioned its importance as regards aspects of integration and participation with other agencies. This may be due to the different levels of awareness about the roles and potentials that can achieved by these technologies in this aspect. For example, referring to the importance of raising awareness among decision makers and staff alike, (PR1-2) said that there is

> *"...still a lack of awareness, among some employees, of the benefits that can be obtained from the use of such technologies tools in the development of performance of the work level. This requires raising awareness at all levels ranging from the directors of departments down to the technicians."*

At the same time, it has been pointed out that the lack of awareness among some decision makers in those agencies has made coordination in utilising these tools consistently difficult. (PP2-2) said:

> *"Some decision makers have a lack of awareness of the importance of the use of this technology as an essential tool through which they can make decisions."*

(PP6-2) added:

> *"Many agencies that provide urban services have a lack of awareness of this technology and they still need to know how to best take advantage of it."*

This in turn may pose an obstacle to taking full advantage of the benefits that can be brought about by these technologies towards improving decision-making in the context

of residential infrastructure delivery and accordingly, reduce the chances of successful implementation.

6.2.4 Coordination of Geospatial Technologies Activities

Planning processes for residential infrastructure delivery requires many types of data including spatial data such as maps, geodetic networks, satellite images, in addition to non-spatial data such as data related to lands and buildings and utility services, statistics that can be linked spatially to produce spatial knowledge. Geospatial technology tools are important in their use as a platform for the integration of these data into one integrated system that facilitates the process of identifying needs and priorities and decision-making. However, providing such integrated systems also requires organisation and coordination of their activities to ensure that these systems are efficient in their use and to achieve optimum benefits from implementation. In fact, the themes related to coordination were the most frequently mentioned themes during the interviews. This gives a clear indication of the importance of this aspect for improving the extent of the benefits derived from the use of these technologies in planning for the delivery of services. The majority of experts believe that the lack of coordination among different agencies resulted from the expansion of geospatial technologies and was one of the main reasons that formed a barrier towards integration of the activities of those technologies.

As previously noted, efforts were exerted at various levels to coordinate the objectives, policies and processes, as well as techniques for geospatial technology activities among the different agencies to reduce individual and random implementation. The establishment of the NCGIS by the Council of Ministers highest regulatory authority in the country was one of the most prominent of these efforts towards ensuring the coordination of efforts between the various agencies. It was also a positive step towards introducing fundamental changes and leading the geospatial technology activities to coordinate a more organised situation. However, a limited number of experts highlighted the role of this committee in this context. This indicates that the committee did not play

an effective role in organising and directing the efforts of these activities even though its membership includes a wide range of representatives from various sectors. Related to this, (CA1-1) stated:

> *"...the NCGIS has already been established and its role is to solve such obstacles, but no decisions have been issued so far in this regard."*

Also, (CA2-1) said:

> *"In fact, this committee has exerted some efforts to support this aspect; however, these efforts are slow, unfortunately. We hope it will play its role effectively in the future."*

He also described the ineffectiveness of the role of this committee in the support of coordinating the activities of these technologies:

> *" ...the adoption of the committee coincided with the establishment of the GCS. It seemed that they were preoccupied with the GCS, so the tasks related to NCGIS became a second priority and so it did not receive much attention."*

However, the job positions occupied by the committee members, and their other obligations, might have an effect on hindering the committee's function. This was stated by (CA3-1):

> *"The committee needs full-time members to work on achieving its objectives as required".*

The quotes reflect the fact that the NCGIS also faces different challenges and needs to make more effort to increase its ability to introduce fundamental changes to geospatial activities in these agencies. Accordingly, the NCGIS contribution to coordination of geospatial activities was, if there was any, minimal. No strategies established by the NCGIS were found at the time of carrying out this research. Therefore, the absence of such organisational arrangements has influenced the ways in which relevant agencies use geospatial tools. It has also made coordination between relevant agencies activities more difficult to achieve whereas the data derived from the interviewees show the importance

of such organisational dimensions in achieving successful coordination. Some experts have alluded to initiative carried out at the local level by the ADA, which the NCGIS did not take part in, to coordinate geospatial technologies activities among the different agencies. However, this initiative did not last long, as such initiatives require greater support by the legislative authorities and institutionalisation of the processes in these agencies so as not to conflict with the reality of organisational complexity. With regard to this, (RP3-2) revealed:

> *"There was a proposal by the ADA for the preparation of a spatial database on the city level for the purpose of coordination and partnership among all the agencies that provide services and we were one of those initiators to participate in this project. A number of meetings were held in this regard, but the project stopped for reasons ascribed to the ADA."*

(RP1-2) also added:

> *"...about seven years ago, there were efforts by ADA in this regard; many meetings were held among the different sectors, and specialised committees including a number of government sectors were formulated to work on unifying efforts and standards associated with this technology, but these efforts were stopped by ADA, and hence results were not realised."*

Despite the lack of success of the efforts in coordinating geospatial technologies activities, a limited number of agencies do coordinate with each other. This attributed to the absence of mechanisms that determine the way they should coordinate the activities of the different technologies to achieve the benefits behind their implementation, and thus, the majority of the current coordination processes lack formal frameworks. In other words, these coordination processes lack the policies, agreements, rules and procedures and even common guidelines that define the mechanisms and channels of coordination. Interestingly, the ongoing coordination among some agencies is still bureaucratic, and executed via the traditional methods i.e. official request letters. In addition, most areas of coordination are limited to such aspects relating to the exchange of spatial data without

other aspects associated with the implementation of those technologies. This was disclosed by a number of experts. For example, (RP2-2) said:

> *"There are limited contributions in terms of exchanging spatial data with Riyadh Municipality and ADA and this is done through official correspondence; data is sent on a CD through an official way."*

(RP3-2) added,

> *"...we are providing spatial data for the bodies that request them through official channels."*

A number of experts believed that the absence of coordination mechanisms led to the unwillingness on the part of some agencies to cooperate in activities related to those technologies. The reason for this could be due to the current methods of coordination that may not correspond with the agencies' priorities or attitudes. For instance, (CA3-1) said:

> *"I think that the technology has been available and is much easier than before, especially in addressing issues related to integration, but desire of various agencies to create coordination among each other has become the key issue."*

Also, (RP1-2) added:

> *"There is cooperation but does not rise to be like a single system due to the different views, responsibilities and priorities of each sector, which are difficult to achieve under one priority or goal."*

On the other hand, the absence of leadership with the ability to coordinate the implementation of geospatial technology activities is one of the key reasons that limit the possibility of integration and thus, cannot be employed to support participation in decision making related to addressing issues regarding residential infrastructure delivery. A number of experts raised this issue and they noted the importance of having a body at local level responsible for leading the coordination of geospatial technology-related activities and improving the arrangements for coordination.

For example, (PP5-2) said respectively:

> *"I think it is important to have a specialised body in the city, equipped with an information centre that has all data related to infrastructure services and provides electronic applications for all relevant authorities in order to avoid duplication and repetition."*

Therefore, having the leadership responsible for such activities who are able to set policies, identify roles and responsibilities that conform with the relevant agencies and the requirements of service delivery, whether through the coordination of the implementation of these technologies activities or convincing those agencies to be more committed to integrating with the relevant authorities is an important factor towards achieving the benefits from implementation.

6.2.5 Geospatial Technologies Users

Geospatial technology users can have a strong impact on the development and exploitation of the potential offered by the different technologies. Generally speaking, the chances of achieving the greatest possible benefits of such technologies depend largely on the extent of the expansion of their use. Therefore, the success of the implementation of these technologies depends largely on the knowledge of the potential users as well as their ability to adapt. In general, issues related to the users of these technologies are among the common drawbacks of improving their uses. In this section "users" refer to individuals working on these technologies within those agencies, whether they are developers or users of applications or devices.

In fact, most of the agencies working in service delivery rely on the consulting offices in this area for the development and use of geospatial technology tools. This gives an indication of the lack of qualified employees who have the required technical qualifications, which in turn affects the development of the implementation of these technologies as well as their uses, whether at agency level or in the context of integration, to provide decision makers with spatial information needed to address service delivery issues.

This was disclosed by the majority of experts. For example, (PP2-2) said:

" ...there is a shortage of cadres who generally work on these technologies, as the number of employees working on the use of this technology is limited, which had a reflection on the development of their use."

A shortage of users with the necessary competence may be one of the main reasons behind the obstacles to successful implementation of geospatial technologies. According to the experts' responses, the reasons for this shortage were multiple. One of the main reasons mentioned was the drain of skilled experienced employees, especially from the public sector. Therefore, the experts believe that finding solutions to retain such employees is vital. In this context, (CA1-2) said:

"...there are limited competent employees with appropriate expertise in this area in addition to the drain of these cadres."

In addition, some experts also believed that the lack of motivation to work on these technologies impact the development and success of their use. This point was raised by managers of departments responsible for their implementation. For example, (PP2-2) said,

"... given the importance of the role that they are doing, I believe that there is a need for more incentives and support."

(PP2-2) also added:

"I think that motivating employees to work on the use of this technology is an important aspect, whether morally or financially."

The implementation of these technologies also requires training and development of users' skills. Lack of rehabilitation and continuous development programmes for employees is one of the topics highlighted by a small number of experts who had expressed their dissatisfaction with the current level of training. This variation in the potential of users may create difficulty in the integration of these technologies between relevant agencies. For example, (PP7-2) said:

"The level of training of staff is below the desired level."

(PP6-2) noted:

> *"Continuing training issues to keep abreast of developments related to these technologies constitute a key issue that requires more attention to support the efficiency of staff."*

6.2.6 Spatial Data

The successful implementation of geospatial technologies depends on the availability of data, which is considered the main driver of various activities for these technologies. In light of the development of technology tools, along with devising modern methods to collect spatial data and the development of ICT, data is more readily available. However, the effective access to spatial data from multiple sources requires a number of organisational and technical considerations to achieve integration and optimal use of such data. Coordination and integration in the planning processes for the delivery of services to the population includes many operations that require the exchange of data among the various relevant stakeholders. In fact, there is awareness of the need for the exchange of spatial data and this is reflected in the policies developed by the government for the integration of geospatial technologies activities among the various agencies. However, the effective exchange of data among these agencies is difficult to achieve in light of the limited coordination and lack of clear and consistent policies governing these processes. Experts at this stage noted that the absence of such policies had a bearing on the reduction of data integration and minimises the benefits of its use in the coordination and integration of service delivery processes. In connection with this, (CA2-1) said:

> *".. although the Council of Ministers issued a decree requiring all government agencies to exchange data that can be used or utilised by others, however, there is a lack of legislative and regulatory framework to give effect to this decision with regard to spatial data".*

The multiplicity of spatial data resulting from the duplication of efforts in the implementation of these technologies was another point raised by the participants. One of the positive points mentioned is that the sources of spatial data were heavily dependent

on a number of key agencies producing spatial data, for example (ADA, MOMRA, KACST, Riyadh Municipality). However, there are updates on these data which are done individually based on the needs of each agency. In this context, (PR2-2) said:

"There is a variety of data sources. The bulk of such data is added by the company periodically by various departments and the other part including base maps and satellite images is obtained from other agencies."

This overlap, redundancy and duplication of efforts is a further obstacle in the quest for the proper use and integration of these data and, therefore, it is difficult to take participatory measures to support decision making. In addition, all participants believed that the absence of standards and interoperability was one of the main obstacles to the lack of interaction in the various agencies in this area. On this issue, all the experts also mentioned that the standards related to spatial data were formulated independently. In other words, each agency adopts specific standards with regard to their spatial data in isolation from other agencies. For example, (PP7-2) said:

"...with respect to the spatial data used, their standards have been developed by our specialists to fit the needs of daily tasks."

Along with issues of interoperability between different agencies arising from the multiplicity of data standards, a number of participants pointed out that the quality and accuracy of spatial data hindered the possibility of the integration of data and its use in the field of service delivery. (CA3-1) said:

"some agencies try to avoid the exchange of data as they are not sure how correct they are."

This may be because data is not updated, or because of the difference in scales and standards used by each agency. Therefore, having a body responsible for editing and reviewing such data would increase its reliability; consequently, such data would be utilised and relied upon when making decisions. On this point (CA1-1) said:

"...data accuracy is the greatest challenge to encourage all to interact and participate."

In addition, some of the experts raised a number of aspects related to data security and privacy issues. This was evident when referring to the importance of taking this into account when exchanging spatial data among different agencies. In addition, they made it clear that these issues had a role in influencing the current level of data exchange where some agencies prefer to retain their data in order to prevent any misuse. For example, (CA2-1) said,

"I think there are concerns from some private sector institutions as well as some people regarding data exchange as they fear misusing or exploiting such data improperly by others."

Another issue is the absence of policies with regards to spatial data copyright, which also contributed to the reduction in effective data exchange. The current traditional method of spatial data exchange, which depends on official correspondence and is sent using CDs, DVDs and portable external hard drives, is the most common method used by the agencies. (PP2-2) said:

"It is important to have rules to guarantee the rights of data producers along with developing specific policies for the dissemination and use of this data."

(RP2-2) added:

" .. exchange of spatial data...through official procedures using an officially delivered CD."

On the other hand, a number of experts thought that the lack of ICT infrastructure related to the exchange of spatial data influenced the level of data exchange among those agencies. (CA1-1) said:

"There are a number of difficulties including the lack of technical infrastructure as many of the agencies that provide services are not technically qualified and do not possess the appropriate hardware to communicate with other agencies for the exchange of spatial data."

This, in turn, would hinders the employment of geospatial tools and support the needs of their activities in context of service delivery.

6.3 Summary of the First Round Results

The pressures faced by the relevant agencies to deliver infrastructure in their pursuit of keeping pace with rapid urban growth calls for quick decisions based on updated, reliable, accurate spatial data. The potential for geospatial tools to support decision-making processes has contributed to the development of their use in those agencies. The economic recovery that the country has experienced recently and the provision of financial support, especially in government agencies, has also played an important role in the spread and development of these technologies. However, the traditional approach is still widely used to deal with service delivery issues.

Data obtained from the interviews reveal that efforts are being made to support the use of geospatial technologies in the development of innovative methods for decision-making processes relevant to service delivery. This gives a clear indication that most of the agencies are keen to take advantage of the potential that these technologies can provide. However, the employment of these technologies to promote the opportunity of coordination and find new forms of cooperation and access to spatial data related to residential infrastructure delivery tasks remains limited. The data indicates that the growth witnessed in the implementation of these technologies has been accompanied by an absence of appropriate organisational and legislative policies that keep pace with their evolution. It also shows that there is a lack of institutional relationships to support geospatial activities coordination and use. This in turn has given absolute freedom to each agency in the selection of programmes and projects that fit their objectives, and was an essential factor to make the implementation of these technologies in each agency individual.

In addition to this, the bureaucratic procedures, inadequate coordination, financial and administrative autonomy enjoyed by these agencies, as well as the lack of interest on the part of decision makers in these agencies to give more consideration to cooperate and willingness to participate and undertake partnerships with other agencies, have also played a role in the lack of cooperation in implementing these technologies. Irrespective

of the various motives for the use of these technologies in those agencies, supporting implementation of their activities has been associated with the level of awareness and interest of decision makers. This, in turn, has created disparity in the use of such tools among different agencies, and has meant the implementation of these technologies in some agencies is still limited. Therefore, having strategies supported by shared visions and goals are an important aspect to address these issues and develop their various activities.

Furthermore, data shows that the lack of leadership that defines priorities and supports the coordination of various activities and proper guidance to achieve common goals has posed some difficulty in coordinating geospatial-related projects in the various agencies. Looking at the data, it seems obvious that this has created a great deal of duplication and fragmentation of efforts in the implementation of activities related to these technologies. Surprisingly, such duplication in the implementation of projects even exists on the level of central agencies and their local branches.

This duplication has contributed to wastage of resources and the repetition of efforts related to spatial data and has formed an obstacle to the establishment of a unified spatial database of the city, which has affected ability to access and use spatial information for decision-making activities. Also, the interoperability issues have not been given much attention or importance in the past. The establishment of NCGIG recently was considered to be an important step to the development of the NSDI, but an official NSDI has not yet been created. The data obtained by interviews with the experts indicate that the NCGIG establishment has not played a critical role in the adoption of consistent standards for spatial data technical specifications and overseeing the implementation of NSDI in an organised and systematic manner. In other words, it was unable to involve the majority of concerned agencies in the implementation of SDI initiative to reduce duplication and costs of spatial data and information, to enhance opportunities of cooperation, interaction, accessibility, utilisation and the consequent sharing of data. According to the data, the main reason for this was due to the delay in establishing appropriate strategies, legislative

and institutional frameworks for developing a NSDI. Additionally, the committee has limited authority and lack of capacity, which was not enough to ensure successful coordination and participation between these agencies even though this initiative can contribute to saving costs related to duplication and provide solutions to many issues related to geospatial technologies implementation. This added to the limited interoperability and exchange of data among agencies in an orderly and continuous manner. It also contributed to making each agency deal with data in different ways. Although there is no reliance on citizens' participation in promoting the construction and modernisation of data, and its production is limited in a number of governmental agencies, the duplication and repetition of efforts related to spatial data has continued in most projects.

In addition, independent and continuous updating of spatial data in the absence of those standards among agencies and the use of each agency's own data standards and specifications, have further complicated the possibility of interoperability. This will therefore continue to affect the interoperability between agencies, if not addressed in an appropriate manner. Although the geospatial technology tools facilitate the processing and conversion of various formats of data in order for them to be shared among agencies, spatial data formats are often mutually incompatible due to the multiplicity of the methods used to collect and use the data among the different agencies. Therefore, data collected by these agencies are predominantly incompatible, in terms of the level of accuracy and reliability of data, scales used, data formats and spatial references. This made it difficult to combine these data into a unified centralised database and provide a consistent framework for different geospatial technologies users and their various tasks.

Issues related to the reliability of spatial data also played a significant role in the reduction of support for making decisions related to the delivery of services on a participatory basis. Data also reveals that most of these agencies did not have an institutional approach or clear policies on sharing of spatial data. It shows that the current approach for exchanging spatial data depends on official correspondence or relations

among officials of those agencies, and does not fit the trends and policies of some agencies. In addition, the lack of policies and legislation frameworks related to data security and privacy as well as intellectual property rights for data producers has also led to reducing the exchange and sharing of those data among agencies.

On the other hand, the costs associated with implementing these technologies was among the key issues limited to achieving the optimum benefit from the implementation of such technologies. Providing adequate and sustainable financial support, along with overcoming the constraints of annual budgets, especially in government agencies, were prominent themes during investigation with experts. They had indicated that in light of the individual funding of these agencies to implement these technologies, the overall cost has become higher than it should be, which hindered the development of the use of these technologies in the context of service delivery. Cooperation and participation in the implementation of participatory projects and activities may contribute to reducing these costs. Nevertheless, the difference in systems, procedures and the organisational culture between the various agencies may hinder sharing costs of implementing such activities among the agencies.

In the same context, the costs of necessary ICT infrastructure that meet geospatial activities' requirements was considered a prominent challenge facing those agencies. The ambitious strategies established by the government in 2003 to develop the e-Government, and support its requirements, have generally played a positive role in improving ICT infrastructure in various sectors. However, these strategies have not taken into account the requirements that support the actual use of geospatial tools in this area, even though one of the NCGIS responsibilities is coordination with the e- Government Programme (Yesser) to ensure the compatibility of joint plans and strategies. This has made the employment of those tools, in the field of service delivery, limited in a number of functions.

In addition to this, the capacity building is another issue faced by some agencies, especially in light of the absence of common strategies and training programmes in

various agencies and the limited role of academia in this regard. Thus, some agencies have difficulty in providing financial support for the rehabilitation of staff and developing the skills necessary to deal with these technologies, and this has contributed to the low level of use of these technologies in performing daily tasks.

Furthermore, the difficulty of retaining qualified employees, the lack of specialised capabilities in this area, especially in government agencies, constitute a challenge to enhancing the role of these technologies in the context of services delivery. The migration of qualified employees, whether at the end of contracted projects or because of a desire to get better wages, is another challenge. The lack of incentives for users of geospatial tools especially in government agencies, also affected the development of skills of specialist staff as well as encouraging non-specialists to use them.

On the other hand, the level of awareness among decision-makers of the importance of participating in the implementation of those activities, as well as understanding the context in which these technologies are employed to improve performance, is still inadequate. This formed an obstacle to the integration of their use for other agencies. In this regard, data reveal that some government agencies are implementing these technologies just in order to carry out limited duties, and not for employing them in the integration processes with other actors in decision-making processes. This gives the impression that the difference in levels of general awareness among decision-makers and users of these technologies on how to take advantage of the available geospatial tools and what they could offer led to them being used in a way that does not contribute to their success in the coordination and integration of residential infrastructure delivery.

As such, it appears there is a divergence in issues that limit the proper use of these technologies in the relevant agencies. This means the efforts invested so far in the implementation of geospatial technologies were not enough to improve decisions related to residential infrastructure delivery. The difficulty within the agencies undoubtedly lies in the choice of acceptable solutions for addressing such issues, which requires a coordinated approach built on consensus and mutual acceptance. Therefore, these issues

have been divided into four areas to allow more in-depth discussions with experts during the second round. The first area relates to organisational aspects associated with the organisation and coordination of geospatial activities that support shared visions, limiting of duplication and repetition of efforts as well as reducing the waste of financial resources involved in implementation. This also involves determining which measures and procedures are appropriate to lead such activities and improve interaction and cooperation in the support of joint efforts for developing the use of these technologies in the decision-making processes relevant to service delivery. The second area represents the aspects connected to the awareness whether of decision makers or users of these technologies, of how to take advantage of the available geospatial tools and what they could offer, along with the issues related to employees and their rehabilitation and developing the necessary skills to deal with these technologies. The third relates to the provision of ICT infrastructure and associated tools for supporting geospatial activities' requirements. Finally, the fourth area includes issues regarding sharing, availability, accuracy and quality of spatial data, as well as interoperability, and the ability to access and use spatial information for decision-making activities. These areas will be discussed in the following chapter.

6.4 Summary

This chapter reported the results of the first round of the study gathered from interviews with the experts representing all relevant agencies. A description of the current status of geospatial technology implementation in the agencies concerned with delivering services in residential areas was provided. The chapter also revealed the issues affecting utilisation of these technologies to support delivery of those services based on experts' opinions, which served as a basis for the following rounds.

The results from the data analysis results in this round produced a number of themes seen to have formed difficulties in the adoption and use of geospatial technologies as tools to support coordination and integration among the agencies. These themes described the difficulties encountered by the agencies as a result of the shortcomings of institutional and organisational settings for implementing geospatial technologies and the availability of ICT infrastructure, as well as challenges related to human aspects that accompany the use of such technologies. The next chapter will present and discuss the results of the second and third rounds of the Delphi study conducted in thisresearch.

Chapter 7: Consensus Strategies for Improving the Adoption and Use of Geospatial Technologies in the Context of Planning Residential Infrastructure Delivery

7.1 Introduction

Results from the data analysis presented in the previous Chapter show that there are various organisational, technical and human issues that contributed to limiting the role of geospatial technology tools in supporting planning for residential infrastructure delivery. These factors constitute an obstacle for taking advantage of the widespread use of these technologies in the agencies responsible for infrastructure provision. Employing the potential offered by these technologies for making participatory decisions is a complex issue, especially in those agencies which differ in their administrative structures, responsibilities and functions along with experiencing from a lack of coordination and cooperation. Therefore, the establishment of strategies, taking into account the consensus of all relevant agencies, is critical to ensure the commitment and cooperation for addressing these factors. These strategies can serve as a framework to improve the adoption and use of geospatial tools available in those agencies and will provide a more structured approach that will achieve the full benefits of a geospatial implementation. This in turn will lead to supporting forms of integration and continuous coordination between the various agencies in order to improve the planning process and shared decision making for service provision that meets the needs of residential areas.

This chapter presents the results obtained from the second and third round of the Delphi study. It also discusses these results with the aim to develop consensual strategies seeking to improve the implementation of geospatial technology to support the planning of infrastructure delivery in residential areas. The chapter is divided into five main sections. The first discusses the existing organisational issues, including aspects related to financial and organisational policies, as well as those associated with supporting the adoption and use of geospatial technologies in the relevant service delivery agencies. The

second section focuses on all the relevant ICT-related elements as well as the associated infrastructure to meet the requirements of geospatial technologies operation and integration. The third section addresses issues related to spatial data, including laws, regulations and standards that meet the requirements of integration and participation of relevant stakeholders. The fourth section highlights the aspects of capacity building, skills, awareness and knowledge of how to deal and interact with these tools. The final section discusses the results that have been obtained.

7.2 Results of the Consultation with Experts for Improving Implementation of Geospatial Technologiesin

This phase of the research sought to find solutions based on consensus and mutual acceptance to improve the use of geospatial technologies in the context of infrastructure delivery. It involved the second and third rounds of the Delphi study.

The second round was based on the results reached in the first round, in addition to the relevant literature. Accordingly, a number of strategies were developed with the aim of obtaining opinions from the panel of experts about their importance in addressing the issues raised in the first round, using a five-point Likert scale, ranging from Not Important to Very Important to begin to move toward consensus between them. The experts were asked for additional comments and to add suggestions based on their experiences. A questionnaire was used as a tool to collect the data in this round, which consisted of four main sections. The first section of the questionnaire highlighted the organisational issues, which covered themes related to the implementation and coordination of geospatial activities as well as the costs accompanying the use of these technologies raised in the first round. In this section, the experts were asked to identify appropriate measures that could be used to organise geospatial activities and limit the duplication of efforts and costs involved in their implementation, as well as enhancing the cooperation between relevant agencies. The second section included themes arising from the lack of awareness of how important the use of geospatial technologies tools and their users is in the relevant agencies. The section sought to ascertain the experts' opinions about appropriate ways of

raising awareness and capacity building improvement to develop and exploit the potential offered by these technologies. The third section contained themes connected with the provision of ICT infrastructure. In this section, experts were asked to determine the measures required to address themes raised relating to providing the necessary ICT infrastructure to enhance the use of geospatial technology tools. The final section covered the themes related to spatial data that emerged during the first round. The panel of experts were asked to give their opinion on the important steps that should be taken to achieve optimal use of such data. Data from this round were analysed using central tendency (mean) to measures the degree of importance for each item. In addition, the level of dispersion (IQR) was used to determine if the item reached consensus, as described in Chapter 4. In this round, the experts had reached consensus on 55 of the 68 items, with an IQR equal or less than 1. The panel of experts did not provide any further suggestions or comments for additional items to be included in the third round.

On this basis, the third round was developed from responses generated in the second round, which sought to achieve a greater level of experts' consensus and bridge the gap between the differences in opinions provided. In this round, a questionnaire was also used for collection of data and the panel of experts were asked to re-rate the items on the same five-point Likert scale. The mean rating of each item derived from the second round was also provided which would enable the experts to consider the replies given by others, and to review their answer in order to reach a final consensus and common agreement on the final strategies. The researcher also followed the same analysis approach as used in the second round. At the end of the round, consensus was reached for 59 of the 68 items, which represented almost 87 percent of the total number of items.

In these rounds, questionnaires were distributed in electronic format using BOS (Bristol On-line Survey) and in hard copies. The response rate in these rounds was equal in terms of the number of participants which reached 18 from a total of 20 experts who had participated in the first round. The following sections provide a detailed summary of the findings from both rounds.

7.2.1 Organisational Aspects

The implementation of geospatial technologies in the KSA during the last two decades witnessed a growing interest especially at the agencies concerned with residential infrastructure delivery. The rapid developments and the roles that these technologies can play in bringing about positive change to improve decision-making related to service delivery has helped to enhance their use. However, disparity in the level of adoption and use of its various tools was evident among different agencies.

In fact, availability of geospatial technology tools in different agencies was insufficient to achieve the full benefits of their implementation. The results in the previous chapter showed that the variations in the organisational context of these agencies have played a critical role in affecting the exploitation of implementing these technologies in order to improve coordination of residential infrastructure delivery processes. This in turn led to a limitation in the benefits of utilisation compared with their widespread diffusion.

The absence of national strategies and guidelines for geospatial development were issues that affected the successful implementation of these technologies. These issues played a part in the duplication of efforts, financial waste, doubled implementation costs, as well as limiting the cooperation between different agencies in this field. Therefore, it can be stated that the absence of institutional organisation in geospatial implementation clearly hampered the integration of their activities and the potential to offer the required support in making decisions. This in turn urged many agencies to focus on enhancing their policies towards the development of using these technological tools independently.

The availability of leadership to coordinate geospatial activities between agencies, through a collaborative approach aiming to unify various efforts, is prerequisite for enhancing integration. This coordination will also support the exploitation of the opportunities offered by these technologies and will assist agencies with decision- making processes. The results of the experts' answers endorsed such an approach where there was a consensus regarding the importance of the presence of a responsible and effective party

to take the lead in organising and directing all activities related to the use of these technologies.

Such agreement may serve as a good indication of the desire of those agencies to cooperate and coordinate with each other, which will reflect positively on the employment of these technologies to address issues related to the delivery of services. In spite of this, there was, however, a lack of consensus identifying the agency most capable of leading these activities. This creates difficulty in coordinating the implementation process, and presents challenges that have an effect on achieving the benefits and exploiting available geospatial tools in these agencies.

This finding reflects the absence of clear strategies and appropriate policies concerning the organisation of geospatial activities and can be attributed to the centralised nature of the country's administration of government agencies, where as yet, no agency possesses the authority empowered to lead such activities. This finding also supports the opinions, communicated in the first round, regarding the limited role of the NCGIS in developing related national policies. In addition, it reflects the confined efforts of the NCGIS in coordinating tasks related to geospatial data activities with the central ministries without having a clear association and comprehensive coordination with other agencies, whether representing the public or private sector at local level.

Another justification can be that the contributions made by the e-government programme (Yesser), in support of the implementation of e-Government initiatives and improved ICT infrastructure in government agencies were at local level. Furthermore, the link between agencies responsible for service delivery with agencies that have the power to direct urban development in the city, whether legislative such as the ADA, or executive such as Riyadh municipality, may also be the motive behind the experts' tendency toward selecting those agencies to carry out such responsibilities.

However, there was a consensus regarding a number of organisational and supervisory tasks that are required to be carried out by a directing agency to enhance

coordination of efforts and the development of growing uses of these technologies (see Table 7-1).

Table 7-1: Average rating of the important level of responsibilities for the agency responsible for organising and directing the geospatial technologies activities

No	Item	Mean*	IQR
1	Developing joint plans and setting priorities for projects related to geospatial activities.	4.8	0
2	General control and supervision of activities related to geospatial technologies, especially those activities that affect other relevant agencies/ organisations.	4.6	1
3	Organising the adoption of the budgets for all programmes and activities related to geospatial technologies in all relevant agencies/ organisations.	3.6	1
4	Conducting regular meetings and follow-up of tasks and responsibilities related to each agency/ organisation.	4.3	1
5	Coordination with other relevant organisations at all levels on activities related to the geospatial technology.	4.7	0.75

*** (Mean): 5 Very Important; 4 Important; 3 Moderately Important; 2 Slightly Important; 1 Not Important**

Such a consensus clearly reflects the challenges faced by the agencies as a result of a lack of efforts in organising the implementation of these technologies in line with their development. Therefore, it was noted that the experts concurred that the coordinating tasks related to developing joint plans and priorities as well as connecting with other relevant organisations was of high importance. This gives an indication of the desire of the experts who represent these agencies to adopt a structured approach in order to avoid duplication and inconsistency in the implementation of these technologies.

Adoption of such proposed strategies may create fundamental changes in supporting the adoption and use of geospatial technologies in processes for the delivery of services. In addition, they may lead to changes in work style and procedures, which requires concluding agreements among different agencies to ensure they are committed to performing their assigned functions and tasks. Therefore, it is important to recognise that there is a need for participation from all relevant agencies in the collective decision-making, which is often an optimal way to coordinate the actions that can be taken in line

with the objectives of various agencies. In this regard, experts were asked to identify the appropriate level of employees to represent the agencies concerned with services delivery when participating in activities related to developing the uses of geospatial technologies. The experts agreed that the managers responsible for geospatial technologies are considered the optimal functional level to represent the various agencies. However, the tasks that will be approved during coordinating meetings will not bring a positive change if there is no agency with the capacity and authority to force all related service delivery agencies to agree on participation and cooperation. The panel of experts was asked to determine the appropriate means and measures by which the various agencies could be encouraged to carry out the agreed responsibilities; however, they failed to reach a consensus. This can be attributed to the differences in the decision-making process within the relevant agencies, which makes the organisation of these activities more difficult.

On the other hand, and as noted earlier, the implementation of geospatial technologies in agencies responsible for delivering services are carried out individually without cooperation with others, which led to disparity in levels of implementation from one agency to another. Such a disparity in implementation makes the possibility of employing these technologies in the context of improving service delivery more difficult. In this regard, the analysis showed that there was consensus among the expert panel on the importance of providing the necessary infrastructures and automated procedures related to services delivery based on geospatial technologies to support and facilitate the organisational efforts and to achieve maximum technological benefits.

However, this requires the provision of adequate budgets which may exceed the financial allocations for some government agencies as indicated in the results from the first round. The following table shows the ratings average of a number of measures which the experts agreed were important in contributing to reducing the costs associated with the implementation of those technologies.

Table 7-2: Average rating of the importance level of the items related to reduce costs associated with improving the development of geospatial technologies activities

No	Item	Mean*	IQR
1	Merging the annual budgets of projects related to the development of various activities based on geospatial technologies into a single project.	3.7	2
2	The participation of more than one party in the implementation of projects related to the implementation of geospatial technologies (for example purchasing equipment and application, field surveys, updating data).	4	1.75
3	Adopting cloud computing to reduce the costs of implementation, operation and maintenance associated with geospatial activities.	4.3	1
4	Linking the expected benefits from the implementation of projects related to geospatial technologies prior to their adoption.	4.4	1
5	Marketing geospatial technologies products (for example, maps and data).	4.4	1

*** (Mean): 5 Very Important; 4 Important; 3 Moderately Important; 2 Slightly Important; 1 Not Important**

According to the table above, it can be noticed that the experts did not reach agreement on elements that include participation in financial costs among the agencies. This reflects the difficulty of linking financial systems between different sectors, especially the agencies that represent the public sector where their financial procedures are linked to the central ministries.

7.2.2 ICT Infrastructure

The rapid developments in geospatial technologies have provided innovative means to support decision making. These developments have motivated many sectors seeking to improve their performance and capacity of using these technologies. Coordination and integration processes as well as participation in decision-making among the agencies responsible for the provision of services require the presence of an appropriate level of electronic equipment to meet their requirements. These tools are represented by a set of hardware and software associated with a wide range of networks and protection programs to collect, store, process and transport multiple types of spatial data. Generally speaking, the availability of such tools is fundamental for creating a work environment that supports

cooperation and exchange of information among all stakeholders in a safe and orderly manner.

Through the first round, the results revealed that readiness of ICT infrastructure in the agencies concerned with residential infrastructure delivery affected the employment of geospatial tools in the planning for services delivery. These issues were discussed with the expert panel to obtain agreement on how they can be addressed. The final round achieved consensus on nine items describing the measures needed to improve ICT infrastructure (see Table 7-3).

Table 7-3: Average rating of the importance level of the items related to the improvement of ICT infrastructure in the agencies concerned with residential infrastructure delivery

No	Item	Mean*	IQR
1	Granting responsibilities relating to the adoption of standards, and specifications, and the supervision of providing ICT infrastructure, to the e-government programme (Yesser).	4.5	1
2	Unifying the standards and specifications of the ICT infrastructure among the different sectors.	4.7	1
3	Raising the level of ICT infrastructure equally among the various agencies.	4.3	1
4	Implementing joint projects for the development of ICT infrastructure at various agencies.	4.4	1
5	Unifying the mechanism of connection among various agencies.	4.5	1
6	Relying on web-based techniques.	4.6	0
7	Adopting cloud computing in the storage, retrieval and exchange of spatial data.	4.4	1
8	Enacting legislation and regulations to regulate electronic work.	4.6	1
9	Restructuring the procedures related to the delivery of services to the population in line with electronic provision.	4.5	1

*** (Mean): 5 Very Important; 4 Important; 3 Moderately Important; 2 Slightly Important; 1 Not Important**

As shown in the table above, most of the statements that are concerned with organising the implementation of ICT and standardisation of procedures received a high level of importance according to their mean average ranking. These include setting legislation and regulations to manage the electronic work, unifying the mechanism of

connection among agencies, in addition to the adoption of unified standards and specifications for the implementation of ICT and granting such responsibilities to a single entity. The high-level agreement that has been reached can be considered a positive step towards improving the readiness of ICT in those agencies, especially ones that suffer from a lack of specialised employees in this field. It would also help to overcome the issues related to the provision of appropriate ICT infrastructure that meet different geospatial activities requirements.

Furthermore, the experts reached a high level of consensus on the importance of the transition to e-work and restructuring the measures related to provision of services to the residents as shown in the table. This gives a good predictor on the desire of agencies to take advantage of modern technology solutions in the development of the current approach for the delivery of services to the population, and the improvement in their ability in decision-making. Moreover, reaching a consensus on cooperation in the implementation of joint projects for the development of ICT is considered a catalyst towards reducing costs associated with their implementation. Perhaps the agreement of experts on the importance of taking advantage of cloud computing to meet requirements of geospatial activities among these agencies is one of the facets that can share the costs of its implementation to improve integration that is required in this field.

7.2.3 Spatial Data Management

With the increasing activities and uses of geospatial technologies in various fields, there is a need to organise and manage multiple spatial data sources to facilitate the joint use and exchange of data. The difficulties that the various agencies face in the exchange and sharing of spatial data resulting from development in the use of geospatial tools and spatial data production has increased the complexity of their handling and management. In fact, the failure of initiatives to develop SDI as mentioned in previous sections had a role in the data repetition and heterogeneity among the available datasets, which made the integration of data among those agencies a complex process. In this context, the expert

panel was asked to assess the importance of a number of measures for overcoming those issues facing the spatial data integration. Table 7-4 shows the average rating of the importance level of each item based on the result from the final round.

Table 7-4: Average rating of the importance level of the items related to address the issues facing the spatial data integration

No	Item	Mean*	IQR
1	Identifying visions and setting clear priorities for SDI implementation on a national level and identifying a strategic and operational policy for achievement, with participation from different sectors at the level of the central ministries.	4.3	1
2	Leadership at national level for the implementation and coordination of activities related to SDI.	4.1	1
3	Leadership at local level to coordinate the partial activities of national spatial data.	4.1	0.75
4	A legal framework approved by the highest authority in the country to support all the activities and programmes related to SDI.	4.6	1
5	Capacity building and raising awareness regarding the importance of participation and cooperation in supporting the implementation of SDI.	4.3	1
6	The use of open source services for the activities of SDI.	4.2	1
7	The development of spatial data standards based on international standards.	4.7	0
8	The use of web technologies for the access and exchange of spatial data.	4.7	0.75
9	Facilitate the participation of the private sector and individuals in the provision of spatial data.	4.7	0

*** (Mean): 5 Very Important; 4 Important; 3 Moderately Important; 2 Slightly Important; 1 Not Important**

As seen in the table above, the mean average for all items was more than 4. Data also show that high consensus was achieved for all items where the IQR was between 0-1. This clearly demonstrates the need for an approach that is more integrated and organised to achieve the optimal use of spatial data among the various agencies. Reaching a high level of consensus as such makes it important to grant NCGIS more authority and administrative autonomy to enable it to carry out such roles. This can be noted through

the agreement of experts on the importance of identifying visions, strategies and setting tasks and priorities for the implementation of SDI at the national level.

Similarly, the experts agreed on having agency at local level to lead such an initiative at that level. This might be attributed to the fact that a number of agencies that are responsible for service delivery have no formal links to NCGIS, in addition to the desire of relevant public sector agencies limiting the centralisation which they are experiencing. According to that perspective, it is important to develop strategies based on both a bottom-up and top-down approach when implementing SDI initiatives. This, in turn, may make the process more responsive to facilitate achieving the successful integration of the multiple spatial databases in those agencies. It also supports the consensus of experts on the importance of facilitating the participation of the private sector and individuals in the provision of spatial data. This makes it imperative to adopt strategies based on wide participation of the public and private sectors for the development of SDI.

The current developments in the use of different technologies can be also exploited for the enrichment of spatial databases. In this regard, the results indicated there was agreement regarding the importance of using web technologies to improve access and exchange spatial data. This may have a positive effect on facilitating the participation of the private sector and individuals in the provision of spatial data. However, this requires addressing the multiplicity of spatial data standards as a key factor to improve the participation and support the exchange and consistency of spatial data produced by those agencies. Therefore, the development of spatial data standards based on international standards is seen as an important aspect, based on the experts' rating.

In addition, issues relating to spatial data that were raised in the first round such as restrictions on access and use, sharing and updating data in addition to security, privacy, and intellectual property rights should be taken into account in respect. Therefore, It was expected that items related to setting up a legal framework for SDI received a high level of agreement among the experts. Meanwhile, strengthening a culture of data sharing and

improving cooperation between relevant agencies also shows a high level of agreement among the experts. This means that there is still a need for capacity building and raising awareness on the importance of SDI, with such initiatives facilitating the successful achievement of its implementation.

7.2.4 Building Human Capacity and Raising Awareness

Workforces with various specialisations are considered an important element in the implementation of geospatial technologies. The success of implementing these technologies is associated with the efficiency, knowledge and skills of the workforce along with the ability to utilise and optimally employ their potential. In the context of the city of Riyadh, the analysis presented in the previous chapter highlighted four main issues of human obstacles that have accompanied the processes of expansion in the implementation of geospatial technologies in the agencies that provide residential infrastructure. The difference in the level of awareness among decision-makers and users of these technologies on how to take advantage of the tools available and what they could offer was one of the important issues that hindered their use in the coordination and integration of residential infrastructure delivery. This is despite government efforts in the development of the use of technologies to improve service delivery. However, the evidence of lack of awareness can be clearly seen in the reliance of these agencies on individual implementation, depending on the nature of the function of each agency, duplication of existing efforts, the following of traditional methods in the exchange of data, and a failure to utilise the available geospatial tools in some agencies along with the inability to keep pace with their development.

Accordingly, Table 7-5 below presents the items that achieved a high consensus level within the expert panel, which included a number of activities that emerged during the study that aim to raise awareness about the importance of the use of geospatial technologies tools in decision-making related to service delivery.

Table 7-5: Average rating of the importance of level of the items related to the activities of raising awareness

No	Item	Mean*	IQR
1	Holding annual conferences and exhibitions.	4	0
2	Offering free training on the use of multiple geospatial tools and applications.	4.3	1
3	Conducting regular workshops for employees from various agencies.	3.8	0.75
4	Forming specialised communities for practitioners and interested parties.	4.3	1
5	Organising informal meetings between specialists from different sectors to discuss challenges and exchange experiences.	3.8	1
6	Raising awareness through school curricula in various stages of education.	4.1	1
7	Using audio-visual media and social media.	4.3	1
8	Issuing electronic and printed publications.	3.7	0.75

*** (Mean): 5 Very Important; 4 Important; 3 Moderately Important; 2 Slightly Important; 1 Not Important**

It can be noted that despite reaching a consensus on the elements described in the table above, there is a variance in the mean averages. The elements that had mean averages ranged between (4 and 4.3) can be described as limited activities in the Saudi context. They are also considered a reflection of the limited opportunities of various agencies to learn about the potential of these technologies for raising the level of awareness. However, it must take into account that undertaking such activities requires wide participation from several sectors along with the agencies concerned with residential service delivery.

Such activities for raising awareness, as referred to by the experts, could contribute to overcoming the associated human behavioural issues in terms of rejecting the use of such technologies. It may also help to stimulate acceptance of organisational change in undertaking tasks and duties and supporting participation, collaboration and interoperability between all stakeholders in relation to service delivery, where reliance on such technologies carries many functional changes. However, the rapid developments in these technologies have created technical difficulties for their users, and keeping pace

with these changes remains an obstacle for many users in these agencies. The shortage of a skilled workforce within the agencies directly also affected the implementation of these technologies. In this regard, experts were asked to identify the appropriate measures for capacity building to keep pace with the variables of these accelerating technologies. Table 7-6 below shows that there was agreement on all items that describe these measures.

Table 7-6: Average rating of the importance level of the items related to capacity building activities

No	Item	Mean*	IQR
1	Expanding the educational base through the provision of different degree levels and the creation of various sections within universities and other educational institutions.	4.3	1
2	Increasing employment opportunities for nationals.	4.7	0
3	Raising the job merits for experienced employees in this area.	4.6	1
4	Providing a good job description for specialised employees.	4.3	1
5	Reducing dependence on consulting companies for project implementation and management.	3.8	0.75
6	Providing training and capacity building programmes.	4.5	1

*** (Mean): 5 Very Important; 4 Important; 3 Moderately Important; 2 Slightly Important; 1 Not Important**

As shown in the table above, the mean values of the items are in the rating average of the importance level of between 4.3 and 4.7 (very important and important), except for the item related to reducing dependence on consulting companies in the implementation of these technologies, which scored the lowest at 3.8 (moderately important). This gives an indication that the experts were not sure whether it is possible to rely on employees in those agencies to undertake all tasks related to geospatial activities. This may in line with their opinions communicated in the first round regarding the shortage of experienced employees in the geospatial field. Therefore, continuing the development of employees and enhancing their skills in handling the variables of these technologies are key elements for achieving optimal utilisation of their implementation. In this respect, the experts' consensus was reached on the items related to improving employees' capabilities as so listed in Table 7-7 below.

Table 7-7: Average rating of the importance level of the items related to improving the employees' capabilities in using geospatial technologies

No	Item	Mean*	IQR
1	Tailoring training programmes based upon job needs.	4.7	1
2	Developing specific programmes based on employees' needs.	4.1	1
3	Obliging employees to attend a specific number of annual training hours to develop their skills.	4	0.75
4	Exploiting competencies within different sectors for conducting on-the-job training.	4.3	1
5	Diversity in the provision of training programmes (for example, distance training programmes).	3.8	0.75
6	Raising the level of coordination among the various agencies to conduct joint training.	4	0.75
7	Preparing a list of training programmes and giving employees the right to choose the appropriate programmes to develop their skills.	3.7	0.75
8	Providing scholarships for employees.	4.2	1
9	Collaborating with academics in preparing and implementing training programmes.	4.3	1
10	Providing financial and moral merits to encourage employees to attend training and relevant professional development.	4.1	1

*** (Mean): 5 Very Important; 4 Important; 3 Moderately Important; 2 Slightly Important; 1 Not Important**

Similarly, there were also high levels of consensus for items concerning the addressing of challenges of retaining qualified and highly skilled employees in the field of geospatial technologies in those agencies. Table 7-8 shows the rating average of the importance level of those items, where its noted that they are located within the range between very important and important.

Table 7-8: Average rating of the importance level of the items related to addressing the challenges of retaining qualified and highly skilled employees in the field of geospatial technologies

No	Item	Mean*	IQR
1	Creating an appropriate and healthy work environment.	4.6	1
2	Capacity building and skills development through enhancing training and rehabilitation programmes.	4.5	1
3	Offering promotions and annual increases by the due date.	4.3	1
4	Granting opportunities to further develop professional capacity.	4.3	1
5	Providing incentives and financial support to the best performing employees.	4.6	1

*** (Mean): 5 Very Important; 4 Important; 3 Moderately Important; 2 Slightly Important; 1 Not Important**

7.3 Discussion of Results

The developments witnessed from the implementation of geospatial technologies in the agencies responsible for residential infrastructure delivery, indicate that there is a clear gap between the availability of those technologies and the ways in which to take advantage of their implementation in the planning for services delivery. The results reached have highlighted a number of organisational, technical and human obstacles which are associated with the limitation of the potential of these technologies for supporting participatory decision making in this context. The consensus reached by experts representing all responsible agencies working in residential services delivery have assisted in providing a robust view of the situation. This view may contribute to broadening the benefit of the adoption and use of these technologies as tools to support more coordination and integration to provide services that meet the needs of residential areas. The following sections seek to discuss the results obtained from the study.

7.3.1 Coordination of Geospatial Activities

In light of the rapid urban growth of Riyadh city and the accompanying spread in residential areas, the need to take appropriate decisions has appeared to address many of the issues relating to the delivery of infrastructure that fits with this expansion. The development taking place in geospatial technologies, and their potential in the provision of data both spatial and descriptive, encouraged most of the agencies concerned with service delivery to seek the benefits from the implementation of such technologies to guide the planning processes and support decisions making. However, the study results have shown that these developments were not sufficient to achieve optimum utilisation of their implementation. This is due to the fact that their implementation was not built on a basis that can be used for shared decision-making among the relevant agencies.

As mentioned earlier in this research, a planning-based approach for the delivery of residential infrastructure was not enough to cope with the challenges of the city’s growth. Urban planning policies, pursued by the government in identifying the city’s urban

boundaries, played an important role in limiting expansion of residential areas outside the city boundary and contributed to reducing government expenditure on infrastructure delivery. However, the procedures for residential land division still lack participation and coordination between the agencies responsible for residential service delivery. This in turn is reflected in decision making related to the planning for service delivery, and has led to the emergence of residential neighbourhoods lacking in integrated infrastructure despite the available capabilities to meet their requirements.

The general lack of organisational frameworks, regarding collective decision making among different stakeholders to plan for the delivery of services in an official way, prevents the agencies from achieving a complete understanding of the needs of residential areas. The results indicate that the complex institutional structures and the fragmentation of responsibilities related to the delivery of services all contributed to isolated decision making among the relevant agencies. The authority granted to the regional council and the ADA for coordinating and supervising the development of the city is an important factor in supporting the agencies' coordination and participation in planning efforts. However, that is offset by administrative and financial centralisation that governs the activities of governmental agencies responsible for planning and implementing the delivery of infrastructure at local level. Institutional fragmentation, as well as the absence of institutional and legislative frameworks supporting capacity for coordination and participation in planning among diverse stakeholders, led to an imbalance in the coordination of development management at city level. This is supported by Alkadry (2015) who pointed out that such organisational practices limited the ability of agencies to set priorities and make decisions related to the planning, implementation and coordination of development projects at local level. In the same context, Al Otaibi (2015) suggests administrative structures, systems and procedures resulted in inadequate coordination and planning, and unsystematic flows of information in public agencies. It is likely that this also affected other agencies that represent the private sector in making decisions related to the delivery of services, where activities are mostly based on the

developmental programmes determined by government agencies. Therefore, the implementation of activities related to infrastructure delivery is being undertaken independently. In other word, the agencies responsible for preparing and adopting the city's plans work independently of the agencies in charge of implementing infrastructure. This, in turn, has created problems in the coordination between the agencies throughout the planning and delivery of residential infrastructure.

Similarly, the institutional and organisational issues have reflected on the integration of geospatial activities among those agencies. In fact, this explains the apparent lack of coordination and duplication of efforts in the context of implementation, which makes the possibility of finding an organised environment to coordinate geospatial activities difficult to achieve. This is consistent with a study undertaken by Lance et al. (2009) which mentioned that the multiplicity of agencies and the complexities of government administrative arrangements creates problems coordinating geospatial activities in an effective manner. Likewise, Vancauwenberghe et al. (2014) highlighted that such organisational issues make coordination of geospatial activities difficult and complex.

From the research results, it is noted that there are governmental efforts to support diffusing geospatial technologies with the aim of improving the performance of all sectors concerned with service delivery. Nevertheless, ongoing developments in the implementation of these technologies still lack clear institutional arrangements, effective leadership, national strategies and programmes, which enhance the cooperation, participation and facilitation of partnerships, as well as the management of geospatial information among different agencies. This became clear from reflection of the results that showed a lack of consensus on identifying an organisation to lead and organise these technological activities to support service delivery in residential areas.

The organisational strategies and measures agreed upon by the expert panel, to support the unification of efforts and coordination of technological activities can be considered a step forward in taking advantage of their implementation in the context of

service delivery. However, commitment and partnership within the agencies in developing programmes, setting priorities and implementation of responsibilities remains a challenge in the absence of national strategies to organise these activities. This was evident in the results of the research, which showed lack of consensus among experts on the legislative frameworks that would oblige the agencies to implement the agreed tasks and responsibilities, as well as sharing the costs for implementing joint projects.

In the context of planning for the delivery of services, most of the information being used has a geographic or spatial component. Insights gained from the investigation suggest that the need for constant access to up-to-date and reliable information in an appropriate manner is a common aim for the agencies to meet decision making requirements. Therefore, the exchange of spatial data can be considered a motivator to improve coordination, unify efforts and collective decision making where it offers clear advantages that encourage the agencies to be more cooperative and structured. This is consistent with a study by Jacoby et al. (2002) which demonstrated that in the absence of a geospatial strategy, the cooperation and commitment in its activities between different participants would limit the benefits accrued from their involvement. However, that may not be possible without SDI which provides an environment allowing for the exchange, access and use of geospatial information.

The evidence from this research suggests that there is difficulty in achieving the successful integration of spatial databases among the various agencies in the absence of SDI, which involves; regulatory frameworks, policies, and legislative guidelines as well as technical standards related to those data. As a consequence, the employment of these technologies in the coordination of service delivery tasks among relevant agencies is difficult to achieve. The current government policies are in fact limited in the organisation and coordination of GIS activities to establish a national SDI. This has created another challenge and a reduction in the integration opportunities for all technology related tasks and activities, which are not solely limited to GIS uses. Therefore, improving the policies

and regulations to include all areas of geospatial information-related technologies is necessary to exploit the opportunities on offer.

The results of this research have also revealed there was a consensus on the importance of implementing the SDI initiative at national level, which is in line with the government policy to adopt a top to bottom approach for the implementation of SDI on a national level. This is consistent with a number of studies indicating that the most prominent examples of the establishment of official initiatives for SDI were implemented on a national level (Rajabifard et al., 2002; Gomarasca, 2009; Zivkovic, 2012).

In this context, Kok and Van Loenen (2005) state that having leadership, high level government support and improving the level of communication between stakeholders are critical to NSDI success. Therefore, activating the role of the NCGIS to carry out its responsibilities in leading and coordinating efforts related to spatial data activities and formalising the processes that take place is imperative to address these issues. However, this requires significant government support through reconsidering its responsibilities and roles, granting administrative autonomy, authority and a budget that allows for the formation of strategies, visions, procedures and arrangements required to develop NSDI and facilitate access to spatial data. Besides, the development of governance and institutional structures is critical for supporting stakeholders to participate in the processes of NSDI implementation and establishing a hierarchy of structures that enables different levels of spatial data access and exchange, whether horizontally (between agencies at local level and other stakeholders) or vertically (between agencies at national and local level).

The results, however, also recognised the need for appointing sub-committees at local level to be responsible for coordinating the activities of NSDI. In light of this, the wide authority granted to the Riyadh Principality by the government to supervise the performance of various agencies in the city, makes it possible to give the principality the responsibility for leading and coordinating SDI activities. This concurs with the results

of Alshehri's (2011) study, which proposed that such activities should be administratively linked to the regional governor. Nevertheless, the lack of experienced and qualified technical employees in this field may hinder the principality leading such activities. The HCDA, chaired by the governor of Riyadh and through its executive arm the ADA, has responsibility for planning the development in the city and coordinating it with the concerned agencies, along with its expertise in this field, makes it capable of leading an SDI initiative at city level. This, in turn, may provide greater opportunities to contribute to the improvement of governance and create frameworks that enable collective decision-making, accountability and coordination, not only on the level of service delivery but also in all different areas of development. It may also help overcome existing organisational challenges, and the complexities of procedures, in addition to changing the traditional approach to the delivery of these services based on the potential offered by these technologies, as well as formalising the processes that occur.

The introduction of such changes, however, needs to address the institutional challenges as a prerequisite prior to implementing and adopting SDI. This involves addressing issues related to the centralisation of decision making, as well as participation and coordination in the planning and implementation of activities. Improving the current institutional structures and setting clear roles and responsibilities for relevant agencies in the management of the city's development are also essential to enhance their capacity to support such activities. Furthermore, the improvement in institutional structures and governance arrangements should run concurrently with establishing legislation and the mechanisms needed for residents' participation in decision-making processes. This is in line with a study by Box (2003), which stressed the importance of shifting from centralised organisational structures and improving the institutional structures and coordination arrangements for developing the SDI.

Likewise, enhancing the opportunities for stakeholders' participation whether producers or users of spatial data, from governmental or private sectors, and its institutionalisation is essential for forming SDI strategies. Therefore, representation of

stakeholders, as indicated by the research results, would support SDI development where its implementation mostly imposes changes to the way geospatial technologies are used within these agencies. It would also help to create SDI policies and standards consistently based on collective decisions, which in turn gives agencies the confidence to adopt them when creating their own spatial data structures. This perception is consistent with the study by Singh (2005), who highlighted the criticality of stakeholders' participation for understanding institutional practices, existing databases and users' needs, and identifying technical, organisational and financial requirements, as well as operational priorities at the developmental stages of SDI. Besides this, there should be similar efforts made to raise the level of awareness on the importance of participation and the advantages of SDI to support its implementation efforts (Eelderink et al., 2008). This is in line with the results of this research, which showed the importance of raising awareness of SDI initiatives.

In addition, the results indicate the importance of developing a web platform to make spatial data broadly available and facilitate accessibility shareable by a multiplicity of stakeholders. Recently, the development of geospatial tools, for example, remote sensing, GPS, mobile mapping linked to devices such as smart phones, tablets and laptop computers, have facilitated the participation of stakeholders and reduced the complexities of data access mechanisms. These developments can be exploited effectively as a means of enriching spatial databases and filling the gap in official spatial data more easily and at lower costs. In other words, users of spatial data, whether private sector institutions or citizens, now make an important contribution in supporting the implementation of SDI. This makes the development of policies that also support the bottom-up approach important in the context of SDI initiatives (Kok, 2012; Poslončec-Petrić and Skender, 2014).

However, the participation of stakeholders requires the development of clear laws and policies regarding data access, use, privacy, confidentiality, liability, intellectual property, and the security considerations of those data (Mansourian et al., 2006; Jackson

et al., 2009; Shorbi and Hussin, 2014). The results of this research considered that such legal frameworks must be approved by the highest authorities in the country, which reflects its importance in ensuring the continued participation of stakeholders. This is in keeping with a study by Janssen (2008), which pointed out that legal frameworks are critical in the promotion and development of SDI and would lead to improving the dissemination and exchange of information, thus ensuring greater sharing and utilisation of spatial information.

7.3.2 Technical Considerations

The ICT infrastructure represents one of the basic pillars of the employment of geospatial tools in coordinating and organising tasks for residential services delivery. The readiness of this infrastructure to accommodate the various interactions between stakeholders provides greater opportunities for expansion in the uses of these technologies, and the achievement of more participatory processes for decision making. The evidence from this study suggests that there is disparity in ICT infrastructure readiness in agencies, and this hinders the exploitation of geospatial tools to support the service delivery process for residents. This is consistent with the results of a study done by Al-Solbi and Mayhew (2005) related to measuring e-readiness in Saudi organisations. The study showed that there are weaknesses in ICT infrastructure on both the public and private sector levels. The issues related to the provision of appropriate ICT infrastructure which meet geospatial activities requirements may vary from one agency to another. However, the difficulties in obtaining budgets and a shortage of skilled employees to deal with these technologies are considered prominent challenges in providing ICT infrastructure in these agencies.

Currently, many spatial applications related to service delivery are no longer working in isolation from the mechanism of e-government. In other words, the geospatial technologies have become an essential part of e-government (Thurston et al., 2003). This perception is also consistent with the study by Singh and Ogra (2011), which indicates

that the issues of planning, governance, and service delivery in urban areas can be addressed through the integration of geospatial and e-government. However, this requires fulfilment of technical requirements in order to promote their integration with e-government (Demuth, 2014).

By looking at the issues mentioned above, one could note that they are consistent with the challenges facing the adoption of e-government services in the Saudi context, as claimed by Alshehri et al. (2012) and El-sofany et al. (2012) both of whom indicated that weaknesses in ICT infrastructure in governmental agencies were the main obstacle to the transition from manual methods to electronic in the implementation of business. Therefore, addressing ICT infrastructure issues is a prerequisite for improving the implementation of geospatial activities.

In this context, the national strategies developed by the government in 2003 for the development of e-government in general have contributed to the improvement of ICT infrastructure in various sectors. The establishment of the e-Government Programme (Yesser) played a positive role in promoting e-readiness in the governmental agencies, and also supporting many e-government initiatives. This is seen clearly in the many programmes and projects implemented, in addition to the formulation of strategies, legislation, policies, and technical specifications necessary for the ICT infrastructure aimed at the integration of electronic services into the public sector.

However, when looking at existing efforts, one finds that they did not take into account the technical considerations that support the effective use of geospatial tools in this area in spite of their membership of NCGIS. One possible explanation for this shortcoming is the lack of coordination and involvement of all government agencies in the formulation of the strategies that it adopted (Alshehri, 2012). Moreover, its ongoing efforts are mostly directed towards a number of initiatives aimed at government agencies on the national level (Abdullah et al., 2006; Alomiri, 2016).

Accordingly, taking the spatial aspects into account within the existing efforts to promote the transition to e-government may contribute to the provision of the ICT infrastructure needed for geospatial technologies' implementation, to support the tasks of services delivery for residential areas. This, in turn, makes it imperative for the e-Government Programme (Yesser), as responsible for the performance of these tasks, to set the appropriate strategies for integration between different activities of e-government and geospatial technologies. This includes setting the plans and timelines, and anticipating budgets and the required human resources, as well as assessing the needs and priorities in each agency in line with the previous plans and strategies. In addition to this it should also develop the means and channels of electronic communication that would allow the concerned authorities to communicate, coordinate and share data in a safe and secure manner. Another important role is to develop standard specifications for the requirements of devices and networks related to data transfer in terms of speed and the capacity required to facilitate linkage between stakeholders in service delivery. Furthermore, it should provide the necessary technical support, especially in agencies that suffer from a lack of qualified manpower, and coordinate the provision of ICT infrastructure to reduce duplication in procurement of their tools and ensure uniformity and compliance, thus reducing the costs of implementation.

However, the participants in the research stressed that this would not be sufficient without granting the e-Government Programme (Yesser) the necessary authority to carry out its role in overseeing the provision of infrastructure for ICT to these agencies. Thus, political support at both the national and local levels is required to ensure overcoming organisational and financial issues and maintain the commitment of various agencies. However, a similar effort needs to be undertaken by the relevant agencies involved to provide an appropriate level of electronic equipment, including hardware, software, networks, protection programs and data storage devices. They should also take the necessary measures to automate the procedures of residential infrastructure delivery based on geospatial technologies, as indicated in the results. It is expected that such

procedures would help these agencies to improve their use of geospatial tools, and thus facilitate better-informed decision-making.

7.3.3 Human aspects

The issues of lack of awareness, training and a qualified workforce are among the key issues in the context of human aspects, and these pose a challenge to the success of the employment of geospatial tools for planning tasks and improving decision-making related to residential infrastructure delivery. This is the case in many countries; although there has been a growth in the geospatial industry, these issues are still major obstacles towards realising the benefits of the implementation of these technologies (Róiste, 2014). In the context of the research, it can be noted that there is a good level of awareness of the benefits of the implementation of geospatial activities. This seems evident in the expanded implementation of many projects related to these technologies in various agencies. However, there is a similar lack of awareness on the level of decision-makers and users in these agencies around the importance of cooperation and coordination in their activities. This, in turn, has negatively impacted the achievement of optimal benefits from their implementation, making it imperative upon such agencies to take a structured approach towards raising the level of awareness about the advantages of integration in implementing these technologies.

The results derived from the study show that there is a need for an approach in which all agencies related to the geospatial as well as educational and media sectors participate in raising the level of awareness and knowledge about geospatial potential. This includes ways to take advantage of them not only within professional circles but also amongst the broader public. The measures agreed by experts in this regard are in line with Sullivan's (2007) results, which stressed that the participation of professional and academic sectors in raising awareness and delivering a sound knowledge of the benefits of geospatial technology would improve the understanding and use of these technologies. Such an approach for raising awareness may contribute to overcoming the associated behavioural

attitudes issues related to dealing and interacting with new technologies. It may also help with stimulating the acceptance of change in the approach adopted to delivering residential infrastructure, and supporting participation and collaboration between all stakeholders, particularly in the aspects related to the exchange of data. In addition, it offers an opportunity for the exchange of experiences and discussing various issues and challenges among specialists and interested parties, which in turn support the optimal use of these technologies. Similarly, the promotion of such efforts, especially those directed at the initial stages of education, may enhance the attraction of students to geospatial education pathways and contribute to bridging the gap in the shortage of qualified professionals in this field (Róiste, 2014). However, this requires finding a balance between market demands and different geospatial educational programmes which is difficult to achieve especially in the Saudi context, due to an inadequacy of information that defines the skills and disciplines required for these professions.

In this context, the majority of agencies included in this study were dependent on contracts with consulting companies in this area to carry out tasks related to geospatial activities, and this reflects the shortage of a workforce capable of dealing with these technologies. The current study suggests that improving geospatial educational opportunities and capacity building in these agencies will be an important in addressing this challenge. These results are consistent with a study by Aina (2009), which emphasises the need to expand the training and education in geospatial technologies to develop qualified workforce that meets the expansion in the implementation of these technologies. However, this must be paired with the provision of suitable work opportunities and setting a clear professional identity for graduates, especially in the public sector, which does not provide appropriate job descriptions for geospatial graduates within the classification of governmental jobs. Thus, following a structured approach to address these issues, there is a need for the participation of relevant sectors to determine the functional requirements of the workforce and the actual shortage in disciplines, as well as the determination of training and education areas necessary for the success of these endeavours.

Furthermore, and in the light of the difficulty of recruiting skilled employees who have expertise in the field of geospatial technologies, there is also a need for the continuous development of the workforce in these agencies. The results in this study stressed the importance of developing programmes and plans for the training of the workforce to meet the needs of the skills required to perform their tasks. It has also indicated the importance of diversity and flexibility in training choices and tools as well as the participation of the relevant sectors in implementing these programmes. This, in turn, may provide extensive opportunities for skills development and knowledge sharing. It may also help agencies to overcome funding shortfalls in their implementation. In addition, it can be utilised in the rehabilitation of non-specialised professionals and thus contributes to reducing the burden on the limited workforces available in these agencies. However, those programmes must be balanced in the sense that they include both technical and theoretical aspects and keep pace with the rapid development of these technologies.

Moreover, the results of the study show that capacity building activities are also one of the measures considered very important to retain a qualified workforce in these agencies. Nevertheless, this necessitates setting the systems that help limit the service termination of the workforce after they receive training. The results in this context highlighted the importance of improving employment conditions, wages and providing rewards in addition to moral support. However, this must be coupled with provide a good working environment to attract a qualified workforce. Furthermore, giving them more confidence to lead geospatial activities and reduce the total dependence on employees of consulting companies that perform some of the tasks related to geospatial activities, especially in the public sector. This necessitates the need to improve the systems of contracting with these companies, in that the transfer of their staff after implementing their assigned tasks to them creates a gap in the provision of a qualified workforce to perform the same duties. Therefore, training and raising the efficiency of the workforce must be one of the terms stipulated in contracts to ensure that the implementation of the

projects will not be affected after their end. This in turn will play a role in reducing re-employment and training resulting from the loss of expertise, and this may positively affect the development of use of these technologies in various agencies.

7.4 Summary

In the city of Riyadh, the majority of agencies responsible for the provision of residential infrastructure sought to introduce geospatial technologies with the aim of improving their decisions. Government support has had an impact on enhancing the implementation of these technologies; however, their development varies from one agency to another. Identifying the factors that affect the adoption and use of geospatial technologies, as indicated in the previous chapter, was an important factor contributing to the development of strategies aimed at improving the optimisation of their implementation. In the light of these factors, the results of this chapter have offered a number of strategies that can be used to improve the exploitation of these technologies in the planning of residential infrastructure delivery, which involves three main elements. The first indicates the need for an organisational framework that supports the unification of efforts, reduction of costs and integration of geospatial activities for appropriate priority decision-making that can potentially improve residential infrastructure development. This includes organising spatial data activities and facilitating and coordinating exchange and sharing, as well as interoperability between stakeholders. The second is related to the ICT infrastructure that enables geospatial activities in forming a range of supportive functions for residential infrastructure delivery. The third element is associated with awareness raising and capacity building that needs to be undertaken in order to bring about improvements in the ability of agencies to perform appropriate tasks and create a comprehensive knowledge of the benefits of these technologies.

However, the government should play its part by developing a new model of governance and supportive institutional structures to enable participatory decision-making for such strategies to be successfully implemented. In line with this, improving the institutional framework for managing the city’s development, and addressing issues

related to fragmented efforts and overlapping responsibilities of agencies in charge of infrastructure delivery are required. There is also a need to introduce improvements to the structure and working procedures of the NCGIS to play a leadership role in the development of the SDI at national level, and formalisation of spatial data exchange taking place within an appropriate institutional framework. This includes the creation of SDI platforms to facilitate interoperability, access, and sharing of spatial data between stakeholders involved in residential infrastructure planning and delivery. Development of the NSDI will be an important step towards SDI development at local level, which in turn, plays a critical role in improving geospatial activities in the context of residential infrastructure delivery. It also provides opportunities to add spatial value and useful support to e-government; hence, its development should not take place in isolation.

Similarly, the implementation of these strategies requires a high level of cooperation and coordination between concerned agencies to develop the plans, programmes and timetables, and estimate the volume of activities, challenges, benefits and financial costs to determine the measures that must be taken when implementing geospatial activities. In addition to this, the contribution of educational institutions is equally important for maximising the benefits of geospatial technology use in the context of residential infrastructure delivery. This can be achieved by enhancing geospatial education pathways at various levels, whilst raising awareness of the importance of these technologies and how to utilise and interact with their activities. These efforts will be valuable in helping the agencies concerned with residential infrastructure provision to improve the implementation of geospatial activities in planning and participatory decision making, besides strengthening their capacity to perform other developmental functions. However, the extent of their success is linked to their ability to bring about those changes, which will be reflected in the residents' responses to these changes and interaction with their activities. In the following chapter, the conclusions of the research, its limitations, original contribution to knowledge and recommendations for further research will be presented.

Chapter 8: Conclusion of the research

8.1 Introduction

During the past five decades, the city of Riyadh has witnessed rapid urban growth associated with many demographic, economic and social variables. As is the case in many cities, this growth has contributed to the accelerated pace in the establishment of residential areas in an unstructured pattern, in order to meet the needs of population growth. This dramatic shift in the spread of residential areas has placed enormous pressure on infrastructure. Therefore, many neighbourhoods suffer from a lack of services, and if they exist, they are often inadequate.

In Saudi Arabia, a number of governmental efforts have been undertaken to organise this growth and to control the spread of unstructured residential areas. These efforts also included the adoption of policies and programs aimed at coordinating residential infrastructure delivery. However, the independent nature of the work of agencies responsible for service delivery, weakness in coordination and participation in decision making have led to an imbalance in the distribution of infrastructure that meets the needs of those neighbourhoods. In addition to this, the lack of data and inaccuracy of available information has created difficulty in developing policies that address these issues.

The escalation of spending for the delivery of public services and utilities has created a need for innovative solutions to facilitate the planning and management processes and decision making needed to meet the requirements of residents. The realisation that the majority of data related to infrastructure delivery is spatially associated, has prompted many of the agencies to use geospatial technologies to develop the performance of their tasks. The government support to promote the implementation of these technologies has contributed to their wide development in the various sectors. However, these agencies often implement geospatial activities independently, which reduced the benefits of their use to support tasks related to planning for infrastructure delivery. Therefore, this research sought to explore critical issues that limit the successful implementation of geospatial

technologies. It also highlighted the challenges that face these agencies with the purpose of improving the implementation of these technologies to support decisions making in the planning of residential infrastructure delivery.

This chapter presents the summary of the research results and demonstrates how the research objectives have been achieved. It also includes the research contributions, and a summary of the research limitations. The research recommendations are then presented, followed by suggestions for further research.

8.2 Research Conclusions

The city of Riyadh developed before 1950 from a small town of no more than 3.5 km2, with limited buildings and surrounded by walls, to a modern city that exceeds an area of 3115 km2. The growth of oil revenues has played an important role in creating a number of social and economic transformations, which contributed to the expansion of the city. In 1953, the government's decision to move government offices from the cities of Makkah and Jeddah to the city of Riyadh was a crucial turning point in the city's expansion and contributed to population growth rates. During that period, there was no master plan in place for the city's progress, hence it was difficult to regulate urban growth due to the accelerated pace of development, which in turn led to the emergence of many urban problems, especially the increase in demand for housing and lack of urban infrastructure. By 1971 the government had adopted the city's first master plan. However, the economic boom in the country, especially between 1974 and 1984, increased population migration to the city due to the available employment opportunities and the development of public services and facilities. This led to urban growth continuing beyond the planned area, shortly after its adoption. The government policy to grant land plots to citizens in areas away from the city centre, to address the housing issues, also played a similar role in the spatial expansion of the urban boundaries of the city. This, in turn, has increased the challenges of providing residential infrastructure throughout the city.

In order to address such issues, the government adopted an urban growth boundary policy in 1989 to control rapid urban growth, and leapfrog development. However, the rapid urban growth rates have caused the lack of infrastructure in many residential areas within these urban boundaries of Riyadh city. Despite the improvements in urban infrastructure delivery over time, a number of institutional issues, centralised decision-making and fragmentation of responsibilities, along with lack of coordination and information flow have played a role in influencing the delivery of residential infrastructure that keeps pace with urban growth.

With the rapid development of technology, the government has made concerted efforts to support the use of ICTs in a bid to raise public sector performance. Improvement in coordination between different sectors, and increasing the efficiency of access to information for meeting the needs of decision making were among the targeted aims of these efforts. Accordingly, the agencies concerned with residential infrastructure delivery have sought to take advantage of the potential offered by these technologies. Geospatial technologies are considered one of the most prominent of these technologies due to their ability to accommodate different types of data, along with spatial representation which contribute to improving many task related to decision making. Despite the rapid development and widespread implementation of these technologies in most of the agencies, the use of their tools in the context of residential infrastructure delivery is still limited. Therefore, the purpose of this research was to explore critical issues that limit the use of geospatial technologies. The research highlighted the challenges that face the agencies concerned with delivery of residential infrastructure, with the aim of identifying strategies that can assist in improving the use of these technologies as tools to support decision making in relation to the planning of residential infrastructure delivery.

Working to realise the research aim, the research started by reviewing the relevant literature to identify how rapid urban growth affects residential infrastructure, and how geospatial technology tools are important to support relevant decision making. The purpose was to establish a theoretical background and an understanding of its

consequences and impacts on infrastructure delivery in residential areas. The literature emphasised that improving urban governance is critical for addressing complex issues related to residential infrastructure delivery and ensuring these services are more responsive to the population's requirements. This emphasised the need for improving transparency and accountability, establishing formation of partnerships, collaborative efforts, facilitating participation in the decision making processes, creating a common vision and structured coordination of tasks between various stakeholders to alleviate the lack of residential infrastructure. The literature also highlighted the importance of drafting the necessary legislation and institutional frameworks, defining responsibilities as well as the balance of power and how to interact and coordinate in order to deliver better public services reflecting the real priorities and resident's needs, as stated in Chapter 2.

It was clear from this review, that geospatial technologies are one of most significant technologies that could be employed in order to achieve these endeavours. This is due to their potential in relating different information in a spatial context and creating a common platform to engage and empower different stakeholders in the process of decision making. It also found that these technologies can be used in bringing about positive changes for supporting interaction and facilitating such coordination whilst offering innovative solutions to achieve the desired integration. The literature review demonstrated that these technologies provide significant contributions in the context of improving planning functions, as they have the ability to provide various information and maps in multiple formats that can facilitate many analysis processes and identify needs and priorities during the process of planning and spatial distribution of infrastructure. However, achieving the benefits from the implementation of such technologies depends not only on technological advance, but also on making many organisational changes and introducing new rules and procedures as preconditions to accommodate the changes resulting from their use. Therefore, institutionalisation of geospatial activities is important. At the same time, the standardisation and interoperability of databases and making it possible to access and share up-to-date spatial data are vital to the effective implementation of

geospatial technologies. Other factors, such as the provision of financial resources, awareness, and the necessary qualified staff, as well as usability and the availability of proper technological infrastructure, are also important to achieve the desired outcomes from their implementation, as mentioned in Chapter 3.

Selecting the research method in order to achieve the research objectives, Chapter 4 included the research methodology, which describes the development of the research from the literature review stage, and data generation and analysis to reach the aim. As stated in Chapter 5, the research sought to identify which factors contributed to the development of geospatial technologies in agencies concerned with residential infrastructure delivery, and to what extent they rely on these technologies to support their decisions. Accordingly, the chapter began with investigations into the case of urban growth and development in the city of Riyadh and explored the relevant agencies and their roles in decision making with regard to planning residential infrastructure delivery and its role in the current deficiencies. In addition, the efforts made and the relevant policies and strategies that support the implementation of geospatial technologies in those agencies were identified. This was investigated by collecting secondary data, which included a review of an extensive set of previous research, studies, official reports and documentation. In addition to this, the researcher attended a formal meeting of the Regional Council, and the meetings of committees that precede the council meeting, to observe the interaction between decision makers and identify the extent of reliance on geospatial technology outputs in making decisions. The results reached in this phase showed that the urban planning approach for adoption of residential schemes, fragmentation of responsibilities and the multiplicity of agencies responsible for residential infrastructure delivery, along with centralised decision making contributed to creating challenges for using geospatial technologies in the context of service delivery. It was found that coordinating and participating in decision making for delivery of services in general, is carried out without using these technologies in spite of ongoing developmental support from the government. The results also revealed that the absence

of strategies, plans and standards that organise the implementation of these technologies have affected the efforts being made to develop their use. This was clearly reflected in the duplication and individual implementation of these technologies, which have limited the benefits achieved from their implementation in supporting the activities related to service delivery. This in turn emphasises that there are insufficient appropriate policies, institutional arrangements and responsibilities that provide a more consistent and systematic approach to the integrated use of geospatial technologies. Accordingly, the researcher conducted further investigations to fulfil the research aim. This entailed pursuing a method able to find solutions based on consensus and mutual acceptance between the agencies. Consequently, the Delphi technique was used over the three rounds, as a way to reach a consensus from the experts representing those agencies, to investigate which issues limit the employment of the potential offered by these technologies and how these issues can be addressed.

As presented in Chapter 6, semi-structured interviews were used during the first round. It was emphasised that although the use of geospatial technologies in many of the agencies responsible for the provision of residential infrastructure has increased, their use is still limited in tasks relating to service delivery. The results stressed that the lack of organisational, institutional and legislative frameworks contributed greatly to the duplication of the implementation of these technologies making geospatial activities largely unexploited. It was also obvious that the lack of agencies with the authority empowered by the government to lead and establish institutional frameworks has played a part in limiting wide-spread use of geospatial technologies especially in a participatory decision-making context. The results also indicated that the financial and administrative autonomy enjoyed by those agencies, and the absence of leadership in organising the geospatial-related activities proved difficult in unifying joint efforts and coordination. They also showed that the difference in motives for the use of these technologies, and lack of willingness on the part of decision makers in some of the agencies to cooperate, were obstacles towards supporting the integration of activities related to these

technologies in the context of residential infrastructure delivery. These issues have created a disparity in the use of such tools from one agency to another. On the other hand, the results derived from this chapter showed that the inability of the NCGIS to adopt NSDI was one of the main issues that caused the repetition of agencies' efforts related to spatial data. This has impacted appreciably on the integration and interoperability of those data, and contributed to reducing the exchanging and sharing between the agencies. Therefore, spatial data in these agencies are within isolated databases and often mutually incompatible.

Furthermore, the costs associated with implementing these technologies and the constraints of annual budgets, especially in government agencies, were seen as a critical issue that limited improvement in the use of these technologies in this context. This has affected the development and use of geospatial tools, and has not provided the necessary ICT infrastructure that meets the requirements of their activities. Moreover, the results indicated that the level of awareness among decision-makers and users of these technologies about what they could offer is still inadequate. In addition to this, there was a lack of specialised staff with the skills necessary to deal with these technologies, along with the difficulty in retaining qualified employees, especially in government agencies. The results also indicated that there is limited support in some agencies for the rehabilitation and development of the skills necessary for employees to deal with these technologies, which contributed to the low level of use.

Based on these results and a review of the relevant literature, a number of strategies were developed that would address the issues raised. As indicated in Chapter 7, the results derived from two rounds of questionnaire surveys showed a consensus among experts involved in the research on a number of strategies. These were divided into four main categories; the first addressing existing organisational issues, including aspects related to financial policies and supporting the adoption and use of geospatial tools in the agencies concerned with residential infrastructure delivery. The second included a number of ICT-related strategies and the related infrastructures needed to meet the requirements of

implementing geospatial technologies, while the third involved strategies related to addressing spatial data issues. The last category encompassed a set of strategies aimed at improving aspects of capacity-building, skills, awareness and knowledge (see section 7.2).

As discussed, the results revealed a number of organisational and institutional issues that should be addressed in order to carry out the proposed strategies successfully. At national level, the results highlighted the need for the central government to exert efforts to improve urban governance and institutionalise participatory decision-making, as well developing institutional structures, procedures, and task distribution, responsibilities, and authorities to manage the city's development. In addition, reducing decentralisation and giving the agencies responsible for residential infrastructure delivery at local level the necessary authorities is crucial for overcoming organisational and financial issues. This will enable their officials to coordinate and engage with other agencies in the implementation of activities related to geospatial technologies. Results also indicated that there is a need to integrate both geospatial activities and existing efforts to develop e-government initiatives. The role of the central government is, therefore, essential for the formulation of policies that will ensure collaboration between government agencies on the one hand and the e-Government Programme (Yesser) on the other. Emphasis has been placed on the importance of granting the NCGIS financial and administrative autonomy by the government, along with providing the necessary competencies to enable it to undertake a leading role in organising and directing all activities related to the use of such technologies. This includes the development of NSDI and the specific policies and legislation to provide greater opportunities allowing for participation, unifying efforts, collaboration, interoperability, and enhance data availability.

At local level, the results pointed out to the importance of assigning tasks related to coordinating the implementation of NSDI activities to the ADA, based on its responsibility to supervise and coordinate the development of the city. This in turn may motivate the relevant agencies to adopt the use of geospatial technologies in the tasks

related to the delivery of services, where the availability of information is considered a priority for improving the performance of their functions. It also supports the facilitating of efforts aimed at cooperating in the implementation of activities to be undertaken in this context. However, the agencies must engage in a high level of coordination and commitment to develop the plans, programmes and timetables, and estimate the volume of activities, challenges, benefits and financial costs to determine the measures that must be taken when implementing geospatial activities.

In order to advance the implementation of these strategies, the results emphasised the institutionalisation of geospatial activities. The requirement for the concerned agencies to take the necessary measures to automate the existing procedures related residential infrastructure delivery, based on these technologies, was also stressed. This in turn calls for the introduction of changes in the organisational environment, where the use of these technologies is likely to affect not only the working style of agencies but also the interaction of citizens. Similarly, the results accentuated the importance of developing ICT infrastructure and providing the necessary hardware, software, networks, protection programmes, and data storage devices for each agency. This includes the development of platforms and electronic means of communication, as well as the utilisation of technological developments that can be used to enhance the implementation of geospatial activities. In addition, the results highlighted the need for agencies concerned with residential infrastructure delivery to undertake capacity building for employees, as well as offering support and involving them in the implementation process. The results also pointed out that the agencies need to work on raising awareness and involve educational institutions, as well as the media to strengthen these efforts. In the meantime, it is imperative that government support is maintained, along with implementing the strategies on a consistent and continuous basis, within clear and specific programmes to overcome the obstacles faced by the agencies during the implementation process, which may reduce the success of such efforts.

8.3 Research Contributions

This research study contributes to existing knowledge in the field of urban studies by providing further insights into how decision-makers could improve their decisions in order to meet the needs and requirements of residential areas in rapidly growing cities. It also provides a better understanding of how the employment of geospatial technology tools could be improved to enhance coordination and integration in the context of residential infrastructure delivery. Specifically, this work adds to the existing body of literature on urban growth and its implications on urban infrastructure, along with the importance of urban governance for supporting decision-making in dealing with this growth. It contributes to literature that examines the role of geospatial technologies in improving the planning and delivery of urban infrastructure by considering the advantages of using these technologies, and the challenges surrounding their implementation, as well as investigating how they can be used as tools to enhance the process of delivering these services in innovative ways.

In addition, the research provides further understanding of the factors that contributed to the rapid growth of Riyadh city, which subsequently led to shortage and inequality in the distribution of residential infrastructure by highlighting the impact of relevant government policies and urban planning practices, and the approach followed by relevant agencies in the processes of residential areas development. The organisational context of the residential infrastructure provision and issues accompanying residential land subdivision approval process, planning and implementation of residential infrastructure was also clarified.

Furthermore, this research study contributes to literature development on the geospatial technology field in the Saudi context, and reveals a lack of studies focusing on the potential of these technologies for supporting infrastructure planning and delivery. It also makes a contribution to the ongoing research into improving the use of geospatial technologies, and provides original empirical evidence about the key issues affecting their implementation in the agencies responsible for residential infrastructure delivery, whilst

strengthening the understanding of the extent of their development. This has included highlighting organisational and human issues, and other issues relating to spatial data and technological infrastructure, along with their impact on the efforts made to optimise the benefits available from the implementation of these technologies.

Importantly, this research makes an original contribution to the existing literature by developing strategies aimed at improving implementation of geospatial technologies in the residential infrastructure delivery context, which are based on consensus between participating experts who represented all relevant agencies. This ensures the strategies are more reliable and applicable. The research study, therefore, contributes to the academic and practical knowledge, as being one of the few studies in this field in Saudi Arabia. This in turn draws attention to the need for further research, in both the academic and practical field, into the development of the uses of geospatial technologies in the context of urban infrastructure planning and delivery.

Moreover, the research study has also identified the stakeholders responsible for improving and enhancing the implementation of these technologies, along with the activities and responsibilities needed to support the successful implementation by providing an approach that can contribute to improving the use of these technologies in different contexts. This can assist the agencies to enhance their efficiency and performance in the management of other developmental programmes and projects in the city. Similarly, the strategies could be used by decision-makers to increase the opportunities for collaboration, integration and citizen participation, which are vital if urban governance in the city of Riyadh is to be improved. Therefore, the strategies developed in this research should help to reduce the duplication of effort, support collaboration, make spatial data more accessible, and enhance the benefits of the geospatial tools available in those agencies.

The contributions of this research have coincided with the national transformation programme recently adopted by the government in Saudi Arabia, which included a number of goals set out for promoting governance, efficient planning, and greater

coordination and collaboration between various sectors. Therefore, the results from this research can be used to provide a better understanding and valuable information to policy-makers on the deficiencies and limitations associated with the utilisation of geospatial technologies in the public sector, and the requirements necessary to exploit their potential. It can also be used as a basis for programmes related to enhancing performance, coordination, participation and to support the current efforts being made, as well as helping to achieve the goals and directions of this national programme.

8.4 Research Limitations

Along with the research challenges and limitations that faced the researcher during the data collection stage as mentioned previously in section 4.7, further limitations that became apparent when carrying out this research should be taken into consideration when interpreting the results. The first limitation is that this research focused on the context of the city of Riyadh, therefore, although the issues concerning geospatial technology may be similar in other Saudi cities, the results are difficult to generalise without further study and exploration. Similarly, the results cannot be generalised to other countries without further investigations.

The second limitation of this research relates to the sample used, this consisted of experts representing decision-makers and managers responsible for geospatial activities from all agencies related to the research topic. They were selected on the basis of their positions, expertise and practice-based backgrounds concerning the topic being investigated, therefore, they were able to provide information, advice and feedback, which assisted significantly in providing broad insights on geospatial implementation issues and how they can be addressed. Nevertheless, it is possible that the perceptions of experts with a theory-based background, or employees, who use geospatial tools especially on issues associated with technical aspects, may differ from those of the decision-makers and managers. Therefore, expanding the number of experts on the panel

can provide new viewpoints and wider perspectives on the research issues, which may result in different outcomes to the ones presented in this research.

Furthermore, the researcher would like to clarify that many reforms and executive programmes, dubbed Saudi Vision 2030, are currently taking place in the Saudi public sector. These include a set of aims that would have an important bearing on enhancing governance and preparing the right environment for expanding the provision of a variety of electronic services aimed at improving the performance of government agencies. Therefore, it is possible that these efforts have the potential to make a positive difference in the field of geospatial technology in the near future. However, the outcomes of this research serve as an important source of information that can be used in support of these endeavours and make a valuable contribution in providing a better understanding of the current context.

8.5 Research Recommendations

The results of this research have provided a set of strategies that, if adopted, could lead to improvements in the use of geospatial technologies to support decision-making related to the planning of residential infrastructure delivery. On the basis of these results, the research recommendations include four key areas that may contribute to the successful implementation of these strategies in agencies responsible for the provision of these services. They may also be useful to the agencies charged with ensuring the further development of their use to take advantage of the opportunities on offer.

The first area involves enhancing the role of local government, allowing it to assume all responsibility for organising and managing the city. This issue, as shown in this research, calls for an enhanced governance structure, with the aim of reducing centralisation, the fragmentation of responsibilities and the multiplicity of authorities responsible for taking developmental decisions at city level. It also calls for consideration to further improvements in the current institutional structure in order to address the existing shortcomings in coordination and the constraints that impede the ability of

agencies concerned with infrastructure delivery to cooperate and engage with other stakeholders in setting priorities, planning and implementing projects. In addition to this, it is imperative to enhance the participation of citizens in decision-making, facilitate access to information, and to develop indicators that support transparency, accountability and performance monitoring.

This leads to the second research recommendation, which relates to the need to improve the approach to the adoption of residential schemes and involves developing relevant urban planning systems to meet the needs of participation, coordination and integration between all stakeholders and introducing geospatial technology applications into the residential land subdivision approval process. This would help increase the availability and development of the high-quality and accurate spatial data required by decision-makers to enable them to obtain clear insights into the service locations and their coverage, as well as accessibility for residents, to determine appropriate decisions and actions when planning for infrastructure delivery.

The third recommendation highlights the importance of making improvements to the procedures and practices of geospatial technology implementation in agencies responsible for residential infrastructure delivery. As this research demonstrated, the institutionalisation of geospatial activities is critical in order to optimise its potential in the context of residential infrastructure delivery. Therefore, the relevant agencies should exert more efforts in improving organisational structures and enhance their ability to adapt geospatial technologies according to their needs and characteristics. This includes facing the challenges of introducing such technologies into the working environment and the consequent changes in organisational structures and processes. In addition, there is a need to ensure there are coordinated efforts and commitment between various agencies to provide a good level of consistency, integration and standardisation of the geospatial activities to achieve the benefits of their implementation. Furthermore, more work is needed in development of ICT infrastructure, which forms fundamental building blocks for geospatial activities. Moreover, participation in capacity-building and knowledge

development, such as training, workshops, seminars, exchanging experiences, holding conferences and events aimed at improving the level of awareness would assist in increasing the adoption of geospatial activities in the context of residential infrastructure delivery.

The final recommendation stresses the necessity to review the government policies related to supporting geospatial activities in the public sector. As this research presented, the providing clear leadership will help to move forward the process of developing geospatial technologies implementation in the country. Furthermore, the establishment of NSDI is critical for success the goals for implementing geospatial technologies. Moreover, there is a necessity to integrate the e-government initiatives and the current efforts to support the implementation of the geospatial activities to promote the use of ICT in the public sector. In addition, the current approach to adopting the budgets of relevant geospatial technology projects supports implementation by each individual public sector agency. This approach often results in a low level of utilisation, duplication, isolated outcomes and high-cost projects. There is therefore a need to put in place strategies and a clear vision of what is expected from the implementation of these technologies to ensure the integration between them and to benefit from their outputs in terms of performance improvements. This would improve the efficiency of these projects and facilitate integration with other agencies. It would also help continue support and sustainable funding within an annual budget for the implementation of geospatial activities.

8.6 Future Research

The results of this study have shown that there are a number of leveraging topics to be explored in more detail in future research. Firstly, there are several areas in which information is still limited. In particular, little information exists about the use of geospatial technology in the context of infrastructure provision in Saudi Arabia; most of the literature has focused on specific subjects, such as using one of the tools in a single agency, or other aspects related to spatial data. Therefore, there is scope for future

research to fill this gap, and it is hoped that this research will help provide a motivation to continue further exploration and to conduct more research in this field.

The results also suggest that further work is needed to explore the proposed strategies in a more focused manner and in greater detail. Additionally, further research is needed to evaluate the strategies developed in this research along with setting the priorities of implementation in order to achieve more practical and reliable results. Similarly, replicating this research to encompass other cities within Saudi Arabia, for example Makkah, Al Madinah and Hail in the eastern region, which have similar organisational structures to those of Riyadh. When interpreting the results, it is important to take into account that the research was limited to agencies responsible for residential infrastructure delivery in the city of Riyadh. Without conducting additional research, it is therefore, hard to generalise the results within other places and situations, or other cities in Saudi Arabia, as well as on different levels such as ministries or central agencies. It would also be interesting to conduct further studies where the research sample size is expanded to include various stakeholders, such as citizens, academics, users of geospatial tools and relevant consulting companies working in agencies that provide residential infrastructure. This would help explore other factors not explored in this research that may be associated with affecting the implementation of geospatial activities.

In addition, further research could be conducted to investigate the potential changes that may occur in the use of these technologies in the context of residential infrastructure delivery as a result of the recent reforms that have taken place in the country. Examples of this include evaluating the development benefits of the use of geospatial technology on decision-making and work performance, and how to involve various stakeholders in the planning process for residential infrastructure delivery and the potential for coordination and collaboration between them. The extent of participation of citizens living in residential area, and their acceptance for using online platforms could also be evaluated, as well as the ease of use and the level of benefit resulting from their use.

Further studies are also needed to development of SDI, which did not receive enough attention from researches in the Saudi context. Possible attention areas could include, identify the roles of stakeholders in SDIs development, and the organisational and practical possibilities or difficulties that may limit of their participation. In addition to this, further research can be conducted to investigate the impact of the new technologies to contribute in support SDIs initiatives, and how it could support e-government processes. Besides, further research focusing on the potential implementation of Free and Open Source Software (FOSS), and the areas related to Volunteered Geographic Information (VGI) as part of the SDI initiative will provide valuable information, helping to enhance these initiatives.

8.7 Summary

This final chapter has summarised the results of the research. It demonstrated that the lack of exploitation of geospatial tools in agencies concerned with residential infrastructure delivery is not a technological issue. The results obtained show that the benefits associated with the implementation of these technologies can be achieved through the integration of efforts by all concerned parties to address the organisational, human and technical issues associated with their use. Meanwhile, it should be stressed that this alone would not be sufficient without developing the organisational aspects of decision-making processes related to the planning of infrastructure delivery in residential areas. The chapter also highlighted the contributions made by the research to the existing body of knowledge, which will help to address research gaps and further research in this field. In addition, the key limitations of the present research were also discussed, and some recommendations for future research derived from this study were made. Finally, this research provides useful information and strategies for decision-makers concerned with delivering residential infrastructure services, and for developing decision support tools based on geospatial technology in order to achieve more balanced urban growth and to overcome the shortage of residential infrastructure in a structured manner.

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APPENDICES

Appendix A: Letter from the Researcher's Supervisor in Northumbria University

northumbria UNIVERSITY NEWCASTLE

Professor Glen McHale BSc (H), PhD, FInstP, FHEA, SMIEEE
Professor of Applied & Materials Physics and
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Royal Embassy of Saudi Arabia
Cultural Bureau in the UK and Ireland
630 Chiswick High Road
London
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To whom it may concern

Dear Sir / Madam

Ref: Student Name: Mohammed Hassan Alqarni
Date of Barth: 28/01/1982
Registration No: 13030765
Program Code: 10FCEIR: PhD

I am writing to confirm that the above named student will need to spend some time in the City of Riyadh from 21/06/2015 to 21/09/2015 in order to collect primary and secondary data for his doctoral project. Mr Alqani's research concerns the development of urban residential infrastructure management practices and is focused on a case study of Riyadh.

If you require any additional information please do not hesitate to contact me on Tel: 07846496064 or by email: S.Alvanides@Northumbria.ac.uk

Your Faithfully

Dr Seraphim Alvanides, Reader
S.Alvanides@Northumbria.ac.uk
Faculty of Engineering & Environment

Professor Andrew Wathey
Vice-Chancellor and Chief Executive
Northumbria University is the trading name of the University of Northumbria at Newcastle

Appendix B: Participant information sheet in English

Participant information sheet

Study title: Developing A Framework to Improve the Implementation of Geospatial Technology in The Planning and Delivery of Infrastructure for Residential Areas in Saudi Arabia: A case study of Riyadh city.

I would like to invite you to participate in my research study, which forms part of my PhD research. You should only participate if you want to; choosing not to take part will not disadvantage you in anyway. Before you decide whether you want to take part, it is important for you to understand why the research is being done and what your participation will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask me if there is anything that is not clear or if you would like more information.

The issue of study:

The city of Riyadh, capital of Saudi Arabia, is experiencing rapid and unprecedented urban growth. As a result of this growth, a number of urban problems have been compounded by issues such as the rapid expansion of the city, accompanied by a shortage of residential infrastructure. In order to address these issues, the agencies concerned with residential infrastructure delivery have sought to find appropriate and innovative solutions to facilitate the planning and management processes and decision making needed to meet the requirements of residents. The realization that the majority of data related to infrastructure delivery is spatially associated has prompted many of the agencies to use geospatial technologies to improve the performance of their tasks. However, there are evidences indicating that the benefits of their use to support tasks related to planning for infrastructure delivery is limited.

The purpose of study:

This study seeks to improve the adoption and use of geospatial technologies in the context of planning for residential infrastructure delivery in the City of Riyadh, through exploring critical factors affecting responsible agencies' ability to achieve the benefits of their implementation. It is envisaged that the findings from this research study will assist in finding a suitable framework to improve exploitation of these technologies to support the tasks related to delivery of services.

Why have I been selected to take part in this research study?

You have been selected to take part because you have direct influence on decision making processes related to infrastructure delivery for residential areas and activities related to the use of geospatial technology in your work area. Your views are therefore extremely valuable to us in order to determine the appropriate measures and means to develop and improve current activities.

What will I have to do if I take part?

If you agree to take part in the research study, we will ask you to answer some questions through successive rounds of consultation with the aim of finding solutions that are based on consensus and mutual acceptance between relevant agencies to improve the use of geospatial technologies in the context of infrastructure delivery. There are no right or wrong answers to the questions; we just want to know your opinions on the subject.

Consent to participate:

Your decision to participate is completely voluntary. By completing and signing the attached consent form it is implied that you consent to take part in the study. You may however decide to withdraw from at any time, without giving a reason.

Confidentiality:

The information you give in the interview will not be connected to your name or other identifying details. The information will be used only for the purposes of this research study.

No one will have access to the interview recording or written notes except my supervisor and myself. Your recording and notes will be stored on university password protected computers, and will be destroyed after the study.

If you have any questions or require more information about this study, please contact me using the following contact details:

Mohammed Alqarni
PhD student, Faculty of Engineering & Environment, Architecture and Built Environment
Northumbria University
E-mail: mohammed.alqarni@northumbria.ac.uk

Thank you for reading this information sheet and for considering taking part in this research.

Appendix C: Consent Form for Research Study in English

Name of Researcher
Mohammed Alqarni
Title of study
Developing A Framework to Improve the Implementation of Geospatial Technology in The Planning and Delivery of Infrastructure for Residential Areas in Saudi Arabia: A case study of Riyadh city.

I, the undersigned, confirm that (please tick box as appropriate):

1	I confirm that I have read and understood the information sheet for the above study and have had the opportunity to ask questions about the study and my participation, as provided in the information sheet dated _____.	
2	I have been given the opportunity to ask questions about the study and my participation.	
3	I voluntarily agree to participate in the research study.	
4	I understand I can withdraw at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.	
5	The procedures regarding confidentiality have been clearly explained (e.g. use of names, pseudonyms, anonymisation of data, etc.) to me.	
6	If applicable, separate terms of consent for interviews, audio, video or other forms of data collection have been explained and provided to me.	
7	The use of the data in research, publications, sharing and archiving has been explained to me.	
8	Select only one of the following: • I would like my name used and understand what I have said or written as part of this study will be used in reports, publications and other research outputs so that anything I have contributed to this project can be recognised. • I do not want my name used in this project	
9	I, along with the Researcher, agree to sign and date this informed consent form.	

Participant:

_____ _____ _____

Name of Participant Signature Date

Researcher:

_____ _____ _____

Name of Participant Signature Date

Appendix D: Participant information sheet in Arabica

نموذج معلومات مشارك

موضوع البحث

تطوير إطار عمل لتحسين تنفيذ التكنولوجيا الجغرافية المكانية في التخطيط وايصال البنية التحتية للمناطق السكنية في المملكة العربية السعودية: دراسة حالة لمدينة الرياض.

1. مقدمة

أود أن أدعوكم للمشاركة في هذا الجزء من دراستي البحثية والتي سيكون لها دور هام في تحسين نتائج البحث. قبل المشاركة في هذه الدراسة من المهم ان تكون على إطلاع بموضوع البحث وما تنطوي عليه مشاركتكم. لذا نأمل قراءة المعلومات الآتية وتقديم الأسئلة إذا كنت ترغب في مزيد من الإيضاحات.

2. مشكلة البحث

تشهد مدينة الرياض نموا سريعا وغير مسبوق. ونتيجة لهذا النمو، تفاقمت عددا من المشاكل الحضرية كالتوسع السريع للمدينة و نقص في البنى التحتية خاصة في المناطق السكنية. من أجل التصدي لهذه المشاكل، سعت الجهات المعنية بإيصال تلك البنى التحتية لتحسين استخدام أدوات التكنولوجيا الجغرافية المكانية لدعم اتخاذ القرار وتسهيل التنسيق مع الجهات الأخرى ذات الصلة لضمان التوسع في تقديم الخدمات و تلبية متطلبات السكان بطريقة منظمة. ومع ذلك، واجهت معظم هذه الجهود نقص كبير في المشاركة والتنسيق من قبل السلطات المختلفة بسبب ازدواجية الأنشطة والتنفيذ المستقل لهذه التكنولوجيات مما ساهم في الحد من الاستفادة من استخدامها في هذا السياق.

3. الغرض من البحث

تسعى هذه الدراسة إلى تحسين اعتماد واستخدام التكنولوجيات الجغرافية المكانية في سياق إيصال البنية التحتية السكنية في مدينة الرياض، وذلك من خلال تسليط الضوء على العوامل التي تؤثر على تحقيق الاستفادة المثلى من استخدامها في الجهات ذات الصلة. ومن المتوقع أن تساهم نتائج هذه الدراسة في إيجاد إطار مناسب لتحسين استغلال هذه التكنولوجيات لدعم المهام المتعلقة بإيصال تلك الخدمات.

4. لماذا تم اختيارك للمشاركة في هذه الدراسة البحثية؟

تم اختيارك للمشاركة لتأثيرك المباشر على عمليات صنع القرار المتعلقة بإيصال البنى التحتية بالمناطق السكنية وكذلك التكنولوجيات الجغرافية المكانية المستخدمة في هذا السياق. وبالتالي وجهات نظركم هي قيمة للغاية بالنسبة لنا من أجل تحديد الطرق والوسائل المناسبة لتطوير وتحسين الانشطة الحالية لاستخدام هذه التكنولوجيات.

Appendix E: Consent Form for Research Study in Arabic

نموذج الموافقة على المشاركة بالدراسة البحثية

إسم الباحث
محمد بن حسن القرني
عنوان البحث
تطوير إطار عمل لتحسين تنفيذ التكنولوجيا الجغرافية المكانية في التخطيط وايصال البنية التحتية للمناطق السكنية في المملكة العربية السعودية: دراسة حالة لمدينة الرياض.

أنا الموقع أدناه، أؤكد أن:

.1	أؤكد أنني قد قرأت وفهمت ما تضمنة نموذج معلومات المشارك اعلاه والمتعلق بمشاركتي بهذه الدراسة البحثية وذلك بتاريخ _____.	☐
.2	أتيحت لي الفرصة لطرح الأسئلة حول الدراسة ومشاركتي.	☐
.3	أنا أوافق تطوعاً للمشاركة بهذه الدراسة البحثية.	☐
.4	أنا أتفهم أنه بإمكاني الإنسحاب في أي وقت دون شرح الأسباب.	☐
.5	تم شرح الإجراءات المتعلقة بالخصوصية بشكل واضح.	☐
.6	تم إيضاح جميع الشروط و الإجراء المتعلقة بتسجيل المقابلة.	☐
.7	تم شرح المسائل المتعلقة بإستخدام المعلومات المقدمة ضمن الدراسة البحثية وكذلك اسلوب حفظها.	☐
.8	نأمل التكرم وإختيار أحد الخيارات الآتية: - أود إيضاح أسمي وجميع ما قمت بتقديمة من آراء ومعلومات لهذه الدراسة البحثية ضمن التقارير و المطبوعات ونتائج تحليل المعلومات بحيث أن جميع ما ساهمت به يمكن الإعتراف به.	☐
.9	- لا أود استخدام إسمي ضمن الدراسة البحثية.	☐
.10	أوافق انا والباحث على التوقيع المؤرخ على نموذج الموافقة على الدراسة البحثية	☐

المشارك:

الإسم _____ التوقيع _____ التاريخ _____

الباحث:

الإسم _____ التوقيع _____ التاريخ _____

Appendix F: Sample of the First Round of Delphi Technique (Semi-Structured Interview)

This semi-structured interview was conducted in the city of Riyadh at XX.

Introduction:

At the beginning of the interview, the interviewer introduced himself and then gave a brief description of the research study once again, assured confidentiality and asked for permission to record the interview and write notes. The interviewer invited the interviewee to introduce himself and his organisation. The interviewee introduced himself as the person responsible for geospatial activities in XX.

Interviewer: First, I would like to thank you for taking time out of your busy schedule to talk with me today. I'd like to begin by asking you to talk about geospatial technologies activities in your organisation. How would you describe the existing responsibilities and functions of geospatial technology tools in the residential infrastructure delivery field and how these tools contribute to facilitating daily tasks?

Respondent: The main benefit of using geospatial technology tools is represented in providing an integrated geographic database covering most of the activities related to our daily work, especially in relation to studies in the management of development in the city. Certainly, the continuous development works in Riyadh require modern databases to facilitate the work of both decision-makers and staff members. An example of this would be the public transport development project, the studies on the transfer of ground infrastructure networks and mainline services took about a year before starting the implementation. This technology has contributed significantly to the studies related to the project at this stage of the project. Therefore, launching all projects and programmes of the XX relies mainly on the use of this technology. In fact, all sectors that perform services in the city are developing their plans, and providing services, based on their own strategies. The pace of development in the city is very fast as you know, and requires more effort to pursue this on a regular basis to collect the data and add them to the city's central spatial database. In general terms, all spatial data relating to facilities, services and the main lines of the infrastructure related to services are available in the spatial data base and we are currently working on adding all sub networks as well. On the other hand, we benefit from this technology by establishing strategic plans in the city, where its maps have been fully built depending on this technology. In addition, the department of planning relies mainly on this technology, as I pointed out, in

studies related to projects. I would also like to point out that in all the projects carried out by consulting companies working with us, the terms of their works include delivery of maps with the spatial data, in a format suitable for the programs of this technology to be added to the central spatial database.

Interviewer: Great, so what were the main drivers behind the implementation of geospatial technology tools in your organisation?

Respondent: As you know, geospatial technology is one of the most important technical tools to facilitate work in different disciplines and fields. We have used the tools of this technology since the mid-eighties; it demonstrated its importance in facilitating our duties and responsibilities due to its potential for linking all databases containing various kinds of spatial maps. So, these technologies have a big role in the collection of data in a single database, and to then use them in various fields, such as planning, studies and supporting decision making processes.

Interviewer: How would you describe the level of support from top management for the adoption of geospatial technology as a tool for the processes of infrastructure delivery**?**

Respondent: Actually, the support by the top management is vital in the development and use of this technology as it is an essential tool for our work. We have an ambitious strategy to make use of this technology and have the ability to cope with its rapid development. Significant sums have been invested in recent years to provide advanced geospatial tools, and this support is expected to increase in the next few years.

Interviewer: You mentioned that your organisation is investing huge amounts to make use of this technology; in your opinion, to what extent do the costs associated with implementation of these technologies have a direct influence on their adoption and use in tasks related to residential infrastructure?

Respondent: In fact, the cost of this technology is high, but the outcome of its outputs and its impact on improving our works is much greater than the value of the provision costs which helped to support its development.

Interviewer: Could you say a little more about that?

Respondent: Well, one of our functions is to develop a comprehensive spatial information centre for the city to support all sectors, so the investment in this technology and its different

tools are necessary. In addition, this technology has provided significant savings in the financial costs for various tasks, such as the cadastral and other field projects. Currently, all sectors in the city, whether governmental or private, or even the researchers, can benefit from the outputs of this technology. For example, all academic bodies such as King Saud University have the ability to use the maps and spatial data base for the purpose of preparing studies and research. Also, other government agencies, for example, Riyadh Municipality and the National Water Company depend on our spatial data in the construction of their databases.

Interviewer: Could we move on to talk about employees who uses geospatial tools in their work, what is your assessment of their roles in influencing activities of these technologies, and what are the main issues which you think need attention?

Respondent: There is considerable variation in the use of this technology by the employees; this depends on the level of knowledge on how to use this technology. In fact, employees who work in departments that use this technology in studies related to their duties have a significant role in the system development. There is a difference in the roles of the employees according to their field of work, for example, employees working in the departments that prepare planning, environment and transport studies have a greater role compared to employees who work in departments operating in the field of architectural studies and construction, operation and maintenance. So whenever the work is more detailed, their role in the development of the databases is reduced. With respect to matters which need greater attention, I think it is important to develop the employees level of English language since all the tools of this technology depend on this language. Also, continuous training during work by obliging the employees to use this technology within their duties, as well as rehabilitation and development at specialized training institutions.

Interviewer: Can you tell me what is the level of qualification for technical employees working on the geospatial technology systems compared to those working in other areas in your organisation?

Respondent: The XX continually develops their employees on the use of this technology. This is represented by providing all necessary requirements for the specialised employees to attend training courses and participate in conferences. In addition, a number of internal training sessions are held periodically, which are available to all employees. Also, the department responsible for this technology is very keen to support this.

Interviewer: Again, moving on to talking about collaboration and coordination in geospatial activities with other agencies responsible for residential infrastructure delivery, has there been any of that?

Respondent: Yes, there is an uneven collaboration with other agencies. For example, there is a high level of cooperation with the Riyadh municipality where the spatial database is almost unified. In the past, spatial data was transferred using an external storage, but now there is an automatic link between spatial databases using Web services technology. We are working now on improvements, in cooperation with the e-Government Programme (Yesser), which provides safe data storage units and also fibre-optic that provides high speed data transfer.

Interviewer: How about other agencies?

Respondent: In fact, we face difficulty in cooperation in this area. These difficulties include the lack of technical infrastructure, as many of the agencies that provide services are not technically qualified, and do not possess the appropriate hardware to communicate with other agencies for the exchange of spatial data. Added to that, there is the inability of some bodies to exchange spatial data; this is because of their own policies concerning the exchange of data. In addition, the available data from some of these agencies might be available in older formats which do not keep pace with the advanced use of others, thereby hindering their use as required. Some agencies also have different types of spatial data in different formats, which also poses a challenge in this aspect.

Interviewer: Could you describe the efforts made by your organisation to support participation processes and the coordination with other residential infrastructure service agencies and also the neighbourhoods' residents in this context?

Respondent: We provide spatial data for all government agencies, and even the private sector, as per their need. We also are currently working on a project called Geoportal using cloud technologies and Web technologies so that all data and maps are available to all service agencies where they enter their data in a way that ensures integration.

Interviewer: So, do you think that geospatial Web-based applications are the appropriate tools that ensure active participation and integration to determine the residents' actual service needs?

Respondent: From our experience, I think that the systems and applications that rely on the use of the Internet are a valuable means to support such tasks. Currently, there are many systems and applications that can efficiently support this. They can also provide various tools that suit all needs related to the tasks of residential infrastructure delivery. One of the most prominent tools is the use of the Internet via cloud technologies through the so-called Geospatial portal technology. In my opinion, this technology can provide perfect solutions. It is also easy to use, and often does not require specialists and trained or qualified users in geospatial technology to work on it. In fact, we don't provide electronic services on our website, but we have an electronic guide, in the form of a geographic browser, that provides detailed and spatial data when searching for any of the city's services, organisations, whether governmental or private, but their use by visitors to the site was low. We developed the same application for smartphones which has almost all the functions of the website, this saw a growing increase in users. So I think that providing applications on smartphones that rely on cloud technologies and open sources would also be suitable.

Interviewer: So what are the key challenges that have a negative impact on the adoption of this technology as a tool to support the integration and coordination between all relevant agencies?

Respondent: In general, the financial costs for providing this technology is one of the most important challenges due to the associated government agencies having specific budgets, which makes it difficult to keep pace with its continued developments. The second challenge is that the outcomes and benefits from implementing these technologies usually need time to become apparent to the decision-makers, and which may influence the decisions to continue their development. Thirdly, the availability of employees with skills and appropriate expertise in this area is low, in addition to the dropout of qualified employees. The final and important challenge is related to the spatial data and information and its activities in general.

Interviewer: In your opinion, how can these challenges be overcome?

Respondent: I think there is a need to unify efforts. Organisational frameworks and legislation are also important in order to unify spatial data and metadata standards, specifications, scales and types of spatial projection and the method for designing and building spatial databases, as well as other conditions associated with its use. In fact, the National Committee for Geographic Information System has already been established and

its role is to solve such obstacles, but no decisions have been issued so far in this regard. Currently, the Ministry of Municipal and Rural Affairs is making efforts to support this aspect and has the technical and technological potentials and it has made great strides in the development of standards that can be relied upon to achieve integration of spatial data from different sources. The problem is that it does not have the authority to regulate and manage the actual coordination between the different agencies. So, the systems, applications, tools, data and standards are available, but the issue lies in the possibility of developing regulations and detailed policies to unify the various efforts and ensure their implementation and commitment in different agencies.

Interviewer: Okay. Do you think that addressing these challenges can contribute to improving the activities of balanced spatial distribution when delivering residential infrastructure?

Respondent: Certainly, there are many advantages offered by these technology tools, essentially contributing to supporting the balanced spatial distribution of services, especially activities related to their delivery, which should be associated with the participation of all concerned parties. They are also important tools in the preparation of studies and future plans for the delivery of services.

Interviewer: So, in your experience, which procedures and measures would encourage the interaction and participation of stakeholders, whether service providers or citizens, in making decisions related to the delivery of residential infrastructure services based on such technologies?

Respondent: Well, data accuracy is the greatest challenge when encouraging everyone to interact and participate. So, I think the accuracy and updating of published information will make the interaction of both residents and service providers more efficient and attract the largest number of users. The other aspect is the usability, so developing applications and systems should take into account how easy they are to use**.**

Interviewer: The last section of questions is about the spatial data. Can you please describe the level of availability of geospatial data related to residential infrastructure?

Respondent: There is disparity in the level of availability of information in the spatial database. However, I can say that we have a good amount of spatial data related to above ground infrastructure such as buildings, roads, etc. which is more freely available than other

data related to underground infrastructure networks. Also, the satellite images that we have for the city are from 2000 until the present time.

Interviewer: What about the geospatial data sources, and data standards that are used by your organisation?

Respondent: We rely largely on the spatial data that produce through our daily work activities and field surveys. Also there is cooperation with some other agencies in exchanging spatial data, as well as some data that is derived from open source data, such as Landsat and Esri as well as Google maps. Regarding both spatial data and metadata standards that are being used, we have our own standards developed by our organisation.

Interviewer: And are there particular strategies used to update such data?

Respondent: Updating our spatial data depends on the type of data and work needs. For example, we update the spatial data related to the road networks and land-mark every three months. Meanwhile, the data related to public services is updated depending on financial allocations, the last update was in 2009 and this year we are working on further updates. With regards to data for land uses, there are two different types of updating methods. The first is annual, which is based on data derived from remote sensing technology; the second is carried out every 10 years through a comprehensive field survey of all land use and population in the city.

Interviewer: Okay, what procedures are followed for exchanging and sharing geospatial data with other agencies?

Respondent: We have cooperation with many organisations in the exchange of spatial data as I mentioned. In fact, the data exchange process relies largely on traditional ways, such as use of CDs or other storage devices, and we seek to improve that. Currently, we are in the process of preparing a new project supported by the regional governor, to improve these processes and establish a system that connects all relevant agencies in the city in one database. This project includes policies, responsibilities and guidelines in order to manage and update the spatial data related to each agency. We also seek to develop a web portal that gives access to such data.

Interviewer: Just one last question, are there any security concerns that may affect data sharing with other organisations?

Respondent: Well, there are no concerns in this aspect, but we do face a number of problems related to data property rights. This is due to the lack of legislations and systems to protect the copyright or property rights over spatial data specifically produced by the government agencies.

Interviewer: So, what is your view on how to address this problem?

Respondent: For us we don't have a problem in terms of use of the published data under the terms and conditions determined, and all users have the right to make use of it. However, there should be policies and legal restrictions to protect the spatial data rights. In fact, we found our data being copied and used even for commercial purposes without permission from our organisation, and in general practices such as these might greatly influence the use and exchange of data.

Interviewer: That's great. Thank you so much for this interview and your time today. Is there anything more you would like to add or deem relevant to the discussed issues?

Respondent: Thank you, I would just emphasize that geospatial technologies are important tools in the development of work, which is developed continuously, and can be used in all areas, so it is important to have an awareness of the benefits and opportunities that these technologies provide, especially by the decision makers to support their use.

Interviewer: Thank you again for your participation and I appreciate you taking the time with me. I would like to mention again that the information you have shared with me is confidential and the data will only be used for the purposes of the research. Again, your personal details and the name of your organisation will be replaced with a code to ensure anonymity.

End of interview

Appendix G: Delphi Technique Questionnaire (Round Two) in English

northumbria UNIVERSITY NEWCASTLE

Developing A Framework to Improve the Implementation of Geospatial Technologyin The Planning and Delivery of Infrastructure for Residential Areas in Saudi Arabia: A case study of Riyadh city

Page 1: Introduction

Dear expert,

I would like to thank you for your valuable contribution to the first phase of this research study. We appreciate your input and welcome you back to participate in the second phase in order to determine the appropriate strategies to develop and improve adoption and use of geospatial technologies to enhance coordination and integration between various stakeholders in the planning process for delivering residential infrastructure.

The results of the first phase of the research indicate that there are a number of factors which constitute obstacles to taking advantage of geospatial technology tools used by the agencies responsible for residential infrastructure delivery. The establishment of strategies that take into account the consensus of all the relevant agencies is critical to address these factors. Therefore, this questionnaire aims to develop common strategies based on consensus, and mutual acceptance among the relevant agencies in order to improve the use of such tools to facilitate the successful coordination and integration among the relevant agencies to overcome the issues of residential infrastructure delivery.

Your answers will be extremely helpful to us, and your individual privacy will be maintained in all published and written data analysis resulting from the research, and will be only used in scientific research purposes.

If you have any questions or require more information about this research, please contact me using the following contact details:

Mohammed Alqarni
PhD student, Faculty of Engineering & Environment, Architecture and Built Environment
Northumbria University at Newcastle, UK
E-mail: mohammed.alqarni@northumbria.ac.uk

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Page 2: Personal information

1. Organisation ✱ *Required*

1.a. If you selected Other, please specify:

2. Job title ✱ *Required*

2.a. If you selected Other, please specify:

3. Email

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Page 3: Section 1: Organisational settings

4. In your opinion, is there a need for an organisation or committee at the level of the city of Riyadh to be responsible for leading, organising and directing all relevant geospatial activities in the agencies concerned with residential infrastructure delivery?
✱ *Required*

- ☐ Yes
- ☐ No

4.a. If you answered No, please explain your reasons in the box below.

4.b. If you answered Yes, please rank (from 1- 5) the qualified organisations that would be able to lead these activities

	1	2	3	4	5
Riyadh Principality.	☐	☐	☐	☐	☐
Riyadh Municipality.	☐	☐	☐	☐	☐
The High Commission for the Development of Riyadh.	☐	☐	☐	☐	☐
The National Committee for Geographic Information Systems.	☐	☐	☐	☐	☐

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E-Government Program (YESSER).	☐	☐	☐	☐	☐

4.b.i. Other, please specify:

4.c. Please assess the tasks and functions of the organisation or committee responsible for organising and directing activities related to geospatial technologies in the agencies concerned with residential infrastructure delivery.

	Very Important	Important	Moderately Important	Slightly Important	Not Important
Developing joint plans and setting priorities for projects related to the geospatial activities.	☐	☐	☐	☐	☐
General control and supervision on activities related to geospatial technologies, especially those activities that affect other relevant agencies/ organisations.	☐	☐	☐	☐	☐

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Organising the adoption of the budgets for all programmes and activities related to geospatial technologies in all relevant agencies/ organisations.	☐	☐	☐	☐	☐
Preparation of controls related to the joint purchase of applications and tools related to geospatial technologies.	☐	☐	☐	☐	☐
Conducting regular meetings and follow-up of tasks and responsibilities related to each agency/ organisation.	☐	☐	☐	☐	☐
Coordination with other relevant organisations at all levels on activities related to the geospatial technology.	☐	☐	☐	☐	☐

4.c.i. Please add further tasks and functions that not covered above.

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4.d. What is the most appropriate level of employee for representing the agencies/organisations when participating in meetings related to geospatial activities?

- Organization manager
- Geospatial department managers
- Other

4.d.i. If you selected Other, please specify:

4.e. Commitment to implementing responsibilities that are agreed with other agencies/ organisations in relation to geospatial activities requires:

Please select exactly 1 answer(s).

- Signing of binding agreements.
- Issuing decisions from higher authorities.
- Memorandas of understanding.
- Formal contracts.
- Other

4.e.i. If you selected Other, please specify:

4.f. Please add any additional comments you feel are important *Optional*

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5. There is a varying level of adoption and use of geospatial technology tools in the agencies concerned with service delivery. Please assess the significance of the following aspects to improve the level of adoption and use of these technological tools in the integration with the concerned agencies in planning for residential infrastructure delivery. * *Required*

More info

	Very Important	Important	Moderately Important	Slightly Important	Not Important
Providing the qualified cadres and necessary infrastructure including devices and applications.					
Obliging agencies concerned with residential infrastructure delivery to automate procedures for service delivery electronically, based on geospatial technologies.					

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Reducing the centralised implementation of projects related to geospatial technologies and granting agencies at local level greater authority in the development of activities related to these technologies.					

5.a. Other (please add below).

6. Costs associated with improving the development of activities related to geospatial technologies may be high in some service delivery agencies. From your point of view, evaluate the significance of the following points in pursuit of mitigating those costs. * *Required*

	Very Important	Important	Moderately Important	Slightly Important	Not Important

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Merging annual budgets of the projects related to the development of various activities based on the geospatial technologies into a single project.					
The participation of more than one party in the implementation of projects related to the implementation of geospatial technologies (for example purchasing equipment and application, field surveys, updating data).					
Adopting cloud computing to reduce costs of implementation, operation and maintenance associated with geospatial activities.					

Linking the expected benefits from the implementation of projects related to geospatial technologies prior to their adoption.					
Marketing geospatial technologies products (for example, maps and data).					

6.a. Please add further points, in this regard, that not covered above based on your experience

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Page 4: Section 2: Raising awareness and building capacity

7. Please rate the best ways to raise general awareness about the importance of the use of geospatial technologies tools in decision making related to service delivery: * *Required*

	Very Important	Important	Moderately Important	Slightly Important	Not Important
Holding annual conferences and exhibitions.					
Offering free training on the use of multiple geospatial tools and applications.					
Conducting regular workshops for employees from various agencies.					
Forming specialised communities for practitioners and interested parties.					
Organising informal meetings between specialists from different sectors to discuss challenges and exchange experiences.					
Raising awareness through school curricula in various stages of education.					

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Using audio-visual media and social media.	☐	☐	☐	☐	☐
Issuing electronic and printed publications.	☐	☐	☐	☐	☐

7.a. Please add any comments you may have that will help to raise awareness.

8. From your point of view, addressing the shortage of qualified employees in various fields of geospatial technologies requires: ✱ *Required*

	Very Important	Important	Moderately Important	Slightly Important	Not Important
Expanding the educational base through the provision of different degree levels and the creation of various sections within universities and other educational institutions.	☐	☐	☐	☐	☐
Increasing employment opportunities for nationals.	☐	☐	☐	☐	☐

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Raising the job merits for experienced employees in this area.					
Providing a good job description for specialised employees.					
Reducing dependence on consulting companies for project implementation and management.					
Providing training and capacity building programmes.					

8.a. Please add any comments or suggestions that you may have.

9. Employees training is one of the key factors needed to take full advantage of using geospatial technologies; please rate the importance of the following points in terms of improving employees' capabilities: ✱ *Required*

	Very Important	Important	Moderately Important	Slightly Important	Not Important

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Tailoring training programmes based upon job needs.					
Developing specific programmes based on employees' needs.					
Obliging employees to attend a specific number of annual training hours to develop their skills.					
Collaborating with academics in preparing and implementing training programmes.					
Exploiting competencies within different sectors for conducting on-the-job training.					
Diversity in the provision of training programmes (for example, distance training programmes).					

Raising the level of coordination among the various agencies to conduct joint training.					
Preparing a list of training programmes and giving employees the right to choose the appropriate programmes to develop their skills.					
Providing scholarships for employees.					
Providing financial and moral merits to encourage employees to attend training and relevant professional development.					

9.a. Other (please add below).

10. Meeting the challenge of retaining qualified and highly skilled employees in the field of geospatial technologies requires: ✱ *Required*

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	Very Important	Important	Moderately Important	Slightly Important	Not Important
Capacity building and skills development through enhancing training and rehabilitation programmes.					
Providing opportunities to attend and participate in conferences.					
Creating an appropriate and healthy work environment.					
Offering promotions and annual increases by the due date.					
Granting opportunities to further develop professional capacity.					
Providing incentives and financial support to the best performing employees.					

10.a. Other (please add below).

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Page 5: Section 3: ICT infrastructure

11. The availability of ICT infrastructure is a key element in the utilisation of the tools of geospatial technologies to improve the integration and coordination among all relevant agencies to deliver services. From your point of view, to what extent are important to attribute all responsibilities relating to the adoption of standards, and specifications, and the supervision of providing this infrastructure, to the agencies concerned with residential infrastructure delivery of the e-government programme (Yesser)? ✱ *Required*

- Very Important
- Important
- Moderately Important
- Slightly Important
- Not important

11.a. If you selected Not important, please explain your reasons

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12. Please rate the importance of each of the following statements: * Required

	Very Important	Important	Moderately Important	Slightly Important	Not Important
Unifying the standards and specifications of the ICT infrastructure among the different sectors.					
Raising the level of ICT infrastructure equally among the various agencies.					
Implementing joint projects for the development of ICT infrastructure at various agencies.					
Assigning activities and responsibilities relating to the maintenance of ICT infrastructure of the various agencies to only one supervisory agency.					
Unifying the mechanism of connection among various agencies.					
Relying on web-based techniques.					

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Adopting cloud computing in the storage, retrieval and exchange of spatial data.					
Enacting legislation and regulations to regulate electronic work.					
Restructuring the procedures related to the delivery of services to the population in line with electronic provision.					
Placing all electronic activities and interactive services related to the services delivery on only one website.					

12.a. Other (please add below).

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Page 6: Section 4: Spatial data management

13. Integration of spatial data among the various relevant sectors to deliver services for residential areas is important to support informed decisions making. Spatial Data Infrastructure (SDI) provides a comprehensive framework to address the issues and challenges facing the multi-source data integration. From your point of view, rate the importance of each of the following statements: ✱ *Required*

	Very Important	Important	Moderately Important	Slightly Important	Not Important
Identifying visions and setting clear priorities for SDI implementation on a national level and identifying a strategic and operational policy for achievement, with participation from different sectors at the level of the central ministries.	☐	☐	☐	☐	☐
Identifying visions and setting clear priorities for SDI implementation on local level and identifying a strategic and operational policy for achievement, with participation from different sectors.	☐	☐	☐	☐	☐

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Leadership at national level for the implementation and coordination of activities related to SDI.					
Leadership at local level to implement and coordinate activities related to SDI.					
Leadership at local level to coordinate the partial activities of national spatial data.					
A legal framework approved by the highest authority in the country to support all the activities and programmes related to SDI.					
Capacity building and raising awareness regarding the importance of participation and cooperation in supporting the implementation of SDI.					

The use of open source services for the activities of SDI.					
Centralised management of spatial data at national level.					
The development of spatial data standards based on international standards.					
The use of web technologies for the access and exchange of spatial data.					
Facilitate the participation of the private sector and individuals in the provision of spatial data.					

13.a. Please add any comments or suggestions that you may have.

14. Please assess the policies mentioned below to ensure compliance with the values of cooperation and partnership among various agencies in SDI activities: ✱ *Required*

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	Very Important	Important	Moderately Important	Slightly Important	Not Important
The issuance of legislation, and regulations by the supreme authority in the country.					
The signing of formal agreements.					
Memorandas of Understanding.					
Formal contracts.					

14.a. Other (please add below).

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15. Please add any additional comments that you think are important for us to consider.

This is the end of the questionnaire.

Thank you for your cooperation and assistance for contributing to this research project.

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Appendix H: Delphi Technique Questionnaire (Round Two) in Arabic

تطوير إطار لتحسين تنفيذ التكنولوجيات الجغرافية المكانية لتخطيط وإيصال البنية التحتية للمناطق السكنية في المملكة العربية السعودية: دراسة حالة لمدينة الرياض

Page 1:

عزيزي الخبير

أود في البداية أن أشكركم على مساهمتكم القيمة في المرحلة الأولى من هذه الدراسة البحثية ونرحب بكم مرة أخرى للمشاركة في المرحلة الثانية والتي تهدف لتطوير تحسين اعتماد واستخدام التكنولوجيات الجغرافية المكانية لتعزيز التنسيق والتكامل بين مختلف الجهات ذات العلاقة بإيصال البنية التحتية للأحياء السكنية

نتائج المرحلة الأولى من البحث تشير إلى أن هناك عددا من العوامل تحول دون الاستفادة من أدوات التكنولوجيا الجغرافية المكانية المستخدمة من قبل الجهات ذات العلاقة بإيصال الخدمات للأحياء السكنية. وضع حلول تأخذ بعين الاعتبار إجماع جميع الجهات ذات العلاقة بإيصال تلك الخدمات أمر هام لمعالجة تلك العوامل. لذلك، أود أن أدعوكم للمشاركة في هذه الإستبانه للمساهمة في وضع استراتيجيات مشتركة على أساس توافق الآراء، والقبول المتبادل بين جميع المشاركين من القطاعات المختلفة لتحسين استخدام تلك التكنولوجيات لتسهيل التنسيق والتكامل الناجح سعياً للتغلب على قضايا ايصال تلك الخدمات بطريقة متكاملة

مشاركتكم مفيدة للغاية بالنسبة لنا، و نحن نؤكد لك بأنه سيتم الحفاظ على الخصوصية في كل مراحل هذه الدراسة وان المعلومات المقدمة ستستخدم فقط لأغراض البحث العلمي

إذا كان لديك أي أسئلة أو تحتاج إلى مزيد من المعلومات حول هذا البحث، يرجى الاتصال بي باستخدام تفاصيل الاتصال الآتيه

محمد حسن القرني

طالب دكتوراه، كلية الهندسة والبيئة

قسم العمارة وبناء البيئة

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Page 2: البيانات الشخصية

1. **جهة العمل** * *Required*

2. **المسمى الوظيفي** * *Required*

- مدير عام / متخذ قرار
- مسؤول الأنشطة ذات الصلة بالتكنولوجيات الجغرافية المكانية
- أخرى

2.a. أخرى (حدد)

3. **البريد الإلكتروني**

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Page 3: القسم الأول: الإعدادات التنظيمية

4. من وجهة نظرك, هل هناك حاجة لجهة مختصة على مستوى مدينة الرياض تكون مسؤوله عن قيادة وتنظيم وتوجيه جميع الأنشطة ذات الصلة بإستخدام التكنولوجيات الجغرافية المكانية في الجهات المعنية بإيصال البنية التحتية للأحياء السكنية؟ ✱ *Required*

- ☐ نعم
- ☐ لا

4.a. عند اختيارك لا، يرجى تحديد الأسباب التي دفعتك لذلك

4.b. عند اختيارك نعم، يرجى ترتيب (من 1الى 5) الجهات الأكثر قدرة على قيادة هذه الأنشطة

	1	2	3	4	5
أمارة منطقة الرياض	☐	☐	☐	☐	☐
أمانة منطقة الرياض	☐	☐	☐	☐	☐
الهيئة العليا لتطوير مدينة الرياض	☐	☐	☐	☐	☐
اللجنة الوطنية لنظم المعلومات الجغرافية	☐	☐	☐	☐	☐
برنامج التعاملات الحكومية (يسر)	☐	☐	☐	☐	☐

4.b.i. اخرى (حدد)

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بناء على خبرتك، يرجى تقييم مهام و وظائف الجهة المسؤولة عن تنظيم وتوجيه أنشطة التكنولوجيات الجغرافية المكانية في الجهات المعنية بإيصال الخدمات للأحياء السكنية *4.c.*

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
وضع الخطط والأولويات المشتركة للمشاريع ذات الصلة بالأنشطة الجغرافية المكانية	☐	☐	☐	☐	☐
الرقابة العامة والإشراف على الأنشطة ذات الصلة بإستخدام التكنولوجيات الجغرافية المكانية، وخاصة تلك التي تؤثر على الجهات الأخرى ذات الصلة	☐	☐	☐	☐	☐
تنظيم واعتماد كافة الميزانيات والبرامج والأنشطة الخاصة بالتكنولوجيات الجغرافية المكانية بجميع الجهات ذات الصلة	☐	☐	☐	☐	☐
إعداد الضوابط المتعلقة بالشراء المشترك للتطبيقات والأدوات المتعلقة بالتكنولوجيات الجغرافية المكانية	☐	☐	☐	☐	☐
عقد الإجتماعات المنتظمة لمتابعة المهام والمسؤوليات المتصلة بكل جهة	☐	☐	☐	☐	☐
التنسيق مع الجهات الأخرى على جميع المستويات بشأن الأنشطة المتصلة بالتكنولوجيات الجغرافية المكانية. (كمدينة الملك عبدالعزيز للعلوم والتقنية، الهيئة العامة للمساحة)	☐	☐	☐	☐	☐

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4.c.i. الرجاء إضافة اي مهام و وظائف اخرى لم يتم الإشاره اليها أعلاه بناء على خبرتكم

4.d. ما هو المستوى المناسب من الموظفين لتمثيل الجهات المختلفة للمشاركة في الإجتماعات ذات الصلة بالأنشطة الجغرافية المكانية

- مدير عام / متخذ قرار
- مسؤول الإدارات المختصة بالتكنولوجيات الجغرافية المكانية
- أخرى

4.d.i. عند اختيار اخرى يرجي تحديد المستوى الوظيفي

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4.e. من وجهة نظرك، إلتزام الجهات المختلفة بالمسؤوليات التي يتم الإتفاق عليها والمتعلقة بالأنشطة ذات الصلة بالتكنولوجيات الجغرافية المكانية يتطلب

- توقيع اتفاقات ملزمة
- إصدار قرارات من السلطات العليا
- مذكرات تفاهم
- عقود رسمية
- أخرى

4.e.i. عند اختيار اخرى يرجى التوضيح

4.f. الرجاء إضافة أي تعليقات إضافية في هذا الجانب تعقد أنها مهمة

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5. هناك مستويات متفاوتة من اعتماد واستخدام أدوات التكنولوجيات الجغرافية المكانية في الوكالات ذات الصلة بإيصال الخدمات. يرجى تقييم أهمية الجوانب الآتيه لتحسين الإستفادة من تلك الأدوات في التنسيق والتكامل لتخطيط ايصال الخدمات للأحياء السكنية * Required

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
توفير الكوادر المؤهلة والبنية التحتية اللازمة بما في ذلك الأجهزة والتطبيقات	☐	☐	☐	☐	☐
إلزام كافة الجهات المسؤولة عن ايصال الخدمات بأتمتة كافة الإجراءات المتعلقة بإيصالها للسكان ضمن منظومة عمل إلكترونية استناداً على التكنولوجيات الجغرافية المكانية	☐	☐	☐	☐	☐
الحد من مركزية تنفيذ المشاريع المتعلقة بالتكنولوجيات الجغرافية المكانية ومنح الوكالات على المستوى المحلي سلطات اكبر لتطوير أنشطة تلك التكنولوجيات	☐	☐	☐	☐	☐

5.a. الرجاء إضافة اي جوانب اخرى لديك لم يتم الإشاره اليها أعلاه

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القسم الثاني: رفع مستوى الوعي وبناء القدرات :Page 4

7. **قييم أفضل الطرق التالية لرفع مستوى الوعي العام حول أهمية استخدام أدوات التكنولوجيات الجغرافية المكانية في صنع القرارات المتعلقة بإيصال الخدمات** ✱ *Required*

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
عقد المؤتمرات والمعارض السنوية المتخصصة	☐	☐	☐	☐	☐
توفير برامج التدريب المجاني المختلفة على استخدام الأدوات والتطبيقات الجغرافية المكانية	☐	☐	☐	☐	☐
تكوين مجتمعات متخصصة للممارسين والمهتمين	☐	☐	☐	☐	☐
عقد ورش عمل منتظمة للموظفين من مختلف الوكالات لمناقشة التطورات ومعالجة التحديات	☐	☐	☐	☐	☐
تنظيم الملتقيات غير الرسمية بين المختصين في القطاعات المختلفة لتبادل الخبرات	☐	☐	☐	☐	☐
نشر الوعي عبر المناهج الدراسية بمختلف المراحل التعليمية	☐	☐	☐	☐	☐
استخدام وسائل الاعلام المرئي والمسموع وكذلك وسائل التواصل الاجتماعي	☐	☐	☐	☐	☐
إصدار النشرات الإلكترونية والمطبوعات	☐	☐	☐	☐	☐

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7.a. الرجاء إضافة أي تعليقات لديك من شأنها أن تساعد على رفع مستوى الوعي

8. **من وجهة نظرك معالجة نقص الكفاءات المؤهلة في مجال التكنولوجيات الجغرافية المكانية المختلفة**

يتطلب ✱ *Required*

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
توسيع القاعدة التعليمية من خلال انشاء العديد من الأقسام والمراحل العلمية المختلفة ضمن الجامعات والمؤسسات التعليمية الأخرى	☐	☐	☐	☐	☐
زيادة فرص توظيف الكفاءات الوطنية	☐	☐	☐	☐	☐
رفع المميزات الوظيفية للكفاءات المتخصصة في هذا المجال	☐	☐	☐	☐	☐
توفير الوصف الوظيفي الجيد للمختصين	☐	☐	☐	☐	☐
التقليل من الاعتماد على المكاتب الإستشارية لتنفيذ وإدارة المشاريع	☐	☐	☐	☐	☐
توفير برامج التدريب وتطوير القدرات	☐	☐	☐	☐	☐

8.a. الرجاء إضافة اي تعليقات او اقتراحات اخرى لم يتم الإشارة اليها اعلاه

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9. التدريب احد أهم العوامل لتحقيق الإستفادة المثلى من تنفيذ التكنولوجيات الجغرافية المكانية، قيم اهمية العناصر الأتية لرفع كفائة الموظفين بناءا على خبرتك * Required

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
ربط البرامج التدريبية بالمهام الوظيفية	☐	☐	☐	☐	☐
تطوير برامج محددة بناء على متطلبات الموظفين	☐	☐	☐	☐	☐
الزام الموظفين بحضور ساعات تدريبية سنوية محددة لتطوير مهاراتهم	☐	☐	☐	☐	☐
استغلال الكفاءات العاملة ضمن القطاعات المختلفة للقيام بتدريب المختصين على رأس العمل	☐	☐	☐	☐	☐
التنوع في تقديم البرامج التدريبية (على سبيل المثال التدريب عن بعد)	☐	☐	☐	☐	☐
رفع مستوى التنسيق بين الوكالات المختلفة لاقامة التدريب المشترك	☐	☐	☐	☐	☐
وضع قائمة بالبرامج التدريبية واتاحة حرية اختيار الموظف للبرامج المناسبة لتطوير مهاراته	☐	☐	☐	☐	☐
إيفاد الموظفين في بعثات دراسية	☐	☐	☐	☐	☐
التعاون مع الجهات الأكاديمية لإعداد واقامة البرامج التدريبية	☐	☐	☐	☐	☐
توفير مزايا مادية ومعنوية لتشجيع الموظفين على حضور الدورات والبرامج التدريبية ذات الصلة	☐	☐	☐	☐	☐

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9.a. أخرى (حدد)

10. لمواجهة التحدي المتمثل في استبقاء الموظفين ذو الكفاءات والمهارات العالية في مجال التكنولوجيات الجغرافية المكانية يتطلب ذلك * Required

	مهم جدا	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
تهيئة بيئة عمل مناسبة وآمنة للاستقرار الوظيفي					
تشجيع الحضور والمشاركة في المؤتمرات					
تنمية القدرات والمهارات من خلال برامج التدريب والتأهيل					
منح الترقيات والعلاوات السنوية في موعد استحقاقها					
اتاحة الفرص لزيادة تطوير القدرات المهنية					
تقديم الحوافز والدعم المادي للموظفين الأفضل اداء					

10.a. أخرى (حدد)

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القسم الثالث: البنية التحتية لتكنولوجيا المعلومات والإتصالات :Page 5

11. توفر البنية التحتية لتكنولوجيا الاتصالات والمعلومات وجاهزيتها عنصر اساسي نحو الإستفادة من ادوات التكنولوجيات الجغرافية المكانية في تحسين التكامل والتنسيق بين كافة الجهات ذات الصلة بإيصال الخدمات. من وجهة نظرك ما مدى أهمية إسناد كافة المسؤوليات المتعلقة بإعتماد المعايير والمواصفات و كذلك الإشراف على توفير تلك البنى التحتية بالجهات ذات الصلة بإيصال الخدمات للأحياء السكنية لبرنامج التعاملات الحكومية (يسر) ✱ *Required*

- مهم جداً
- مهم
- متوسط الأهمية
- قليل الأهمية
- غير مهم

11.a. عند إختيارك غير مهم يرجى تحديد الأسباب

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12. الرجاء تقييم مدى أهمية كل من العبارات التالية * Required

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
توحيد معايير ومواصفات البنية التحتية البنية التحتية لتكنولوجيا الاتصالات والمعلومات بين القطاعات المختلفة	☐	☐	☐	☐	☐
رفع مستوى البنى التحتية البنية التحتية لتكنولوجيا الاتصالات والمعلومات بشكل متساوي بين الجهات المختلفة	☐	☐	☐	☐	☐
تنفيذ المشاريع المشتركة لتطوير البنية التحتية البنية التحتية لتكنولوجيا الاتصالات والمعلومات	☐	☐	☐	☐	☐
اسناد الانشطة والمسؤليات المتعلقة بصيانة البنية التحتية البنية التحتية لتكنولوجيا الاتصالات والمعلومات للجهات المختلفة تحت اشراف جهة واحدة	☐	☐	☐	☐	☐
توحيد آلية الإرتباط بين الجهات المختلفة	☐	☐	☐	☐	☐
الإعتماد على التقنيات التي تستند على الانترنت	☐	☐	☐	☐	☐
اعتماد الحوسبة السحابية في تخزين واسترجاع وتبادل البيانات المكانية	☐	☐	☐	☐	☐
سن التشريعات واللوائح لتنظيم العمل الإلكتروني	☐	☐	☐	☐	☐

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اعادة هندسة الإجراءات ذات الصلة بإيصال الخدمات للسكان بما يتلائم مع تقديمها الكترونياً	☐	☐	☐	☐	☐
وضع كافة الأنشطة الإلكترونية والخدمات	☐	☐	☐	☐	☐
التفاعلية المتعلقة بإيصال الخدمات للسكان في موقع الكتروني موحد					

12.a. أخرى (حدد)

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القسم الرابع: إدارة البيانات المكانية :Page 6

13. **تكامل البيانات المكانية بين بمختلف القطاعات ذات الصلة بإيصال الخدمات للأحياء السكنية امر هام لدعم اتخاذ القرارات المستنيرة المتعلقة بتوفيرها. انشاء البنية التحتية للبيانات المكانية توفر الأطر الشاملة لمعالجة القضايا والتحديات التي تواجه تكامل البيانات. من وجهة نظرك قيم مدى أهمية كل من العبارات التالية** *Required* *

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
تحديد الروئ ووضع أولويات واضحة لتنفيذ البنية التحتية للبيانات المكانية على المستوى الوطني وتحديد الاستراتيجية والسياسة التنفيذية لتحقيقها بمشارك القطاعات المختلفة على مستوى الوزارات المركزية	☐	☐	☐	☐	☐
تحديد الروئ ووضع أولويات لتنفيذ البنية التحتية للبيانات المكانية على المستوى المحلي وتحديد الاستراتيجية والسياسة التنفيذية لتحقيقها بمشاركة القطاعات المختلفة على مستوى مدينة الرياض	☐	☐	☐	☐	☐
القيادة على المستوى الوطني لتنفيذ وتنسيق الأنشطة المتعلقة بالبنية التحتية للبيانات المكانية	☐	☐	☐	☐	☐
القيادة على المستوى المحلي لتنفيذ وتنسيق الأنشطة المتعلقة بالبنية التحتية للبيانات المكانية	☐	☐	☐	☐	☐

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القيادة على المستوى المحلي لتنسيق انشطة جزئية للبيانات المكانية الوطنية					
إطار قانوني معتمد من السلطه العليا في البلاد لدعم كافة الأنشطة والبرامج المتعلقة البنية التحتية للبيانات المكانية					
بناء القدرات ونشر الوعي بأهمية المشاركة والتعاون لدعم تنفيذ البنية التحتية للبيانات المكانية					
استخدام الخدمات المصدر المفتوح لأنشطة البنية التحتية للبيانات المكانية					
ادارة مركزية للبيانات المكانية على المستوى الوطني					
تطوير معايير البيانات المكانية استنادا الى المعايير الدولية					
استخدام تقنيات الإنترنت للوصول وتبادل البيانات المكانية (web)					
تسهيل مشاركة القطاع الخاص والأفراد في توفير البيانات المكانية					

13.a. أخرى (حدد)

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14. قيم افضل الوسائل لضمان الإلتزام بالتعاون والمشاركة بين الوكالات المختلفة لأنشطة البنية التحتية للبيانات المكانية * Required

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
اصدار تشريع، انظمة، لوائح من السلطة العليا في البلاد	☐	☐	☐	☐	☐
توقيع اتفاقيات رسمية	☐	☐	☐	☐	☐
مذكرات تفاهم	☐	☐	☐	☐	☐
عقود رسمية	☐	☐	☐	☐	☐

14.a. أخرى (حدد)

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15. الرجاء إضافة اي تعليقات اضافية لم يتم تغطيتها وترى انه من المهم أخذها في الإعتبار

هذه هي نهاية الاستبيان

شكراً لكم على مساهمتكم القيمة في دراستنا البحثية

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Appendix I: Delphi Technique Questionnaire (Round Three) in English

northumbria UNIVERSITY NEWCASTLE

Developing A Framework to Improve the Implementation of Geospatial Technologyin The Planning and Delivery of Infrastructure for Residential Areas in Saudi Arabia: A case study of Riyadh city

Page 1: Introduction

Dear expert,

Thank you for your participation in the first and second rounds which were very useful and yielded valuable results for this research study. You are invited to participate in the final round of this research study by completing this questionnaire; which has been developed based on the aggregate responses of all the experts who participated in the previous rounds.

The aim of this questionnaire is to revise, or reaffirm, your responses to the previous questionnaire in view of responses and opinions expressed of all the experts who participated from different sectors to obtain further consensus and convergence of opinions in order to improve the adoption and use of geospatial technology tools to facilitate the successful coordination and integration among the relevant agencies to overcome the issues of residential infrastructure delivery.

Again, your answers will be extremely helpful to us, and your individual privacy will be maintained in all published and written data analysis resulting from the research, and will be only used in scientific research purposes.

*** Please note that the rating average is based on a 5-point Likert scale, where 5 Very Important and 1 Not Important, as well as the percentage of some answers.**

If you have any questions concerning the questionnaire, please contact me using the following contact details:

Mohammed Alqarni
PhD student, Faculty of Engineering & Environment, Architecture and Built Environment
Northumbria University at Newcastle, UK
E-mail: mohammed.alqarni@northumbria.ac.uk

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Page 2: Personal information

1. Organisation ✱ *Required*

2. Job title ✱ *Required*

2.a. If you selected Other, please specify:

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Page 3: Section 1: Organisational settings

3. In your opinion, is there a need for an organisation or committee at the level of the city of Riyadh to be responsible for leading, organising and directing all relevant geospatial activities in the agencies concerned with residential infrastructure delivery? ✱ *Required*

- ☐ Yes (88.9%)
- ☐ No (11.1%)

3.a. Please identify the qualified organisations that would be able to lead these activities ✱ *Required*

- ○ Riyadh Principality (2.3).
- ○ Riyadh Municipality (3.8).
- ○ The High Commission for the Development of Riyadh (3.6).
- ○ The National Committee for Geographic Information Systems (3.1).
- ○ E-Government Program (YESSER) (2).

3.b. Please assess the tasks and functions of the organisation or committee responsible for organising and directing activities related to geospatial technologies in the agencies concerned with residential infrastructure delivery. ✱ *Required*

	Very Important	Important	Moderately Important	Slightly Important	Not Important
Developing joint plans and setting priorities for projects related to the geospatial activities (4.8).	☐	☐	☐	☐	☐

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General control and supervision on activities related to geospatial technologies, especially those activities that affect other relevant agencies/ organisations (4.3).					
Organising the adoption of the budgets for all programmes and activities related to geospatial technologies in all relevant agencies/ organisations (4).					
Preparation of controls related to the joint purchase of applications and tools related to geospatial technologies (3.7).					
Conducting regular meetings and follow-up of tasks and responsibilities related to each agency/ organisation (4.2).					

Coordination with other relevant organisations at all levels on activities related to the geospatial technology (4.4).					

3.c. What is the most appropriate level of employee for representing the agencies/organisations when participating in meetings related to geospatial activities? * *Required*

- Organisation manager (25%).
- Geospatial department managers (75%).

3.d. Commitment to implementing responsibilities that are agreed with other agencies/ organisations in relation to geospatial activities requires: * *Required*

- Signing of binding agreements (50%).
- Issuing decisions from higher authorities (37.5%).
- Formal contracts (12.5%).

4. There is a varying level of adoption and use of geospatial technology tools in the agencies concerned with service delivery. Please assess the significance of the following aspects to improve the level of adoption and use of these technological tools in the integration with the concerned agencies in planning for residential infrastructure delivery. * *Required*

More info

	Very Important	Important	Moderately Important	Slightly Important	Not Important

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Providing the qualified cadres and necessary infrastructure including devices and applications (4.8).					
Obliging agencies concerned with residential infrastructure delivery to automate procedures for service delivery electronically, based on geospatial technologies (4.4).					
Reducing the centralised implementation of projects related to geospatial technologies and granting agencies at local level greater authority in the development of activities related to these technologies (3.7).					

5. Costs associated with improving the development of activities related to geospatial technologies may be high in some service delivery agencies. From your point of view, evaluate the significance of the following points in pursuit of mitigating those costs. * *Required*

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	Very Important	Important	Moderately Important	Slightly Important	Not Important
Merging annual budgets of the projects related to the development of various activities based on the geospatial technologies into a single project (3.5).	☐	☐	☐	☐	☐
The participation of more than one party in the implementation of projects related to the implementation of geospatial technologies (for example purchasing equipment and application, field surveys, updating data) (4.1).	☐	☐	☐	☐	☐
Adopting cloud computing to reduce costs of implementation, operation and maintenance associated with geospatial activities (4).	☐	☐	☐	☐	☐

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Linking the expected benefits from the implementation of projects related to geospatial technologies prior to their adoption (4.4).					
Marketing geospatial technologies products (for example, maps and data) (4).					

5.a. Please add any further comments you wish to make about organisational settings in box below. *Optional*

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Page 4: Section 2: Raising awareness and building capacity

6. Please rate the best ways to raise general awareness about the importance of the use of geospatial technologies tools in decision making related to service delivery: * *Required*

	Very Important	Important	Moderately Important	Slightly Important	Not Important
Holding annual conferences and exhibitions (3.8).					
Offering free training on the use of multiple geospatial tools and applications (4.1).					
Conducting regular workshops for employees from various agencies (4.4).					
Forming specialised communities for practitioners and interested parties (3.8).					
Organising informal meetings between specialists from different sectors to discuss challenges and exchange experiences (4.1).					

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Raising awareness through school curricula in various stages of education (4.4).					
Using audio-visual media and social media (4).					
Issuing electronic and printed publications (3.7).					

7. From your point of view, addressing the shortage of qualified employees in various fields of geospatial technologies requires: ✱ *Required*

	Very Important	Important	Moderately Important	Slightly Important	Not Important
Expanding the educational base through the provision of different degree levels and the creation of various sections within universities and other educational institutions (4.3).					
Increasing employment opportunities for nationals (4.5).					

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Raising the job merits for experienced employees in this area (4.6).					
Providing a good job description for specialised employees (4.2).					
Reducing dependence on consulting companies for project implementation and management (3.2).					
Providing training and capacity building programmes (4.5).					

8. Employees training is one of the key factors needed to take full advantage of using geospatial technologies; please rate the importance of the following points in terms of improving employees' capabilities: * *Required*

	Very Important	Important	Moderately Important	Slightly Important	Not Important
Tailoring training programmes based upon job needs (4.5).					

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Developing specific programmes based on employees' needs (3.7).					
Obliging employees to attend a specific number of annual training hours to develop their skills (3.9).					
Exploiting competencies within different sectors for conducting on-the-job training (3.8).					
Diversity in the provision of training programmes (for example, distance training programmes) (3.5).					
Raising the level of coordination among the various agencies to conduct joint training (4).					

Preparing a list of training programmes and giving employees the right to choose the appropriate programmes to develop their skills (3.7).					
Providing scholarships for employees (4.2).					
Collaborating with academics in preparing and implementing training programmes (4.4).					
Providing financial and moral merits to encourage employees to attend training and relevant professional development (4.1).					

9. Meeting the challenge of retaining qualified and highly skilled employees in the field of geospatial technologies requires: ✱ *Required*

	Very Important	Important	Moderately Important	Slightly Important	Not Important
Creating an appropriate and healthy work environment (4.6).					

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Capacity building and skills development through enhancing training and rehabilitation programmes (4.3).					
Offering promotions and annual increases by the due date (4.6).					
Granting opportunities to further develop professional capacity (4.2).					
Providing incentives and financial support to the best performing employees (4.6).					

9.a. Please add any comments or suggestions regarding raising awareness and building capacity.

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Page 5: Section 3: ICT infrastructure

10. The availability of ICT infrastructure is a key element in the utilisation of the tools of geospatial technologies to improve the integration and coordination among all relevant agencies to deliver services. From your point of view, to what extent are important to attribute all responsibilities relating to the adoption of standards, and specifications, and the supervision of providing this infrastructure, to the agencies concerned with residential infrastructure delivery of the e-government programme (Yesser)? (4). ✱ *Required*

- Very Important
- Important
- Moderately Important
- Slightly Important
- Not important

11. Please rate the importance of each of the following statements: ✱ *Required*

	Very Important	Important	Moderately Important	Slightly Important	Not Important
Unifying the standards and specifications of the ICT infrastructure among the different sectors (4.6).					
Raising the level of ICT infrastructure equally among the various agencies (4.3).					

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Implementing joint projects for the development of ICT infrastructure at various agencies (4.3).					
Assigning activities and responsibilities relating to the maintenance of ICT infrastructure of the various agencies to only one supervisory agency (4).					
Unifying the mechanism of connection among various agencies (4.3).					
Relying on web-based techniques (4.5).					
Adopting cloud computing in the storage, retrieval and exchange of spatial data (4.1).					
Enacting legislation and regulations to regulate electronic work (4.2).					

Restructuring the procedures related to the delivery of services to the population in line with electronic provision (4.2).	☐	☐	☐	☐	☐
Placing all electronic activities and interactive services related to the services delivery on only one website (4).	☐	☐	☐	☐	☐

11.a. Please add any additional comments or suggestions regarding support of ICT infrastructure.

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Page 6: Section 4: Spatial data management

12. Integration of spatial data among the various relevant sectors to deliver services for residential areas is important to support informed decisions making. Spatial Data Infrastructure (SDI) provides a comprehensive framework to address the issues and challenges facing the multi-source data integration. From your point of view, rate the importance of each of the following statements: ✱ *Required*

	Very Important	Important	Moderately Important	Slightly Important	Not Important
Identifying visions and setting clear priorities for SDI implementation on a national level and identifying a strategic and operational policy for achievement, with participation from different sectors at the level of the central ministries (4.2).	☐	☐	☐	☐	☐
Identifying visions and setting clear priorities for SDI implementation on local level and identifying a strategic and operational policy for achievement, with participation from different sectors (3.9).	☐	☐	☐	☐	☐

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Leadership at national level for the implementation and coordination of activities related to SDI (4.1).					
Leadership at local level to implement and coordinate activities related to SDI (3.8).					
Leadership at local level to coordinate the partial activities of national spatial data (4.1).					
A legal framework approved by the highest authority in the country to support all the activities and programmes related to SDI (4.5).					
Capacity building and raising awareness regarding the importance of participation and cooperation in supporting the implementation of SDI (4.5).					

The use of open source services for the activities of SDI (4.1).					
Centralised management of spatial data at national level (4.3).					
The development of spatial data standards based on international standards (4.4).					
The use of web technologies for the access and exchange of spatial data (4.7).					
Facilitate the participation of the private sector and individuals in the provision of spatial data (4.6).					

13. Please assess the policies mentioned below to ensure compliance with the values of cooperation and partnership among various agencies in SDI activities: * *Required*

	Very Important	Important	Moderately Important	Slightly Important	Not Important
The issuance of legislation, and regulations by the supreme authority in the country (4.6).					

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The signing of formal agreements (4.1).					
Memorandas of Understanding (3.5).					
Formal contracts (3.7).					

13.a. Please add any additional comments or suggestions that you may have.

14. Please add any additional comments that you think are important for us to consider.

This is the end of the questionnaire.

Thank you for your cooperation and assistance for contributing to this research project.

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Appendix J: Delphi Technique Questionnaire (Round Three) in Arabic

تطوير إطار لتحسين تنفيذ التكنولوجيات الجغرافية المكانية لتخطيط وإيصال البنية التحتية للمناطق السكنية في المملكة العربية السعودية: دراسة حالة لمدينة الرياض

Page 1:

عزيزي الخبير

شكرا لمشاركتكم في الجولتين الأولى والثانية والتي اسفرت عن نتائج قيمة لهذه الدراسة. انتم مدعوون للمشاركة في الجولة النهائية لهذه الدراسة والتي تم انشائه استنادا إلى الردود الإجمالية لجميع المشاركين في الجولات السابقة من هذه الدراسة

الهدف من هذه المرحلة هي إطلاعكم على الردود والمقترحات المقدمة من قبل المشاركين بالقطاعات المختلفة وتقيمها، وكذلك لإتاحة الفرصة لكم لإعادة النظر في إجابتكم من أجل التوصل إلى توافق نهائي واتفاق مشترك لتحسين اعتماد واستخدام التكنولوجيات الجغرافية المكانية لتعزيز التنسيق والتكامل بين مختلف الجهات ذات العلاقة بإيصال البنية التحتية والخدمات للأحياء السكنية

مشاركتكم بهذه المرحلة مهمة للغاية بالنسبة لنا والتي تعتبر جزء من متطلبات هذه الدراسة البحثية. ونؤكد لكم مرة أخرى بأنه سيتم الحفاظ على الخصوصية في كل مراحل هذه الدراسة وان المعلومات المقدمة ستستخدم فقط لأغراض البحث العلمي

يرجى ملاحظة ان التقييم يستند على **مقياس ليكرت** لقياس التوافق من 5 درجات بحيث يعتبر (5) مهم جداً وَ (1) غير مهم وكذلك النسبة المئوية لبعض الأجابات

إذا كان لديك أي أسئلة بخصوص الاستبيان، يرجى الاتصال بي على البريد الإلكتروني أو أرقام الهاتف المدونة أدناه

محمد حسن القرني

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Page 2: البيانات الشخصية

1. **جهة العمل** ✱ *Required*

2. **المسمى الوظيفي** ✱ *Required*

- مدير عام / متخذ قرار
- مسؤول الأنشطة ذات الصلة بالتكنولوجيات الجغرافية المكانية
- أخرى

2.a. أخرى (حدد)

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Page 3: القسم الأول: الإعدادات التنظيمية

3. من وجهة نظرك, هل هناك حاجة لتولي احد الجهات على مستوى مدينة الرياض مسؤولية قيادة وتنظيم وتوجيه جميع الأنشطة ذات الصلة بإستخدام التكنولوجيات الجغرافية المكانية في الجهات المعنية بإيصال البنية التحتية للأحياء السكنية؟ ✱ *Required*

- نعم , 88.9%
- لا , 11.1%

3.a. يرجى تحديد الجهة الأكثر قدرة على قيادة هذه الأنشطة ✱ *Required*

- أمارة منطقة الرياض (2.3)
- أمانة منطقة الرياض (3.8)
- الهيئة العليا لتطوير منطقة الرياض (3.6)
- الجنة الوطنية لنظم المعلومات الجغرافية (3.1)
- برنامج التعاملات الحكومية يسر (2)

3.b. بناء على خبرتك، يرجى تقييم مهام و وظائف الجهة المسؤولة عن تنظيم وتوجيه أنشطة التكنولوجيات الجغرافية المكانية في الجهات المعنية بإيصال الخدمات للأحياء السكنية ✱ *Required*

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
وضع الخطط والأولويات المشتركة للمشاريع ذات الصلة بالأنشطة الجغرافية المكانية. » 4.8					
الرقابة العامة والإشراف على الأنشطة ذات الصلة بإستخدام التكنولوجيات الجغرافية المكانية، وخاصة تلك التي تؤثر على الجهات ذات الصلة. » 4.3					

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تنظيم واعتماد كافة ميزانيات و برامج وانشطة التكنولوجيات الجغرافية المكانية بجميع الجهات ذات الصلة. » 4	☐	☐	☐	☐	☐
عقد الإجتماعات المنتظمة لمتابعة المهام والمسؤوليات المتصلة بكل جهة. » 4.2	☐	☐	☐	☐	☐
التنسيق مع الجهات الأخرى على جميع المستويات بشأن الأنشطة المتصلة بالتكنولوجيات الجغرافية المكانية كمدينة الملك عبدالعزيز للعلوم والتقنية، الهيئة العامة للمساحة. » 4.4	☐	☐	☐	☐	☐

ما هو المستوى المناسب من الموظفين لتمثيل الجهات المختلفة للمشاركة في الإجتماعات ذات الصلة بالأنشطة الجغرافية المكانية ✱ *Required* *3.c.*

- ☐ مدير عام / متخذ قرار (25%)
- ☐ مسؤول الإدارات المختصة بالتكنولوجيات الجغرافية المكانية (75%)

من وجهة نظرك، إلتزام الجهات المختلفة بالمسؤوليات التي يتم الإتفاق عليها والمتعلقة بالأنشطة ذات الصلة بالتكنولوجيات الجغرافية المكانية يتطلب ✱ *Required* *3.d.*

- ☐ توقيع اتفاقات ملزمة (50%)
- ☐ إصدار قرارات من السلطات العليا (37.5%)
- ☐ عقود رسمية (12.5%)

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4. هناك مستويات متفاوتة من اعتماد واستخدام أدوات التكنولوجيات الجغرافية المكانية في الوكالات ذات الصلة بإيصال الخدمات. يرجى تقييم أهمية الجوانب الآتيه لتحسين الإستفادة من تلك الأدوات في التنسيق والتكامل لتخطيط ايصال الخدمات للأحياء السكنية * *Required*

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
توفير الكوادر المؤهلة والبنية التحتية اللازمة بما في ذلك الأجهزة والتطبيقات. » 4.8	☐	☐	☐	☐	☐
إلزام كافة الجهات المسؤولة عن ايصال الخدمات بأتمتة كافة الإجراءات المتعلقة بإيصالها للسكان ضمن منظومة عمل إلكترونية استناداً على التكنولوجيات الجغرافية المكانية. » 4.4	☐	☐	☐	☐	☐
الحد من مركزية تنفيذ المشاريع المتعلقة بالتكنولوجيات الجغرافية المكانية ومنح الوكالات على المستوى المحلي سلطات اكبر لتطوير أنشطة تلك التكنولوجيات. » 3.7	☐	☐	☐	☐	☐

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5. **التكاليف المرتبطة بتحسين وتطوير أنشطة التكنولوجيات الجغرافية المكانية قد تكون مرتفعة في بعض الجهات ذات الصلة بإيصال الخدمات .من وجهة نظرك، قيم أهمية النقاط الآتيه للمساهمة في تخفيف تلك التكاليف**

✱ *Required*

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
دمج الميزانيات السنوية للمشاريع المتعلقة بتطوير الأنشطة المختلفة القائمة على التكنولوجيات الجغرافية المكانية ضمن مشروع موحد. » 3.5	☐	☐	☐	☐	☐
مشاركة أكثر من جهة في تنفيذ المشاريع المتعلقة بالتكنولوجيات الجغرافية المكانية, على سبيل المثال: شراء الأجهزة والتطبيقات، المسوحات الميدانية، تحديث البيانات. » 4.1	☐	☐	☐	☐	☐
اعتماد الحوسبة السحابية لخفض تكاليف تنفيذ وتشغيل وصيانة الأنشطة المرتبطة بالتكنولوجيات الجغرافية المكانية. » 4	☐	☐	☐	☐	☐
ربط اعتماد المشاريع المتعلقة بالتكنولوجيات الجغرافية المكانية بالفوائد المتوقعة. » 4.4	☐	☐	☐	☐	☐
تسويق منتجات التكنولوجيات الجغرافية المكانية, على سبيل المثال، الخرائط والبيانات. » 4	☐	☐	☐	☐	☐

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5.a. الرجاء إضافة أي تعليقات اضافية حول الجوانب التنظيمية تعقد أنها مهمة

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القسم الثاني: رفع مستوى الوعي وبناء القدرات :Page 4

6. قييم أفضل الطرق التالية لرفع مستوى الوعي العام حول أهمية استخدام أدوات التكنولوجيات الجغرافية المكانية في صنع القرارات المتعلقة بإيصال الخدمات * *Required*

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
عقد المؤتمرات والمعارض السنوية المتخصصة. » 3.8	☐	☐	☐	☐	☐
توفير برامج التدريب المجاني المختلفة على استخدام الأدوات والتطبيقات الجغرافية المكانية. » 4.1	☐	☐	☐	☐	☐
تكوين مجتمعات متخصصة للممارسين والمهتمين. » 3.8	☐	☐	☐	☐	☐
عقد ورش عمل منتظمة للموظفين من مختلف الوكالات لمناقشة التطورات ومعالجة التحديات. » 4.4	☐	☐	☐	☐	☐
تنظيم الملتقيات غير الرسمية بين المختصين في القطاعات المختلفة لتبادل الخبرات. » 4.1	☐	☐	☐	☐	☐
نشر الوعي عبر المناهج الدراسية بمختلف المراحل التعليمية. » 4.4	☐	☐	☐	☐	☐
استخدام وسائل الاعلام المرئي والمسموع وكذلك وسائل التواصل الاجتماعي. » 4	☐	☐	☐	☐	☐
إصدار النشرات الإلكترونية والمطبوعات. » 3.7	☐	☐	☐	☐	☐

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7. من وجهة نظرك معالجة نقص الكفاءات المؤهلة في مجال التكنولوجيات الجغرافية المكانية المختلفة

يتطلب * Required

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
توسيع القاعدة التعليمية من خلال انشاء العديد من الأقسام والمراحل العلمية المختلفة ضمن الجامعات والمؤسسات التعليمية الأخرى. » 4.3	☐	☐	☐	☐	☐
زيادة فرص توظيف الكفاءات الوطنية. » 4.5	☐	☐	☐	☐	☐
رفع المزايا الوظيفية للكفاءات المتخصصة في هذا المجال. » 4.6	☐	☐	☐	☐	☐
توفير الوصف الوظيفي الجيد للمختصين. » 4.2	☐	☐	☐	☐	☐
التقليل من الاعتماد على المكاتب الإستشارية لتنفيذ وإدارة المشاريع. » 3.2	☐	☐	☐	☐	☐
توفير برامج التدريب وتطوير القدرات. » 4.5	☐	☐	☐	☐	☐

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8. التدريب احد أهم العوامل لتحقيق الإستفادة المثلى من تنفيذ التكنولوجيات الجغرافية المكانية، قيم اهمية العناصر الأتية لرفع كفانة الموظفين بناءا على خبرتك * Required

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
ربط البرامج التدريبية بالمهام الوظيفية. » 4.5					
تطوير برامج محددة بناء على متطلبات الموظفين. » 3.7					
الزام الموظفين بحضور ساعات تدريبية سنوية محددة لتطوير مهاراتهم. » 3.9					
استغلال الكفاءات العاملة ضمن القطاعات المختلفة للقيام بتدريب المختصين على رأس العمل. » 3.8					
التنوع في تقديم البرامج التدريبية, على سبيل المثال التدريب عن بعد. » 3.5					
رفع مستوى التنسيق بين الوكالات المختلفة لاقامة التدريب المشترك. » 4					
وضع قائمة بالبرامج التدريبية واتاحة حرية اختيار الموظف للبرامج المناسبة لتطوير مهاراته. » 3.7					
إيفاد الموظفين في بعثات دراسية. » 4.2					
التعاون مع الجهات الأكاديمية لإعداد واقامة البرامج التدريبية. » 4.4					

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توفير مزايا مادية ومعنوية لتشجيع الموظفين على حضور الدورات والبرامج التدريبية ذات الصلة. » 4.1	☐	☐	☐	☐	☐

9. لمواجهة التحدي المتمثل في استبقاء الموظفين ذو الكفاءات والمهارات العالية في مجال التكنولوجيات الجغرافية المكانية يتطلب ذلك ✱ *Required*

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
تهيئة بيئة عمل مناسبة وآمنة للاستقرار الوظيفي. » 4.6	☐	☐	☐	☐	☐
تنمية القدرات والمهارات من خلال برامج التدريب والتأهيل. » 4.3	☐	☐	☐	☐	☐
منح الترقيات والعلاوات السنوية في موعد استحقاقها. » 4.6	☐	☐	☐	☐	☐
اتاحة الفرص لزيادة تطوير القدرات المهنية. » 4.2	☐	☐	☐	☐	☐
تقديم الحوافز والدعم المادي للموظفين الأفضل اداء. » 4.6	☐	☐	☐	☐	☐

9.a. الرجاء إضافة اي من تعليقات او مقترحات حول الجوانب المتعلقة بزيادة الوعي وبناء القدرات

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القسم الثالث: البنية التحتية لتكنولوجيا المعلومات والإتصالات :Page 5

10. الإستفادة من ادوات التكنولوجيات الجغرافية المكانية في تحسين التكامل والتنسيق بين كافة الجهات ذات الصلة بإيصال الخدمات. من وجهة نظرك ما مدى أهمية إسناد كافة المسؤوليات المتعلقة بإعتماد المعايير والمواصفات و كذلك الإشراف على توفير تلك البنى التحتية بالجهات ذات الصلة بإيصال الخدمات للأحياء السكنية لبرنامج التعاملات الحكومية يسر. » 4 ✱ *Required*

- مهم جداً
- مهم
- متوسط الأهمية
- قليل الأهمية
- غير مهم

11. الرجاء تقييم مدى أهمية كل من العبارات التالية ✱ *Required*

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
توحيد معايير ومواصفات البنية التحتية البنية التحتية لتكنولوجيا الاتصالات والمعلومات بين القطاعات المختلفة. » 4.6	☐	☐	☐	☐	☐
رفع مستوى البنى التحتية البنية التحتية لتكنولوجيا الاتصالات والمعلومات بشكل متساوي بين الجهات المختلفة. » 4.3	☐	☐	☐	☐	☐
تنفيذ المشاريع المشتركة لتطوير البنية التحتية البنية التحتية لتكنولوجيا الاتصالات والمعلومات. » 4.3	☐	☐	☐	☐	☐

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اسناد الانشطة والمسؤليات المتعلقة بصيانة البنية التحتية البنية التحتية لتكنولوجيا الاتصالات والمعلومات للجهات المختلفة تحت اشراف جهة واحدة. » 4	☐	☐	☐	☐	☐
توحيد آلية الإرتباط بين الجهات المختلف. » 4.3	☐	☐	☐	☐	☐
الإعتماد على التقنيات التي تستند على الانترنت. » 4.5	☐	☐	☐	☐	☐
اعتماد الحوسبة السحابية في تخزين واسترجاع وتبادل البيانات المكانية. » 4.1	☐	☐	☐	☐	☐
سن التشريعات واللوائح لتنظيم العمل الإلكتروني. » 4.2	☐	☐	☐	☐	☐
اعادة هندسة الإجراءات ذات الصلة بإيصال الخدمات للسكان بما يتلائم مع تقديمها الكترونياً. » 4.2	☐	☐	☐	☐	☐
وضع كافة الأنشطة الإلكترونية والخدمات التفاعلية المتعلقة بإيصال الخدمات للسكان في موقع الكتروني موحد. » 4	☐	☐	☐	☐	☐

11.a. الرجاء إضافة أي تعليقات ذات الصلة بتكنولوجيا الاتصالات وتقنية المعلومات تعقد أنها مهمة

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Page 6: القسم الرابع: إدارة البيانات المكانية

12. تكامل البيانات المكانية بين بمختلف القطاعات ذات الصلة بايصال الخدمات للأحياء السكنية امر هام لدعم اتخاذ القرارات المستنيرة المتعلقة بتوفيرها. انشاء البنية التحتية للبيانات المكانية توفر الأطر الشاملة لمعالجة القضايا والتحديات التي تواجه تكامل البيانات. من وجهة نظرك قيم مدى أهمية كل من العبارات التالية *Required* *

	مهم جداً	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
تحديد الروئ ووضع أولويات واضحة لتنفيذ البنية التحتية للبيانات المكانية على المستوى الوطني وتحديد الاستراتيجية والسياسة التنفيذية لتحقيقها بمشارك القطاعات المختلفة على مستوى الوزارات المركزية. » 4.2	☐	☐	☐	☐	☐
تحديد الروئ ووضع أولويات لتنفيذ البنية التحتية للبيانات المكانية على المستوى المحلي وتحديد الاستراتيجية والسياسة التنفيذية لتحقيقها بمشاركة القطاعات المختلفة على مستوى مدينة الرياض. » 3.9	☐	☐	☐	☐	☐
القيادة على المستوى الوطني لتنفيذ وتنسيق الأنشطة المتعلقة بالبنية التحتية للبيانات المكانية. » 4.1	☐	☐	☐	☐	☐
القيادة على المستوى المحلي لتنفيذ وتنسيق الأنشطة المتعلقة بالبنية التحتية للبيانات المكانية. » 3.8	☐	☐	☐	☐	☐

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القيادة على المستوى المحلي لتنسيق انشطة جزئية للبيانات المكانية الوطنية. » 4.1					
إطار قانوني معتمد من السلطه العليا في البلاد					
لدعم كافة الأنشطة والبرامج المتعلقة البنية التحتية للبيانات المكانية. » 4.5					
بناء القدرات ونشر الوعي بأهمية المشاركة والتعاون لدعم تنفيذ البنية التحتية للبيانات المكانية. » 4.5					
استخدام الخدمات المصدر المفتوح لأنشطة البنية التحتية للبيانات المكانية. » 4.1					
ادارة مركزية للبيانات المكانية على المستوى الوطني. » 4.3					
تطوير معايير البيانات المكانية استنادا الى المعايير الدولية. » 4.4					
استخدام تقنيات الإنترنت للوصول وتبادل البيانات المكانية. » 4.7					
تسهيل مشاركة القطاع الخاص والأفراد في توفير البيانات المكانية. » 4.6					

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13. قيم افضل الوسائل لضمان الإلتزام بالتعاون والمشاركة بين الوكالات المختلفة لأنشطة البنية التحتية للبيانات المكانية * Required

	مهم جدا	مهم	متوسط الأهمية	قليل الأهمية	غير مهم
اصدار تشريع، انظمة، لوائح من السلطة العليا في البلاد. » 4.6	☐	☐	☐	☐	☐
توقيع اتفاقيات رسمية. » 4.1	☐	☐	☐	☐	☐
مذكرات تفاهم. » 3.5	☐	☐	☐	☐	☐
عقود رسمية. » 3.7	☐	☐	☐	☐	☐

13.a. الرجاء إضافة اي تعليقات اضافية حول الجوانب المتصلة بإدارة البيانات المكانية وترى انه من المهم أخذها في الإعتبار

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14. الرجاء إضافة اي تعليقات ترى انه من المهم أخذها في الإعتبار لتحسين استخدام ادوات التكنولوجيات الجغرافية لتحسن التنسيق والتكامل لإيصال البنية التحتية والخدمات للأحياء السكنية

هذه هي نهاية الاستبيان

شكراً لكم على مساهمتكم القيمة في دراستنا البحثية

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