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THE CHALLENGES OF IMPLEMENTING AND SUSTAINING GEOGRAPHICAL INFORMATION SYSTEMS IN THE COOK ISLANDS

by

Manarii Benjamin Etches

A thesis submitted in partial fulfilment of the
requirements for the degree of
Master of Information Systems

School of Computing, Information
and Mathematical Sciences
Faculty of Science, Technology and Environment
University of the South Pacific

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Declaration

Statement by Author

I, Manarii Benjamin Etches, declare that this thesis is my own work and that, to the best of my knowledge, it contains no material previously published, or substantially overlapping with material submitted for the award of any other degree at any institution, except where due acknowledgement is made in the text.

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Statement by Supervisor

The research in this thesis was performed under my supervision and to my knowledge is the sole work of Manarii Benjamin Etches.

Signature  Date 14 November, 2017

Name: Dr John Lowry

Designation: Senior Lecturer

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Abstract

The objective of this mini-thesis is to investigate GIS environment in the Cook Islands. We will first review how GIS is performing in developed and developing countries, including GIS performance in PICs. This is important as to see how GIS is carried out in the Cook Islands compared to other countries. The Literature Review chapter covers this in detail. It was decided that the most appropriate method to derive and analyse required data for this research was to carry out a combination of semi-structured and structured interviews. The 'Research Onion' concept was instrumental as a guide to assist in my decision to administer open and close-ended questions to participants; this allowed a comprehensive analysis to take place. The framework analysis model recommended by Ritchie and Spencer (1996) was used to derive common themes from qualitative findings. This is covered within the Methodology chapter. The results of this thesis came close to answers I required to address my research questions. Contained within my Results chapter are qualitative data relative to participants' responses and quantitative figures of close-ended questions. The Discussion chapter makes further comparisons of research results with other countries developing or implementing GIS. Finally, my conclusion of this research provide answers of challenges faced by GIS practitioners developing, implementing and sustaining GIS in the Cook Islands. It is hopeful that the results of this research will benefit other PIC's looking to establish or improve existing GIS capacity.

List of Abbreviations

BCI	Bluesky Cook Islands
DRM	Disaster Risk Management
DRM&R	Disaster Risk Management and Response
EMCI	Emergency Management Cook Islands
FAA	Federal Aviation Administration
FLIS	Fijian Land Information System
GIS	Geographical Information Systems
GIT&S	Geo-Spatial Information Technologies and Systems
HTML	Hyper Text Mark-up Language
ICM	Integrated Coastal Management
ICT	Information and Communication Technology
ICT4D	ICT for Development
IFRC	International Federation of the Red Cross
IP	Internet Protocol
IT	Internet Technology
LIS	Land Information System
LINZ	Land Information New Zealand
MMR	Cook Islands Ministry of Marine Resources
MPA	Marine Protected Area
NSDP	National Sustainable Development Plan
NZODA	New Zealand Official Development Assistance
OGC	Open Geospatial Consortium
OPM	Office of the Prime Minister
OSGeo	Open Source Geospatial Foundation
PAC	Public Access Computing
PCRAFI	Pacific Catastrophic Risk Assessment Financing Initiative
PGIS	Participatory GIS
PIC	Pacific Island Country
PLA	Participatory Learning and Action
PPGIS	Public Participatory GIS
QGIS	Quantum GIS
RMIPA	Republic of the Marshall Islands Ports Authority
RS	Remote Sensing

SOA	Service-Oriented Architecture
SOE	State-Owned Enterprise
SOPAC	Secretariat of the Pacific Applied Geo Science and Technology Division
SPC	South Pacific Commission
SPREP	Secretariat of the Pacific Regional Environment Programme
TCP	Transmission Control Protocol
UNDP	United Nations Development Programme
UN-OCHA	United Nations Office for the Coordination of Humanitarian Affairs
USLE	Universal Soil Loss Equation
USP	University of the South Pacific
WWW	World Wide Web
XML	Extensible Mark-up Language

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Chapter One

1.1 Introduction

The Cook Islands is made up of fifteen small islands scattered over approximately two million square kilometres of the South Pacific Ocean and a total land area of approximately 850000 square miles (Wood, 1967). Of the seven northern group islands, six are atolls, four of eight of the southern group islands are *makatea* islands and the others islands including Rarotonga, are volcanic (Wood, 1967). Rarotonga is the capital of the Cook Islands and is situated within the southern group of islands. The Northern Group islands are more than 1,250 kilometres from the capital, with the northern most island of Penrhyn approximately 1,365 kilometres from Rarotonga (Wood, 1967). These islands lie east of Tahiti of approximately 1140 kilometres, south of Hawaii of approximately 4730 kilometres and northeast of New Zealand of 3010 kilometres (Office of the Prime Minister, 2016). The Cook Islands is home to approximately 14,974 people, with a further 2,820 temporary residents (National Statistics Office, 2011). Approximately three-quarters of the population reside on the main island of Rarotonga (Policy and Planning Division, 2016). In 1965, the Cook Islands declared internal self-governing country in free association with New Zealand (Office of the Prime Minister, 2016). Since then, depopulation has been a continuous problem as Cook Islanders are eligible to New Zealand passports. The government views outward migration as a major threat to sustainable development. A steady increase in the number of migrant workers, primarily in the tourism industry, has acted as a counter to outward-migration (Office of the Prime Minister, 2016). The tourism sector, being the main economic driver for the country, has had much attention for development over the past decade. This is relative to infrastructure based projects such as the redevelopment of Rarotonga's main water supply, waste management projects, and renewable energy programs.

1.2 ICT in the Cook Islands

With regards to the development of Information Communication Technology (ICT), it is slowly progressing. Bluesky Cook Islands (BCI), a privately owned Samoan company, currently holds the monopoly of telecommunications to and from the Cook

Islands (Bluesky Cook Islands, 2015). Mobile devices (such as laptops, phones and tablets) are accessible, however internet speeds were still a problem for end-users as BCI is reliant on orbital satellites to connect to the international internet backbone, which is at times unreliable. However, the Cook Islands government have plans to improve internet speeds and costs by introducing fibre optic undersea cabling (Scott, 2016). Government recognises the importance of establishing fast, reliable and affordable internet for the country to increase economic and educational opportunities (NSDP, 2016-2020). Within the National Sustainable Development Plan (NSDP) 2016 -2020, ICT is not indicated as priority area for development. In fact, ICT is regarded as a tool to support government initiatives. Interestingly enough, most of these major projects are guided by Geographical Information Systems (GIS) and spatial analysis. GIS technology was only recently recognised as an essential tool for the development of infrastructure based projects. For example, land use maps, agriculture, environment, maps of existing electrical infrastructure and cadastral planning have helped to guide the development of a NZ$65 million dollar *Te Mato Vai* (water mains upgrade) project on Rarotonga (Office of the Prime Minister, 2016). Government's national project of 100% renewable energy goal by 2020 (SPREP 2011), has also adopted GIS maps to guide the implementation of the project throughout the Northern- and Southern-Group Islands.

Over the last decade, the ICT division of the Office of the Prime Minister (OPM) have been working hard to establish an e-government platform. Its core purpose is to support ICT needs of government bodies (Fernandes & Hunter, 2011). In spite of the success in establishing inter connectivity of most government departments and the establishment of some core competency skills, the ICT division are experiencing a variety of challenges such as staffing, capacity, funding, building and maintaining confidence with government departments (Fernandes & Hunter, 2011).

1.3 GIS in the Cook Islands

Over the past decade, the Cook Islands has experienced an increasing interest in GIS. This new technology has been used by some organisations in the Cook Islands to support decision makers in resource management, infrastructure development, emergency response, and planning. However, the development and sustainability of

GIS within these organisations has been somewhat "ad hoc" in terms of capacity building, technical support, adequate financing, and opportunities for further development.

Like most PICs, Geographical Information technology is fairly new for the Cook Islands. There are only a handful of technicians within government departments using GIS software on a regular basis, and most have acquired software skills on the job. Additionally, one state-owned enterprise (SOE) is using GIS for its commercial operations and decision making. Lastly, there is only one qualified GIS specialist working in the whole of the Cook Islands. This GIS group is small and it is likely that members have stories to tell of the challenges and tribulations within their areas of work.

While interviewing one of the older participants[1] of this research, I was able to get an insight to the history of GIS in the Cook Islands, when it started, who was involved and how it all began. One of the first GIS projects in the Cook Islands took place in the 1980's and was carried out by New Zealand Official Development Assistance (NZODA). The purpose of this project was to survey land use capabilities throughout the Cook Islands. The island of Atiu was used as pilot project, for the establishment of local technical expertise in surveying and the use of GIS software. As stated by the participant, "That project of course utilised GIS which was the first time we got exposed to it.... They funded the actual survey and training for PC ArcInfo." This particular project was to complement survey work carried out in the 1970's. Soil boundaries of the southern group islands were determined then, but was all in analogue format, ..." this was done by the department of science and industrial research in New Zealand.", claims the participant. The purpose of ArcInfo GIS was to refine the work of industrial research New Zealand utilizing digital technology. As a result of that particular pilot project, land use survey projects have been on-going and carried out in other parts of the Cook Islands.

The Secretariat of the Pacific Applied Geo Science and Technology Division (SOPAC) identified the need to establish GIS capacity within some PICs.

[1] Participants in this survey did not want their names to be disclosed.

Consequently, in 2010, SOPAC initiated an online, GIS pilot scheme in the Pacific, known as the Geo Portal system. In 2015, through the Emergency Management division of the Office of the Prime Minister, the Cook Islands first Geo Portal system was launched as an official platform for disaster risk management. Consequently, the research questions will help to identify some of the key challenges of GIS in the Cook Islands that are related to the challenges of implementing and sustaining Geo Portal systems. The development of the Cook Islands Geo Portal system is unchartered territory and this experience has the potential to inform other PICs about the lessons learned from this pilot scheme.

1.4 Research Questions

The participants were asked five qualitative research questions:

1. What were the past challenges in developing a GIS system?
2. What are the future challenges to sustaining GIS systems?
3. What opportunities are there for developing GIS capabilities?
4. What, if any, opportunities does GIS offer the Cook Islands or other PICs?
5. Currently, what form of GIS collaboration or information sharing is there between the Cook Islands Government departments?

The participants were also asked six quantitative questions:

1. Where was the GIS system developed?
2. What kind of software platform is used for your GIS system?
3. Who recommended the GIS system platform of choice?
4. What is the source of funding for your GIS system?
5. How many qualified person(s) maintain/monitor the GIS system within the organisation?
6. How many hours per day in total are dedicated to operate GIS?

1.5 Summary

This chapter introduced the Cook Islands, its ICT situation, and some history of GIS in the country.

This report continues with chapters comprising a literature review, a description of the methods used in this research, the results of the research and concludes with a discussion of the findings and results.

Chapter Two
Literature Review

2.1 Introduction

This literature review focuses on how the use of GIS technology has been carried out within the developed world, developing world, PIC's and, finally, the Cook Islands.

First, it is important to briefly review how ICT development has supported developing countries as it is emphasised in some of the GIS-based literature. Economic growth and sustainability of developing countries are of major importance to PICs. It is also essential for this research to briefly examine GIS in developed countries to make comparisons of GIS carried out in other parts of the world to GIS within the Cook Islands. This will assist in the discussion of the status of GIS technology and its progress in the Cook Islands.

2.2 ICT in Developing Countries

Walsham & Sahay (2002, p.18) describes the "digital divide" between those people with access to technology and the ability to make practical use of it, and those without. Of those who have access to the internet, there exists the challenge of educating them to use the internet effectively (Walsham & Sahay, 2002). Connectivity to the internet in poorer areas in developing countries was still a problem (Walsham & Sahay, 2002).

Heeks (2010) describes ICT as a basis for infrastructure development which was essential for general development of an economy. In 2010, US$800 billion was spent on information and communication technologies (ICTs) in developing countries by donor groups such as the World Bank (Heeks, 2010). Much of this investment was spent in developed countries as well, being the origin of ICT hubs (Heeks, 2010). The rise in mobile phones, the internet and the expenditure by users in developing countries is evidence that ICT increased due to donor investments (Heeks, 2010).

Heeks (2010) describes a model of ICT for development (ICT4D) as a way of identifying ICT contributions to economic development. The ICT4D model analysed:

a) The readiness of an economy for ICT, this includes policies and human resources.
b) The availability of physical ICT devices such as mobile phones and computer desktops within tele-centres.
c) The uptake of ICT, which focuses on the sustainable use of technology over time.
d) The impact which includes development results, outcomes or outputs of technology within an economy.

Jensen (2007) adds to this assertion, arguing that though there is a "digital divide" between those who can afford ICT and those who cannot (Jenson 2007, p. 920). There are farmers and fisherman in Kerala (India) that are benefiting from ICT, using mobile phones to determine the best markets for their products (Jenson, 2007). So it is not just call-centre workers and software engineers that are benefitting from ICT and using ICT on a regular basis, but those that have partial access to ICT are making good use of it as well (Jenson, 2007). Contrary to the digital divide, Jensen (2007) describes the "digital provide" as being the benefits gained of farmers and fisherman who do not have mobile phones to source markets from those who did (Jenson, 2007, p. 920). Jenson (2007) describes this as spill over gains for those who do not have access to ICT. Focus for ICT development should be on productivity or outputs of ICT as opposed to the focus on access and infrastructure of ICT (Heeks, 2002). Proof of ICT contribution to development happens as the impacts of ICT materialised in developing countries (Heeks, 2002).

Heeks (2010, p.107) also describes "hard-soft gaps" as a contributor to failures of information systems. In this case, internet technology (IT) development is based on rational thinking rather than the incorporation of cultural or political values (Heeks, 2010). Therefore, there is a disparity in "hard" rational design and "soft" political/cultural actuality. This was apparent for donor agencies carrying out rational IT objectives of developed countries within developing countries. For example, GIS concepts incorporate assumptions and context derived by Western rationalism and is

a problem when implemented in developing countries (Heeks, 2010). Additional to this, contextual gaps can be related to differences in information, technology, processes, objectives, values, staffing and skills (Barret et al., 2001). For example, when GIS was introduced to officials in India, the process of transitioning from long established practices to GIS was not straight forward. The reality is forestry decisions are based on district politics and social dynamics. Even if GIS provides timely and efficient analysis, it often falls short for local considerations; such was the case for forest districts in India (Barret et al., 2001). Furthermore, forest officials were anxious with use of GIS and other ICT applications as it was more scientific. Other forest officials regarded GIS as an opportunity to grow, to acquire new skills and further their careers (Barret et al., 2001). Barret et al., (2001) is supported by Britton (2000) claiming that the migration of skilled staff in PIC will always be a problem.

When introducing GIS to developing countries, not only does technology transfer takes place, but the transfer of assumptions, history and values of how work should be carried out (Barret et al., 2001). There is a huge difference between Western values and values of developing countries which influence's the technology transfer process (Barret et al., 2001). For example, developing countries are faced with limited resources such as a limited spread of computers as well as the scarcity to opportunities of spatial planning, and GIS technological transfer is based on the assumption that basic maps and basic spatial concepts are established within developing countries (Barret et al., 2001).

2.3 GIS in Developed Countries

GIS has been of great interest within many disciplines around the globe (Maguire, 1991). According to Maguire (1991), defining GIS was not an easy task. Perceptions of what GIS was and what it could do varied from discipline to discipline As a new discipline in itself, it was applied in various disciplines including mathematics, geography, surveys, computer science, zoology, economics and many others (Maguire, 1991). Consequently, GIS was unique in its heterogeneous nature and use in a wide variety of applications. The key difference of GIS compared with other information systems is the combination of databases, spatial analysis and mapping features (Maguire, 1991). The utilisation of these features along with the integration

of geographical data make GIS a robust tool to support decision-making. Maguire (1991) defined a GIS as a unified combination of technical components comprising of data, software, live-ware, and hardware. Moreover, Maguire (1991) states that this combination was normally utilised within institutions implementing GIS. Most GIS systems take time to mature before being routinely adopted.

Technological innovation and development, such as software and hardware, have put GIS in an ideal position for many applications (Fu-ling et al., 2007). For example, client/server web technology and the internet have led GIS to more opportunities such as databases, spatial data warehousing, data visualisation and spatial data knowledge mining. These are cutting edge technologies that are paving the way for further GIS development (Fu-ling et al., 2007).

In China, to successfully train GIS students, there were several expectations made of them. These included a firm grasp of technical knowledge, opportunities to practice their skills in various disciplines, encourage students to participate in domestic and international education and training opportunities in scientific research and development (Fu-ling et al., 2007). These expectations are to encourage students to be innovative in GIS (Fu-ling et al., 2007). Fu-ling et al. (2007) asserts that in order to improve GIS education standards in China, emphasis is required on scientific policy, an active involvement with the education reform, the encouragement of students to be innovative and the promotion of high-tech development strategies.

The growth of the internet has paved a way for geo-portal technology and GIS dissemination. Geo-portal systems were effective for disseminating GIS and capabilities through geographical Web services (Tait, 2005). The definition of a geo-portal is a web site where geographic material can be found with the emphasis of displaying geographic content (Tait, 2005). However, there are challenges identified in the use of geo-portal systems (Tait, 2005). Below I briefly discuss some of these challenges.

From the perspective of the GIS communities, there is a need to publish desktop-based maps onto the World Wide Web (WWW) using a geo-portal (Tait, 2005). Standard technical features of a geo-portal are search and browse capabilities of

geographic content (Tait, 2005). Other standard web services that support the geo-portal framework includes transmission control protocol (TCP), Internet protocol (IP), extensible mark-up language (XML) and hypertext mark-up language (HTML) (Tait, 2005). As a result, technical developmental challenges were encountered including the presentation of geographic content with associated functions, in a user friendly format (Tait, 2005). Fortunately, service-oriented architecture (SOA) was incorporated within the development framework. The SOA supported the presentation of geographical content at the user level, geographic functionality and data management of map content, such as raster and vector files. SOAs advanced the technical development of geo-portal systems which was widely accepted by GIS communities.

Geo-portal systems are becoming a standard way of sharing GIS content for both GIS and non-GIS users (Tait, 2005). Furthermore, GIS materials with associated geographical functionality are accessible via the internet and are helping to expand GIS communities (Tait, 2005). In spite of this development, there is still more work to be done to improve geo-portal functions and use (Tait, 2005).

Other challenges include the lack of standardised data that proves problematic for non-GIS users (Tait, 2005). It is important to address this challenge as it may reduce the confidence of non-GIS users with geo-portal systems, subsequently diminishing the effect of GIS dissemination (Tait, 2005).

Web based geospatial processing has evolved since 2005. Konstantinos et al. (2013) affirmed that the Open Geospatial Consortium (OGC) made it possible to use geo spatial web services such as Web Feature Service (WFS), Web Mapping Service (WMS) and Web Coverage Service (WCS) to allow data processing over the internet. These consequently led to the use of cloud based systems as viable medium to process and disseminate maps without the need of traditional GIS desktop applications. Wagner (2015) described ten GIS interactive cloud based systems such as Google Maps, Map Quest and CartoDB that have grown in popularity in a few years.

A web GIS collaborative spatial Delphi framework is an effective method to encourage collaborative planning of natural and traditional resources amongst decision makers (Dragićević & Balram, 2004). This method allows participants to enhance interaction in planning, consider traditional approaches in resource management and visualize data, which enhances understanding of planned objectives (Dragićević & Balram, 2004). Web GIS technologies are continually progressing, therefore functionalities and theories of applications will inevitably evolve to improve frameworks for communication, data interaction and decision making amongst policy makers and stakeholders involved in resource planning (Dragićević & Balram, 2004). Despite the success of the web GIS collaborative spatial Delphi framework, there are still more application improvements required to support policy makers and stakeholders involved with resource planning a management (Dragićević & Balram, 2004).

Roiste (2012) asserted that there is a shortage of geospatial skills in New Zealand. Geo spatial oriented organisations were more likely to employ graduates with industry experience, however there were little opportunities for internship programs Roiste (2012). In terms of growth and up-skilling of staff, organisations were supportive of staff attending conferences or vendor courses rather than pursue an academic qualification through a university. Roiste (2012) compares geospatial growth to other developed countries, such as United Kingdom and United States, and Roiste affirms that there exists strong growth of GIS in other developed countries compared to New Zealand.

Sui (2014) described open GIS as an approach to advance the GIS field. International Organisations such as the Open Source Geospatial (OSGeo) foundation were established to support open GIS, including open data, open software and open education and learning, (Sui, 2014). Embracing open GIS will help to resolve issues such as big data and understanding the planet better, (Sui, 2014).

Song et al. (2015) described the challenge of computing/analysing geospatial data intensive environments. Song et al. (2015) asserted that the use of GIS cloud technology such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS), as a solution to address big data storage issues and

geo analytical processing. Future improvements to information systems will therefore be associated within cloud system architectures rather than limitations with data such as storage capacity.

2.4 GIS in Developing Countries

Zeller & Wise (2002) discuss of cost, infrastructure, education and political stability as the main constraints to the use of GIS in developing countries. Additionally, one of the biggest problems with the use of GIS is the cost of computer equipment (Zeller & Wise, 2002). Gomez (2013) asserted that public access computing (PAC) are increasing in developing countries.

At a minimal cost, developing countries have demonstrated they can take advantage of GIS software as a management tool to achieve many positive outcomes. For example GIS has been used to control dengue outbreaks in Nicaragua (Chang et al. 2009). Public health workers used a combination of GIS mapping technologies such as ArcGIS and Google Earth to carry out health control strategies to address dengue breeding sites (Chang et al. 2009). Through the Global Fund, it was possible to implement these health programs at a low cost and without reliance of the internet (Chang et al., 2009).

GIS in South Africa, proved to be extremely useful in the development of policies, development planning, management and knowledge creation (MacDevette et al., 1994). GIS was used in all levels of government and private sector to assist with the development of information systems within areas such as geology, climate, education, census and the development of infrastructure based projects, including telecommunications and electricity infrastructures (MacDevette et al., 1994). However, political support was required to get the private sector, universities, non-government organisations, government and other institutions, to work together to develop acceptable user friendly standards that would have enabled communities to engage with GIS development more effectively (MacDevette et al., 1994). There was a need for senior officials in government to embrace GIS as an alternative tool for decision-making (MacDevette et al., 1994).

GIS and remote sensing (RS) can be used to construct ecological, economic and political patterns that are not so obvious for those carrying out research on the ground (Turner, 2003). These technologies have the potential to expand ones knowledge of the environment and anthropology in human ecological research (Turner, 2003). Spatial data analysts did not consider human culture and political ecology such as the colonial era that may have affected grazing pastures and herd management (Turner, 2003). Turner (2003) notes that technical expertise was unique for these technologies and these skills struggled to coincide with ecological and social research as these were unique disciplines (Turner, 2003). In spite of the usefulness of spatial information technologies, there was still much to discover how these technologies can be adopted by communities or individuals (Mohamed & Ventura, 2000).

2.5 GIS in Pacific Island Countries

2.5.1 Britton's Experiences

Britton (2000) addressed the use of GIS development for PICs. In this article he describes how Western GIS technology, literature and industry, do not fit appropriately in GIS development projects within PICs. For example, he discusses how technology transfer, including expertise, was not as simple as one might expect. Given that GIS has immersed very well in developed countries of plentiful resources, implementing GIS in PICs should be straight forward. This is fundamental to modernisation theory where developing countries learn and evolve from the developed world. However, this is not the case for PICs. Britton notes that established GIS communities in the West were developed over time, especially with project opportunities outside the classroom. This resulted in independent GIS learning across multiple disciplines. These types of opportunities do not exist for developing countries. He notes that capacity building projects for GIS communities require a great deal of assistance from Western GIS trainers. Resources, a small population base, emigration of skilled workers, language and communication are all constraints for GIS development in developing countries (Britton, 2000). Apart from this, the hindrance of development is not only associated with the technology itself, but a range of issues including infrastructure, culture, attitude, skills, knowledge,

management and leadership. Subsequently, Western GIS education practices often do not consider these issues beforehand.

Because technology changes rapidly in Western countries, the geography science field was not maturing with changes reflective on theoretical material (Britton, 2000). The changes in technology also reflected on GIS as its definition was unclear in Western countries. As a result, technology transfer to developing countries was also a problem, (Britton, 2000). These problems included economic, technical, and cultural differences between developed and developing countries. The issues were beyond the scope of the technology. However, projects that had the means to transfer technology do not acknowledge this as a problem (Britton, 2000). This resulted in poor GIS diffusion. A more effective solution was to implement GIS training and education for individuals and management of organisations, integrating a social setting instead of a formal approach. Small populations exist within PICs and a typical GIS community was comprised of no more than five people (Britton, 2000). Therefore GIS implementation should be focused on individuals recognising their aspirations, personal motives, abilities and also taking into account their cultural values. GIS implementation must strategically align with culture as this will reflect on communication, learning and lead to the discovery of a process of which was best suited for GIS development (Britton, 2000).

Britton acknowledges development of GIS is important for the Pacific region. There was a need to utilise GIS within conservation and infrastructure based projects in PICs (Britton, 2000). However, Britton identified various issues during implementation of GIS training and education, including the limited number of GIS users in the community with a limited knowledge base, inappropriate training methods implemented over short periods and technical issues. Britton noted that GIS learning projects actually stood a better chance of success if the training programs were carried out over longer periods. This will allow development groups to learn the culture, including the attitude and behaviour of how local staff learns. Additionally, projects carried out over longer periods were more successful as the time-frame allowed needs to be recognised and skills transfer to occur. It was asserted that those development staff with allot more experience in GIS training were often more effective (Britton, 2000). Despite some of the success stories, Britton asserted that

more research was needed to assess how GIS and education is to be diffused in developing countries.

Britton (2000, p. 6) described a "richer model" for GIS advancement in developing countries. This model suggests that before GIS development is carried out in developing countries, one must try to understand their unique strengths of the people in the country for GIS development, their expectations, the limitations faced, the conditions they work in, the learning environment and the realities that exist. More specifically, this includes approaching local GIS communities to develop existing strengths and learning environments by providing local GIS users long term work projects. This would result in the development of skills and abilities of GIS independently.

Britton noted that aide funded development programs implemented by external parties usually failed. Projects attached with GIS components struggled due to poor timeframes, poor planning, no follow-ups and the loss of opportunities. Projects carried out over longer periods were more successful as the time-frame allowed needs to be recognised and skills transfer to occur.

There are local groups within PICs that will seek overseas assistance to carry out GIS work. Britton asserts that while this approach was cost effect and efficient, it was not necessarily sustainable. In order for GIS sustainability to take place, developing countries should reduce the reliance of external assistance (Britton, 2000).

Britton (2000) emphasizes that GIS education and training is best delivered by regional and educational organisations of the Pacific. These Pacific institutions must collaborate with GIS entities of the developed world. Furthermore, the informal human development area including GIS Individuals and GIS local user groups was also expanding at the time Britton wrote the article. He noted that these user groups helped reduce the cost of regional training conferences.

2.5.2 Britton's Experiences - Fiji

Within Fiji, the use of digital communication, user group meetings, networking and newsletters were effective means for the establishment of a strong GIS community. This approach was seen as a more cost effective method to enhance GIS skills of practitioners within Fiji government and education institutions. However, growing the GIS user base to include other PICs was always a challenge, due to the cost of communication, particularly internet, and travel. This is why SOPAC and USP were excellent organisations to diffuse GIS in the region. While formal GIS education has its place within the USP, SOPAC endeavoured in GIS education and development for PICs. These organisations are committed to GIS diffusion in PICs including end-user networking and provide long term solutions and sustainable human resource development of GIS in PICs. Advancing the local user group internationally was also challenging as the costs and distances to attend events were unrealistic for local GIS users.

SOPAC, now called SPC are committed to promoting the use of GIS in PIC as a tool to better respond to climate change and disasters (SPC 2016). The PCRAFI project was one example of consolidating map layers of PIC for the purpose of developing disaster risk modelling tools (UNFCCC 2012). PIC map layers can be viewed at http://gsd.spc.int/maps-and-spatial-data-repository, available at the time of this thesis.

2.5.3 GIS in Vanuatu

On the island of Efate, Vanuatu, GIS was used in conjunction with the universal soil loss equation (USLE) model to analyse erosion caused by natural disasters such as cyclones and human activities (Dummas & Fossey, 2009). Using the USLE model with GIS mapping was a method recommended to examine soil erosion within other PICs (Dummas & Fossey, 2009). USLE results in Vanuatu would have been better if adequate land use data (agriculture data) was sufficiently available. In spite of limited research funds available in the Pacific, especially for soil degradation and coastal management, the USLE model was suitable for the Pacific as it was still possible to derive soil erosion scenarios in conjunction with GIS, and with limited

data available (Dummas & Fossey, 2009). It is duly noted that with limited funding available in PICs for research, there are methods available that will allow one to produce information required, however it is not in the best of quality due to limited research data available.

2.5.4 GIS in American Samoa

Challenges identified within the GIS community of American Samoa were getting GIS data into the hands of community activists and resource managers (Wright, 2002). Apart from that, there was the challenge of implementing GIS training for groups to use GIS tools to make better and meaningful decisions (Wright, 2002). There were also duplication of work, services and competition between a small number of highly skilled GIS practitioners in America Samoa (Wright, 2002). An approach suggested to address some of these challenges were to harness a small student pool with the intention of practicing GIS in the workforce, both in-country and abroad, and through a mentors training programme supported by academic institutions (Wright, 2002).

2.5.5 GIS in the Solomon Islands

Using GIS to develop marine conservation programs was fast becoming popular. GIS tools were used to assist with the development of marine protected areas (MPAs). Incorporating spatial information such as artisanal fishing data and indigenous knowledge was important for MPA development in the Solomon Islands (Aswani & Lauer, 2006). Mapping human behaviour and human activities based on local knowledge was unique as it allowed researchers to form meaningful conjectures relative to marine and environmental ecology. Furthermore, incorporating indigenous knowledge for marine conservation was rewarding for local people as they felt a sense of empowerment participating in conservation programs (Aswani & Lauer, 2006). Spatial data visualisation was an effective method to convey scientific information with locals who lacked a technical background (Aswani & Lauer, 2006). Using GIS data management functions such as data storage, data editing and data spatial analysis helped to better understand and manage sophisticated socio-ecological systems (Aswani & Lauer, 2006).

2.5.6 GIS in Niue

Dawe (2000) described how the use of global positioning system (GPS) devices and GIS database supported the mapping of water pipelines within some of the villages of Niue. SOPAC assisted with this project by providing existing map layers such as coastlines, dwellings and roads, which helped to narrow the search of underground water pipes (Dawe, 2000). Despite the success of the project within a short period, extended work was required to map the water pipelines for several of the other villages. It was hoped that development of these GIS maps would be used to assist the Niuean government with maintenance, planning and management of Niue's water supply for the future (Dawe, 2000).

2.5.7 GIS in Fiji

In 1989, the Fijian government supported the establishment of a Fijian Land Information System (FLIS), (Rakai & Williamson, 1995). This initiative was crucial for the economic planning and land utilisation. While there were achievements made under the FLIS strategy such as the support of the project by local groups, there were also issues faced then, including training of local staff and data standards of which third party users of LIS could not agree with, (Rakai & Williamson, 1995). Rakai & Williamson (1995) also claimed that incorporating customary land tenure systems was challenging as western tenure systems were influential and did not benefit rural indigenous communities), (Rakai & Williamson, 1995).

An issue highlighted by the Fijian government and development partners concerning GIS databases within PICs was that Geographical databases are spread over various agencies of PICs (Chung, 2009). It was agreed that these information systems needed to be shared, updated and amalgamated for the development of effective disaster risk management and response (DRM&R) programs, (Chung, 2009). In 2008, a web-based information portal called the Pacific Disaster Net, for Disaster Risk Management (DRM) was developed by various regional and international technical organisations including the United Nations Office for the Coordination of Humanitarian Affairs (UN-OCHA), the International Federation of Red Cross

(IFRC), SOPAC, and the United Nations Development Programme (UNDP) (Chung, 2009). The aim of the website system was to centralize geographic databases throughout the Pacific in the hope to enhance DRM and disaster risk reduction (DRR) capacity of PICs (Chung, 2009).

2.6 GIS in the Cook Islands

One of the goals of the Cook Islands Heritage Trust was to develop an online database system to digitally record all birds and plants throughout the Cook Islands (McCormack, 2007). Basic GIS was incorporated into this project to geographically display the locations of animals and plants. However, McCormack indicated a lack of GIS skills and personnel to sustain the GIS component of the project (McCormack, 2007).

GIS mapping was incorporated into the monitoring program of Cook Islands black pearls. Since 2001, Manihiki black pearls of the Cook Islands have faced a rapid decline in exports. This was partly due to a disease outbreak in the oysters containing pearl nuclei, which affected the growth of pearls (McKenzie, 2004). A sustainable development plan of the black pearl industry to avoid future disease outbreaks was the goal of the Cook Islands Ministry of Marine Resources (MMR), (McKenzie, 2004). Besides various methods used to monitor the chemical and physical parameters within the lagoon, GIS mapping of the lagoon bathymetry was indeed a useful tool to assist with the development of a lagoon management plan for best pearl farming practice (McKenzie, 2004). GIS capacity building workshops were carried out by SOPAC to educate staff of MMR to use GIS for monitoring and analysis purposes of Cook Islands black pearls (McKenzie, 2004). In addition to the objectives of the workshops, it was expected that GIS would be applied in other areas of marine resource management of the Cook Islands (McKenzie, 2004).

2.7 Integrating Traditional Knowledge into GIS

Within PICs, there is an opportunity for people to contribute traditional ecological knowledge in GIS systems for the development of marine conservation areas, (Calamia, 1999). PICs establish agencies to manage and develop marine resources

strategies; however actual control and management of resources are of local groups (Calamia, 1999). Opportunities exist to manage resources more effectively if locals are included in the development of geographical information systems with the incorporation of traditional knowledge, (Calamia, 1999). Involving locals in the development process of marine conservation empowers the people as they are more likely to make better local decisions that align with government objectives. Calamia (1999) suggested that a setup of GIS workstations within local communities utilizing standard GIS attributes may be another way to acquire GIS data for government agencies. Funds are limited for conservation programs, therefore using GIS and local marine knowledge was an effective strategy for marine agencies to carry out their work and to ensure that marine conservation were effective (Calamia, 1999).

Latu (2009) encourages the use of GIS visualisation techniques to support sustainable development in environmental, economic and social initiatives of PICs. However, some politicians and economists within PICs view conservation activities as a restriction to economic development (Latu, 2009). Latu notes that decision makers in traditional societies are often unaware of expert advice supported by GIS spatial information, even though the uses of GIS is improved to factor in modelling and visualisation of terrain features that would have allowed decision makers to view the condition of resources they were managing for future use (Latu, 2009). Latu (2009) also asserts that if objectives set by PICs were to manage resources sustainably, then information needed to be reliable and made available for interested groups, even for the public. This type of approach can be called a public-participatory GIS (PPGIS) which Latu says is an effective method for decision-making of resource management (Latu, 2009). Janssen et al. (2012) asserted that access to public information can help stimulate innovation and improve decision-making , however there was no real way to forecast what the returns of investment were. More research was required into the benefits and value of open data (Janssen et al., 2012).

This is supported by Sieber (2006), who described the use of PPGIS in public consultations. That is, involving the public to develop policies and to promote the goals of social groups, including nongovernmental organisations and community based organisations (Sieber 2006). Using PPGIS is a unique method to engage

participants as it allowed them to include traditional knowledge, environmental or social factors that may not have been initially considered. At the same time, participants get a sense of empowerment by being part of the decision-making process Sieber (2006). Latu (2009) described that empowering local people in PICs with GIS and visualisation tools means educating, providing and allowing them to have access to technology to incorporate their knowledge and experience and to be able to use GIS tools on their own.

2.8 GIS and Regional Organisations in the Pacific

This concept of PPGIS was advocated by regional organisations such as SOPAC and the Secretariat of the Pacific Regional Environment Programme (SPREP) who are actively promoting the use of GIS technology and visualisation tools through a series of workshops and conferences throughout the Pacific (Latu, 2009). In order for sustainable technical development to be established in PICs, such as the education of spatial analysis, ICT experts are encouraged to do their best to understand the people, the culture and traditions within societies (Latu, 2009).

The European Development Fund, in conjunction with SOPAC, implemented an ICT development project within PICs (Allinson, 2003). The purpose of the fund was to reduce the vulnerability of PICs through the planning and management of systems associated with hazards, water and sanitation through the establishment of ICT expertise, such as GIS and RS (Allinson, 2003). The project included objectives to strengthen water resources and sanitation; aggregate construction; and hazard mitigation and risk assessment. Apart from these objectives, the project also aimed to address issues such as the lack of technical expertise, lack of ICT resources and the lack of accurate, timely and reliable data. GPS, database management, GIS and RS were identified as essential tools for this project (Allinson, 2003). The use of ICT with GIS tools was promoted as the solution to improve and support decision making for sustainable development in PICs. What was also identified were possible areas that required strengthening such as the establishment of a RS support centre, capacity building of open source and development, increased collaboration between stakeholders, improved policies between stakeholders, establishment of infrastructure (such as tele-centres) and the development of human resources (Allinson, 2003).

The development of the Integrated Coastal Management (ICM) plan for marine resource management within cultural and indigenous coastal areas of Fiji was achieved by incorporating GIS with community based discussions, (Thaman & Aalbersberg, 2004). The ICM plan included the integration of GIS maps of health and population created by a GIS graduate and other specialist within the field of marine science (Thaman & Aalbersberg, 2004). With regards to capacity building and sustainability of the ICM program, staff of the Institute of Applied Science, USP, as well as community members, were trained with SOPAC in GIS. The implementation of the ICM program was implemented in conjunction with capacity building initiatives of leaders, continuous support by stakeholders and promotion and awareness of the project (Thaman & Aalbersberg, 2004). It was expected that marine resource management will be in a better position as this will improve income opportunities for locals, enhance coastal water quality and management of live coral, through the ICM program and GIS development (Thaman & Aalbersberg, 2004).

2.9 Challenges for GIS Development in Pacific Island Countries

Participatory GIS (PGIS) was an emergent practice for developing countries. This was a combination of participatory learning and action (PLA) and geo-spatial information technologies and systems (GIT&S) (Rambaldi et al., 2006). Despite the effectiveness of using PGIS in developing countries, there were still challenges identified. Since PGIS was focussed on community, this was not the case as implementation carried out by those originating from developed countries was focussed on data management (Rambaldi et al., 2006). Additionally, PGIS faces methodological and implementation issues such as the socio-political context that provides the basis for PGIS applications (Rambaldi et al., 2006).

Experience in GIS development in PICs has indicated that one of the key challenges for the development and implementation of GIS have more to do with the behaviour and attitudes of people towards technological advances and opportunities (Britton, 2000). The successful development of GIS systems is more than just the learning and application of the technology: It also depends on the relevance of GIS within an

organisation and the emotional attachment by GIS technicians to their work (Britton, 2000).

Another challenge is the slow development of a GIS community as this usually does not happen quickly: “The main problem that remains for GIS development in the PICs is the amount of time it will take to establish a robust and sustainable local GIS community” (Britton, 2000, p. 15).

The aim of this mini-thesis is to critically examine the development and use of GIS technology in the Cook Islands from its beginning to the present day. Outcomes from this research will contribute to the body of literature dealing with the development of GIS technologies in developing countries in general, and PICs more specifically.

2.10 Summary

This chapter reviewed the literature on the subject and found that the questions about GIS in the Cook Islands were a gap in the literature.

The next chapter outlines the methods used to conduct this research.

Chapter Three
Methodology

3.1 Introduction

The objective of this chapter is to describe the processes that were used to collect and analyse the data of this report. The data collection and analysis was for the purpose of yielding results in order to answer the research questions. The task was to derive research data and information by first determining appropriate scientific and systematic processes (Kothari, 2004). These processes, which are outlined in this methodology, were modelled using 'The Research Onion' (Saunders, Lewis &Thornhill, 2011, p. 106) (see Figure 1).

3.2 The Research Onion

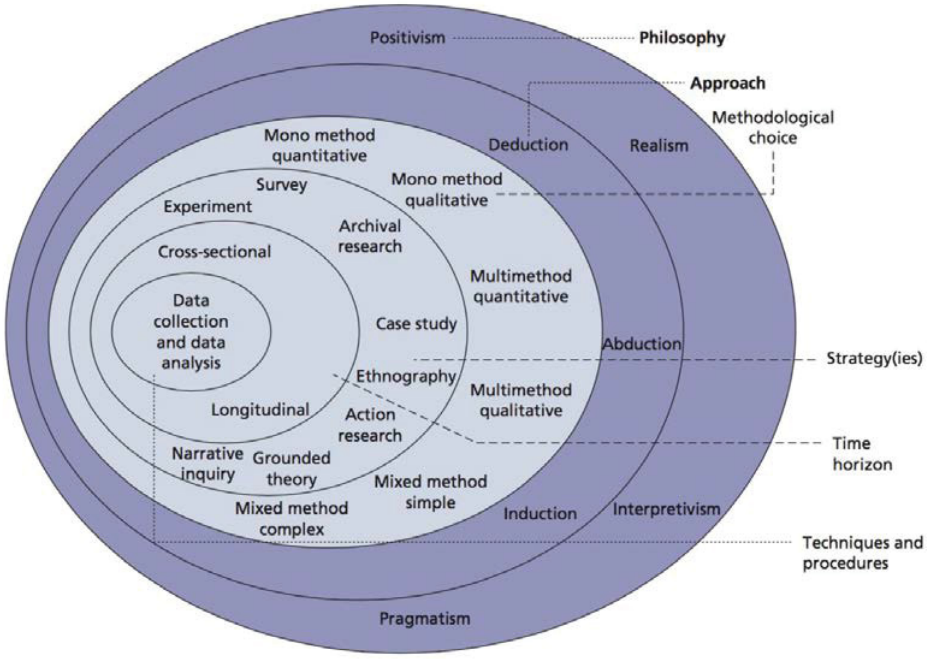

Figure 1: The Research Onion (Saunders & Thornhill, 2011, p. 106).

Saunders et al., (2011) described the Research Onion as a model to depict various data collection and analysis procedures that may be considered before collecting research data. Saunders et al., (2011) argued that when peeling aware each onion

layer, working towards the central part of the onion, the researcher should be able to determine the most effective technique and procedure for data collection and analysis (Saunders et al., 2011).

The Research Onion assisted this researcher to think about why and how processes or procedures for collecting data should be carried out (Kothari, 2004) and was a useful academic research framework for the establishment of a research strategy (Bam, 2014). The end result of the Research Onion was to provide this researcher with a clear methodological path to collect and analyse research data (Saunders et al., 2011). The six layers are now explored, from the outer to the inner layers, and the processes used in this research are described.

3.2.1 Philosophy

Philosophy, the outer layer of the Research Onion, encouraged the researcher to consider his principal assumptions in order to understand the philosophical choices that underpinned the choices made for the research (Saunders et al., 2011).

This research was influenced by two philosophies: interpretivism and pragmatism. Interpretivism is relative to social constructivism and in order to understand the particular actions of others, it was important for the researcher to explore or interpret the meanings and motivations of their actions (Saunders et al., 2011). Bodner (1986) stated that knowledge creation is expected, using a constructivist approach, and that 'knowledge is constructed in the mind of the learner' (Bodner, 1986, p.1). To make sense of this world, a researcher must interpret and construct the meaning of actions (Schwant, 1994). How the participants interpreted their roles in accordance with the meaning they gave those roles and how the researcher interpreted the participants' roles in accordance with his own set of meanings (Saunders et al., 2011), informed this research.

Pragmatism steers the focus towards the practical consequences of research findings and recognises that there are a number of ways in which the world can be interpreted (Saunders et al., 2011). Pragmatism supports the use of mixed research methods and analysis which results to useful social knowledge (Yvonne, 2010). Pragmatism also

allows that multiple methods of research may be the most appropriate for a particular study (Saunders et al., 2011). The use of pragmatism in this study reflected the researcher's acknowledgement of the importance of firstly, using mixed methodology in order to best answer the research questions; secondly, the interpretations of the participants and the researcher; and lastly, the practical consequences of the research results.

3.2.2 Approach

This research worked with information presented, an inductive approach, as opposed to the creation or evaluation of a hypothesis, which is a deductive approach (Saunders et al., 2011). Using an inductive approach allowed the research to generate a conceptual framework based on the exploration of a phenomenon, identification of themes, and analysis of data (Saunders et al., 2011). The strength of the inductive approach was to facilitate the understanding of how human beings interpreted the social world (Saunders et al., 2011).

3.2.3 Methodological Choice

A mixed methods format was chosen as the most appropriate option for this research. Adopting a mixed method approach for this research facilitated the likelihood of yielding high quality results (Johnson et al., 2007) because this is a richer approach to the interpretation, data analysis, and data collection (Saunders et al., 2011).

This mixed method research used both qualitative as well as quantitative data collection techniques and it was possible for both to be carried out in sequential order (Saunders et al., 2011). Creswell (2013) asserted that a mixed methods approach was popular amongst researchers seeking to acquire data both qualitatively and quantitatively.

Data collection for this research consisted of a series of qualitative, semi structured interviews with GIS practitioners within the Cook Islands. At the conclusion of each qualitative interview a series of questions from a brief questionnaire was put to the participants in order to collect quantitative data (see Appendix A).

Emden and Sandelowski (1998) asserted that though there are numerous methods to carry out good quality research, qualitative interviews were one of the most ideal forms of collecting data. Moreover, interviews are the most commonly used method for collecting qualitative data (Diccico-Bloom & Crabtree, 2006).

It is important however, that the validity and reliability of the data thus collected is ensured for excellent research results (Emden &Sandelowski, 1998). Creswell and Miller (2000) emphasised the use of validity procedures such as triangulation (a search for convergence of information from various sources to identify a common theme) and member checking (credibility check of the interviewee) to produce the best qualitative results. By interviewing several participants, this research triangulated the data and the experienced GIS practitioners who were interviewed had excellent credibility.

The qualitative, semi structured interviews involved predefined open-ended questions including undetermined questions that surfaced through the dialogue between the researcher and the participant (Emden & Sandelowski, 1998). These were followed by the closed-ended questions that were collecting the quantitative data (Whiting, 2008).

3.2.4 Strategies

The strategies used in this research were a combination of ethnography and a survey. Ethnography requires researchers to be involved with the people they are studying in order to understand their human experience (Cunliffe, 2010). The researcher is required to be engrossed in the society of the participants in order to develop rapport with them (Saunders et al., 2011). So as to record how a particular community lives, the researcher studies ‘events, language, rituals, institutions, behaviours, artefacts, and interactions’ (Cunliffe, 2010, p. 227).

The researcher had been a GIS practitioner in the Cook Islands for some years, was immersed in the community he was studying, and had already built relationships and interacted with the research participants prior to this study.

A brief survey, using a questionnaire, was conducted with each participant in order to collect quantitative data.

3.2.5 Time Horizon

Cross-sectional studies are those that study certain research phenomena and are carried out over a short period of time (Saunders et al., 2011). Considering the limited time frame available, a cross-sectional design was used for this research.

3.2.6 Techniques and Procedures

The data was collected in a series of individual, qualitative interviews with the participants, which were immediately followed by a brief, quantitative survey.

The data were analysed using two different techniques: a framework analysis of the qualitative data and a quantitative analysis, with descriptive statistics, of the quantitative survey.

Srivastava and Thomson (2009) stated that framework analysis was an excellent qualitative method for research that had a set of issues to be dealt with, a predefined sample to work with, was carried out within a short period of time, and aimed to answer explicit questions. The framework analysis procedure was comprised of key issues, determined from the data, which was sieved through a five-step process:

1. Familiarisation – the researcher is immersed with the data collected;
2. Identification of a thematic framework - common themes are noted in the data;
3. Indexing - the identification of data portions that belong to a particular theme;
4. Charting – the thematic data was formatted systematically and placed within headings and sub headings; and
5. Mapping and interpretation - data evaluation and making sense of the data set (Srivastava & Thomson, 2009).

Ritchie and Spencer (1994) advocate the categorisation of research questions into four areas; namely contextual, diagnostic, evaluative and strategic. In the context of this research, this is demonstrated in the table below:

Table 1: The Categorisation of the Research Questions

Category	**Goal**	**Sample Questions**
Contextual	Identifying the form and nature of what exists.	What is the nature of people's experiences? What factors affect or determine the nature of GIS systems? What components operate within a GIS system?
Diagnostic	Examining the reasons for behaviour of what exists.	What factors underlie particular attitudes or perceptions of a GIS practitioner? Why are decisions or actions taken, or not taken? Why do particular needs arise? Why are services or programs not being used?
Evaluative	Appraising the effectiveness of what exists	How are objectives achieved? What affects the delivery of program services? How do services affect subsequent behaviour? What are the barriers that exist that prevent GIS systems operations?
Strategic	Identifying new theories, policies or plans.	What type of services are required to meet needs What actions are required to make programs or services more effective? How can systems be improved? What strategies are required to overcome defined problems?

A brief survey was conducted with each participant in order to collect quantitative data that could be analysed quantitatively with descriptive statistics.

3.3 Detailed Description of the Research

The researcher carried out one-on-one interviews with five Cook Islands based GIS practitioners, all of whom participated willingly in the research. The participants were aged between 25 to 54 years and the mean age was 42.8 years. The interviews lasted from thirty minutes to one hour and were conducted in a private room at the participant's workplace.

The research participants were five of the fourteen current members of the GIS group. The majority of members operate within government departments and organisations such as state-owned enterprises, while the rest work in non-profit organisations and the private sector. Thus the participants make up roughly a third of the Cook Islands GIS community. The mix of participants reflected the membership with four working for the government and one working outside the government.

Prior to the commencement of each interview, the researcher covered the ethical issues. Participants were informed that any information they provided would only be used for this research project and a thesis based on this research would be submitted to the USP for assessment. Additionally, the participants were told that any personal information, such as their name or age, would not be disclosed within the thesis. The participants were made aware that they could withdraw from the research at any time without any penalty and that if they were not comfortable answering a particular question, they were not required to do so. The participants were asked to give their permission for the interviews to be recorded. Participants were then asked to sign the consent form/questionnaire for confirmation and authentication purposes.

Each participant was then asked a series of five qualitative questions. During a few of the interviews, some of the questions were re-worded by the researcher for clarification, as some of the participants were finding it difficult to gather their thoughts with the predetermined questions. There were some occasions where prompt questions were required by the researcher. These were usually to clarify the meaning of answers, to gain more information, and to steer the focus back to the predetermined questions.

Following the qualitative interviews, the participants were asked the six quantitative questions on the printed questionnaire and their answers were written on the paper by the researcher.

The researcher made hand-written notes during the interviews and recorded the interviews on his laptop computer. The voice recordings were transcribed immediately after the interviews to ensure the accuracy of the information, which was backed up by the written notes.

At the end of the interview participants were given the opportunity for additional comments. Three participants did not wish to make any further comments, as they were satisfied with the answers they provided throughout the interview. However, two participants expressed concerns or gave additional information on matters directly and indirectly related to GIS in the Cook Islands.

3.4 Summary

This chapter described in detail the methods used to conduct this research.

The results of the interviews and the survey questionnaire are given in the next chapter.

Chapter Four
Results

4.1 Introduction

This chapter shows the results of interviews conducted with five GIS practitioners based in the Cook Islands. The results are presented in two distinct parts, qualitative findings based on the analysis of semi-structured interviews and quantitative results from surveys conducted with the participants.

A note about the presentation of the findings: In order to preserve the participants' anonymity, any identifying information has been deleted. Where this has occurred, the information has been replaced with (…) or (a generic name) to indicate where this replacement occurred. The meanings of the participants' words have not been altered.

4.2 Qualitative Questions

The participants were asked five qualitative research questions:

1. What were the past challenges in developing a GIS system?
2. What are the future challenges to sustaining GIS systems?
3. What opportunities are there for developing GIS capabilities?
4. What, if any, opportunities does GIS offer the Cook Islands or other PICs?
5. Currently, what form of GIS collaboration or information sharing is there between the Cook Islands Government departments?

4.3 Qualitative Findings

Question 1: What were the past challenges in developing a GIS system?

In response to this question, the participants indicated that there had been a number of challenges to developing a GIS system.

One challenge was the task of converting paper-based material to a digital GIS format. This particular task required a great deal of time and effort to carry out as there was limited capacity in human resources, technology, and expertise, to cope with the large volumes of data. In one case, these limitations meant that the conversion could not be done in the Cook Islands.

"...most of the information was in physical copies/analogue copies so nothing was digitised. So one of the first priorities was to gather all the information and put it in a format that can be interpreted in GIS digital format including tabular format. So it was a huge exercise. We ended up contracting it out to a company ... (overseas)".

Another challenge was the task of sifting through thousands of uncategorised records to assign geographical coordinates to asset data.

"We compiled data and formed tables to bring up on the (computer). The issue that we had then was we didn't have the actual coordinates of all (the data) .... So when we put it on (the computer) it was all placed in the middle of the map of (the island.) It took me a while to move the points to the location of (the data) .... There were thousands of points, all plunked in the middle of the island".

A further challenge was the limited technology available, as computers were not only expensive but also had low computing capability to process applications.

"...when we started off in the 1980's....there were limitations on hardware.... PCs 386 cost about seven grand... there wasn't much you can store on, I think it was a 20MB hard drive and in terms of RAM I think it was 640 kilobytes....".

One participant described the promising start to, and support for, GIS in his division. However, this subsequently dwindled due to lack of support.

"When I jumped on as the GIS Officer I was .... going out and doing all the mapping ... as time went on they saw that it was a good idea to have a full time position in place for a GIS person ... but I think they hit a bit of a wall with the other divisions .... It wasn't really a priority for them".

The analysis of the responses from the participants to Question 1 about past challenges showed that:

- The participants had been faced with a huge task;
- There were limitations of personnel, skills, and technology;
- The participants demonstrated, hope, enthusiasm, commitment, and motivation; and
- The participants had subsequently been left feeling somewhat disappointed as their expectations were not met and there was limited support.

Question 2: What are the future challenges to sustaining your GIS system?

The participants indicated that the future challenges revolved primarily around the attitudes of colleagues, managers, and heads of government ministries. In addition, the poor ICT infrastructure and lack of skilled personnel throughout the Cook Islands also created challenges for the future development of GIS.

Participants discussed the lack of understanding of GIS at management level. One described how managers encourage the use of GIS but would not spend the money necessary for its proper implementation.

"... the main challenge I've noticed is the lack of understanding by management in ministries. I keep hearing that there is a need for GIS but there is a lack of willingness to invest in it".

Another participant stated that the GIS officers always have to justify projects. This poses an obstacle to support and creates an inability to advance GIS.

"... a big challenge ... always having to explain these projects with your manager and they find it hard to understand it so yeah it's the understanding and support to advance".

One participant indicated that, despite repeated trainings and capacity building exercises, the staff were still reluctant to incorporate GIS into projects. Workplace training was key to adopt GIS into workflow environment.

"I try to include them as much as I can, for capacity building purposes. But, like I said, I can provide them with as much training buts really up to them to include GIS in their work plan, rather them just constantly learning the introductory stuff and not use it".

Participants also related stories of having their expert advice sought and then ignored.

"The sad thing about it is, you explain it to the people who are depending on you to provide the advice, and they don't listen to you. That's what pisses me off."

Another future challenge was that the national ICT infrastructure was limited by the slow and unreliable Internet connection in the Cook Islands and the lack of skilled GIS human resources in the government network.

"And probably the more recent challenge is the slow internet connection ... ICT.... or internet communication ... to me the network is very limited .... Simple things, like get (*sic*) access *to our database from outside. I still couldn't get to it from (overseas), even though I wrote how many emails".*

One participant described how he was using his own hardware due to the lack of government hardware.

"*... I have my old GPS device but ... you need to have a camera, you need to have a GPS and you need to have a laptop for this kind of work. For me I have my own video camera just to get information from old people ... you record it, I bought that. I got my other camera, just for images".*

The participants also highlighted the limitations in GIS human resources throughout the Cook Islands. One participant explained that while some outer islanders had

been trained in GIS on the main island of Rarotonga, they still lacked capacity in GIS.

"There's no one else on (outer island 1) that knows how to do the work. There's no one in the outer islands. There are two guys in (outer island 2)… they flew over to (outer island 1). I was way ahead of them and they had been trained here on Rarotonga and I am too advance (*sic*) *for them".*

Analysis of the responses to Question 2 about future challenges found that:

- The lack of understanding from colleagues and management was limiting future development of GIS;
- This lack of understanding also led to advice being ignored, needs being unacknowledged, and GIS officers resorting to using their own personal hardware for work;
- The participants were feeling sadness and frustration, annoyance at having to use personal resources; and undervalued; and
- Some participants expressed feeling 'pissed off' and there was a sense of hopelessness from them.

Question 3: What opportunities are there for developing GIS capabilities in your place of work?

Participants indicated that the opportunities to develop GIS in the workplace are hampered or prevented by the managers' lack of understanding of GIS. This manifests itself in a number of ways.

One participant complained about not getting GPS units that were budgeted for and how it would be a useful tool to improve geo coordinates accuracy,

"I asked for a GPS unit two years ago. We budget for it but he used the money somewhere else. That really pissed me off … When other departments ask for our coordinates; we tell them it's not really accurate. They ask how come? We tell them

we don't have a GPS unit. If we had a unit, we'd go right around the island to pick up everything".

Another participant stated,

"*I was supposed to run those training programs but we never had time. When I had time, nobody else had the time. Even for a couple of days …"*

A participant talked about having to explain the technology,

"… but I guess the problem is them, they don't know what they really want and of course, on our side is trying to understand what they really need or what they really want. So I guess, the job will be up to us to explain to them what the technology can do for them. I've come across this many times".

The lack of management understanding has led to staff not using the GIS data due to lack of training and its non-inclusion in work plans. It was clear that if an organisation was to adopt GIS, a re-engineering of business processes was required.

"We need to incorporate it into their work plan so they are not just to capture data, but to display that data within GIS applications".

There is no funding for GIS development and staff,

"And again that was another challenge because (the project) wasn't allocated any funds for the position, so I was actually funded by external sources …"

However, one participant, whose employer was enthusiastic about GIS, stated that while there were still limitations of available technology, the training of staff in GIS was on-going and encouraged;

"If there's a training session we book a time of the day, we go in the (training) room and we sit down, we have to do that, and everyone attends …"

The analysis of the participants' responses to Question 3 about workplace opportunities for GIS showed that:

- One participant, who worked for an organisation that was supportive of GIS development, felt good about passing on his knowledge to others; enjoyed developing human resources, and was optimistic about the future of GIS at his workplace;
- In general, the participants believed that the opportunities to develop GIS in the workplace were hampered or prevented by the lack of staff and management understanding; the lack of training; the GIS budget being spent on other things; the underutilisation of the GIS data; and that the only available funding for GIS was from overseas; and
- Again, the participants expressed frustration, feeling hopeless and 'pissed off', and undervalued.
- To leverage GIS skills gained within the workplace, opportunities exist with USP for GIS staff to acquire a Bachelor of Geo Science.

Question 4: What, if any, opportunities does GIS systems offer the Cook Islands or other PICs?

Only one participant was able to point to a GIS development in the Cook Islands, which had the potential to create opportunities.

"*So this is um ... is innovative in the sense that we are one of the first countries to actually establish (this) office and to actually have all the technical systems in place and we've kinda taken a different approach from different countries where we are doing this slow and steady making sure we have the legislative components are sorted, making sure we have the technical components sorted before we actually start (sharing this)".*

Analysis of the responses to Question 4 about opportunities showed that:

- One organisation had developed a new system using GIS that had potential opportunities for the Cook Islands and other PICs; and
- The GIS officer was pleased with the result, proud of this innovative system, and wanted to share it with others in the country and region.

Question 5: What form of GIS collaboration or information sharing is there between the Cook Islands Government departments?

The participants indicated that there was no formal collaborative structure in place for GIS information sharing.

One participant stated,

"*It's just trying to get to that advance level of sharing because I think.... a lot of the problems we have here is you gather information, you create data sets, but that's where it stops, like ... ah ... you wanna be able to share that information …".*

Another participant said,

"*I think we are alright with producing information it's just getting that information out there …"*

However, the participants described how GIS officers have created an informal GIS user group.

"We have a Cook Islands GIS user group and we all work together quite well. Like if I ever have any questions or things like that, I can always email them and usually get a good response. This is also a good way to bounce off ideas from one another".

Analysis of the responses to Question 5 on collaboration and information sharing found that:

- There is no formal information sharing or collaboration on GIS in either the public or private sector; and

- The participants' feelings of lack of support, advancement, and value were offset by the support they received from the members of the GIS user group.

4.4 Quantitative Questions

The participants were asked six quantitative questions:

1. Where was the GIS system developed?
2. What kind of software platform is used for your GIS system?
3. Who recommended the GIS system platform of choice?
4. What is the source of funding for your GIS system?
5. How many qualified person(s) maintain/monitor the GIS system within the organisation?
6. How many hours per day in total are dedicated to operate GIS?

4.5 Quantitative Results

Question 1: Where was the GIS system developed?

This questioned was quantified in three distinct categories:

1. *Overseas*- the development was supported externally;
2. *Locally* - the development took place in-country; or
3. *Combination* - development took place in with combined efforts of both overseas and in-country capacity.

The results show that three GIS systems were developed in combination and two were developed locally (see Figure 2).

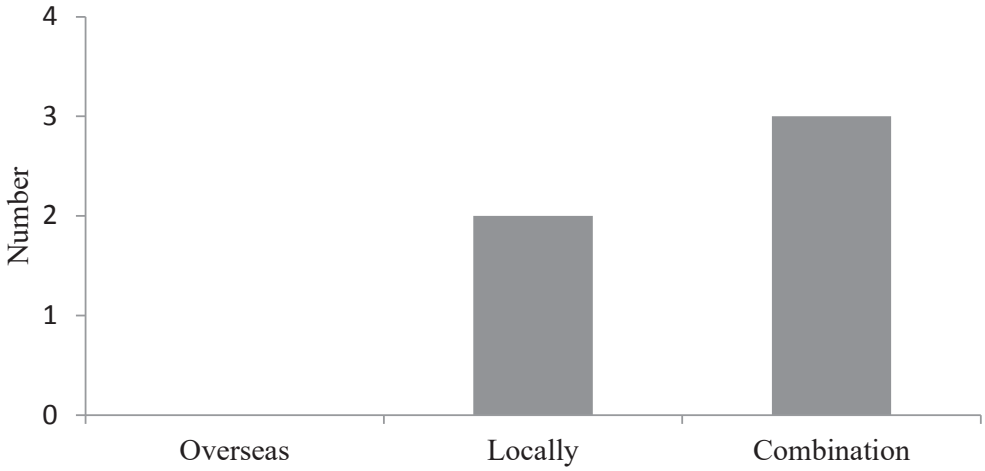

Figure 2: Where the GIS System was Developed.

Question 2: What kind of platform is used for your GIS system?

The broad types of GIS software are:

- Commercial based products;
- Open-source solutions; or
- A combination of both.

The results show that three GIS systems use commercial software, one uses open-source software and one uses a combination of both (see Figure 3).

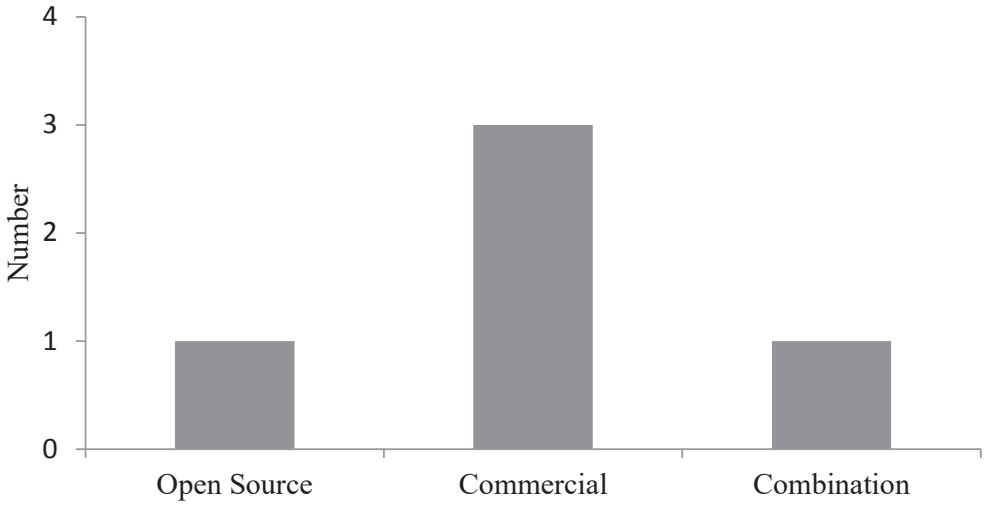

Figure 3: The Software Platform that is Used for GIS Systems.

Question 3: Who recommended the GIS system platform of choice?

This question was to determine if GIS advice for a platform of choice was sourced from:

- IT personnel in country;
- Overseas; or
- A combination of both.

The results show that two GIS systems received advice from IT personnel in the Cook Islands, two from overseas, and one from a combination of both (see Figure 4).

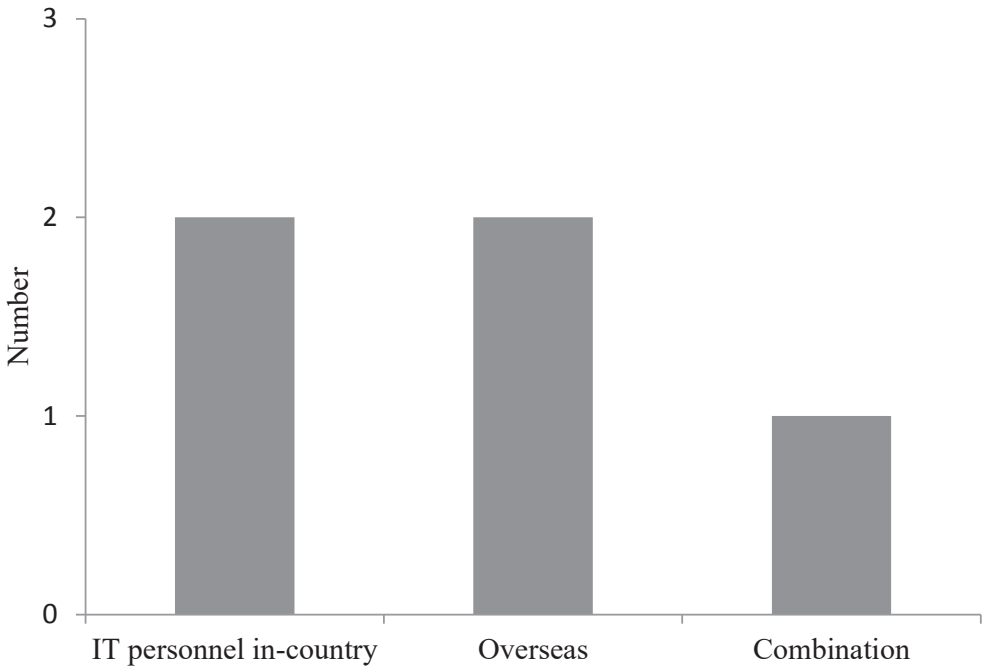

Figure 4: The Source of Recommendations for the GIS System Software Platform.

Question 4: What is the source of funding for your GIS system?

This question was asked in order to determine the level of funding support provided by:

- The Cook Islands government;
- Aid from overseas donors; or
- A combination of both.

The results of this question show that two GIS systems had received aid funding from donors; two GIS systems had received a combination of both, and one GIS system had received funding from the Cook Islands Government (see Figure 5).

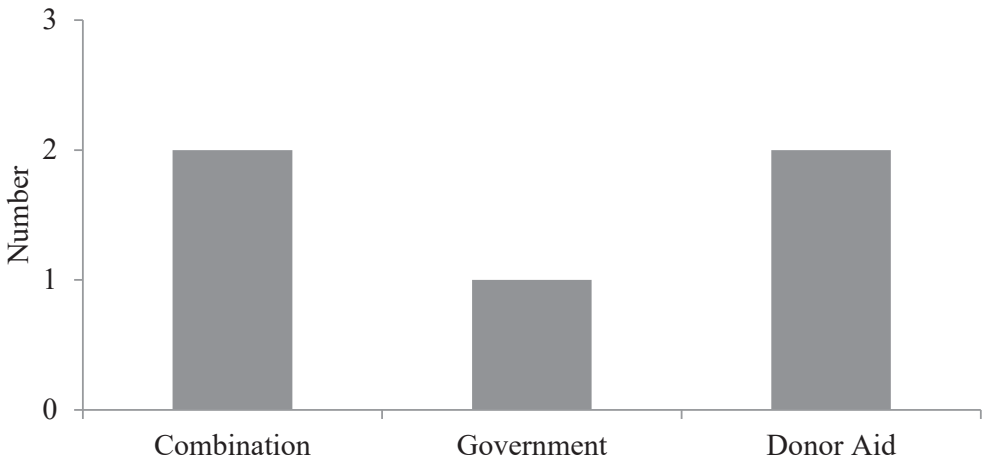

Figure 5: The Sources of Funding for the GIS Systems.

Question 5: How many qualified person(s) maintain/monitor the GIS system within the organisation?

This question was asked in order to determine the number of personnel working on GIS systems, within each organisation.

The results show that one organisation has four GIS personnel, and the other four organisations have one GIS staff member each (see Figure 6).

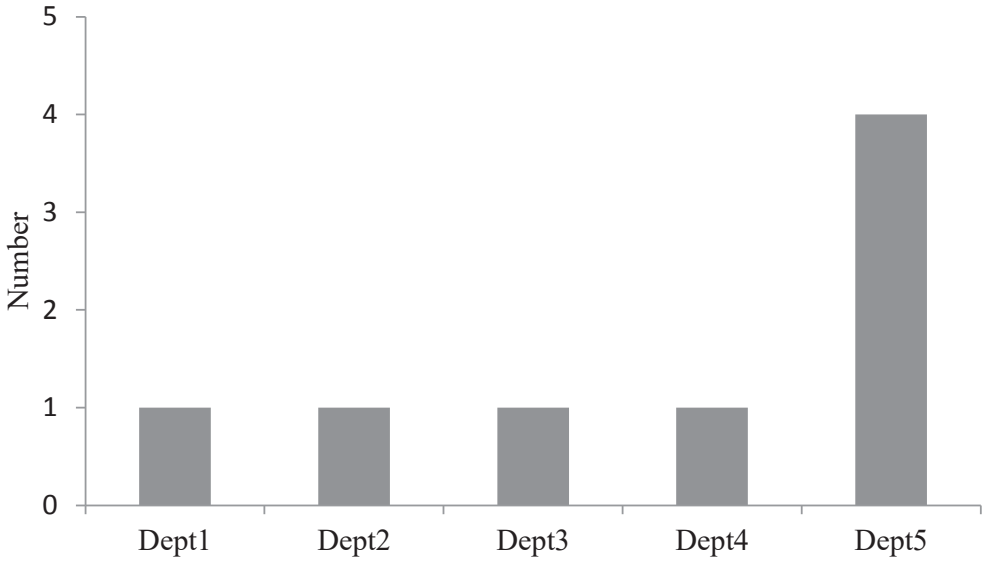

Figure 6: The Number of Person(S) Working on the GIS System Per Organisation.

Question 6: How many hours per day in total are dedicated to operate GIS?

This question was asked in order to determine the amount of time the GIS officers are working on GIS systems.

The results show that one organisation spends 17 hours daily on its GIS system, another one spends five hours daily on its GIS system, two organisations spend three hours each on their GIS systems, and one spends at least two hours a day on GIS (see Figure 7).

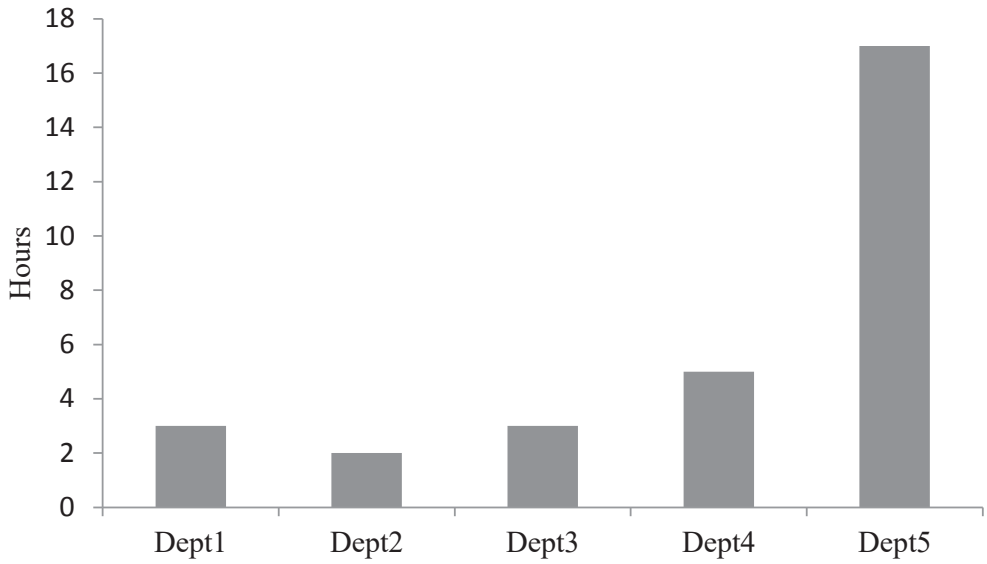

Figure 7 The Number of Daily Hours for Operating a GIS System.

4.6 Summary

This chapter showed the findings of the qualitative research and the results of the quantitative research conducted for this report.

The next chapter discusses these findings and results and draws conclusions from them.

Chapter Five
Discussion

5.1 Introduction

This chapter discusses the results in the previous chapter and draws conclusions from this research. The purpose of this study was to identify the challenges of developing and sustaining GIS in the Cook Islands. Cook Islands GIS practitioners were interviewed to collect qualitative as well as quantitative data for analysis.

Like other PICs, the Cook Islands are faced with limited IT specialist services. This study shows how GIS evolved in the Cook Islands as well as how it continues to develop. The research revealed that there had been various challenges in developing GIS in the past; that GIS challenges are currently being experienced, and are expected to continue in the near future; that opportunities for developing GIS in the Cook Islands appear limited; and that a GIS user group has been formed for collaboration and information sharing.

In light of GIS software used within the Cook Islands, this thesis identified three distinct GIS software used amongst the participants. Quantum GIS (QGIS), is the primary open-source solution used, MapInfo and ArcGIS are the commercial based applications in use. Figure 3 indicates that GIS commercial based software has a strong presence in the GIS community. Most of the GIS applications are used to develop desktop based maps. However, with the advent of the Cook Islands Geo Portal project of the EMCI and the recent introduction of ESRI Arc GIS server portal through the *Marae Moana* (marine conservation) Project, the GIS community are encouraged to use web based solutions to promote, collaborate, enhance and prevent the duplication of GIS maps through geo portal systems. Through the *Marae Moana* project, the Cook Islands government was donated a three year licenses of ESRI Arc GIS products including ArcPro Desktop and ESRI Arc Server Portal. The most recent development is that ESRI Arc Portal has been installed on the Cook Islands government network and is ready for use. The current technical level of ESRI Arc software amongst the GIS community in general is minimal, however with close collaboration and information sharing amongst the group, including the support of

ESRI Arc community, the prospects for the use of ESRI Arc products in the Cook Islands have dramatically improved.

As enticing as these geo portal opportunities are for the GIS community, there are a number of challenges that are preventing geo portal systems from being used effectively. These challenges are subject to this research and are discussed within this chapter.

5.2 Discussion of the Qualitative Findings

5.2.1 Past Challenges

The first qualitative finding identified the challenge of converting paper-based material to a digital GIS format. This particular task required a great deal of time and effort to carry out as there was limited capacity in human resources, technology, and expertise, to cope with the large volumes of data. In one instance, this included sifting through thousands of uncategorised records to assign geographical coordinates to asset data. This finding supports Ayris (1998), who asserted that the digitising of information was time consuming and required careful thought in the criteria.

This finding also concurs with Steinmueller (2001), who found that developing countries were faced with limitations with IT in general and with specialised services, such as GIS, in particular. In the Cook Islands, if an IT service is unavailable in country, organisations often look to New Zealand or Australia for assistance. In one finding, these limitations meant that the conversion service was not done in the Cook Islands and the GIS digitisation process was contracted to a company overseas.

The second finding discovered that another past challenge was that the high cost of computing hardware, together with the very limited performance, had made it difficult to implement GIS projects in the Cook Islands. This finding supports Zeller and Wise (2002), who asserted that one of the biggest problems with the use of GIS was the cost of computer equipment. This finding also concurs with United Nations

Secretariat (2008) and Allinson (1999), who stated that computing software and hardware used for GIS mapping in the PICs was not sufficient for GIS operations. However, Britton (2000) stated that the reductions in costs of microcomputers have helped to address a few problems in implementing GIS in PICs.

The third finding was that, despite initial enthusiasm for GIS, this subsequently dwindled due to lack of support. This finding is in agreement with Dragicevic and Balram (2004), who stated that GIS technologies would need to evolve in order to improve the framework for communication, data interaction, and decision making for policy makers. This finding also concurs with Britton (2000), who discussed the need to understand the unique strengths of people, their expectations, the limitations faced, the conditions they work in, the learning environment, and the realities that exist.

5.2.2 Future Challenges

The first finding with regards to future challenges was the lack of understanding of GIS by managers. This manifests itself in a number of ways: GIS officers having to justify projects; the use of GIS is encouraged but management does not spend the money necessary for its proper implementation; and staff not using GIS due to lack of training and its non-inclusion in work plans. This finding supports Britton (2000) who asserted that the lack of GIS support at management level in other PICs led to technology, funding, and human resources issues. These issues included capable staff being re-allocated into other divisions (Britton, 2000). This finding also concurs with Ndou (2004), who stated that developing countries have ICT funding, policy, and human resource issues.

The second finding revealed that the national ICT infrastructure was limited by the slow and unreliable Internet connection in the Cook Islands and a lack of appropriate hardware. This finding concurs with Walsham and Sahay (2002), who concluded that connectivity to the Internet in poorer areas in developing countries was still a problem. This finding also supports Zeller and Wise (2002), who found that cost, infrastructure, education, and political stability were the main constraints to the use of GIS in developing countries. Lastly, this finding agrees with Britton (2000), who

asserted that, compared to global standards, the cost and speed of Internet in the Pacific hindered the diffusion process of GIS in the region.

The third finding was that there were limitations in GIS human resources throughout the Cook Islands. One participant, who carries out GIS projects in the outer islands, explained that even those outer islanders who had been trained in GIS on the main island of Rarotonga, still significantly lacked capacity in GIS. This finding supports Turner (2003), who stated that technical expertise was unique for these technologies, and Mohamed and Ventura (2000), who found that, in spite of the usefulness of spatial information technologies, communities or individuals were struggling to adopt this technology. This finding also agrees with Forstreuter (2011), who stated that PICs needed assistance to establish GIS.

5.2.3 Workplace Opportunities for Development

The overall finding was that opportunities to develop GIS in the workplace were hampered or prevented by the lack of staff and management understanding, which was demonstrated in several ways.

Firstly, there was a lack of training. This finding supports Britton (2000), who identified various issues during implementation of GIS training and education. These included the limited number of GIS users in the community, who had a restricted knowledge base, and inappropriate training methods, which were only implemented over short periods (Britton, 2000). This finding agrees with Chen et al. (2010), who asserted that developing countries were slow in developing technological knowledge and Ndou (2004), who discovered that ICT training was lacking in those countries.

Secondly, the lack of training had meant that staff were not using the GIS data in their work, nor were they, or their managers, including it in their work plans. The one participant, whose employer encouraged GIS use and training among all the staff, found those running regular training sessions for all employees in an informal way, was successful. This finding concurs with Britton (2000), who found that effective GIS training and education programs in organisations, for both individuals

as well as management, was achieved by integrating the training social settings instead of formal approaches. This finding also supports Britton (2000), who noted that GIS learning projects stood a better chance of success if the training programs were carried out over longer periods. This finding also agrees with Jovanović, V & Jovanović, R. (2002), who asserted that the establishment of GIS involves training of personnel, including experts, in the management and implementation of GIS.

Thirdly, not only were managers seeking good expert advice from the GIS officers, which was subsequently ignored, but also managers were spending money, previously budgeted for GIS GPS hardware, on other items that were not related to GIS. The importance of GPS to the development and implementation of GIS that the participants related supports Dawe (2000), who described how the use of GPS devices and GIS database supported the mapping of water pipelines in Niue.

Lastly, only very limited funding was allocated to GIS and its development. Moreover, the majority of funding for GIS in the Cook Islands had come from overseas. This finding supports Heeks (2010), who stated that, in 2010, donor groups, such as the World Bank, spent US$800 billion in developing countries on their ICT. This finding also concurs with Allison (2003), who described the funding of GIS in PICs as part of an ICT development project by the European Development Fund in conjunction with SOPAC.

5.2.4 Opportunities from GIS in the Cook Islands and PICs

The only finding from this question was that one organisation in the Cook Islands had successfully used GIS to create an innovative system, which had the potential to create opportunities across the country and across the region.

5.2.5 Collaboration and Information Sharing

The first finding was that there was no formal information sharing or collaboration on GIS in either the public or private sector. This finding is in contrast to the current practice in Fiji, where the use of digital communication, user group meetings, networking, and newsletters had been effective in establishing a strong GIS

community (Britton, 2000). This finding also diverges from Tait (2005), who recommended the use of geo-portal systems as a means to effectively share GIS information.

The second finding was that the GIS officers have taken the initiative and created an informal GIS user group at which they gain support, information, and recognition from each other. This finding agrees with Allinson (1999) who discovered that a Cook Islands GIS user group had been formed after SOPAC conducted training in the country. This finding also supports Britton (2000), who not only acknowledged the benefits of informal human development, including GIS individuals and GIS local user groups, but also asserted that these were expanding. Additionally, the fact that there was only a handful of members in the Cook Islands GIS user group concurs with Britton (2000, p. 15), who stated "The main problem that remains for GIS development in the PICs is the amount of time it will take to establish a robust and sustainable local GIS community".

5.2.6 Participants' Responses

This research uncovered a wide range of emotions felt within the Cook Islands GIS community. The participants expressed hope, enthusiasm, commitment, and motivation. On the other hand they also felt frustration, disappointment, and hopelessness, as well as feeling undervalued and 'pissed off'.

One participant described the promising start to, and support for, GIS in his division. However, the support and enthusiasm dwindled due to the poor attitude towards GIS. Another participant indicated that, despite some training and capacity building exercises, the staff were still reluctant to incorporate GIS into projects. These findings support Petch and Reeve (1999), who asserted that the successful implementation of new managerial strategies may be largely influenced by organisational politics, as people can be unpredictable in their response to change. These findings endorse Wright (2002), who found that the best methods to train personnel in American Samoa were by implementing mentorship or apprenticeship programmes.

These findings concur with Britton (2000), who asserted that one of the key challenges for the development and implementation of GIS in PICs was the behaviour and attitudes of people towards technological advances and opportunities. The successful development of GIS systems is more than just the learning and application of the technology: It also depends on the relevance of GIS within an organisation and the emotional attachment by GIS technicians to their work (Britton, 2000). "[I]mplementation of GIS in the developing world, as elsewhere, must address the personal motives, fears, aspirations, abilities and context of practical and emergent GIS practitioners"(Britton, 2000, p. 5).

5.3 Quantitative Results Discussion

5.3.1 Where the GIS System was Developed

The answers to the first quantitative question showed that three of the GIS systems were developed in a combination of overseas and local developers, while two of the GIS systems were developed locally. This result supports Gum (2014), who found that the Republic of the Marshall Islands Ports Authority (RMIPA) were only able to successfully develop a GIS map of the airport when they worked in combination with the Federal Aviation Administration (FAA). This result also agrees with Aswani and Lauer (2006), who asserted that the development of GIS for protected marine areas in the Solomon Islands was made possible by combining local knowledge with GIS technology. Lastly, this result supports Forestreuter (2011), who found that the Cook Islands MMR worked closely with SOPAC in order to develop GIS systems for monitoring black pearls on the island of Manihiki.

5.3.2 The Software Platform

The responses to the second question show that four out of five organisations used commercial software either exclusively or in combination with open-source software. Only one organisation used open-software alone. This result demonstrates that there is a strong presence of commercial based GIS software and minimal use of open source GIS software in the Cook Islands. This result supports Wright (2002), who found that commercial software and hardware were both used in American Samoa to

build GIS capacity. This result is in contrast to the research and recommendations of Chen et al. (2010), who asserted that open source GIS software was best suited for developing countries.

5.3.3 Who Recommended the Platform

The results of third question show that two of the software platforms were recommended by IT personnel in the Cook Islands, two were recommended by overseas organisations, and only one recommendation was made from a combination of local and overseas advice. This result supports Britton (2000), who asserted that PICs that will frequently seek overseas assistance to carry out GIS work. However, Britton (2000) asserted that while this approach appeared cost effective and efficient in the short term, it was not necessarily sustainable. This view was endorsed by Allinson (1999), who stated that one of SOPAC's key objectives was to facilitate sustainable GIS software solutions for PICs.

5.3.4 The Source of Funding

The answers to the fourth question show that most GIS funds in the Cook Islands come from aid donors, with four out of the five organisations receiving support from this source. Only one GIS system had received funding solely from the Cook Islands Government. This result supports Allinson (2003), who found that donor funds are being channelled towards the development of ICT and GIS in PICs. This result also concurs with Heeks (2010), who asserted that donor investments were making a difference in the ICT sector of developing countries. Lastly, this result agrees with Forestreuter (2011), who asserted that US aid supported GIS development in the PICs in hardware, software, and salaries.

5.3.5 The Numbers of Personnel and Hours per Day

The results of the fifth and sixth questions show that four organisations have only one GIS staff member each, which meant that the time dedicated to GIS in these organisations, ranged from two to five hours per day. However, one organisation has four GIS officers, which resulted in 17 hours per day spent on operating their GIS

system. These results concur with Forestreuter (2011), who found that SOPAC was required to finance full time GIS positions in order to enable GIS development in PICs.

5.4 Limitations

This research experienced limitations. They were:

- **Size of the Thesis:** As a mini thesis the size was limited to a relatively small word count. This meant that other aspects of the research questions could not be explored.
- **Time Available:** This research had to be carried out and completed within a few months, which also limited the scope of the research.
- **Resources Available:** Additional resources would have been helpful in order to acquire some research equipment such as a tape recorder. This equipment could have improved the successfulness and the effectiveness of the research by a better quality of recording and playback.

5.5 Recommendations

The aim of this research was to provide an insight into developing and implementing GIS in the Cook Islands. Additionally, as the Cook Islands is a small developing country, this study could serve as a case study for other PICs looking to implement GIS. Therefore, to assist the GIS development in the Cook Islands and other PICs, the following recommendations are made.

- Managers of departments that are using GIS should be educated in order to:
    - Understand GIS technology
    - Know its capabilities and functions;
    - Apply it to their projects; and
    - Support the staff who implement GIS.

- A robust ICT infrastructure should be created in the Cook Islands as soon as possible because:
    - It is paramount for the technical development of GIS;
    - It would allow dissemination of GIS to the rest of the Cook Islands more effectively;
    - It would support the use of geo portal systems as a geographical information sharing platform; and
    - It would facilitate the establishment of GIS networks.

Although, the constraints of hardware to support GIS are gradually becoming less of a problem, the cost of commercial GIS software is an issue for the Cook Islands and also likely to be one for PICs. There have been developments in open source GIS software that make it a practical GIS solution for the Cook Islands. Therefore, it is recommended that open source software is sourced and adopted. Not only will this give the country an affordable GIS software platform but also this will enable the Cook Islands to tap into the knowledge of the many thousands of developers of GIS software globally.

5.6 Conclusion

The presentation and discussion of the findings and results of this research indicate that there are a range of challenges for GIS practitioners in the Cook Islands.

The results showed that the challenges of the past were considerable. Not only was the enormity of the task an obstacle but also there were severe limitations of technology and personnel. Nevertheless, the GIS officers had embraced the challenges as highly motivated and hopeful practitioners of a new and dynamic system that would benefit the Cook Islands.

The study found that, having successfully established GIS systems, the officers faced additional challenges, which continue to affect the future of GIS in the Cook Islands. The primary cause of these challenges was found to be the lack of understanding by management about GIS. This, in turn, led to crippling limitations on usage, funding, training, and development as well as misunderstandings and ignorance from

colleagues. It is apparent that these continue to be obstacles and create an inability to advance GIS in the Cook Islands. Furthermore, opportunities to develop GIS in the workplace are hampered or prevented by the managers' lack of understanding of GIS, leading to such situations as GIS-budgeted expenditure having been used for other projects.

ICT infrastructure and network support is important to advance GIS in the Cook Islands. In spite of emphasis made by the Cook Islands Government to establish an e-government inter-connected network, this research found that there are challenges to overcome, such as poor ICT infrastructure, limited human resources, and minimal technical expertise.

It was apparent in this study that the Cook Islands GIS officers had strong feelings, which they freely expressed. The GIS practitioners initially felt enthusiasm and motivation, along with a sense of making a difference for the nation. However, the officers now feel frustration, disappointment, and 'pissed off'. Additionally, they feel undervalued and, the longer these negative experiences and feelings continue, the more hopelessness they expressed. Nevertheless, despite these strong and valid emotions, the GIS officers continue to achieve moments of triumph, which, when they share these with the other members of the user group, help to boost their confidence and enable them to carry on.

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Appendix A

GIS Research Questionnaire

I, ……of,

Name of Organisation: .....……

agree to participate in research for a USP, Master of Information Systems by answering the qualitative and quantitative questionnaire below and having my/our responses collated, analysed, and published in the research thesis.

Signed: …….

Dated: ……..

Qualitative Questions

1. What were the past challenges in developing a GIS system?
2. What are the future challenges to sustaining GIS systems?
3. What opportunities are there for developing GIS capabilities?
4. What, if any, opportunities does GIS offer the Cook Islands or other PICs?
5. Currently, what form of GIS collaboration or information sharing is there between the Cook Islands Government departments?

Quantitative Questions

1. Where was the GIS system developed?
    a. Overseas ☐
    b. Locally ☐
    c. Combination ☐
2. What kind of platform is used for your GIS system?
    a. Open source: ☐
    b. Commercial: ☐
    c. Combination: ☐
3. Who recommended the GIS system platform of choice?
    a. IT personnel in-country: ☐
    b. IT personnel overseas: ☐
    c. In-house: ☐
    d. Other: (please specify) ☐

    ……..
4. What is the source of funding for your GIS system?
    a. Government: ☐
    b. Donor Aid: ☐
    c. Combination: ☐
5. How many qualified person(s) maintain/monitor the GIS system?
    a. Number of persons: …….
6. How many hours/day are dedicated to operate the system?
    a. Hours/day: …….