

Case Study

Workforce and its Impact on the Development of Geospatial Technologies to Support the Delivery Management of Urban Infrastructure: Current Status and Future Needs- A Case Study of Riyadh City, Saudi Arabia

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Abstract Geospatial technologies have created new opportunities for handling spatial information and are becoming more frequently used in many fields. As with other information and communication technologies, receiving growing attention in many disciplines where exerted efforts have been made to take full advantage of their rapid developments. Today, geospatial tools are employed in various fields related to urban management and planning, where they have become important tools in improving decision making. This, in turn, has led to a substantial demand for a qualified workforce able to harness the potential of these technologies. This study focuses on geospatial technology workforces working in the agencies responsible for service delivery in residential neighbourhoods in the city of Riyadh. The Delphi technique was used to understand the needs of the workforce and to highlight the aspects that can support users of these technologies to improve related activities. The study found that there is a shortage of qualified professionals who can bring about the desired outcomes regarding the potential offered by the use of these technologies. Issues of awareness, capacity-building and retention of qualified employees, along with lack of incentives, pose similar problems preventing the development of relevant activities. The results provide a number of strategies that may contribute to positive changes that can be implemented to overcome the challenges.

Keywords *Awareness; Capacity Building; Geospatial Technology; Training; Workforce*

1. Introduction

There is no doubt that the rapid developments in various technologies have played positive role in improving geospatial use and the availability of geospatial data in different contexts. These developments have contributed to providing support to decision makers, where can be used as a common platform to incorporate various database types, represented spatially, into one integrated system to facilitate decision-making. Despite the potential benefits offered by these technologies, the success of their use depends significantly on a qualified workforce who have a combination of specialised skills and competencies. In the city of Riyadh, several public and private sector agencies, concerned with residential infrastructure delivery, depend on the use of geospatial technologies to support administrative workflows and improve the planning processes and decision-making. This takes

on many forms based on the nature of the tasks that fall within the scope of their responsibilities. Although government support has had an impact on enhancing the implementation of these technologies, the development of their use in the context of residential infrastructure delivery is still limited. This study focuses on the human aspects and provides a comprehensive understanding of workforce issues that limit the development of geospatial technologies in the agencies, and the extent of its impact on the development of their activities. It also explores how to address and overcome these issues to achieve the benefits offered by these technologies.

1.1. Background

The rapid development of geospatial technology tools and their capability to improve decision-making have contributed to increasing their use; this has been largely linked to recent developments in the ICT domain. Several studies have discussed the issues of a geospatial workforce. These studies clearly show that the demand for a more qualified geospatial workforce is increasing. They also indicate that the rapid growth in the utilisation of geospatial tools, and the increased availability of spatial data, have created an increasing demand for a workforce having various skills and high expertise in all areas of the geospatial industry (Becony  et al., 2008; Solem and Schlemper, 2008; Disera, 2011; Musakwa, 2017).

Numerous shortcomings have been associated with the availability of a qualified workforce able to harness the potential of geospatial technologies. Understanding the needs of a geospatial workforce is considered a vital component to develop the use of these technologies, where a team of staff with the necessary knowledge, qualifications and skills is required. In fact, the geospatial workforce is made up of a number of individual specialists equipped with multiple skills. With the advancements of ICT, this field is no longer confined to professionals and specialists in geospatial related disciplines. Currently, there are diverse geospatial technology usages entwined with information technologies and other disciplines, which has created difficulties in categorising the needs of the workforce, who are going to use these technologies with a specific set of skills (Marble, 2006; Pettit and Pullar, 2009; Dangermond, 2011; Pfeffer et al., 2015).

Recognising the importance of this, efforts have been undertaken to introduce geospatial technologies as part of the curriculum at different stages of educational institutions systems to meet the needs of current and future workforce. However, this remains a low priority in both developed and developing countries due to a number of technological, pedagogical, administrative and curricular challenges (Favier and Schee, 2014; Chen and Wang, 2015; Starkenburg et al., 2018). As is the case in many countries, the progress of geospatial education in Saudi Arabia has not developed at the same pace as the utilisation of this technology, this is due to a number of administrative challenges and other factors associated with awareness regarding the importance in this field (Al-Garni, 2005; Aina, 2009). In fact, progress in establishing effective strategies and pedagogical practices focusing on geospatial technology education is still being made (Perkins, 2015). This reflects the difficulty in suggesting a unified policy for teaching geospatial technology, where it is often viewed as a field that integrates with many disciplines in different academic departments. Therefore, the academic curricula could not be generalised in order to meet the demand for a geospatial workforce. This, in turn, reflects a decrease in actual enrolment rates of students in geomatics majors. It has also affected the future of the geospatial workforce, which remains undefined as a clear employment category in many countries (Tejpal et al., 2012; Donert, 2015).

The accelerated growth of the geospatial industry calls for further job analyses to be conducted to understand the different occupations associated with geospatial technologies in different contexts, and to provide suitable education and training (Bishop and Grubestic, 2016). Indeed, the use of geospatial technologies is not without its shortcomings, as they may not be accepted by various users due to the lack of necessary skills. Research carried out by Crawford and Young (2008) confirms that the existence of training opportunities, along with educational programmes, has important implications in

meeting the demand of a multidisciplinary workforce who have knowledge and the broad skillset required to master the use of geospatial technology. Giuliani et al. (2013) add that providing suitable levels and quality of education and training, a necessary infrastructure, along with an understanding of the value of geospatial data in decision-making are essential components for capacity building. Meanwhile, Beerens (2006) suggests that capacity building should include not only professionals operating in the field of geospatial, but also managers and other decision makers who are responsible for relevant legislation and institutional arrangements. This, therefore, can help to raise awareness of the geospatial industry in general and making investments in capacity building is imperative to generate the required workforce. Thus, providing a well-trained workforce requires financial investment and considerable resources for successful geospatial technology development.

2. Data Used and Methods

This study seeks to highlight the issues that affect the geospatial workforce in the agencies responsible for planning the delivery of residential infrastructure. The main question that this study aspires to answer is to identify what are the issues faced by geospatial workforce and how are they being addressed. Indeed, answering this question will require taking into account the differences in the activities of geospatial technology, and the aims of their use in each agency. Accordingly, studying and dealing with these issues in a comprehensive manner is critical to determine the most appropriate ways they can be addressed. The Delphi technique was adopted as a means of gathering opinions on the key issues that face a geospatial workforce in their workplaces and to obtain a consensus on the most appropriate ways to address them.

Delphi preparation	Round 1	Round 2	Round 3
- Selection of a panel of participating experts.	(An exploration phase)	(An evaluation phase)	(An evaluation phase)
- Development of the first-round questions.	Face to face semi-structured interview	A structured questionnaire	A structured questionnaire
- Arrangement for conducting the first round.	(Sample size: 20)	(Sample size: 18)	(Sample size: 18)

Figure 1: The Delphi process

The study involved 24 experts representing relevant agencies chosen through purposive sampling. The expert panel consisted of the decision-makers and department managers who are responsible for geospatial activities in agencies concerned with the delivery of residential infrastructure, along with officials representing the national committee for geographic information systems and the e-government programme. The aim was to include experts representing all agencies concerned with the delivery of residential infrastructure and other government agencies that provide the support for working with these technologies (see Table 1). A total of 20 experts agreed to participate in the study, of those 20 only 18 completed the final round. The study was conducted in three iterative rounds in which qualitative data were collected in the first round and quantitative data in subsequent rounds. Qualitative data were collected using semi-structured face-to-face interviews, while quantitative data were collected through questionnaires in electronic format and in hard copy form to experts who did not provide an email address, or who had asked for a printed version. In the first round, all the questions asked in the interviews were open questions to encourage experts' free expression of views and raise issues that were significant to them. The data collected was analysed by using thematic analysis. The most commonly recurring themes were identified, and which served as a basis for the following rounds. The second and third round questionnaire was formulated using the themes

generated from the first round. The analysis of the data obtained in these rounds was based on measures of central tendency (mean) to measure the responses to each item, with the level of dispersion (interquartile range IQR) used to determine the level of consensus of expert opinions (Hsu and Sandford, 2007).

Table 1: Agencies concerned with the delivery of residential infrastructure and other that provide the support for working with geospatial technologies

No	Organisation or Agency
1	Riyadh Municipality
2	The General Department of Education
3	Saudi Post
4	General Directorate of Health Affairs
5	The Branch of Ministry of Islamic Affairs
6	General Directorate of Civil Defence
7	Public Security Department
8	Saudi Telecom Company
9	National Water Company – Riyadh
10	Saudi Electricity Company – Riyadh
11	The High Commission for the Development of Riyadh
12	The National Committee for Geographic Information Systems
13	E-Government Programme (YESSER)

For this research, an IQR of 0 to 1 indicates consensus achieved, which illustrates the difference between the first and third quartiles of the distribution of data ($IQR = Q3 - Q1$). Consensus was reached for 24 of the 28 strategies after the second round while in the third round, consensus was reached for all strategies and, consequently, no further rounds were required.

3. Results and Discussion

3.1. Data Analysis

3.1.1. The First Round

This round sought to elicit experts' views about issues associated with geospatial workforce and the need to improve performance. Semi-structured interviews were used as a tool for data collection. The reason for using the interview method was to enable the researchers, through open discussions with the panel of experts, to explore the issues closely and consider how they can be addressed. The results would then assist in the creation of themes for the following rounds.

Three main themes were identified from the first-round of data analysis. The first theme refers to the issues associated with a lack of awareness among decision makers and relevant employees in the agencies. The views of the experts showed that there are different levels of awareness about the roles and potentials that can be achieved by geospatial technologies, which made developing the use of these tools consistently difficult. As a consequence, this 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 service delivery.

In addition, the experts frequently expressed that capacity building is an issue faced by most agencies, especially in light of the absence of common strategies and training programmes and the limited role of academic institutions. The difficulty in providing financial support for the rehabilitation of staff and developing the skills necessary to deal with these technologies were also mentioned. The experts also recognised that there is a shortage of a qualified workforce, despite an increasing need. According to

the experts' responses, most of the agencies working in service delivery rely on employees from the relevant 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. At the same time, it has been pointed out that a lack of rehabilitation and continuous development programmes opportunities for employees, and dissatisfaction with the current level of training, have contributed to the low level of use of these technologies for performing daily tasks.

The drain of skilled experienced employees, especially from the public sector, whether at the end of contracted projects or because of a desire to earn better wages was another theme mentioned by the experts. They believe that finding solutions for the retention of such employees is vital. Along with this, the lack of incentives for users of geospatial tools, especially in government agencies, was also raised during interviews. The experts argued that this has affected the development of the required skills of specialist employees as well as encouraging non-specialists to use the tools.

3.1.2. The Second and Third Round

The second round was based on the results from the first round and a review of the relevant literature; a number of strategies were developed to address the issues raised with the aim of obtaining expert opinions regarding the importance of each strategy. In this round, experts were asked to determine the importance of each strategy, using a 5-point Likert-type scale anchored by 1 (not important) and 5 (very important). To enhance this, they were also asked to place comments and add suggestions based on their experiences. The third round sought to achieve further consensus and bridge the gap between the differences in opinions provided in the second round. The strategies, along with rating a summary of the responses obtained from the experts in the second round were also presented. This was to enable the experts to consider the replies given by others in the previous round, and a review of their assessment to reach a final consensus and a common agreement on the final strategies.

The analysis in the first round highlighted the main issues of workforce that have accompanied the utilisation of geospatial technologies in the agencies that provide residential infrastructure. The difference in the level of awareness among decision-makers and employees 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 the development of their use in context of residential infrastructure delivery. Table 2 below presents the items that achieved a high consensus level within the expert panel, which included a number of activities that aim to raise awareness about the importance of the use of geospatial technologies tools in decision-making related to service delivery.

Table 2: 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

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. 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 3 below shows that there was agreement on all items that describe these measures.

Table 3: 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 development of relevant departments and courses in 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

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 4 below.

Table 4: Average rating of the importance level of the items related to improving the employees' capabilities in using geospatial technologies

No	Item	Mean	IQR
1	Designing 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	3.7	0.75

No	Item	Mean	IQR
	choose the appropriate programmes to develop their skills.		
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

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 5 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 5: 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

3.2. Discussion

The issues of lack of awareness, training and qualified capacities are among the key issues that face geospatial workforce development, 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 study, it can be noted that there are different levels of awareness, whether among decision makers or employees in these agencies around the importance of their utilisation to support cooperation and coordination in the activities of infrastructure delivery. 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 utilising these technologies, which is consistent with what have been reported by other researchers (Dangermond, 2011; Marsden, 2015).

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. 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.

4. Conclusion

Geospatial workforces with various specialisations are considered an important element in the development of geospatial activities. The success of utilising this technology is essentially associated with users' knowledge and skills along with the ability to optimally employ their potential. This study draws attention to the issues associated with geospatial workforces in the agencies accountable for providing residential services. It reveals that the current geospatial workforce is lacking, and that the agencies are inadequately prepared to address this issue. The causes are multiple and include limited awareness, capacity building as well as the ability to retain a qualified workforce. The study provides a robust view built on consensus and mutual acceptance among the relevant agencies to determine the most suitable solutions for addressing these issues. However, more efforts need to be made in facing the challenges of introducing such technologies into the working environment and the consequential changes in organisational structures and processes. At the same time, concerted efforts and sustained support on a consistent and continuous basis, within clear and specific programmes, are needed to overcome the obstacles that may arise when implementing the strategies.

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