A Public Safety, Participatory Crowdsourcing Smart City Model for a Developing Country

by

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By

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Abstract

Worldwide the population in cities is increasing. It is the responsibility of local government to provide public safety services in order to ensure the safety of their citizens and, yet, the local government often have inadequate resources to do this. '*Smart Cities*' is a new and innovative concept that has emerged during the past few years and which involves using current infrastructure and resources more effectively and efficiently. One of the methods used to collect data in a smart city is participatory crowdsourcing but, in order to ensure effectiveness and efficiency, it is essential that a large amount of data be collected from the participants in such a project, who are generally citizens residing in the city.

This study was conducted in the city of East London, which is part of the Buffalo City Metropolitan Municipality (BCMM). The study made use of a Design Science approach with a mixed method data collection method. The quantitative data collection comprised a questionnaire that was completed by 394 participants, while the qualitative data collection included a detailed literature review, conversational analysis and observations arising from the building of the crowdsourcing system prototype. The design artefact produced by this research is a model based on the literature, conversational analysis and the principles and concepts learnt from the prototype. Thus, this model represents what must be incorporated in the prototype to assist with the implementation of a public safety, participatory crowdsourcing smart city in a developing country.

The model includes three areas – the crowdsourcing system, the city (Buffalo City Metropolitan Municipality) and the citizens of East London. The crowdsourcing system incorporates factors of information security, specifically the CIA triad, and the usability of the crowdsourcing system. Usability includes characteristics such as the quality of the system and interface, as well as the usefulness of the public safety, participatory crowdsourcing system which was used to measure the confidence of the East London citizens in the system. Three steps were identified in the literature as being necessary for the implementation of a smart city project by a city. These steps include the planning, development and delivery of the smart city project. Finally, the trustworthiness of the public safety participatory crowdsourcing system is determined by the ability, reliability and benevolence of the system. These three characteristics were included in the citizen factor of the model.

Keywords: smart city; crowdsourcing; public safety; developing country.

Declaration

I, Liezel Cilliers, hereby declare that:

- The work in this thesis is my own work.
- This thesis has not previously been submitted in full or partial fulfilment of the requirements for a qualification at any other educational institution.
- I am fully aware of the University of Fort Hare's policy on plagiarism and I have taken every precaution to comply with the regulations.
- I am fully aware of the University of Fort Hare's policy on research ethics and I have taken every precaution to comply with the regulations. Ethical clearance certificate number: **FLO011SCIL01.**

  Name: Liezel Cilliers

  Signature: 

  Date: 10/01/2014

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Chapter 1
INTRODUCTION

1.1. Prologue

Worldwide the population in cities is increasing and, in fact, it is estimated that more than half the world's population currently resides in urban areas (Owen, 2009; UNPD, 2007). This urban movement presents government and municipalities with very definite challenges that must be considered as city infrastructure and consequently service delivery is put under severe strain. Local government cannot keep up with this demand for service delivery and must find alternative methods to use existing resources more effectively and efficiently (Harrison & Donnelly, 2011).

One possible solution to the problem is a *'smart city'*. This concept makes use of Information and Communication Technologies (ICTs) in order to integrate the operation of urban infrastructure and services, including buildings, transportation, electrical distribution, water distribution and public safety (Harrison & Donnelly, 2011).

There are several methods that may be used to collect data from the citizens in a smart city. One of these methods, crowdsourcing, refers to a group of individuals who collect data, or who report on certain events of a similar nature, and pool all the data which has been collected (Mehta, 2011). The data gathered may then be transferred to central information processing systems in order to anticipate upcoming events or isolate problems areas (Ling & Masao, 2011). Crowdsourcing is especially advantageous in developing cities as existing ICT infrastructure can be used (Kumar, Agarwal, & Manwani, 2010)

It is essential that developing cities find a way to use information more intelligently in order to consume resources more effectively and efficiently (Harrison & Donnelly, 2011). Smart city projects have been implemented in the developed (first world) countries and, while these projects do provide valuable insights into the way in which to implement a smart city initiative successfully, the requirements of a developed, as opposed to a developing city, differ (Kumar, Agarwal & Manwani, 2010). Some of the typical challenges in a developing city include low literacy rates, high unemployment rates, high poverty levels and the unavailability of technology, all of which will impact on the implementation and success of a smart city (Kumar et al., 2010). Relevant literature indicates that,

currently; there is no specific model for the implementation of a smart city project in a developing country. However, this research project aims to address this gap in the literature.

This introductory chapter starts with a brief introduction to a smart city, followed by the description of the problem area under investigation in this research project. This is followed by a discussion of the problem statement and research questions. A summary of the outline of the research design and research methodology follows. The proposed model is introduced in section 1.6, while an outline of the remaining chapters in the thesis concludes this chapter.

1.2. Introduction to a Smart City

Smart cities have the potential to assist local government or municipalities to use existing resources more effectively and efficiently. In this thesis, the terms '*local government*' and '*municipalities*' will be used interchangeably. Smart cities integrate the operation, repairs and upgrading of urban infrastructure and services and may impact on a variety of areas in a city (Harrison & Donnelly, 2011). These include the economy, people, governance, mobility, environment and living, health care and public safety. The areas mentioned will be discussed in more detail in section 3.5. Some of the recorded benefits of smart cities include the reduction in resource consumption, improving the utilisation of existing infrastructure capacity while making new services available to citizens and commuters, and improving commercial enterprises through the publication of real-time data pertaining to the operation of city services (City, 2009; Stockholm, 2006).

For smart cities to function effectively and efficiently, it is essential that large amounts of data are collected (Dimitriou, 2012). Hence, data collection in a smart city may make use of either crowdsensing or crowdsourcing. In view of the privacy concerns associated with crowdsensing this research project chose to make use of crowdsourcing. These privacy concerns are is discussed in more detail in section 3.5.

Crowdsensing makes use of various sensors to collect data. These sensors may either be part of the existing infrastructure, such as water or electricity networks, or else citizens with a mobile device may volunteer to attach sensors to their mobile phones (Demirbas, Bayir, Akcora & Yilmaz, 2011). In view of the fact that crowdsensing is involuntary, the participants do not have any control over what, when or where the data is recorded. This may, however, be seen as an invasion of privacy as the data collected may reveal private

information about the citizens. Once citizens are made aware that their private data is being recorded, researchers have found that they are sometimes unwilling to participate in involuntary participatory sensing campaigns (Christin, Kanhere, Reinhardt & Hollick, 2011).

Crowdsourcing is a term which refers to a group of individuals who collect data, or who report on certain events of a similar nature and pool all the data which has been collected (Mehta, 2011). The mobility of mobile phone users also has distinct advantages for the local government as a larger area is covered by the citizens and unusual events, such as accidents, may be observed and reported on (Christin et al., 2011). In addition, the privacy concerns associated with crowdsensing are eliminated in this form of data collection. Both crowdsensing and crowdsourcing was considered by the research team as data collection methods for this research project.

Primary data in this research project was gathered from continuous meetings with the International Business Machines (IBM) team and the UFH team regarding research project matters. This form of data is commonly referred to as conversational analysis, and is the phrase used in this study when comments and recommendations were collected from these meetings. Making use of conversational analysis, it was felt by the researchers that these advantages would be beneficial in the public safety domain and, therefore, crowdsourcing was chosen as the data collection method most suitable for this research project.

When making use of crowdsensing and crowdsourcing a large amount of data may be gathered in a relatively short period of time and it is, therefore, a more effective method of data collection as compared to the traditional data collection methods. An example of crowdsourcing in Canada and the United States of America is the non-emergency telephone number, 3-1-1, which was introduced in 2003 to provide quick access to non-emergency municipal services. Citizens may use this telephone number either to obtain information about non-emergency services or to report non-emergency problems. Typical problems that are reported include dead animals to be removed, debris in the roadway, illegal burning, broken streetlamps, parking meters and traffic lights, noise complaints as well as potholes, sinkholes and utility holes in the streets. The number is intended to divert non-emergency concerns from the 9-1-1 number (Schaffers, 2010).

Public safety involves the prevention of and protection from events that could endanger the safety of the general public in terms of significant danger, injury/harm, or damage. Examples of such events are crime or disasters (natural or man-made) (PSECGC, 2008). This research study focusses on public safety which can include both non-emergency and

emergency matters. While the focus of this study is not on maintenance, the principles of the 3-1-1 crowdsourcing data gathering methods are followed. The next section will discuss the smart city framework that has been proposed by Chourabi, Nam, Walker, Gil-Garcia, Mellouli, Nahon and Scholl (2012).

1.2.1. Smart City Framework

Chourabi et al. (2012) have proposed a smart city framework that identifies eight core areas that must be considered when implementing smart cities. These areas include technology, policy, city, people/communities, economy, built infrastructure, the natural environment and governance of the system (refer to Figure 1.1).

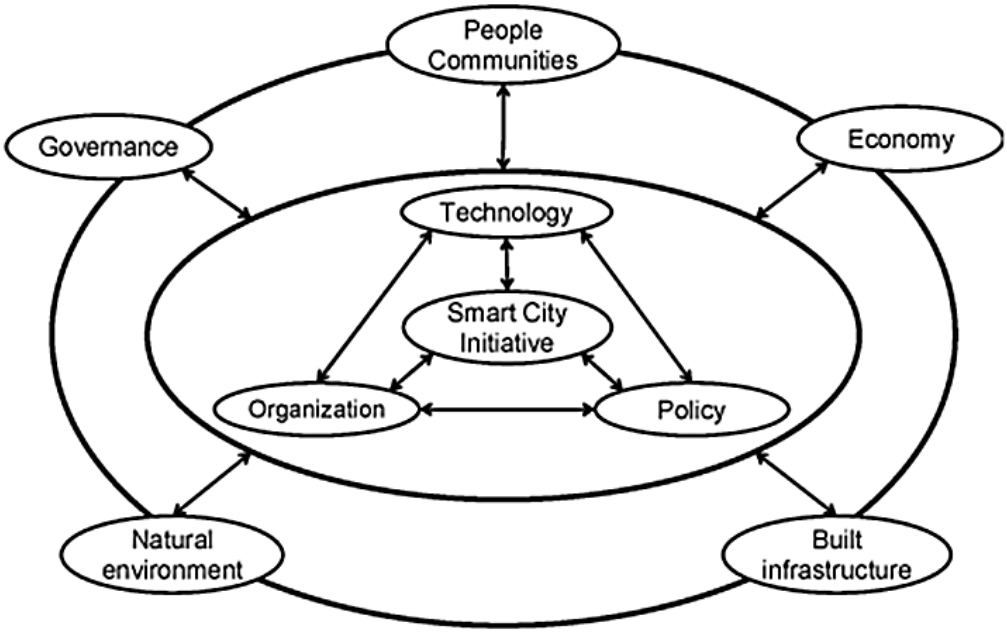


Figure 1.1: Smart City Framework (Chourabi et al., 2012)

The aim of this framework is to explain the impact of the organisational, technical and contextual areas on the success of smart city initiatives. According to Chourabi et al. (2012), the inner layer of the framework (Technology, Organisation and Policy) will impact on the success of a smart city initiative more than the outer layer (People/Communities, Economy, Built Infrastructure, Natural Environment and Governance). However, all the areas will have some kind of impact on each other and on the smart city, depending on the context of the project. However, in view of the fact that the smart city framework was only published in 2012, little is known about the relationships between the various areas identified in the framework. This research project will investigate the relationship between three of the areas indicated in the Chourabi et al. (2012) framework, namely, the City (the local government, Buffalo City Metropolitan Municipality), People/Community (of East

London) and Technology (crowdsourcing system). The next section will briefly investigate the relationship between these areas.

1.2.2. Increased Participation and Trust

Large amounts of data are necessary if a smart city is to be effective. While the advantages of smart cities are documented, research suggests that the users of smart cities are often reluctant to participate in smart city initiatives. Kelley (2009) posits that trust in the crowdsourcing system will increase as a result of the following two aspects: Firstly, the risk associated with the system must be reduced, and secondly, the user must enjoy a positive and meaningful interaction with the system.

Ling and Masao (2011) have suggested that, in future, one of the main obstacles which will have to be overcome in order to increase trust in information systems will be how to put control measures in place to protect and secure the information obtained from the user. Thus, to decrease the vulnerability or risk, it is essential that control mechanisms be put in place in order to create a structure that allows the one party to rely on the other without having to consider the issue of trustworthiness or without expectations of reciprocation (Mayer, Davis, & Schoorman, 1995). Unfortunately, these control measures decrease the speed with which trust is developed in a relationship trust and, therefore, the efficiency of the overall relationship (Covey, 2006). Accordingly, uncertainty reduction is a necessary condition for the development of trust (Flowerday & Von Solms, 2006).

Geffen (2000, p. 275) defines trust as follow: *"... the belief that the other party will behave in a socially responsible manner and, by doing so, will fulfil the trusting party's expectations without taking advantage of its vulnerabilities."* Mayer et al. (1995) developed the Model of Trust on the principle that trust is viewed as a trait that leads to a generalised expectation about the trustworthiness of others. The Model of Trust will be used throughout this research project in order to identify the various characteristics that will determine the trustworthiness of the crowdsourcing system. These characteristics include the ability, reliability and benevolence of the public safety, participatory crowdsourcing system and will be discussed in Chapter 5.

Information security is an issue of primary concern to the citizen and, thus, it is vital that the information provided to the crowdsourcing system be complete and accurate if it is to elicit the appropriate response from the emergency services. Furthermore, information

security may be divided into three distinct characteristics, namely, Confidentiality, Integrity and Availability (CIA triad). These three characteristics are defined as follows (Whitman & Mattord, 2005):

- Confidentiality – The confidentiality of information refers to the prevention of the disclosure or exposure of information to unauthorised individuals or systems;
- Integrity – Information has integrity when it is whole, complete, and uncorrupted;
- Availability – The availability of information enables authorised users to access information without interference or obstruction, and to receive the information in the required format.

A further factor that is referred to in this research project in relation to trust is user satisfaction. If the crowdsourcing system is viewed as user-friendly by the user, this will increase the confidence of the citizen in the crowdsourcing system. The three chararacteristics of usability as per the ISO/IEC 9241-11, 1998 standards are defined below (Wallace, Reid, Clinciu & Kang, 2013):

- Effectiveness: the accuracy and completeness with which users achieve specified goals;
- Efficiency: the resources expended in relation to the accuracy and completeness with which users achieve goals, and
- Satisfaction: the comfort and acceptability of use.

These three characteristics were used to evaluate the three different parts of the public safety, participatory crowdsourcing system, namely, the interface quality, system quality and usefulness of the system. These will be further discussed in section 5.4. Table 1.1 provides an overview of the three different factors and their associated characteristics that will be included in this research project.

Table 1.1: Overview of Different Variables and Characteristics in the Research Project

Factor	Characteristics	Discussed in:
Trust	Ability	section 5.2.4.1.2
	Reliability	section 5.2.4.1.2
	Benevolence	section 5.2.4.1.2
Information Security	Confidentiality	section 5.3.3.1
	Integrity	section 5.3.3.2
	Availability	section 5.3.3.3
User Satisfaction	Effectiveness	section 5.4.3.1
	Efficiency	section 5.4.3.1
	Satisfaction	section 5.4.3.2

The next section will discuss the significance for this research project.

1.3. Description of the Problem Area

This research project was conducted in the city of East London, which is part of the Buffalo City Metropolitan Municipality (BCMM). The BCMM has the fastest population growth rate of any metropolitan area in South Africa (Skenjana, 2013). However, as is obvious from the regular service delivery protests undertaken by various communities in East London, service delivery in the city is considered to be extremely poor (Mukhuthu, 2012). The reasons for the poor service delivery include infrastructure backlogs in especially the rural parts of the constituency, internal problems within the BCMM, such as political infighting and poor administrative and financial controls, poorly functioning ward committees and low human resource capacity (Managa, 2012; Ahmed & Sundaram, 2011; Sikhakane & Reddy, 2009; Van der Waldt, 2007). These challenges, together with the socio-economic challenges in the city, will be discussed in more detail in Chapter 2.

South Africa has the largest prison to population ratio on the African continent (Naidoo & Mkize, 2012). The researchers took this into consideration while deciding in which of the smart city focus areas the participatory crowdsourcing system was to be implemented. It was felt that public safety would an appropriate smart city focus area as crime affects the quality of life of all citizens and would, therefore, be applicable to all the citizens in East London. This decision will be discussed further in section 2.7.

The resources available in the BCMM to deal with public safety are limited. This means that the BCMM is required to provide solutions with regards to improvement of public safety making use of new and innovative approaches. A smart city is one of the innovative solutions that are available to the BCMM and will be discussed in the next section.

1.4. Problem Statement

With the growing number of people living in cities, the challenges faced by local governments to maintain service delivery to an acceptable standard are immense. The urban movement presents local government with very definite challenges to be addressed as city infrastructure and limited resources put service delivery under severe strain. Further problems, such as corruption and mismanagement of existing resources are a further source of poor service delivery. In order to improve poor service delivery, it is essential that cities find a way to use information more intelligently in order to consume resources more effectively and efficiently.

Smart cities are a new and innovative concept that has emerged during the past few years and which involves using current infrastructure and resources more effectively and efficiently. Although smart city projects have been implemented in developed countries, there is currently no model to assist with the successful implementation of a smart city project in a developing country. The lack of such a model is important as the characteristics of a developed and developing city differ and will affect the successful implementation of a public safety, participatory crowdsourcing smart city. Some of the typical challenges in a developing city include low literacy rates, high unemployment rates, high poverty levels and the unavailability of technology, all of which will impact on the implementation and success of a smart city (Kumar et al., 2010). The objective of this research project is then to provide a model to implement a public safety, participatory crowdsourcing smart city in a developing city. The smart city, in turn, will assist local government to make use of existing resources in a more effective and efficient manner, which will address the research problem.

1.5. Objective of the Study

The primary objective of this research study is to produce a model that will represent all the factors that need to be in place in order to implement a public safety, participatory crowdsourcing smart city project in a developing country.

1.6. Research Questions

The following research question was formulated in accordance to the research objective:

What factors need to be in place in order to implement a public safety, participatory crowdsourcing smart city project in a developing country?

In order to answer the research question, the following sub-questions were addressed:

- **How can a smart city improve public safety in a developing country?**

  The answer to this first sub-question will inform the reader on the way in which a smart city may improve different areas and, in particular, public safety in a developing city. The benefits of a smart city are discussed in Chapter 3, together with some of the public safety smart city projects that have been implemented around the world.

- **How does the trust factor effect the implementation of a public safety, participatory crowdsourcing smart city project in a developing country?**

  The second sub-question investigates the way in which trust would influence the implementation of a public safety, participatory crowdsourcing smart city project in a developing country. A large amount of data is needed if a smart city is to operate effectively and efficiently. In order to collect sufficient information by making use of crowdsourcing, it is essential that the citizens participate in the smart city project. The trustworthiness of the system is investigated in order to improve the participation of citizens or in Chapter 5.

- **How does the information security factor effect the implementation of a public safety, participatory crowdsourcing smart city project in a developing country?**

  If citizens are to trust the participatory crowdsourcing system, the risk associated with reporting information to the system must be minimised. This is especially important in a public safety context where the information reported must be both complete and accurate to ensure the correct response from the emergency services.

- **How does the usability factor effect the implementation of a public safety, participatory crowdsourcing smart city project in a developing country?**

  Citizens are more likely to participate in a smart city project if they have a positive user experience when interacting with the crowdsourcing system to report public safety matters. This interaction of the citizen with the crowdsourcing system will be investigated by making use of the usability features of the system.

The next section will discuss the research design that was used in the study. This will include a discussion on the research paradigm and the research methodology that was used in the research project.

1.7. Significance of the Research Project

This research project was implemented in the developing city of East London and it is anticipated that it will provide valuable insights into the requirements necessary to implement a public safety, participatory crowdsourcing smart city project in a developing county. A smart city will allow local government to use existing resources more effectively and efficiently in order to improve the quality of living, and in particular public safety, of the citizens.

In developing cities, such as East London, smart cities can be used to involve citizens in the management of the city. Also, crowdsourcing do not require expensive ICT investment, but make use of existing infrastructure which provides local government with an additional technique for collecting data from the public. The information collection can be used to make smarter decisions about resources, which allows for more effectively and efficiently management. The next section will discuss the problem statement.

1.8. Research Design

According to Mouton (2001), the research design must be tailored to address the research problem or research question. It is, thus, important to select an appropriate research paradigm with which to guide research design decisions and to justify such decisions.

1.8.1. Research Paradigm

It is essential that research follow a specific paradigm (Collis & Hussey, 2003). A wide variety of philosophical paradigms exist, arising out of different ideas, views and perspectives of the world (Oates, 2006). In Chapter 6 the five most important paradigms in Information Systems research are discussed: Positivism, Interpretivism, Critical Theory, Pragmatism and Design Science Research.

Design Science is a problem-solving paradigm which ensures that knowledge and understanding of a problem are achieved through the building and application of an artefact. This research paradigm enables the researcher to make use of both quantitative and qualitative data collection methods. In addition, it places the focus of the research on the artefact that is produced. In view of the fact that the objective of this research project is to produce a model for the implementation of a public safety, participatory crowdsourcing smart city project in a developing country, the Design Science Research paradigm and an inductive logic approach was deemed to be the most suitable. The next section will discuss the research methodology used in the study.

1.8.2. Research Methodology

Burns (2000) describes research methodology as an organised research process which consists of sequences, procedures and systems. From an epistemological viewpoint, this research project uses General Systems Theory. This widely used and interdisciplinary theory studies the properties of a system as a whole in order to learn and understand the behaviour of the system within the real world (Checkland, 2000). As a system may consist of several subsystems, it was important to define the system that would be investigated in this research project.

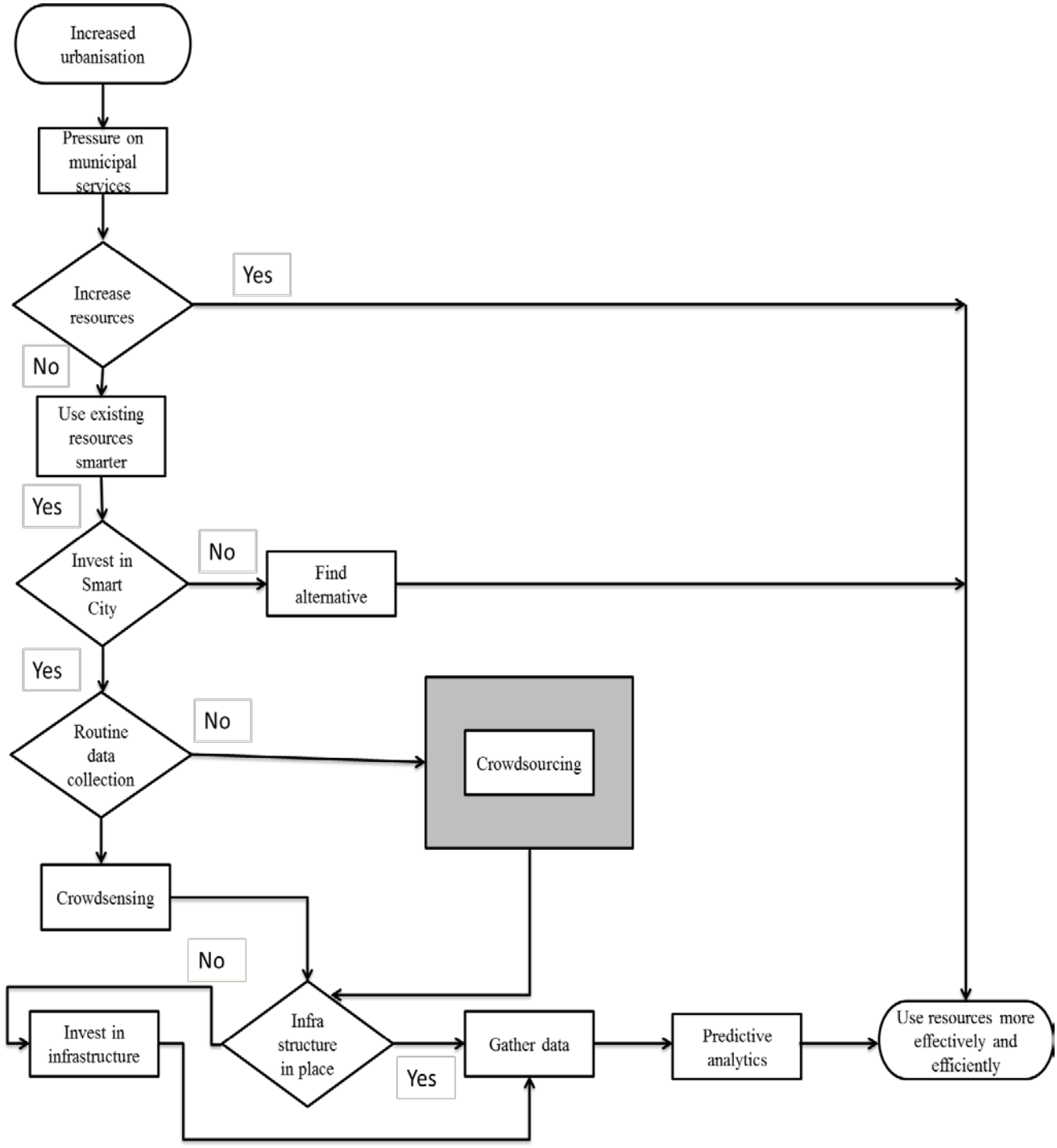


Figure 1.2: System Hierarchy for a Smart City Project

A system may be placed in a specific hierarchy within a research area. A hierarchy refers to the principle that parts or entities are meaningfully treated as wholes and are built up of smaller parts which, themselves, are wholes (Checkland, 2000). This principle is illustrated in Figure 1.2, which depicts the various parts or subsystems of the decision of local government to become a smart city, as proposed in this study. The grey block labelled '*Crowdsourcing*' is the subsystem that is investigated in this research project.

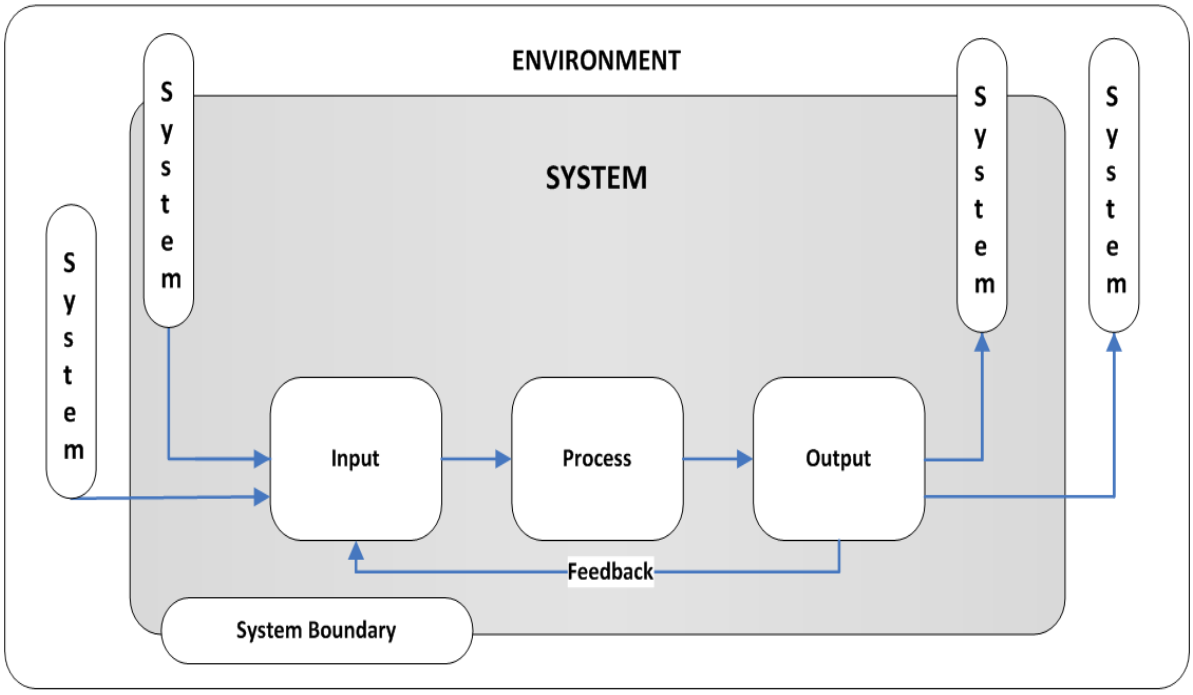
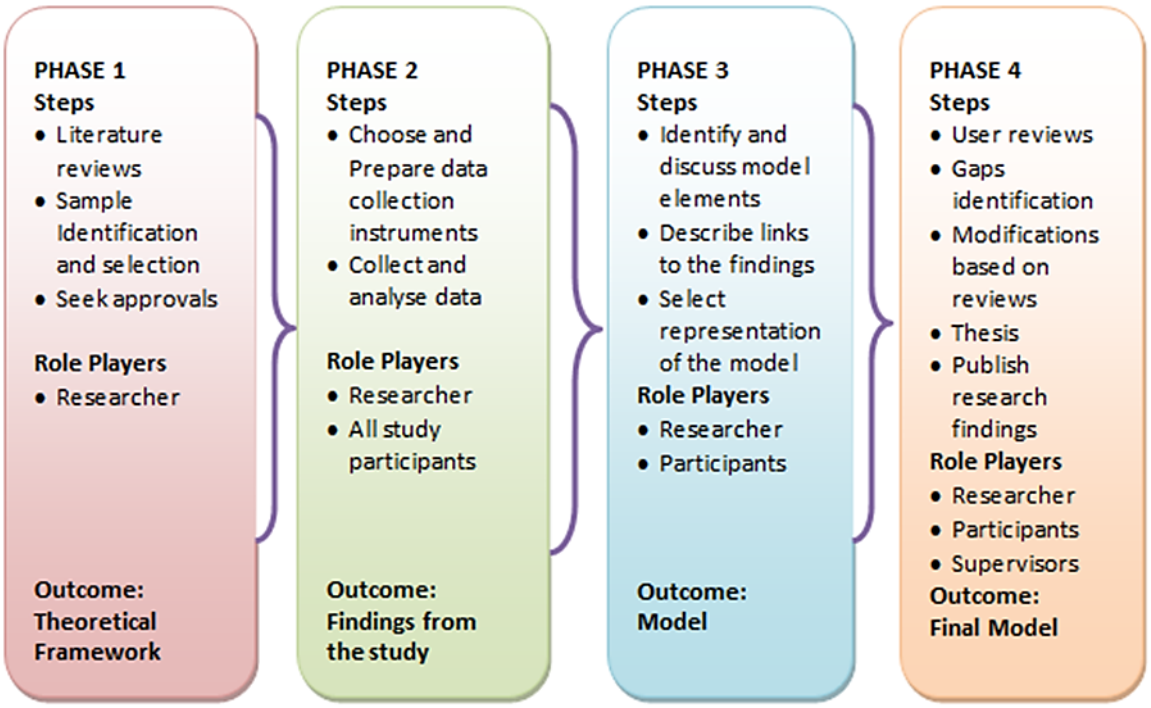


Figure 1.3: Graphical Representation of a System (Zuccato, 2005)

As can be seen in Figure 1.3, the system is separated from the wider environment by a system boundary. According to Checkland (2000), the system boundary is the area within which the decision-making process of the system has direct influence. In this study, the implementation of a public safety, participatory crowdsourcing smart city project in a developing country will represent the system. The system consists of inputs – the factors that must be in place in order to implement a public safety, participatory crowdsourcing system in a developing country. The process represents the actual implementation of the system, while the output is improved public safety in East London. The feedback loop represents the information that the BCMM provides to the citizens of East London about the information reported to the crowdsourcing system. Possible tools that can be used in the feedback loop include reports, statistics or graphs. The research process that will be applied during this research project is discussed next.

The most widely cited set of guidelines for Design Science Research is the seven guidelines as proposed by Hevner, March, Park and Ram (2004) and discussed in section 6.4. The various guidelines are shown at the bottom of each phase for this research project and illustrated in Figure 1.4. The aim of this is to show that all the guidelines will have been conformed to at the end of the study.



Design science Steps/Guidelines				
	Guideline 2 – Problem Relevance Guideline 5 – Research Rigor Guideline 6 – Design as a search process	Guideline 6 – Design as a search process	Guideline 1 – Design as an Artefact	Guideline 1 – Design as an Artefact Guideline 3 – Design Evaluation Guideline 4 - Research Contribution Guideline 5 – Research Rigor Guideline 7 – Research Communication

Figure 1.4: Research Methodology used in This Research Project

The overall evaluation of the project, which was carried out to identify errors and problems, is presented in Chapter 8. In addition, three papers were written (see Appendix B). The next section will briefly discuss the data collection methods used in this research project.

1.8.3. Data Collection Methods

This research project makes use of a mixed method approach to data collection. Both primary and secondary data was collected and analysed in order to answer the research question. The primary data collection consisted of observations from the development of the crowdsourcing system prototype, conversational analysis and a questionnaire while the secondary data collection included a detailed literature review.

The goal of the mixed method approach is not to replace either quantitative or qualitative data collection methods, but rather to use the strengths of both methods in a single research project (Burke, Estrin, Hansen, Parker, Ramanathan, Reddy, et al., 2006). The research project makes use of an inductive logic approach and, therefore, it may be argued that Interpretive research is the dominant paradigm of the project. However, the use of a Positivistic data collection and analysis technique, a questionnaire, was used to assist the researcher with the validation of the model: A Public Safety, Participatory Crowdsourcing Smart City project in a developing country. The research methodology of the research project will be elaborated upon in Chapter 6

A crowdsourcing system was developed in conjunction with IBM. The system enabled citizens to report their public safety issues by making use of an Interactive Voice Response (IVR) system. Several iterations of refinement were needed during the building of the prototype in order to refine the system. Making use of conversational analysis resulted in the decision to use an IVR system rather than a Short Message Service (SMS) because of the illiteracy rate in East London. In addition, the analytics of the information would not be possible if the language of the SMS was not in English or not correctly spelled.

In order to motivate the citizens of East London to participate, this research project made use of a lucky draw in terms of which the study participants could win one of three iPads. Participants were asked to provide their name and a contact number, if they wished to be included in the lucky draw, when they registered on the website. The system is explained below in Figure 1.5.

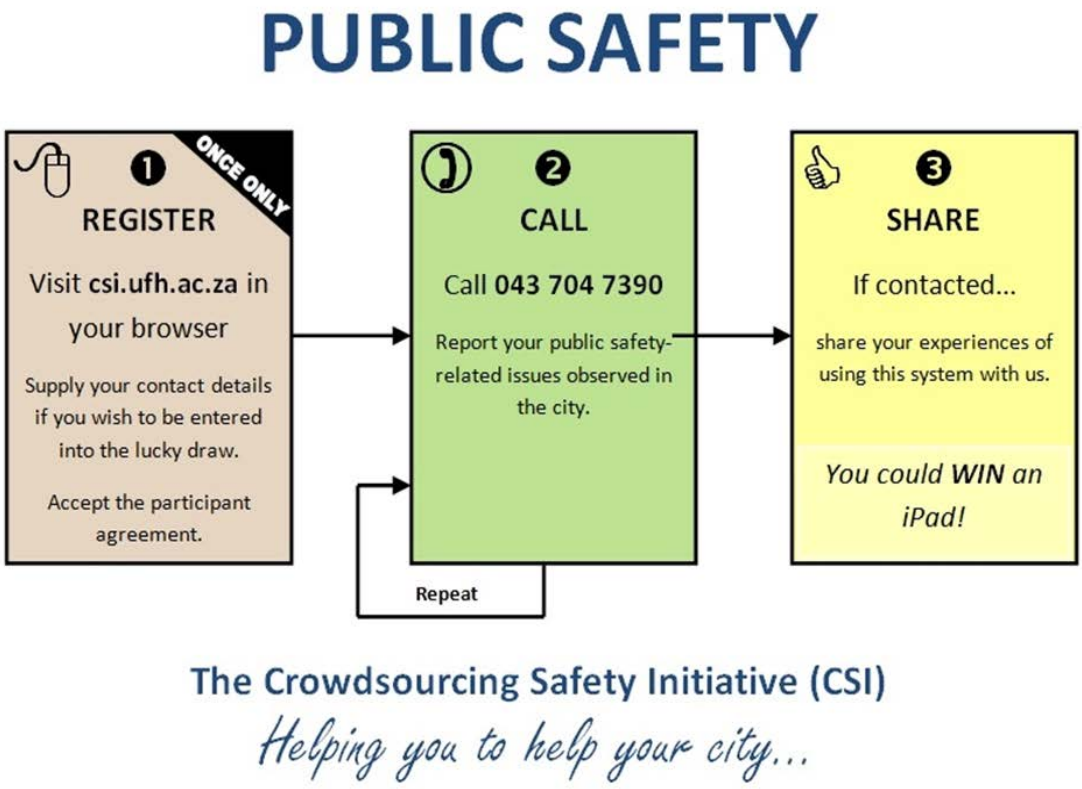


Figure 1.5: Steps Involved in the Crowdsourcing Safety Initiative Project (UFH, 2013)

During the first step, citizens registered on the official Public Safety Initiative website in order to accept the terms and conditions of the project (see Appendix C). A lucky draw competition was used as an incentive to encourage citizens to participate in the project. If they chose to be included in a lucky draw competition they were required to supply their contact details. Step two involved telephoning the number provided and reporting a public safety matter while step three entailed completing the on-line questionnaire that had been sent to the registered participants to enable them to share their experience of using the crowdsourcing system in order to get feedback and validate the model.

The second primary data collection method was conversational analysis. This technique was used to obtain information from voice technology experts in the telecommunication industry while making use of tools such as teleconferences, e-mails and telephone calls. The advantage of the tools mentioned are that it minimising the geographical distances between the various researchers in this project (India, Israel and South Africa) relatively inexpensively. Furthermore, the tools also facilitate communication within the research group as information can be disseminated to the entire group simultaneously. This was especially useful during the building of the prototype

The third primary data collection method was a questionnaire that was sent to the participants in the project who had registered on the website. Existing questionnaires

found in the literature were used in the development of the current questionnaire to ensure the validity of this data collection instrument. The questionnaire probed the overall experiences of the participants when they had made use of the public safety, participatory crowdsourcing system. The results of the questionnaire will be discussed in Chapter 9 as part of the user review.

The secondary data collected for the study involved an extensive and thorough literature survey of relevant Internet sources, frameworks, methodologies, journal articles, past research, reports and books (Olivier, 2004). Every attempt was made to ensure that the content of the research was as current as possible. This included the literature, which was selected from respected authorities in the field. The next section focuses on the population chosen for the purposes of the study.

1.8.4. Sample and Population

The study population identified for this research project included the citizens of East London who had access to a telephone and the Internet (to access the participant agreement). Residents of East London were recruited through the marketing of the crowdsourcing system in local newspapers, flyers and the social media.

Shi (2009) proposed a formula that may be used to determine the correct sample size in order to produce an estimate of the population proportion with a certain level of precision. By making use of the formula, it was determined that 384 participants needed to complete the questionnaire (see section 6.6). A convenience sample was chosen from the citizens of East London who had registered on the website. The next section will discuss the analysis of the data which was obtained from the questionnaire.

1.8.5. Data Analysis Method

The quantitative data from the online questionnaire was analysed using the Statistical Package for Social Sciences (SPSS 21). Both descriptive and inferential statistics were used to analyse the results from the questionnaire. These results are presented in Chapter 8 and are used in a user review in order to validate the proposed model introduced in Chapter 7.

1.9. Public Safety, Participatory Crowdsourcing (PSPC) Smart City Model for a Developing Country

According to Hevner et al. (2004), one of the guidelines that must be satisfied in Design Science is the development of an artefact. The aim of this research project is to produce a model that may be used to implement a public safety, participatory crowdsourcing smart city project in a developing country. Oates (2006, p. 108) maintains that models are "*used to aid in problem understanding and solution development*". The model that has been developed to implement a public safety, participatory crowdsourcing smart city project in a developing country is depicted in Figure 1.6.

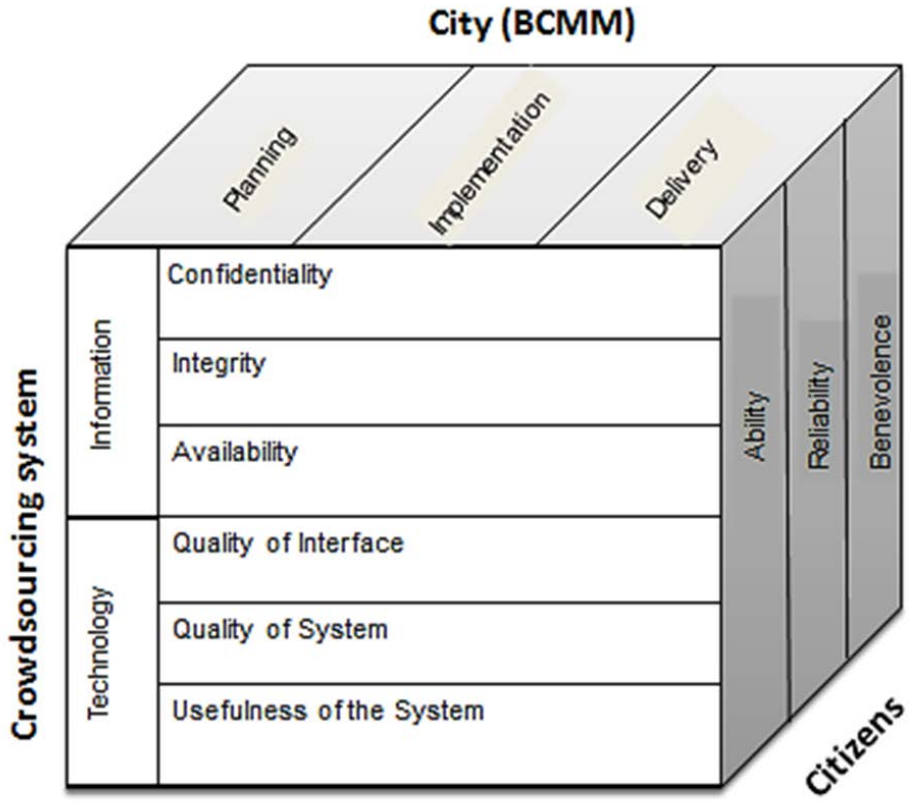


Figure 1.6: PSPC Smart City Model for a Developing Country

The PSPC smart city model for a developing country will be discussed in more detail in Chapter 7. A user review was conducted in order to refine the model and the results of the review are presented in Chapter 8. At this stage it is important to note the three areas that make up the model, namely, the participatory crowdsourcing system, the city (BCMM) and the citizens of East London. The delimitation of the study is discussed in the next section.

1.10. Delimitation of the Study

The target group identified for the research project included telephone users in the East London area. The system made use of voice prompts which implied that residents with a hearing impairment were not included in the study. The telephone number provided was used to report public safety related matters. However, the residents were not allowed to report serious emergencies which required immediate assistance. While the data reported may be used for predictive analytics in order to make more efficient decisions about the way in which resources are used in order to increase public safety, this exercise falls outside the scope of this study. The next section discusses the content of the chapters in the thesis.

1.11. Ethical Considerations of the Study

Punch (2006) states that it is the author's responsibility to comply with academic integrity and honesty, as well as to respect other people. Punch (2006) continues by listing categories of ethical issues which should be considered by researchers.

- Informed consent was obtained by sharing all necessary information about the research project with all the participants. The terms and conditions of the research project were displayed on a website. It was a legal requirement that participants had to agree to the terms and conditions of the research project before they could report public safety matters via the IVR system.
- Participants were guaranteed anonymity by constructing the questionnaires in a manner which ensures no personal information was captured.
- The misuse of results was mitigated by ensuring information gathered from participants was only used for the indented and expressed purpose of the research. This research project made use of crowdsourcing, thus the participants could decide what public safety information to report making use of the IVR system.
- Participants were allowed to refuse participation in the research project at any time.
- Additionally, ethical clearance was obtained before any candidates participated in this research study (ethical clearance number: FLO011SCIL01).

The next section provides an outline of the chapters.

1.12. Outline of the Proposed Chapters

The chapter outline of the thesis is as follows (see Figure 1.8). Chapter 1 discusses the background to the research project and the problem statement. The research methodology used in the study is introduced. Chapter 2 introduces the city of East London as the context within which the study was conducted and discusses some of the problems facing the city, with specific reference to public safety. Chapter 3 examines the concept of smart cities with specific emphasis on city management in developing countries. Chapter 4 introduces the smart city models and frameworks found in literature, while Chapter 5 focuses on the theories used in this research project. Chapter 6 discusses the research design and methodology used in this research project. Chapter 7 introduces the PSPC smart city model for developing countries, while Chapter 8 contains the results from the user survey that was conducted. Chapter 9 discusses the conclusions that were drawn based on the research findings and offers suggestions for future research.

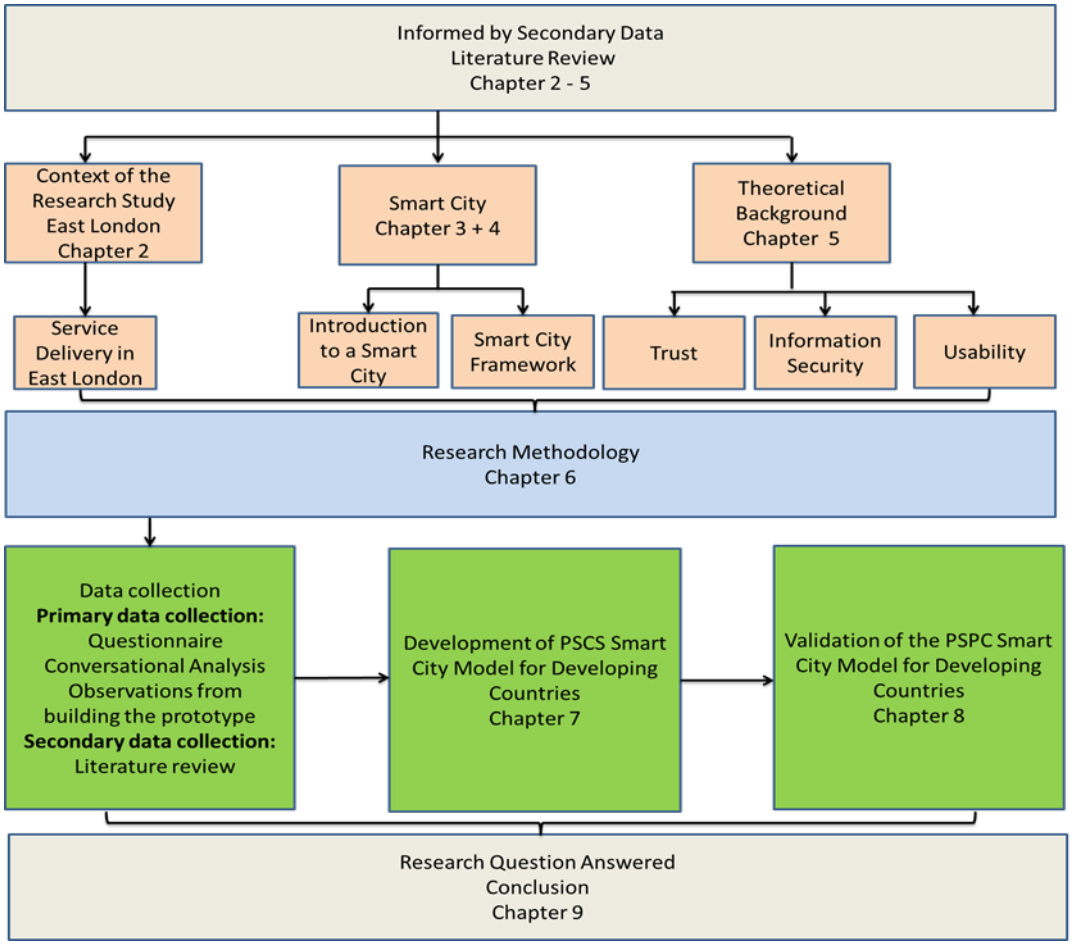


Figure 1.7: Chapter Road Map

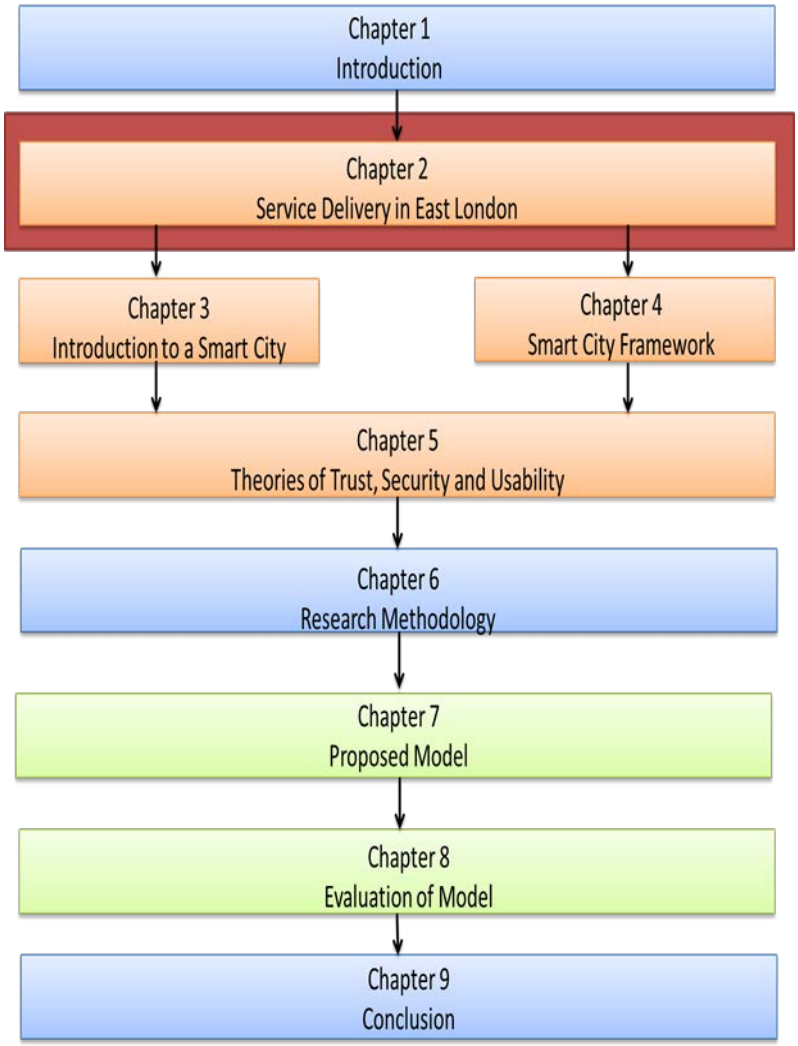
1.13. Summary

With the growing number of people living in cities, governments are facing the immense challenge of ensuring service delivery of an acceptable standard. Smart cities is a new and innovative approach that has been formulated during the past few years and which is aimed at the more effective use of current infrastructure and resources. However, there is little research available on the topic of smart cities.

A framework that identifies the various factors of a smart city was published in 2012 by Chourabi et al. (2012). However, while the framework identifies the various areas that must be considered when implementing a smart city, there is limited research available into the relationship between these areas. Accordingly, this research project aims to produces a model that investigates the relationship between three of these areas (City, People/Community and Technology) in a developing country context.

Crowdsourcing is effective only if a large amount of data is collected from the citizens of a city. In order to promote the participation of the citizens in a public safety, participatory crowdsourcing system, it is essential that the following two controls be in place. Firstly, the system must be user friendly and, secondly, the risks associated with using the system must be minimised. These concepts, which were discussed above, were used to develop a model to be used to implement a public safety, participatory crowdsourcing smart city project in a developing country. The next chapter contains an overview of the context in which the crowdsourcing system was implemented for the purposes of this study.

CHAPTER 2
Service Delivery in East London



2.1 Introduction

2.2 Characteristics of a Developing City

2.3 An Introduction to the Eastern Cape

2.4 A Brief History of the Buffalo City Municipality

2.5 The Buffalo City Metropolitan Municipality

2.6 Service Delivery Problems within the Buffalo City Metropolitan Municipality

2.7 Definition of Public Safety

2.8 Conclusion

2.1. Introduction

Smart cities provide local authorities with an opportunity to become more effective and efficient by making use of ICTs. As discussed in the previous chapter, this is important as the combination of finite resources and an increasing urban population is increasing the pressure on the already strained services provided to the public.

This chapter focuses on two of the areas that are included in the PSPC smart city model for developing countries (section 1.6). These two areas include the **City** – in this research

project the Buffalo City Metropolitan Municipality – and the **Citizens** – for the purposes of this study the citizens of East London.

Thus, this chapter discusses the context in which this research project was conducted. The city of East London is introduced as a developing city. The current problems associated with the poor service delivery in East London are identified and discussed as these problems will affect the successful implementation of a public safety, participatory crowdsourcing, smart city project.

East London is situated in the Buffalo City Metropolitan Municipality in the Eastern Cape Province of South Africa. This chapter provides a brief overview of the city, including the history of the establishment of the Buffalo City Municipality after 1994 and the service delivery problems which the local authorities inherited and are currently experiencing. The functions of the various government structures in South Africa are discussed as well as the reasons why the Buffalo City Municipality was declared as a Metropolitan in 2011. This chapter also discusses some of the reasons for the service delivery problems in the Buffalo City Metropolitan Municipality, with particular emphasis on the issue of public safety. The next section provides an overview of both the Eastern Cape Province and the Buffalo City Metropolitan Municipality.

2.2. Characteristics of a Developing City

Although there is no universal definitions of the terms '*developed*' and '*developing*' state and neither are there agreed-upon criteria of how to assess whether a country is in a '*developed*' or '*developing*' state there are, nevertheless, some general reference points that may be considered. In order to standardise these reference points, various classification methods have been developed by the United Nations, International Monetary Fund and World Bank (Sullivan & Steven, 2003). These three classification methods will be used to determine the state of development of South Africa.

The United Nations utilises the Human Development Index in order to rank countries according to their level of development. The Human Development Index includes four criteria for the tracking of changes in developmental levels over time. These criteria include life expectancy at birth, mean years of schooling, expected years of schooling and gross national income per capita (United Nations, 2008). Countries with a Human Development Index of below 0.5 are considered to be at a low level of human development, those with a score of 0.5 to 0.79 at a medium level of development and

those with values of 0.8 and above are considered to be at a high level of human development. In terms of the Human Development Index, South Africa is placed 121 out of 186 countries with a score of 0.629. This, in turn, places the country in the medium human development category (United Nations Development Programme, 2013).

On the other hand, the International Monetary Fund makes use of a flexible classification system to determine in what category a country should be placed. The factors to be considered include the per capita income level, export diversification and the degree of integration into the global financial system (IMF, 2012). In terms of this score card the International Monetary Fund places South Africa in the emerging and developing countries range (IMF, 2012).

The World Bank classification uses one criterion only, namely, the Gross National Income (GNI) per capita (World Bank, 2010):

- Low income countries have a GNI per capita of US$1026 or less;
- Lower middle income countries have a GNI per capita between US$1026 and US$4036;
- Upper middle income countries have a GNI per capita between US$4036 and US$12476;
- High income countries have a GNI of more than US$12476.

GNI per capita is calculated using the gross national income, converted to U.S. dollars, and divided by the midyear population (World Bank, 2013). The GNI per capita indicator for South Africa has increased steadily from 2008 to 2012. Currently, South Africa is considered as a developed country as it falls in the upper middle income range (World Bank, 2013). In terms of these three classification methods, South Africa may be said to be in a developing state according to the United Nations and International Monetary Fund. The next section provides an overview of the city in which the study was conducted.

2.3. An Introduction to the Eastern Cape

South Africa consists of nine provinces, of which the Eastern Cape is the second largest province in terms of geography and the third largest province in terms of population. The province is home to approximately 6.7 million people, representing 13% of the total population in the country (ECSECC, 2012).

The Eastern Cape is considered to be one of the poorest provinces in South Africa. This is borne out by the high rate of poverty (57%) and the high rate of unemployment (30.4%) in the province (StatsSA, 2012; ECSECC, 2012). These rates are significantly higher than the national average of 44% poverty rate and 25.2% unemployment rate (ECSECC, 2012). In addition, the Eastern Cape also has the lowest Grade 12 pass rate in the country (61.6%) and an illiteracy rate of 20%, which is also considerably higher than the national average (ECSECC, 2012).

The province includes two major urban areas, namely, the Nelson Mandela Metropolitan Municipality (NMMM) and Buffalo City Metropolitan Municipality (BCMM)(BCMM, 2013; Sikhakane & Reddy, 2009). The economies of both these metropolitan areas are based primarily on manufacturing – the most important being the automotive industry. Other important economies in the province include renewables and green industries, forestry and timber processing, pharmaceuticals, plastics and chemicals, capital goods and tourism. The infrastructure in the province includes two harbours, one in each metropolitan area, and three airports (East London, Port Elizabeth and Mthatha) (SouthAfrica.Info, 2013). The next section will discuss the history of the BCMM.

2.4. A Brief History of the Buffalo City Municipality

During the apartheid era the delivery of municipal services were based on ethnicity and divided along racial lines. The facilities and services provided to the former white communities were excellent as most of the resources available were allocated to these municipalities, while the black (which included African, Indian and Coloured) communities were under-resourced with poor facilities (Makgetla, 2007). After the collapse of the apartheid system, a democratically elected government was formed. This new government was mandated to address the poverty, inequality and racial segregation of municipal services which had existed prior to 1994 (Managa, 2012; Sikhakane & Reddy, 2009).

The Local Government Transition Act (Act 209 of 1993) was intended to facilitate the local transformation process with the restructuring and transformation of municipalities being guided by the following legislation: Local Government Municipal Structures Act (Act 117 of 1998), Local Government Municipal Systems Act (Act 32 of 2000) and the Integrated Development Plan (Sikhakane & Reddy, 2009; Buhlungu & Atkinson, 2007).

As a result of the relevant legislation, the Buffalo City Municipality (BCM) was established in 2000. This involved the merging of the municipalities of East London and King William's Town, together with their respective surrounding areas, and the former Ciskei homeland (Sikhakane & Reddy, 2009). As indicated in Figure 2.1 the BCM is situated on the east coast of Eastern Cape Province.

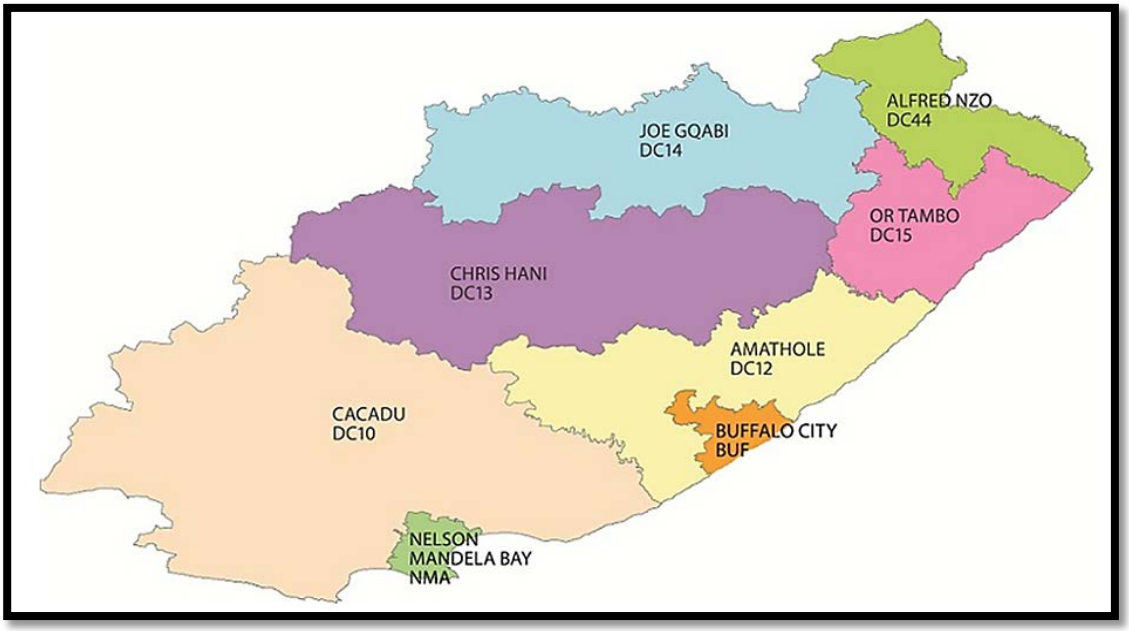


Figure 2.1: Map Showing the Districts in the Eastern Cape (The Local Government Handbook, 2012)

However, the BCM was not able to provide adequate services to the community as a result of the backlogs it had inherited in some of the areas that were now included within the municipal borders. Accordingly, the BCM requested assistance from the National Government which then included BCM in the Project Consolidate list so as to grant BCM additional funding. In addition, further assistance was sought through external partnerships within the public and private sector (Sikhakane & Reddy, 2009).

The BCM was declared a metropolitan municipality in 2011 (BCMM, 2013). East London is the largest city in the Buffalo City Metropolitan Municipality and it has several rural areas adjacent to it (Sikhakane & Reddy, 2009). The BCM also includes the townships of Mdantsane, Zwelitsha, Dimbaza, Bisho, Tyutyu, Phakamisa, Sweetwaters and Llitha (Buffalo City Metro, 2013A).

East London has an extremely narrow industrial base and is reliant on a few primary industries. The largest private industry in the BCM is Mercedes Benz South Africa which employs more than 2 500 people. The largest employer in the area is the provincial government, followed by the Buffalo City Metropolitan Municipality. There is also a well-

established informal business sector which includes hawkers and taxi drivers (Managa, 2012).

Currently the population in the BCM is estimated to be 1.4 million, with approximately 761 996 people living in the city of East London itself (East London, 2013; ECSECC, 2012). The majority of the population lives on the periphery of the city where there is poor infrastructure and services plus a high unemployment rate. Those who are employed must travel considerable distances to their workplaces, resulting in high transportation costs (Managa, 2012).

Mdantsane is a large township on the periphery of East London, and is home to more than 650 000 people (Kwizera, 2012; Chigor & Okoh, 2012). People relocating from the rural areas in order to seek better employment opportunities in the cities are accommodated in the township and this, in turn, has increased the demand for services in this area (Sikhakane & Reddy, 2009). The trend towards urbanisation in the area has meant that BCM recorded the highest growth rate for all the metropolitan areas in the country during 2012 (Skenjana, 2013). Although the city's population continues to increase, East London remains a developing city in comparison to other cities in South Africa.

The BCM has to provide services such as housing, electricity and water, sewerage and refuse removal to this increasing population. The community in East London is considered to be a low-income community which is characterised by high unemployment and poverty. As mentioned in section 2.3, the Eastern Cape has an unemployment rate of 30.4%, which is considerably higher than the national average. This, in turn, means that a large part of the community is dependent on free municipal services (StatsSA, 2012). The impoverished communities are not able to afford to pay the municipal taxes for the services rendered – the main source of revenue for the BCM – making cross-subsidisation necessary. In other words, the small tax base established in the more affluent areas has to sustain the services within a larger area with little or no additional revenue being generated. This problem was addressed in part by both the national and provincial governments which provided increased subsidies for certain functions (Sikhakane & Reddy, 2009). This section contained a brief introduction to the Buffalo City Municipality (BCM) and the problems that it inherited after 1994. The next section will discuss the development of the Buffalo City Metropolitan Municipality (BCMM).

2.5. The Buffalo City Metropolitan Municipality

A municipality is an administrative unit which is mandated to run the affairs of the area and to provide services to the population under its jurisdiction. It is, therefore, an administrative unit with managerial capabilities (Nhlapo, Kusumba, & Rugiiga, 2011). In addition, a municipality in South Africa must partner with local communities in order to find sustainable ways to meet the social, economic and material needs of the citizens (Managa, 2012; Nhlapo et al., 2011). The community, non-governmental organisations and pressure groups play a pivotal role in ensuring sustainable development in the municipality. Thus, communication channels must be set up and used to gather and share information while simultaneously strengthening the public confidence in the municipality (Apraku, 2010).

The highest law making body in a municipality is known as a Municipal Council. The South African Constitution provides for national and provincial governments to play a supervisory role in the constitutional system of co-operative governance. However, it is incumbent on the national and provincial governments to exercise their executive and legislative authority in such a manner that it does not impede a municipality's ability or right to exercise its executive and legislative authority (Apraku, 2010). The reason for the decentralisation of responsibility is that services are delivered and consumed at a local level (Ahmad, Devarajan, Khemani, & Shah, 2005). The leadership of a municipality, including the mayor, municipal manager and ward councillors, is subjected to the political control of central government as central government has the power to appoint these leaders (Nhlapo et al., 2011).

The role of the municipal council is set out in the constitution and includes an annual review of the following (Apraku, 2010):

- the needs of the people in the community;
- its priorities in meeting those needs;
- its processes for involving the community;
- its organisational and delivery mechanisms for meeting the needs of the community, and
- its overall performance in achieving these objectives.

Municipalities may be categorised into three models according to Act 108 of 1996 and the Local Government: Municipal Structures Act, 1998. These include category A –

metropolitan municipalities that have exclusive municipal executive and legislative authority; category B – local municipalities that share legislative and executive authority with category C municipalities – district municipalities that have legislative and executive authority in an area with more than one municipality (Sikhakane & Reddy, 2009).

The requirements for a metropolitan municipality (category A) are set out in the Government Gazette number 19614, volume 402 of 1998. This determines that a municipality may be regarded as a category A municipality if it is comprises a city with areas of high population density; intensive movement of people, goods and services; extensive development; multiple business districts and industrial areas; a centre of economic activity with a complex and diverse economy; a single area for which integrated development planning is desirable and with strong, interdependent social and economic linkages between its constituent units (Government Gazette, 1998). The first six metropoles that were established included the Cities of Johannesburg, Tshwane (Pretoria), Ekurhuleni (East Rand), Ethekwini (Durban), Nelson Mandela Bay (Port Elizabeth) and Cape Town (Sikhakane & Reddy, 2009). Since then the Metropole of Buffalo City (East London) and the Metropole of Mangaung (Bloemfontein) have been added – See Figure 2.2 below.

Figure 2.2: Representation of Various Metropolises in South Africa (Sikhakane & Reddy, 2009)

The Buffalo City Metropolitan Municipality is overseen by the Executive Mayor of Buffalo City who is responsible for the overall strategic and political direction of the city. In

addition, the municipal manager is responsible for the administration of the city while also providing the link between the political and administrative arms of the city government. The heads of the various departments in the Buffalo City Metropolitan Municipality are responsible for the implementation of policy and procedures while ward councillors are the link between the municipal government and the residents (Buffalo City Metro, 2013B).

The vision of the Buffalo City Metropolitan Municipality is "*to be a people-centred place of opportunity where the basic needs of all are met in a safe, healthy and sustainable environment*" (Buffalo City Metro, 2013B). Some of the main challenges facing the municipality include the restructuring of the various areas included after the merger of East London, King William's Town and Bhisho, many of which have a critical backlog as regards infrastructure and service delivery problems. Poverty is a main concern for the municipality. The median income for the citizens of East London is approximately R 2 655 per month, which is very close to the average income of a non-white South African family (R2 800 pm), although many are still significantly below subsistence levels at R1 500 per month (Buffalo City Development, 2013; Sikhakane & Reddy, 2009).

In an effort to address these challenges, the Buffalo City Metropolitan Municipality (2013B) has developed an Integrated Development Plan. This document serves as a tool to enable the municipality to achieve the following objectives:

- To provide democratic and accountable government for local authorities;
- To ensure the provision of services to communities in a sustainable manner;
- To promote social and economic development;
- To encourage community participation in local government matters, and
- To promote a safe and healthy environment.

This section has detailed the establishment of the Buffalo City Metropolitan Municipality and also some of the challenges it faces. The section also discussed the functioning of the municipality and the various roles of the municipality within the administrative structures. The next section provides details about the general status of services within the municipality and some of the most common complaints voiced by residents.

2.6. Service Delivery Problems within the Buffalo City Metropolitan Municipality

This section will discuss the service delivery problems experienced in the BCMM in terms of the various categories as set out in the Integrated Development Plan. These categories

include the provision of democratic and accountable government for local authorities, the sustainable provision of services to communities and the promotion of social and economic development as well as encouraging community participation in local government and promoting a safe and healthy environment.

2.6.1. To provide democratic and accountable government for local authorities

According to Coetzee and Stanz (2008), the most important reason people join organisations is in order to focus their attention and energy on a selected goal. In the case of a municipality, this goal would be the provision of products and/or services to citizens.

The general status of the services rendered by the BCMM is often reported in the media as being poor while there are numerous complaints about poor service delivery, financial mismanagement and corruption. There is also an increasing trend not to include citizens in the decision-making processes in the municipality (Apraku, 2010; Sikhakane & Reddy, 2009). The reasons cited behind these complaints include political power struggles, socioeconomic problems and the increased need for services as a result of urbanisation (Sikhakane & Reddy, 2009; Van der Waldt, 2007; Ahmad et al., 2005).

National government has made the decision to decentralise the responsibility for service delivery to municipalities as these services are consumed at a local level. While in principle this was a sound decision, it was found that there is an acute lack of capacity in municipalities as regards taking responsibility for public services (Ahmad et al., 2005). This problem was initially created by the mandate from National Government that African National Congress comrades must be deployed to municipal positions, regardless of their qualifications (Managa, 2012). Sikhakane and Reddy (2009) reported that most of the municipal employees employed in terms of this mandate were from previously disadvantaged communities and had had little or no little exposure to the municipal setting prior to their appointment. This situation was exacerbated the low level of education of the majority of these employees (Pieterse, 2008). The end result of this mandate was found to be nepotism and maladministration within municipalities as they were being managed by incompetent and disorganised staff (Managa, 2012). This point is illustrated is the Auditor-General's financial report for 2010/2011 that revealed that 7 out of 283 audited municipalities only had received a clean audit for the year. It was found that R5 billion in unauthorised expenditures had been incurred by 112 municipalities – an increase of R2.3 billion from the previous year (Mosombuka, 2011). On the other hand, some

municipalities had under spent on their budgets as a result of a lack of project management, poor financial management and a lack of leadership skills (Managa, 2012).

Further reasons for the poor human resources capabilities found in municipalities will now be discussed. For example, politically well-connected, but under-qualified, managers continue to be employed despite producing poor results. The deterioration in service delivery is often attributed to a lack of the necessary skills to manage municipal services. The public sector frequently struggles to compete with the private sector for qualified staff in the more senior and technical positions. This is evident in the many vacant posts in, particularly, the rural municipalities (Managa, 2012; Sikhakane & Reddy, 2009). In addition, the following reasons may be hampering the successful implementation of a public safety, participatory crowdsourcing smart city project in East London:

- Service delivery has come under increasing pressure in East London as a result of the increasing urban population that is demanding better services. The population is, however, not able to participate in local government at present as there are few formal mechanisms to do so.
- A typical problem in developing countries is the lack of capacity and skills on the part of the workers. This is also true in East London, where local government employees do not have either the skills or the education to provide effective and efficient public services. As regards to this research project the lack of skill, especially on the part of municipal administrators and ICT staff, presented problems for the implementation and running of the smart city in East London,
- Political power struggles may also deter investment in the city of East London. In view of the fact that the decision to become a smart city must be supported by all the stakeholders within the city (see section 3.7), political power struggles would directly influence the successful implementation of a smart city project.

The next section discusses the way in which the BCMM may ensure the provision of sustainable services to communities.

2.6.2. To Ensure the Provision of Services to Communities in a Sustainable Manner

The BCMM has a disproportionately small tax base in proportion to the large rural areas that are incorporated within its boundaries (Managa, 2012). As already mentioned, the majority of the population is not able to pay for services, while there is also only a limited number of industries that can be taxed within the constituency. This, in turn, means that

there is limited scope for expansion only as regards to the revenue base that is composed of property taxes (rates) and water and electricity service fees (Van der Waldt, 2007).

Several financial management initiatives have been introduced in an effort to improve financial administration in the BCMM. One of the most important of these was Project Consolidate in 2006. This project was initiated by the National Government in order to support capacity building in local government and provide free basic services to the poor. In addition, the National Treasury has launched its own capacity building programme to assist municipalities with their financial management systems (Buhlungu & Atkinson, 2007). Both of these projects aim to provide municipalities with the resources required to maintain financial viability through the expansion of their cost-bases. Some of the most important concerns addressed by these projects include the maintenance of assets; developing and extending services to new consumers; ensuring that all revenue is fully recovered; exploring additional sources of revenue; alternative service delivery mechanisms and considering levels of service in relation to affordability (Savage, 2007).

Financial support is required if a public safety, participatory crowdsourcing smart city is to be implemented. Making use of conversational analysis, the researchers deemed it appropriate to make use of crowdsourcing for the purposes of this research project as it would be possible to exploit the existing telephone infrastructure. This, in turn, would decrease the entry cost of the project which means the technology would be feasible to use in a developing country. This is important in the context of a developing city that often does not have the financial resources at its disposal to acquire the newest technology (Kumar, Agarwal, & Manwani, 2010). The next section discusses the socio-economic problems in the Buffalo City Metropolitan Municipality and how these problems impact on service delivery.

2.6.3. To Promote Social and Economic Development

Several socio-economic factors also contribute to the poor recovery of revenue for services delivered in the BCMM. The first such factor is poverty. More than half (57%) of the citizens in East London are classified as poor and, thus, they qualify for free services. In addition, of the 69.6% of those who are employed most are considered to be low-income earners, and, thus, they are not able to afford to pay for municipal services (Sikhakane & Reddy, 2009). The second socio-economic factor that must be considered is that of crime. Rising crime in the area has resulted in less investment opportunities and reduced tourism. Thus, the rising crime is perceived as a direct restriction as regards to development. The last socio-economic factor is the poor educational level of the local

work force. Almost 20% of the population in the Eastern Cape is considered to be functionally illiterate, while 7.2% of those who are functionally illiterate have never attended school (ECSECC, 2012). At the opposite end of the spectrum, increasing numbers of qualified people are moving to both the larger cities and overseas countries which offer them better remuneration (Pieterse, 2008).

The resource poor communities, which were included within the municipality boundaries during both the 1994 and, more recently, when the metropolitan was established, are not able to afford to pay the rates for services rendered. This, in turn, means that municipalities are unable to supplement their budgetary allocations with rates payments (McDonald, 2002). Thus, the limited resources provided by National Government and the rates paid in the more affluent areas have to be used to accommodate the demand of the resource poor communities for better services (Van der Waldt, 2007). In this vein, the following could influence the successful implementation of a public safety, participatory crowdsourcing, smart city project in East London:

- High poverty levels may deter the citizens of East London from participating in the smart city project. For example, the cost of a phone call may be an inhibitor as regards to making use of crowdsourcing.
- A low level of education is another characteristic of a developing country and must be taken into account when deciding on the technology to use in a smart city (Kumar, Agarwal, & Manwani, 2010). Illiterate users may not be able to participate if text is the primary way in which to report public safety matters. These two problems are discussed further in section 3.4.4. The next section discusses the involvement of the community in local government matters.

2.6.4. To Encourage Community Participation in Local Government Matters

As mentioned previously, there is an increasing trend not to include the community in municipal affairs. Despite the Local Government: Municipal Systems (Act 32 of 2000), which states that communities are entitled to participate in any public consultation and decision-making processes in their local municipality, communities often find themselves excluded from local decision making and accountability by the officers who represent their wards (Managa, 2012).

Ward committees are important structures which were introduced by government to promote participatory democracy. However, in general, ward committees are not functioning properly and, as a result, citizens are not receiving the information, capacity

building and guidance they require (Sikhakane & Reddy, 2009). On the other hand, local residents are often not fully aware of their civil rights, probably because of a lack of education which, in turn, results in municipal employees not being held accountable for poor service delivery (Managa, 2012). As mentioned in section 2.6.1, it is essential that the citizens participate in the smart city project if sufficient information is to be generated. A benefit of smart cities, if realised, is that the citizens then have an avenue to participate directly in the functioning of their city. The next section focuses on the public safety of the communities within the municipal boundaries.

2.6.5. To Promote a Safe and Healthy Environment

Political campaign manifestos have contributed to the disillusionment of communities as politicians make promises in order to satisfy the voters during each new election campaign. However, after the election, when these promises are broken, communities voice their dissatisfaction through protests (Managa, 2012). Since 2007, as is evidenced by the increasing number of service delivery protests, the dissatisfaction of the local communities has increased. Protest action in South Africa was at its height between 2009 and 2010 when it was associated with high levels of violence. On average there were 8.8 protests per month in 2011. This was, however, much lower as compared to the 17.5 protests per month in 2009. This decline in the number of protests may be the result of the municipal elections which were held in May 2011 where election promises were made to the community (Municipal IQ, 2011).

Since 2011 a change has taken place with more protests taking place in the metropolitan areas as opposed to non-metropolitan areas. A third of these protests took place in the informal settlements in these metropolitan areas (Municipal IQ, 2011). The Municipal IQ report suggested that protests do not occur in the municipalities with the worst service delivery, but rather in those municipalities with the highest population growth and urbanisation rate. This, in turn, suggests that communities living in informal settlements with high rates of poverty and unemployment and on the periphery of metropolitan areas are more likely to demand better service delivery as they live near suburban areas. In certain municipalities in Limpopo, the Free State and Gauteng, government has been forced to appoint interim administrators to run the municipalities. This was done as the provinces concerned were not able not fulfil their executive obligation in terms of legislation or the Constitution in order to maintain an essential national standard or to meet the minimum standards for the rendering of a service which had been established (Managa, 2012).

As will be discussed in section 3.7, the participation of various stakeholders is necessary if the public safety, participatory crowdsourcing smart city is to be implemented. However, if the project becomes a political ploy used to garner support before an election, it will not be supported by the citizens.

This section has dealt with some of the general problems experienced in South African municipalities and, especially, in the BCMM. The problems that were discussed include capacity problems such as a lack of skilled and educated municipal administrators; socio-economic factors such as poverty, crime and poor educational levels; urbanisation; maladministration; limited income as a result of a small tax base; limited participation on the part of citizens as ward committees are not functional, and broken promises after elections. Making use of conversational analysis, these problems were taken into account during the process to determine whether the city of East London would be suitable for the context of this research project. However, it emerged from the discussion that the city of East London would, indeed, be suitable as East London is an example of a city in a developing country. Public safety was reported as problem in the city where a smart city could contribute to the quality of life of the citizens of East London (see section 2.7.1). The smart city concept would provide the BCMM with alternative and innovative ways in which to improve public safety as there is no possibility of increasing the existing resources. The next section will, therefore, focus on public safety as the context in which the participatory crowdsourcing system was implemented for this research project.

2.7. Definition of Public Safety

Public safety involves the prevention of and protection from events that could endanger the safety of the general public in terms of significant danger, injury/harm, or damage. Examples of such events are crime or disasters (natural or man-made) (PSECGC, 2008). The next section will discuss the first factor that may contribute to a lack of public safety, namely, crime.

2.7.1. Crime

According to Liebermann, Landman, Louw and Robertshaw (2000), crime is not the result of one event but, rather, it is the result of a combination of several factors. In order to reduce the crime rate in a city there are two different approaches that may be taken, namely, punishment for or prevention of the crime. The traditional penal approach aims to deter criminals through punishment once they have been arrested and tried in court.

However, this approach is not working in South Africa as the country has the world's seventh highest number of prisoners, outranking countries with populations that are 5 times larger than the population of South Africa. South Africa also has the highest ratio of prisoners to total population in Africa, with 348 prisoners for every 100 000 population (Naidoo & Mkize, 2012; CSVR, 2009).

In comparisons between the annual crime rates for the various provinces in South Africa, the Eastern Cape is consistently in the top three provinces in the serious crime categories, namely, murder, sexual assault and robbery at residential premises. These three categories represent a variety of public safety issues that are likely to be reported if a participatory crowdsourcing system were implemented. Figure 2.3 depicts the percentage of murders committed in the various provinces. The Eastern Cape had the second highest percentage of murders committed in South Africa for 2012, after Kwazulu-Natal (Crimestats South Africa, 2013).

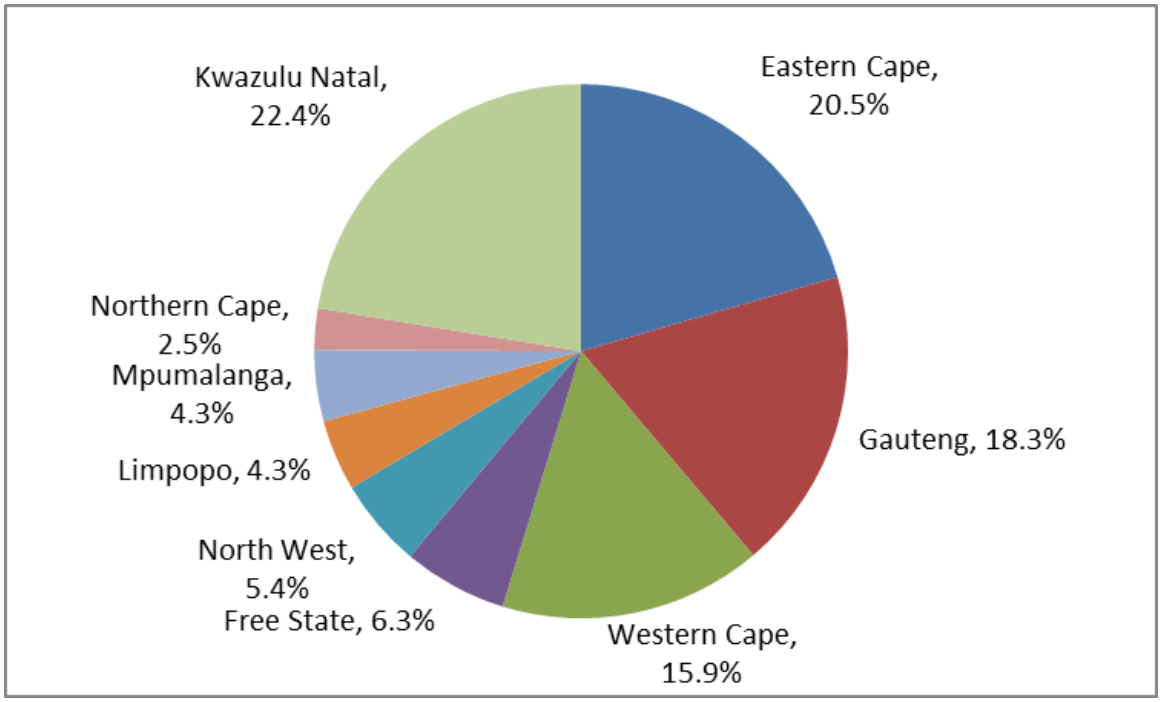


Figure 2.3: Percentage of Murders Committed in South Africa per Province (Crimestats South Africa, 2013)

Figure 2.4 depicts the percentages of sexual assaults per province for South Africa. As may be seen from Figure 2.4, the Eastern Cape has the third highest percentage of sexual assaults in the country after Kwazulu-Natal and Gauteng (Crimestats South Africa, 2013).

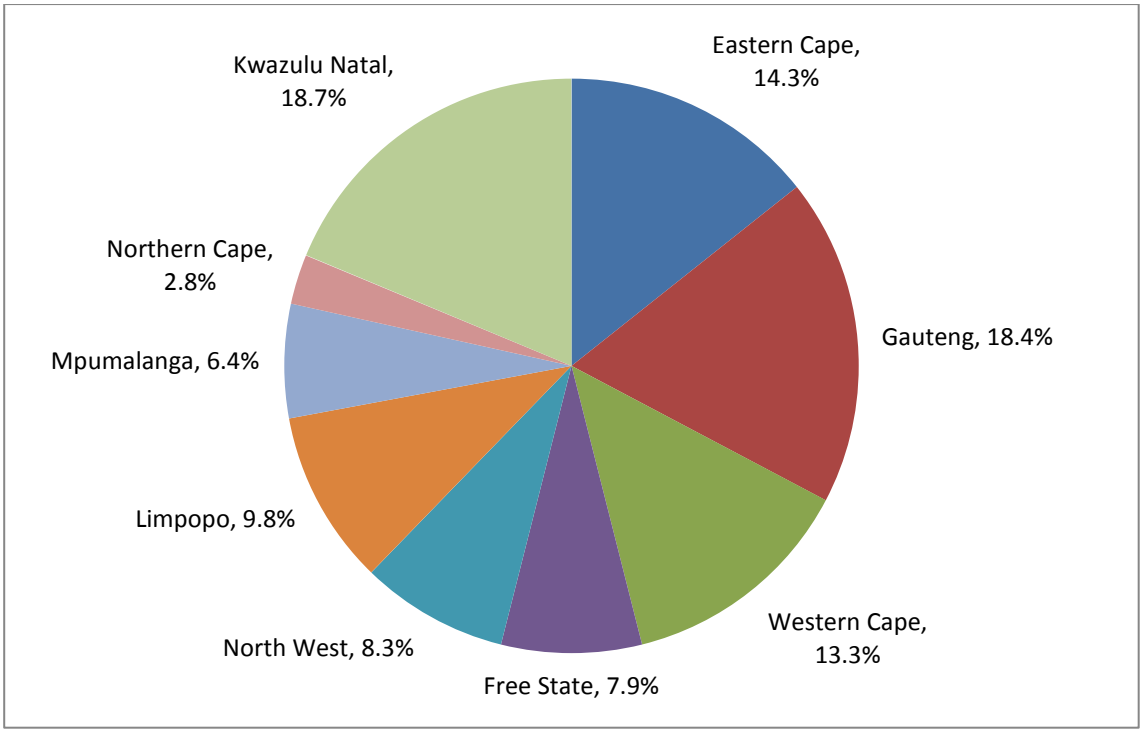


Figure 2.4: Percentage of Sexual Assaults in South Africa per Province (Crimestats South Africa, 2013)

The last category that would of interest concerning the participatory crowdsourcing system is robbery at residential premises. As depicted in Figure 2.5 the Eastern Cape is placed third after Gauteng and Kwazulu-Natal with a percentage of 9.6% for this crime category in 2012 (Crimestats South Africa, 2013).

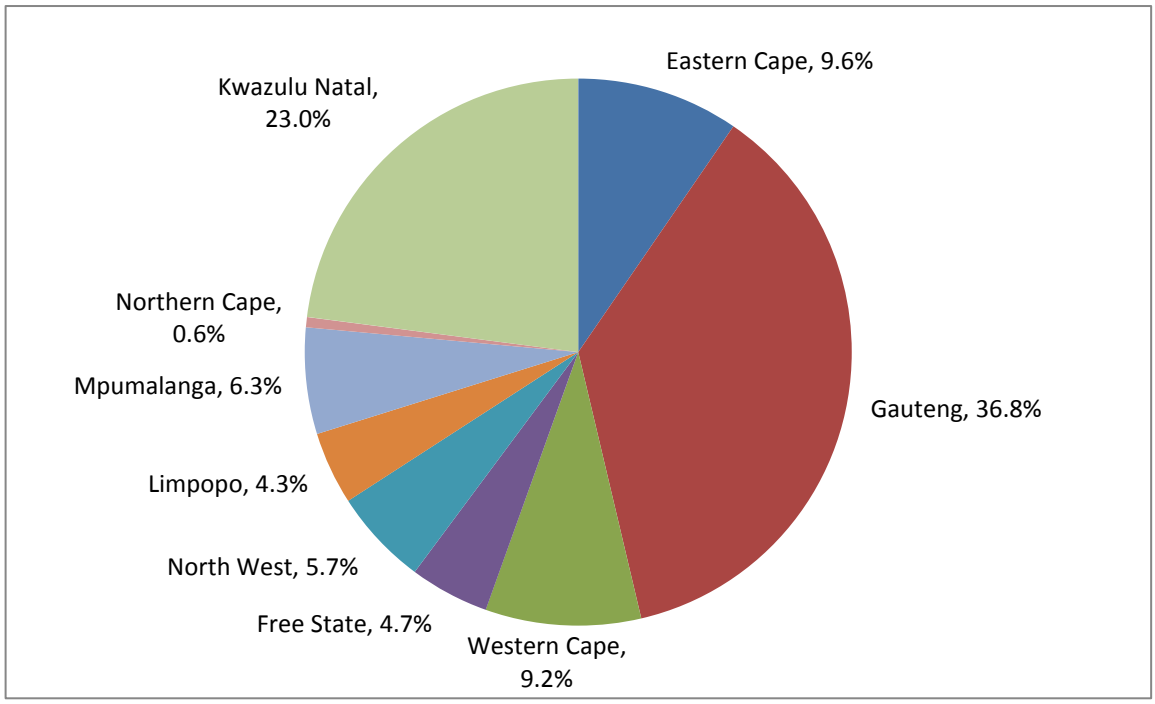


Figure 2.5: Percentage of Robberies at a Residential Premise in South Africa per Province (Crimestats South Africa, 2013)

There are many factors that have been identified as the reasons for these statistics, in particular, the apartheid policies prior to 1994. Law enforcement in the township areas was not a priority under the apartheid regime and this, in turn, resulted in the development of a culture of informal mechanisms of justice and criminal groups operating in these areas (Liebermann et al., 2000).

A further factor that may play a role in the high violent crime rate is the inequality found in South Africa. The Centre for the Study of Violence and Reconciliation reported that South Africa is one of the most unequal societies in the world (CSVR, 2009). There is a reported link between inequality and questions about self-worth amongst people who are confronted with the extreme disparities between their own positions and those of people who are significantly better off than they are. This is especially important in the black community of South Africa where the gap between the '*have and have-nots*' is increasing. Other factors closely associated with inequality include high levels of poverty, structural unemployment as well as social and political exclusion and marginalisation (CSVR, 2009). Making use of conversational analysis, these statistics and reasons were all taken into account in the decision concerning which smart city area the study should focus. In order to ensure the participation of all the citizens in East London, it was essential that the focus area of the study be both inclusive and important. The researchers were of the opinion that the statistics mentioned above provided sufficient evidence that public safety is an issue of concern in East London and that it affects the quality of life of all the citizens in the city. Figure 2.6 provides a summary of the complex interplay between the various factors involved in crime (Liebermann et al., 2000).

Figure 2.6: Various Factors that Influence Crime (Liebermann et al., 2000)

The alternative approach to reducing the crime rate is the prevention of crime. Although the prevention of crime is often regarded as the '*soft approach'*, it does have very distinct benefits for both government and the community. It costs R69 000 per annum to house a prisoner. On the other hand, the prevention of a crime lessens the impact of crime on potential victims while improving the quality of life in communities (Naidoo & Mkize, 2012).

It is essential that crime prevention focus on three areas if crime is to be reduced. These include altering the environment in which crime occurs; changing the conditions which are considered to cause crime; and providing a strong deterrent to crime in the form of an effective criminal justice system (South African Government, 1998). Crowdsourcing may be used in order to alter the environment in which the crimes occur. Examples of such projects include the use by the Memphis Police Department in the United States of America and the police department in Rio de Janeiro, Brazil, of predictive analytics in order to predict hot spots for crime and, thus, to increase visible policing in these areas (McConnachie, 2012; Horn, 2012). These projects will be discussed in section 3.6.

2.7.2. Natural and Man-made Disasters

It is essential that municipalities make provision for the second aspect cited in the definition of public safety (protection from events) and which includes '*man-made and*

natural' disasters (PSECGC, 2008). Municipalities are responsible for the delivery and maintenance of services and infrastructure. These include roads, water, sewerage, electricity supply, the management and planning of the town's development, and the protection of the infrastructure and facilities, including parks, forests and recreational assets as well as buildings and properties (Liebermann et al., 2000). When any of these services are interrupted as a result of a disaster, whether man-made or natural, it is the responsibility of the municipality to respond appropriately in order to provide relief and to restore services as soon as possible (Botha, Van Niekerk, Wentlink, Coetzee, Forbes-Biggs, & Maartens, 2011).

Botha et al. (2011) recognise that a disaster *per se* does not refer so much to the size of the physical event, but rather to the inability of the community to absorb the impact of the event within the constraints and capacity of the city concerned. However, this type of situation cannot be dealt with as a pure line function responsibility and it is vital that all spheres of government be included. This, in turn means that disaster risk management must become an integrated, multi-sectoral, multi-disciplinary approach with the exclusive aim of reducing the risks associated with hazards and vulnerabilities. In order to do this, disaster risk management must not focus only on a response oriented approach, but also on a proactive approach (Botha et al., 2011). In order to facilitate this process, the Disaster Management Act of 2002 was published to provide guidance and best practices aimed at helping to achieve more effective disaster prevention, mitigation and preparedness.

While each town in South Africa has a different disaster risk profile, there is often a lack of the awareness, resources and political will required to implement an effective and proactive disaster risk management plan at local government level. However, in view of the fact that this is the first level of response, it is imperative that functional strategies, policies, programmes and projects be in place to enable an effective response. It is for this reason that it is incumbent on each district and metropolitan municipality to formulate a Municipal Disaster Management Framework and to establish a Municipal Disaster Management Centre (Botha et al., 2011).

The proactive approach to disaster management includes the acquisition, assessment, processing and distribution of information. Crowdsourcing may be used to generate information on a massive scale as people in the disaster struck area may share data with the authorities in real-time while the processing and analysis of the data may be conducted anywhere in the world (Ortmann, Limbu, Wang, & Kauppinen, 2011). During the recent disasters in Haiti (2010) and Japan (2011), crowdsourcing was used to collect

and disseminate information between the victims and the relief organisations. There were, however, difficulties with the communication infrastructure as relief organisations typically have their own information systems which may not be compatible with ad hoc, social media infrastructures such as Twitter. Integration between the two information infrastructures must be done manually but, with the time constraints in a disaster situation, this is not always feasible. Other problems include trust in the data reported and semantic problems in interpreting the data. Nevertheless, despite these flaws, many relief organisations have recognised both the potential and the value of crowdsourcing in order to gather information and they are working towards making it part of their decision-making processes (Ortmann et al., 2011).

This section provided a broad overview of the definition of public safety. It further discussed how crowdsourcing, in particular, may be used to gather or provide information in order to improve public safety. The next section focuses on public safety in the Buffalo City Metropolitan Municipality and discusses the various departments within the municipality that are responsible for this function.

2.7.3. Public Safety in the Buffalo City Metropolitan Municipality

The Directorate of Health and Public Safety is responsible for the public safety of the citizens in East London while the Department of Public Safety provides the traffic safety and crime prevention services, fire and rescue services, and disaster management services that ensure the safety of all the communities within the metropolis. In order to accomplish these goals, the Department of Public Safety comprises three divisions, namely, Traffic and Law Enforcement, Fire and Rescue Services and Disaster Management (Buffalo City Metro, 2013C).

The Traffic and Law Enforcement division, in turn, consists of the traffic enforcement and law enforcement sections (Buffalo City Metro, 2013C). The traffic enforcement section is responsible for the enforcement of the law in respect of the National Road Traffic Act and applicable by-laws. Thus, the role of this section is to focus on all aspects of traffic safety, including learner and driving licences; vehicle registration, roadworthiness and licensing; the erection and maintenance of road signs and surface markings; maintaining a record of motor vehicle accident statistics and traffic law enforcement, including the coordinating of protest marches and gatherings in terms of the Gatherings Act 205 of 1993 (Buffalo City Metro, 2013D). The law enforcement section is responsible for the enforcement of municipal by-laws, the protection of municipal assets and crime prevention (Buffalo City Metro, 2013C).

The Fire and Rescue Services division is responsible for services such as fire inspections, fire training courses, fire prevention, fire fighting, and the rescue and recovery of injured victims. On the other hand, the Disaster Management division provides risk and vulnerability assessments; advice about preparedness for disasters; response, relief and recovery, and the rehabilitation and reconstruction of infrastructure (Buffalo City Metro, 2013C). In addition, the Disaster Management Centre also provides the capabilities required to deal with a wide range of emergencies while providing support to communities affected by public safety events or disasters when the community cannot cope by relying purely on its own resources (Buffalo City Metro, 2013E).

There are several different emergency services available in the Buffalo City Metropolitan Municipality. These include Traffic Services for East London and King William's Town, Fire East London and King William's Town and the provincial ambulance services. However, the problem with these emergency services is that they work in silos without any internal coordination (Managa, 2012). In addition, the various duties and responsibilities of the different emergency services are confusing. For example, the law enforcement services of the BCMM are not responsible for policing and cannot be contacted during an emergency. The correct authority to contact would be the South African Police Services (Buffalo City Metro, 2013F).

2.7.4. Media and Crowdsourcing

Local municipalities recognise that citizens play a crucial role in preventing and minimising the impact of impending public safety situations. Thus, the citizens are encouraged both to educate themselves about the hazards and risks they may face and also to take the necessary steps to prevent or reduce the impact of a public safety situation (Buffalo City Metro, 2013E). One of the ways in which citizens may report public safety problems is through the *Go! & Express Newspaper*. As more people turn to the media to report issues that are important to them, the newspaper has become a popular form media to raise awareness about public safety (Foster & Linehan, 2013).

The newspaper launched a public campaign in 2012 to highlight the poor state of service delivery in East London. The Spotlight on Services Campaign was launched on 1 November 2012 with the aim of providing a public platform for the citizens of East London to raise their concerns about the state of services and maintenance within the city. Within the first week the newspaper had received hundreds of letters and photographs from concerned residents (Go! & Express Newspaper, 2012).

This campaign provided the community with an opportunity to report public service issues, albeit on a limited scale. However, this is an example of a crowdsourcing project which demonstrates the need for such systems to be put in place in a more formal and systematic manner. The information obtained from such a system may then be analysed by BCMM in order to predict future problems and maintenance of municipal infrastructure.

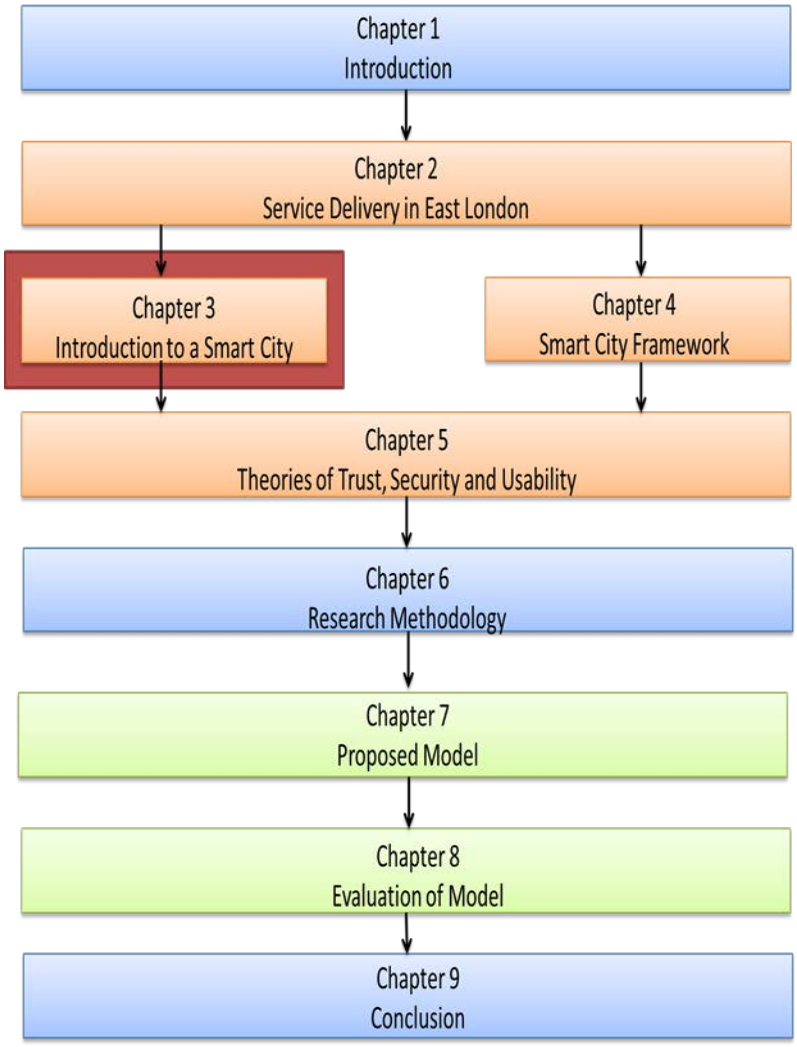
2.8. Conclusion

This chapter focused on two of the areas that are included in the PSPC smart city model for developing countries, namely, the city (BCMM) and the citizens of East London. The chapter provided the context in which this research project was conducted. The city of East London is a developing city in South Africa. The BCMM was established after the amalgamation of the cities of East London, King William's Town and Bhisho. Included in the municipal boundary lines are a large township and various other rural areas. The municipality serves an estimated 1.4 million people and had the highest growth rate of all the South African metropoles in 2012 (Skenjana, 2013).

Public safety in East London is an issue of concern and it must be addressed by the BCMM. The BCMM is not able to generate sufficient revenue from the citizens of East London in order to provide enough resources to ensure public safety. The reasons for this situation include a low income constituency and a small industrial tax base. The municipality is further faced with huge backlogs of services in the rural areas while East London citizens are demanding improved service delivery. Internal problems such as political infighting, poor administrative and financial controls, poorly functioning ward committees and low human resource capacity constitute further challenges to service delivery.

Provision was made for the issue of public safety in East London to be addressed through the Directorate of Health and Public Safety. While the structures are in place to respond to possible public safety situations, the various departments work alone with no or little integration. In addition, the responsibilities of the various departments are also unclear, thus confusing the public. The next chapter will introduce the concept of a smart city and the way in which this concept may be used to improve public safety in a developing city.

CHAPTER 3
Introduction to a Smart City



3.1 Introduction

3.2 Smart Technology

3.3 Definition of a Smart City

3.4 Smart Technologies

3.5 Benefits of Smart Cities

3.6 Public Safety in Smart Cities

3.7 How to Become a Smart City

3.8 Conclusion

2.9. Introduction

Worldwide the populations in urban areas are increasing as people move to cities in search of better economic opportunities and social services (Washburn & Sindhu, 2010). Since 2008, the majority of the world's citizens have been living in cities and this number expected to increase to 80% by 2028 (McConnachie, 2012). According to the Living Planet Report, the human race will require the resource equivalent of two planets by 2030 to maintain its lifestyle if the demand on the planet continues to increase at the current rate (Buhl & Jetter, 2009).

The growing urban movement and increasing energy needs pose specific challenges to local government services and infrastructure (Washburn & Sindhu, 2010; Alusi, Zuzul, Eccles & Edmondson, 2011). These challenges include a combination of poor management, the deterioration of existing infrastructure and finite resources such as energy, health care, housing and water (McConnachie, 2012; Di Maio, 2012; Washburn & Sindhu, 2010).

Chapter 3 will introduce the smart city concept. The chapter will discuss the definition and benefits of a smart city and the technology that makes a smart city possible. In addition, the chapter will present the steps that a city must follow in order to become a smart city. The various areas that a smart city could impact on, as described by Giffinger, Fertner, Kramar, Kalasek, Milanovic and Meijers (2007), are also discussed. These areas include the smart economy, people, governance, mobility, environment and living. Public safety, the context of this study, is included in the smart living area and some examples of public safety smart city projects around the world are provided. This chapter then answers the first research sub-question: **How can a smart city improve public safety in a developing country?**

As regards the PSPC smart city model for a developing country that was introduced in section 1.7, this chapter will provide an insight into two of the areas proposed by Chourabi et al. (2012), namely, **technology** or, in the context of this research project, the public safety, participatory crowdsourcing system and the steps a **city** must undertake in order to implement a smart city. The next section will introduce the technology that is required for a smart city to exist.

2.10. Smart Technology

It was established in Chapter 2 that the city of East London is not using its existing resources effectively and efficiently. Although it is not possible for the city to increase its resources substantially, the city is, nevertheless, expected to serve an ever increasing community. Buhl and Jetter (2009) propose that cities must become '*smarter*' if they are to save and use resources more effectively and efficiently. This is in line with Figure 1.2, the flow diagram that was introduced to illustrate how a city can become '*smarter*'. Pressure on municipal services will either result in an increase in resources or, if this is not possible, the more efficient and effective use of existing resources. The decision as to whether or not to become a smart city must then be taken. The technology that makes a smart city possible is discussed in the remainder of this section.

Technology and, in particular, Information and Communication Technologies (ICTs), are enabling cities to become smarter (Washburn & Sindhu, 2010). Forrester defines Smart Computing as:

> A new generation of integrated hardware, software, and network technologies that provide Information and Communication Technology (ICT) systems with real-time awareness of the world and advanced analytics to help people make more intelligent decisions about alternatives and actions that will optimize business processes and business balance sheet results (Washburn & Sindhu, 2010, p. 2).

Some of the critical city infrastructure that may benefit from smart computing include the city administration, education, healthcare, public safety, real estate, transportation, and utilities (Washburn & Sindhu, 2010; Dirks, Gurdgiev, & Keeling, 2010).

There are several prereguisites before a smart city may be implemented (Sanou, 2013). These include a policy decision to prioritise and invest in future development strategies, cost-benefit assessments and the setting of strategic socio-economic priorities (Komninos, Pallot & Schaffer, 2012). The role of technology in these development strategies is pivotal. At the end of 2012, there were more than 6.8 billion mobile telephones in the world, with an estimated 96% of the world population being connected to a cellular network. Our world is also becoming increasingly interconnected. By the end of 2012 an estimated 40% of the world will have access to the Internet (Sanou, 2013). With the introduction of the Internet of Things (IoT), in terms of which objects of daily life will become able to connect to a data network, the possibility for interconnectedness becomes infinitely more (Atzori, Iera, & Morabit, 2010). Thirdly, many things are becoming more intelligent with new computing models and advanced analytics being able to transform a mountain of data into intelligence faster than ever before. This intelligence may, in turn, be used to increase the efficiency and responsiveness of systems in order to conserve limited resources (Palmisano, 2008). Fourthly, smart computing technologies make use of a combination of advanced information technology, analytics and systems thinking to improve both how a city works and how it stimulates a knowledge-driven economy (Dirks et al., 2010). Thus, all of the factors mentioned above enable smart cities to maintain and improve the quality of life of their citizens in a sustainable manner (Barile, Spohrer & Polese, 2010). In the next section the various definitions of a smart city are discussed.

2.11. Definition of a Smart City

The term '*smart cities*' is not new as it was first used by Bollier in 1998 during the Smart Growth movement in Portland, Oregon, United States of America. Since 2005, however, the phrase has been adopted and made known commercially by technology companies such as Cisco, IBM, and Siemens (Harrison & Donnelly, 2011).

There is no one-size-fits-all definition for a smart city. Depending on the approach taken, it is possible to find several different definitions of what constitutes a smart city in literature (Nam & Pardo, 2011). The two most common approaches focus either on the purpose of the technology, or on the technology itself. An example of the first appraoch is that of Washburn and Sindhu (2010) who define a smart city by placing the emphasis on the use of smart technologies in a city faced with urban crises, deteriorating conditions, scarcity of resources, inadequate and poor infrastructure, energy shortages and price instability as well as global environmental and human health concerns. Giffinger et al. (2007) extend this definition by identifying six key areas of a city on which a smart city may have an impact. These include the economy, people, governance, mobility, environment and living and will be discussed in section 3.5. Caragliu, Del Bo and Nijkamp (2009, p. 6) provide the following rather elegant definition:

> The point of departure is the definition which states that a city may be called 'smart' when investments in human and social capital and traditional (transport) and modern ICT communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory government.

In contrast to these definitions, the following definitions place the focus on the technology itself. IBM (2010) provides a view of a smart city with three tiers, namely, the instrumented, interconnected and intelligent tiers. Real-time data is sourced from the world by making use of both physical and virtual sensors (instrumented) which are interconnected across multiple processes, systems, organisations, industries or value chains, thus making intelligent decision making possible. This view is supported by Hall (2000) in his definition that local government is able to monitor and integrate its critcal infrastructure.

However, no matter the approach used to define a smart city, the benefits of a smart city have been well documented in literature with these benefits including the improved sustainability, empowerment and quality of life of the citizens of the city (Komninos et al.,

2012; Ferro, Caroleo, Leo, Osella & Pautasso, 2013). These benefits may be realised through two different catalysts. The first such catalyst refers to the collection and analysis of data which improves the government's ability to forecast and manage urban flows and to push the collective intelligence of the city forward. This, in turn, enhances the problem solving capabilities of the government (Schaffers, 2010). The second such catalyst refers to the competitiveness of a city in the economic world as regards to attracting skilled and knowledgeable workers (Schaffers, 2010; Washburn & Sindhu, 2010). Smart cities enable research, innovation and the upgrading of the skills of their citizens in order to promote the knowledge economy. This, in turn, means that an active labour market policy that enables the smart city to sustain employment, strengthen social cohesion and reduce the risk of poverty (Washburn & Sindhu, 2010). In the next section the technological developments that enable smart cities to develop and prosper are discussed.

2.12. Smart Technologies

There are several new and innovative technologies that enable advances in a smart city. Four of these innovative technologies will be discussed briefly below. These include the Internet of Things (IoT), cloud computing, mobile devices and the Spoken Web and they will be discussed in the next sections.

3.4.1. Internet of Things

Currently, as illustrated in Figure 3.1, ICTs are able to provide connectivity for almost anyone, anytime and in any place. One of the ICTs that enable us to do this is the IoT that provides the capability to connect anything, both in the physical and the virtual environments (Dimitriou, 2012). It is estimated that 50 billion devices will be connected to the Internet by 2020 (Komninos et al., 2012).

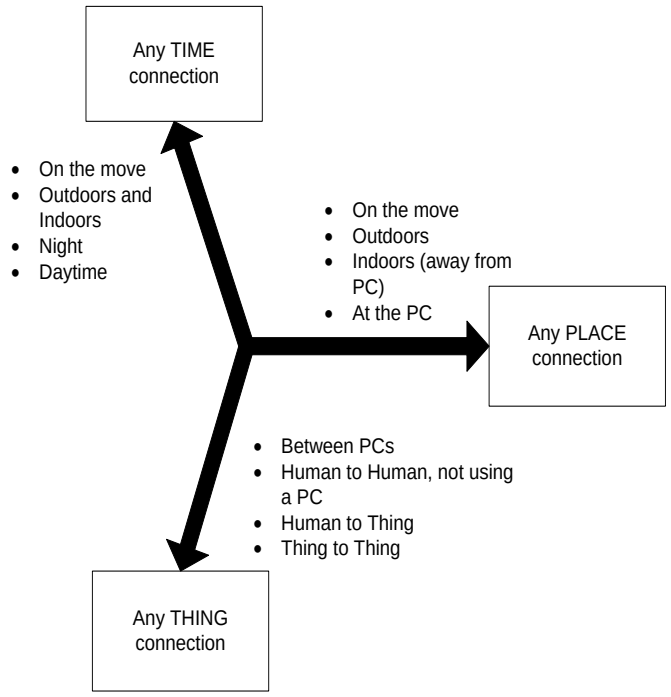


Figure 3.1: IoT Connection Capability (Komninos et al., 2012)

Interconnectivity is achieved through the placing of a large number of electronic devices in everyday objects such as houses, vehicles, buildings and other public environments (McConnachie, 2012). This is also referred to as crowdsensing. It is possible for these electronic devices, which may range from radio-frequency detection to nanotechnology, to collect a large amount of data that is then analysed in order to provide generic solutions to all those cities intending to make use of smart technology (Dimitriou, 2012). Possible uses of smart technology include fleet and freight management, security/surveillance, transport and mobility, vending/payment terminals, smart networks and industrial processes (Santucci, 2009).

However, the technology is not without challenges, the majority of which involve the interaction between the technology and the environment. It is essential that the technology be flexible enough to adapt to the environment while, at the same time, interacting seamlessly with the environment in order to achieve a specific purpose (Dimitriou, 2012). Security challenges include the lack of legal direction in respect of both the way in which to protect the privacy of the individual and also appropriate ethical behaviour (Santucci, 2009). These challenges were both considered when the decision was made to use crowdsensing or crowdsourcing for the purposes of this study. The researchers felt that the privacy of the individual would be protected if participatory crowdsourcing was used as the participants were free to choose what they wished to report. It was also felt that crowdsourcing was sufficiently flexible to adapt to the research

environment as the entry barriers of the technology were low in view of the fact that the existing telephony infrastructure was being used. The mobile telephone enables citizens to report public safety matters anywhere and in real time. This is especially important in the pubilc safety domain as information must be reported immediately in order to alert the relevant authorities. The next section will provide an overview of cloud computing

3.4.2. Cloud Computing

Cloud computing is the second type of technology that enables smart technology. Cloud computing provides new ways of delivering the computing resources which make use of recent advances in ICT such as high-speed networks, virtualisation, and the standardisation of platforms and applications (Komninos, Pallot, & Schaffer, 2012). In the immediate future, cloud computing will be delivered through the use of large commercial clouds although governments in the developing countries are in the process of developing G-clouds for the larger cities. The G-cloud will provide platforms for small business applications and e-services. A further advantage of cloud computing is the flexibility of the system and its ability to maintain operations in times of austerity. The reduction in the fixed cost of ICT is achieved because companies choose to make use of virtual, instead of physical, spaces (Gimenez, Fuentes, Oancea, Gimenez, Pertejo, Dimitriou, et al., 2013; Komninos et al., 2012; Townsend, Maguire, Liebhold, & Crawford, 2011). Thus, cloud computing enables developing countries to make use of new technologies such as crowdsourcing as it decreases the cost associated with implementing these new technologies. Crowdsourcing services may be hosted in the cloud by a service provider while the interested parties are able either to rent or to buy the services they require. For the purpose of this study the IVR system was hosted by IBM India and, therefore, the cloud was not necessary. The next section contains a discussion on mobile technology.

3.4.3. Mobile Technology

Ninety six percent of the world population is reported to own a mobilephone (Sanou, 2013). This high percentage may be attributed to the expanding mobile infrastructure in the developing countries and the decreasing cost of mobile phones (Nass, Robles, Heenan, Bienstock, & Treinen, 2003). The high penetration rate of mobile phones means that the mobile phone is becoming an extremely effective method of gathering and distributing information (Kumar et al., 2010). However, there are also factors that must be taken into account when mobile phones are used for the purposes of data gathering. Kumar et al. (2010) caution that it is essential that the technology employed involves

simple ways of applying advanced solutions if it is to be successful, while Nass et al. (2003) warn that the technology must be used correctly so as not to limit the quality or quantity of data gathered. Speech recognition and production technologies are one of the technological developments that may be used to gather information telephonically and which comply with both of these recommendations (Kumar et al., 2010). Making use of conversational analysis, it was decided that the mobile phone would be an appropriate technology to include in the study. The reasons for this decision were mentioned in section 3.4.1. The Spoken Web technologies are discussed in the next section.

3.4.4. The Spoken Web

The Spoken Web makes use of speech recognition or IVR software to enable the navigation of the user-interface (Nass et al., 2003; Kumar et al. 2010). IVR systems provide prerecorded messages to the user who then supplies an audio input in return and thus can navigate through the directory (Greeff, Coetzee, & Pistorius, 2008). The audio input may be either an automatic speech recognition (ASR) or a touch tone dialling (TMF) (Agarwal, Kumar, Nanavati & Rajput, 2011). There are three ways in which the information can be collected in the Semantic Web. The first data collection method comprises the system navigational log which records every interaction between the system and the caller, including the prompts presented, options selected, and the content listened to. Secondly, the calls may be transcribed and manually coded and, thirdly, interviews or questionnaires may be used to collect further information. The data collected will cover typical usage patterns, content quality and organisation, system navigation, feature preference, suggestions and overall satisfaction (Patel, Chittamuru, Jain, Dave, & Parikh, 2010). In this research project the third method, a questionnaire, was used to collect information from the registered participants about their interaction with the crowdsourcing system in order to validate the model.

There are several advantages to an IVR system for both the users and the developers of the technology. The users generally find the technology convenient as it allows them to use the IVR system at their own pace while making use of their preferred mode of communication. This, in turn, implies greater control over the delivery of the service. Chang and Heng (2006) further suggest that an IVR systems also offers advantages in certain situations such as emergencies as the mobile technology reduces the waiting time while also being convenient, efficient, flexible and saving time and cost for the user (Alcock & Millard, 2006).

For the developer, the major advantage of the IVR system is that the system has very low entry barriers as only an existing telephonic (mobile or landline) infrastructure and a basic phone is required (Kumar et al., 2010). In addition, the system also provides a less expensive and more scalable method with which to collect information as compared to the traditional practises such as interviews or questionnaires (Nass et al., 2003). Patel et al., (2010) further reported that illiterate users are able to make use of the IVR system. Patel et al., (2010) also found that the Spoken Web also overcomes traditional linguistic and cultural barriers as the end user is screened from the complexity of the technology through an intuitive user interface.

Once the data has been collected, techniques such as transcribing the data, data mining and predictive analytics may be used to transform the data into useful information. Typical examples of data collection include collecting and correlating data from various sources, identifying unusual or suspicious activities and identifying previously unknown patterns or relationships in large data sets so as to identify emergency situations (Giminez, 2012).

Making use of conversational analysis, an IVR system was deemed to be the best data collection method for the purposes of this research project. The reasons why an IVR system was deemed to be the most appropriate include the greater geographical coverage that mobile phones provide, the efficiency of the IVR system and the fact that it enables users to report matters at their own pace. This was regarded as especially important as the speech based IVR system was a new technology for many of the citizens of East London. In addition, a speech based IVR system does not exclude illiterate users as does a SMS service while it was also possible to use the existing telephony infrastructure (mobile or landline). The latter lowered the entry level barriers as regards the implementation of the research project. The challenges involved in the use of of new technologies that are not available in developing countries were also eliminated as an existing technology infrastructure was used. The building of the crowdsourcing system prototype will be discussed in more detail in Chapters 6 and 7. The next section will explain the most common telephonic data collection methods.

3.4.5. Crowdsensing and Crowdsourcing

As mentioned in the previous section, 96% of the world's population is connected to a cellular network (Sanou, 2013). This, in turn, means that telephones and, in particular, mobile phones, are extremely useful as instruments with which to collect information. When mobile phones are used to carry out large-scale data collection making use of

sensors or people, this is known as either participatory crowdsensing or crowdsourcing (Christin et al., 2011; Burke et al., 2006).

The data gathered via both crowdsensing and crowdsourcing may be analysed in order either to anticipate upcoming events or to isolate problem areas (Ling & Masao, 2011). There are several different role players in this process.

- Firstly, there are the initiators who are responsible for devising the campaign and establishing the data collection specifications;
- Secondly, there are the gatherers or mobile users who participate in opportunistic data gathering;
- Thirdly, there are the evaluators who are responsible for the verification and classification of the data which has been collected, and
- Lastly, the analysts will process, interpret and present the data which has been collected and the conclusions drawn from the data (Christin et al., 2011; Burke et al., 2006).

Figure 3.2 depicts the four stakeholder groups as well as their general roles and responsibilities in a crowdsourcing project and, in particular, in this research project.

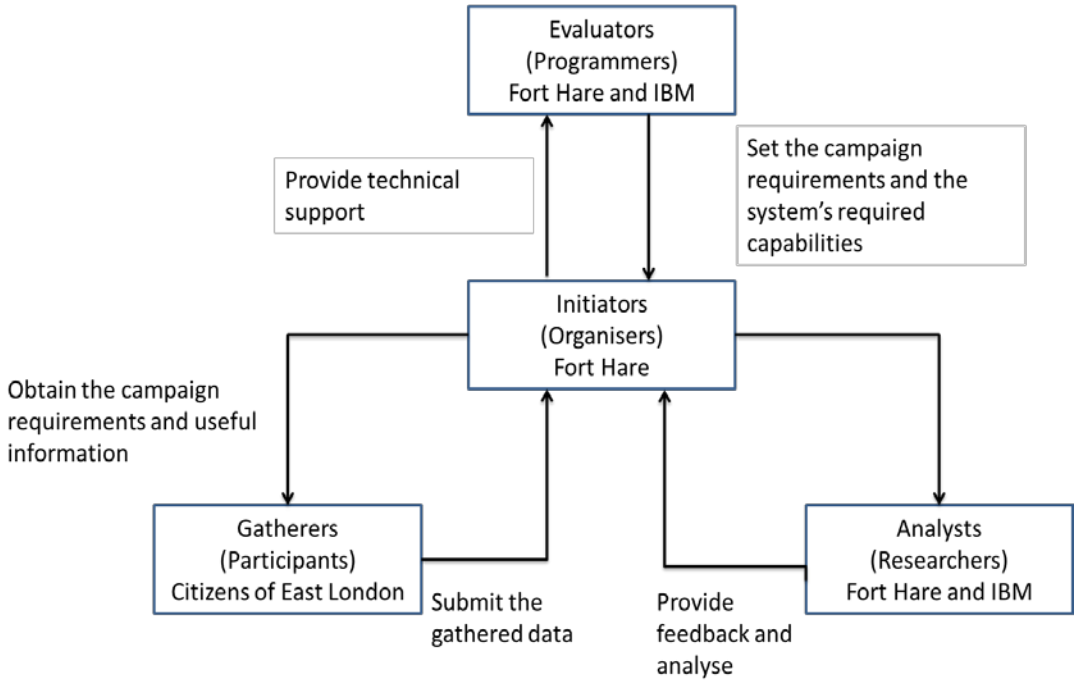


Figure 3.2: Crowdsourcing Stakeholders (Adapted from Yang, Zhang, & Roe, 2011)

Next, participatory crowdsensing and crowdsourcing are defined and examples provided where these data gathering methods were used to improve public safety.

Crowdsensing refers to the involuntary participation of data gathering by the end user while making use of a mobile device with various sensors attached to it. These sensors may include magnetometers, accelerometers, passive infrared based proximity, acoustics, and light and heat sensors that may be placed in or interface with a smart phone via Bluetooth in a relatively inexpensively way (Demirbas et al., 2011). Even without any modifications, mobile phones may be used as sensors. For example, the cameras in mobile phones may be used as video and image sensors and the microphone as an acoustic sensor while the GPS receivers are able to provide data about the location of the user (Christin et al., 2011).

Crowdsourcing, on the other hand, refers to the voluntary participation of individuals who are able to choose when and what they want to report. This approach is based on the motivational involvement of individuals as regards to reporting what they are observing in their immediate environment (Mehta, 2011). This approach may be used to gather data on a large scale about short-term concerns such as accidents or other public safety related issues. In addition, the citizens, who possess intimate knowledge about the patterns and anomalies in their immediate environment, are able to contribute appropriate information. This not only empowers the community, but it also enhances the quantity, quality and credibility of this community-gathered data (Burke et al., 2006). This notion is supported by Corburn (2004) who found increasing evidence that important contextual information may be missed if the data gathering is not supported by the experiences and knowledge of the local citizens.

There are several applications available to collect information about a variety of subjects should crowdsensing and crowdsourcing be used. For example, there is the CarTel application, which collects information about the traffic and condition of the roads. Mobile phones are used to take pictures (e.g. of accidents) while data about time and location stamps and acceleration data is used to determine traffic conditions. CarTel then provides the user with a map of the most congested roads in a city by making use of real-time data collected from the users of the roads (Hull, Bychkovsky, Zhang, Chen, Goraczko, & Miu, 2006). The green GPS application makes use of mobile phones and specialised sensing devices which are able to access the gauges and instrumentation of the user's vehicle. The data is stored on a memory card which is uploaded by the participant to the application. Once the data has been analysed it provides users with a map of the routes on which the least fuel would be consumed (Ganti, Pham, Ahmadi, Nangia & Abdelzaher, 2010). As presented in Table 3.1, Christin et al. (2011) identified more applications which are specifically designed to address public safety concerns, for example, air pollution, noise and road conditions. These three public safety concerns are important in the

developing country context as they affect the quality of life of all citizens. Nevertheless, in the developing countries, air and noise pollution are generally not subject to the stringent control measures which are found in developed countries, while the road infrastructure in these countries is not as developed as that in the developed countries. The various crowdsensing or crowdsourcing modalities used in each application to gather information are listed on the right of the table.

Table 3.1: Comparisons of Applications that Make Use of Crowdsensing or Crowdsourcing (Adapted from Christen, Kanhere, Reinhardt & Hollick, 2011)

Monitored subject	Applications	Crowdsensing				Crowdsourcing	
		Time stamps	Pictures	Sound	Location (GPS)	Acceleration	Pollution
Air pollution	Haze Watch	X			X		X
	PollutionSpy	X			X		X
Noise	NoiseTube	X		X	X		
	Ear-Phone	X		X	X		
	NoiseSpy	X		X	X		
	Noise Sense	X		X	X		
	MoVi	X		X	X	X	
	MetroTrack	X		X	X		
Road conditions	NeriCell	X		X	X	X	
	Virtual Trip Lines	X			X		
	VTrack	X			X		
	Transit Tracking	X			X	X	
	CarTell	X	X		X	X	
	GreenGPS	X			X		

According to Dimitriou (2012), there are several challenges that must be taken into account when data is collected in the smart city environment. These include the scale and heterogeneity of the environment as well as the degree of automation. This, in turn, means that there must be a system in place to control the aggregation, brokering and collection of data e.g. distributing public safety data to the relevant authorities to enable them to respond. However, such a system is also extremely complex and needs to be maintained regularly in order to ensure optimal usage. As discussed in Chapter 2, the lack

of skilled ICT workers and ICT infrastructure in the developing countries also constitutes a challenge tor the succesful implementation of smart cities.

The second challenge involves secure and reliable access to the information services for multiple stakeholders while maintaining the protection of the integrity of both the data and the system. This is especially important in a public safety environment where a timeous response is required. This well be discussed further in Chapter 5 (Monares, Ochoa, Pino, Herskovic, Rodriguez-Covili, & Neyem, 2011).

The third challenge involves the protection of the privacy of the individual during the use of either crowdsourcing or crowdsensing. A mobile phone may be used to collect data on a large scale without the participant being aware what information is being recorded. However, this may be seen as an invasion of privacy as the data may reveal private information about either the location or the routine of the participant. These invasions of privacy may include the recording of private discussions, taking photographs of private scenes and/or monitoring the user's path and locations visited by the user. Once participants become aware of these consequences, researchers have found that they are often unwilling to participate in voluntary participatory crowdsensing campaigns. Thus, inview of the fact that a large number of participants are required in order to validate information, it is essential that mechanisms to protect user privacy be put in place in order to address these concerns (Christin et al., 2011). Making use of conversational analysis, this concern was taken into account and it was decided that participatory crowdsouring would be a more appropriate method to use to collect the data required for this research project. The concept of privacy in crowdsourcing is discussed in detail in the next section.

3.4.6. Privacy and Crowdsensing

There are several definitions that may be used to describe privacy in ICT and, specifically, in participatory crowdsourcing systems. However, the most important aspect that must be included in any definition is the level of user control over sensitive data (Renaud & Galvez-Cruz, 2010). Christin et al. (2011, p. 13) proposed a definition that includes this aspect and which also provides for the active participation of users in the pursuit of the protection of their privacy. This definition is as follows:

> Privacy in participatory (crowd)sensing is the guarantee that participants maintain control over the release of their sensitive information. This includes the protection of information that can be inferred from both the sensor readings themselves as well as from the interaction of the users with the participatory sensing system.

Thus, it is vital that the system enable the user to control the type of data, degree of granularity and the spatiotemporal context released to third parties. In order to do this, the system must incorporate usable and understandable mechanisms with which to enable these actions (Christin, 2010). In addition, the participatory crowdsensing system must include mechanisms to protect the privacy of the users with these mechanisms protecting the spatiotemporal information and identity of the user (Christin et al., 2011).

Christin et al. (2011) analyse privacy in crowdsensing by making use of the Theory of Contextual Integrity. This theory includes two dimensions, namely, the appropriateness and distribution of the information received. These dimensions are aimed at alleviating concerns about privacy in crowsensing. Appropriateness determines whether the revelation of particular information would be appropriate in a given context, while distribution focuses on information transfer from one party to another. Additional factors that would determine the sensitivity of the data and which must be taken into consideration include socio-cultural and contextual differences. For example, the individual reporting the data may make different privacy decisions depending on the number of recipients that would have access to his/her data (Tang, Lin, Hong, Siewiorek, & Sadeh, 2010). The literature has reported that individuals are prepared to divulge information about their location to a single recipient based on logical decision making. However, factors such as the willingness to attract attention or protect or enhance their reputation are taken into account when such information is shared with a larger group of people. In this study, the citizens did not know who would have access to the public safety information that they reported to the participatory crowdsourcing system. Thus, the privacy concerns of the citizens had to be taken into account as they may not have been willing to divulge private information if they did not know who would access to the information.

There are several safety concerns associated with crowdsensing. While privacy concerns relating to senors that measure time and location have been covered extensively in the literature, the safety concerns of other sensors have received less recognition. These safety concerns are discussed below:

- **Time and location** – time and location stamps may reveal home and work locations as well as the routines of users. GPS receivers may be found in most smart phones but, even without this GPS receiver, WiFi or cellular network based triangulation may be employed to determine the location of the user (LaMarca, Chawathe, Consolvo, Hightower, et al., 2005).

- **Sound** – sound samples may be recorded intentionally by the user or captured automatically by the mobile phone at predetermined intervals. This, in turn, means that the user is not able to prevent the recording of private conversations about intimate or confidential subjects. In addition, background noises unique to a particular public location or event may inttude on the privacy of the user as the user's current location is revealed (Christin et al. , 2011).
- **Pictures and videos** – even if users protect their own identity when taking pictures, personal information is revealed about the other people in the vicinity and who are captured in the images. This may lead to privacy concerns for both the user and their social relations as it may be possible to draw conclusions about the social circle of the user as well as the behaviour of those captured in the picture. With the advent of online social media, such as Facebook, far-reaching consequences for users may be expected.
- **Acceleration** – while readings that measure the acceleration of the user does not seem like it could invade the user's privacy, they may, nevertheless, reveal private information about a user. If the phone is stored next to the hip of the user, it may provide information about the gait of the user. This data may then be used to deduce the identity of the individual concerned as well as the activity in which he/she is involved. Employers may use this information to verify what employees are doing during working hours (Gyorbiro, Fabian, & Homanyi, 2009).
- **Environmental data** – air compositions, in particular, and as measured by recording particles and gas concentrations or barometric pressure may be combined with other secondary information in order to identify the location of the participants (Christin et al., 2011).
- **Biometric data** – this data may be used to determine the current physiological state of the participant. While this information is useful to medical staff in determining health anomalies or diseases, the possibility that the information may be leaked to other parties must also be considered. For examples, such other parties may include health insurance companies that may use the information to revoke contracts or increase premiums if a particular disease is identified (Christin et al., 2011).

If the user is not comfortable using crowdsensing because of privacy concerns, then crowdsourcing is the best alternative as the user is able to control the data that is is reported. Other measures that may be taken to increase user participation include education about the use of the sensors as well as the use of pseudonyms or alias which

ensure that participants remain anonymous. Once the data has been collected it must be sanitised in order to protect the identity of the users or to remove sensitive information before it is released to other parties e.g. analysts (Christin et al., 2011).

This section explained how mobile phones may be used to gather data from citizens by making use of crowdsensing and crowdsourcing. This data must, however, be analysed and reported if meaningful information is to be provided to local governments on ways in which to use resources more effectively and efficiently. This research project made use of participatory crowdsourcing in order to collect information about public safety in East London. This information was then used for the purposes of predictive analytics in order to identify and predict public safety problems in the city.

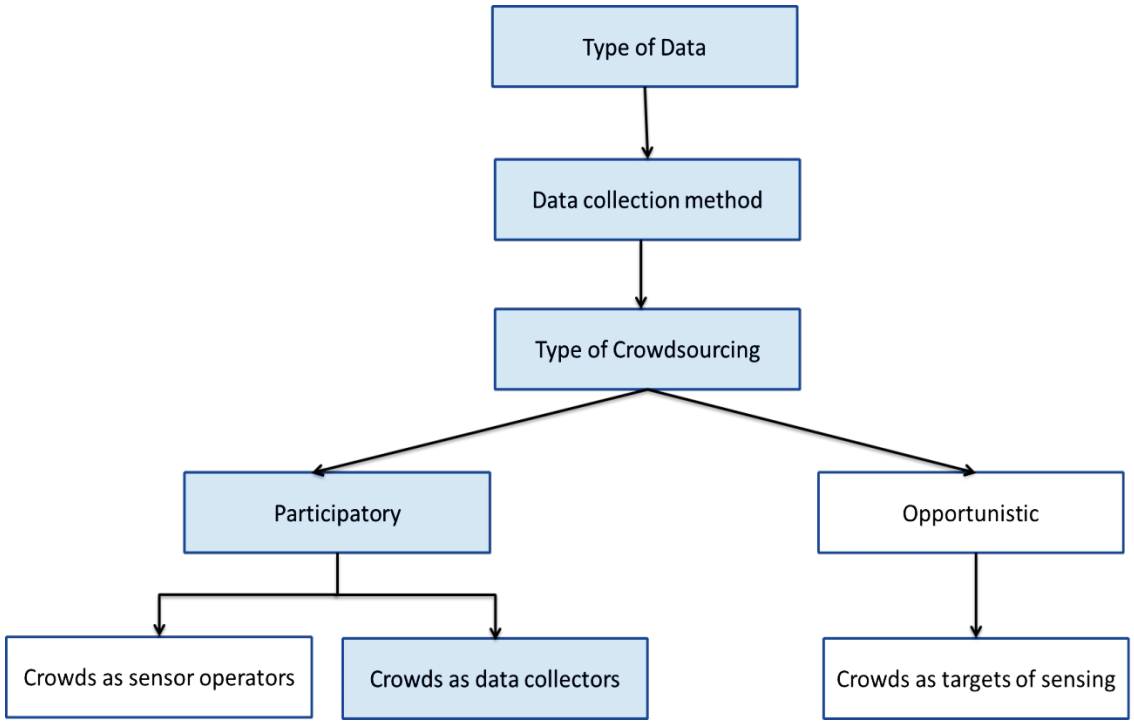


Figure 3.3: Components of Crowdsourcing

Figure 3.3 illustrates the path that was followed in this research project in deciding the various components of crowdsourcing that would be used. This path was established by means of conversational analysis. Firstly, the type of data that was needed was considered. As discussed earlier, public safety comprised the context in which this smart city initiative would be implemented. As discussed in section 1.8.3, it was also decided that a speech based technology and IVR system would be more suitable in the city of East London. As the citizens of East London could choose what they wanted to report and when, participatory crowdsourcing is deemed appropriate for the purposes of the study. Lastly, the citizens of East London is used to collect data about public safety in the city.

The next section discusses the impact that such reported information may have on a smart city.

3.5. Benefits of Smart Cities

Giffinger et al. (2007) identified six key areas of a city in which smart cities could make a difference. These include the economy, people, governance, mobility, environment and living (see Figure 3.4). These six areas are supported by urban development and growth theories and provide a broad scope for smart city initiatives.

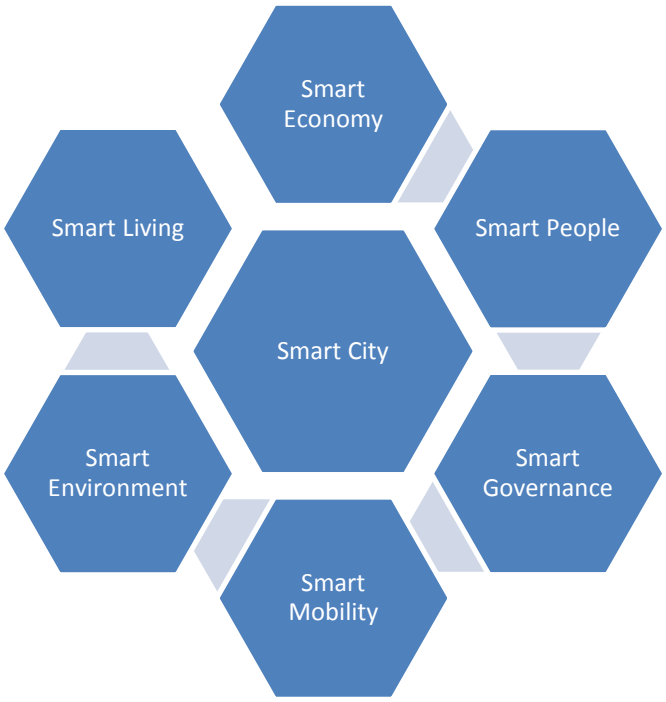


Figure 3.4: Illustration of a Smart City (Giffinger et al., 2007)

The application and benefits of the specific areas of a smart city are discussed below.

3.5.1. Smart Economy

The smart economy, as the term suggests, is dependent on the commercial sector of the city (Monbiot, 2000). A smart economy supports entrepreneurship, business innovation, productivity, international accessibility (imports and exports) as well as a flexible labour market (Giffinger et al., 2007). The net benefit of such an economy can be that unemployment is reduced while the quality of living for the citizens in such a city is increased. Examples of a smart economy in action include the following (Schaffers, 2010; Dirks et al., 2010; Washburn & Sindhu, 2010; Palmisano, 2008; Giffinger et al., 2007):

- Telecommuting may eliminate business travel as the users of telecommuting are able to collaborate making use of videoconferencing.
- Documents may be stored and accessed in the cloud with the concomitant cost benefit as companies are not responsible for hardware and software maintenance and upgrades.
- Specific industries such as tourism may benefit from a smart economy with transactions and authentication in respect of tourists being done by making use of one smart card. Current examples of this include Wikicity in Rome, Real-Time City in Copenhagen and Visible City Amsterdam.
- With the implementation of smart technologies, money becomes obsolete and this, in turn, eliminates robberies. For example, the mobile payment systems used at the 2012 Olympic Games in London.
- Smarter retailing accelerates supply chains while strengthening loyalty and improving profit margins. Smart technologies assist businesses to become more efficient as the businesses are able to use real-time information in order to render their supply chains, life cycle assessments and environmental accounting more efficient.

All of these examples are important in the developing city context of this research project as the smart economy enables businesses to participate in the global economy without large expenditure or overheads. The smart economy may also attract investment in industries such as tourism as convenience and safety is priortised in these industries. The next section discusses the way in which technology may make a city smarter.

3.5.2. Smart People

Smart people initiatives focus on assisting people to learn, adapt and innovate through the use of smart technologies (Coe, Paquet, & Roy, 2000). Eger (2003) maintains that this may be done through education, social learning and investments in social capital. Social sustainability creates a sense of belonging and social cohesion in a community (Carley, Jenkins, & Small, 2001). However, while social learning initiatives enable people to learn from one another, some writers argue that this approach of creating smarter people is ineffective (Hollands, 2008). On the other hand, Washburn and Sindhu (2010) point out that smart technology may improve the quality of education and this, in turn, may contribute to improving the quality of life of citizens. Thus, social approaches may

contribute directly to smart people while other approaches would contribute to the smart city as a whole. The next section will discuss the issue of smart governance.

3.5.3. Smart Governance

According to Giffinger et al. (2007), smart governance refers to the effective and efficient delivery of government services. As urbanisation increases, more people rely on local authorities to provide basic services (Washburn & Sindhu, 2010). It is, thus, essential that local governments be aware of the condition of their cities and be able to assist their citizens where necessary. The use of smart technologies means that data is available in real time while information and analytics may be used for informed decision making. Examples of smart governance initiatives include the following (Schaffers, 2010; Dirks et al., 2010; Washburn & Sindhu, 2010; Palmisano, 2008; Hollands, 2008; Giffinger et al., 2007):

- The increased availability and efficiency of the health care system while cost is reduced as the patients may be monitored at home or else telemedicine may be used to provide medical assistance to remote areas.
- Digital citizenship becomes possible with a smart card that is issued to each citizen. An example of such a smart city initiative is the implementation of a smart card system in Southampton, England. The aim of the smart card is to provide citizens with access to numerous government services. In addition, the smart card also allows access to public transportation and libraries.

It is clear from the benefits mentioned above that smart governance would enable local governments to provide efficient and effective services to citizens while being cost effective. The next section discussed the benefits of smart mobility.

3.5.4. Smart Mobility

Traditional transportation methods consume large amounts of natural resources while resulting in air pollution. Transport affects the majority of citizens as it is part of their daily existence. According to the 2010/11 Income and Expenditure Survey, with the mounting cost of petrol prices, 17% of the daily household budget in South Africa is spent on transport as compared to the percentage of income spent on food, which accounts for 12.8% of overall spending only (Isa, 2012). It is becoming essential to find how to decrease the cost of transport in order to keep the cost of living down. In this context

smart mobility focuses on public transportation in terms of improving the quality, accessibility and environmental sustainability of the various transport modes (Giffinger et al., 2007). It does this by making use of dynamic traffic control and GPS systems in order to render transportation systems more cost effective. Some of the smart mobility examples include the following (Schaffers, 2010; Dirks et al., 2010; Washburn & Sindhu, 2010; Buhl & Jetter, 2009; Palmisano, 2008; Hollands, 2008; Giffinger et al., 2007):

- Encourages the increased use of public transportation in order to reduce traffic congestion by means of real-time traffic information.
- Congestion pricing makes use of an electronically collected toll system to indicate to drivers when they should consider taking mass transit, reschedule their trip or pay a higher fee for making use of the road at peak times. The smart technology determines the most congested roads in the city and charges road users an additional toll for taking the route during peak congestion periods. The most commonly cited example of smart mobility is the modern traffic control system in Stockholm, Sweden. In the past, the major congestion on the roads had meant losses from both an economic (loss of productivity, wasted hours and pollution) and a quality of life point of view. In order to address this issue, a dynamically priced congestion charge for cars to enter Stockholm was introduced by making use of sensors, control instruments and automatic license plate detection. This enabled the city to reduce the amount of traffic by 25%, reduce emissions by 40% and increase the use of public transport by approximately 40 000 people daily.
- Electric cars with charging points in the city would help promote a green environment.

The examples above all make transport smarter in cities. The next section discusses the smart environment in a city.

3.5.5. Smart Environment

Smart environment refers to environmental sustainability, ecological protection and the efficient use of resources such as water and electricity (Giffinger et al., 2007). Cities are the largest contributors to economic growth, but they also consume large volumes of natural resources. Recent statistics indicate that the 20 largest megacities in the world consume 75% of the energy used worldwide. It is estimated that smart cities could reduce worldwide emissions by 15% over the next decade (Lindsay, 2010).

The smart environment becomes more sustainable as it is increasingly able to measure and conserve resources intelligently. Buildings contribute more to greenhouse gases than all forms of transportation combined. However, smart computing technologies are able to manipulate heating and cooling systems and power down lights when not in use, thus resulting in reduced operating costs and the increased value of properties (Palmisano, 2008).

The smart network initiative is an example of an initiative which contributes to the smart environment. The smart network utilises a collection of sensors, digital meters, hot and cool ventilation systems, transformers, distribution systems and supervisory control and data acquisition systems (Wildeman, Gilpin, & Knoll, 2009). This system automatically collects and analyses data about the production and consumption of electricity as to enable electricity to be distriibuted automatically in a more efficient and effective manner (Massoud, 2005). The ongoing success of the smart grid initiative may encourage the same concept to be applied to the consumption and distribution of clean water.

The use of smart technologies means that the environment becomes more sustainable with the added advantage that these smart technologies empower business to become more eco-friendly. This, in turn, results in reduced cost for both businesses and individuals as utilities such as water and electricity are not wasted. The last section provides an insight into the way in which the quality of life may be enhanced by making use of smart technology.

3.5.6. Smart Living

Smart living relates to the lifestyle of the citizens and addresses basic living needs. Smart living includes the city's healthcare and safety (Giffinger et al., 2007). These will be discussed in further detail below.

3.5.6.1. Healthcare

Healthcare refers to the quality of health services in a city (Rosenstock, 2005). In order to improve the quality of health services, smart healthcare provides storage and communication technologies that may be used to render the service more effective (Washburn & Sindhu, 2010). Medical records would benefit the most from smart technologies as they may be stored, backed-up, shared and made available immediately on request. A city in Spain has centralised all patient information in order for health care workers in all the health institutions in the region to have access to the information. The

initiative has succeeded to provide the 13 000 health care workers in the region access to the correct patient information for the 9 million outpatient visits annually (Washburn & Sindhu, 2010). The second component of smart living relates to the public safety of all citizens.

3.5.6.2. Public Safety

Public safety is the focus of this study in East London. However, it is also a priority world wide with European governments spending as much as 45% of their annual budget on public safety (Gonzalez & Rossi, 2011; Kaiserswerth, 2010). Public safety involves the prevention of and protection from events such as crime or disasters (natural or man-made) that could endanger the safety of the general public in terms of significant danger, injury/harm, or damage (PSECGC, 2008). This definition is important as it not only includes criminal activity, but any incident that may endanger citizens. Examples of such incidents include forest fires, floods, road and infrastructure damage, unreliable electricity and water infrastructure and unsafe areas for recreational purposes (Mehta, 2011; Washburn & Sindhu, 2010; Schaffers, 2010).

Smart technologies may be used to provide the real-time information which enables law enforcement services to respond rapidly to emergencies and threats (IBM, 2011A). Kaiserswerth (2010) reported that the city of Madrid has spent 30 million Euro to build a dashboard that is able to coordinate the police, fire, highway, hotline and ambulance units. This dashboard makes use of traffic video, surveillance cameras, maps with GPS data, and the status and location of personnel. This was made possible by the fact that smart technologies are able to improve both the availability and coordination of information during public safety events, thus enabling emergency services to minimise the risk and damage associated with these events.

A second example of smart technologies used to improve public safety, is the New York Police Department (NYPD) in the United States of America which collects criminal data at a centralised location. The data is then analysed and made available to all officers via various portals such as e-mail, public computers and mobile phones. This initiative has resulted in a 27% decrease in crime (Washburn & Sindhu, 2010). The next section discusses examples of more public safety smart city initiatives in various parts of the world.

3.6. Public Safety in Smart Cities

One of the key priorities of government and policy makers is the protection of the citizens in their constituencies. In recent years the emphasis in public safety has changed from merely responding to a more proactive approach in terms of which public safety situations may be anticipated and prevented. This is made possible by the use of smart technologies in the public safety domain (Gimenez et al., 2013). These technologies enable a more data-driven approach to public safety by making use of both data and analytics. The data may be used to determine what the threats are and how to respond to such threats effectively (McConnachie, 2012; IBM, 2011B).

An example of such a proactive approach is closed-circuit television (CCTV). CCTV has proved to be effective in discouraging criminal activity. The use of both video analytics and a CCTV system equipped with sensor technologies enables the detection of either criminal or reckless activities (Washburn & Sindhu, 2010).

Washburn and Sindhu (2010) maintain that smart city initiatives relating to public safety focus essentially on the development of a state-of-the-art public safety network. Such a public safety network will include a first responder network, emergency dispatch and coordination, CCTV, video analytics and real-time geo-localisation information. The public safety network described by Washburn and Sindhu (2010) is conceptualised in Figure 3.5. There is a first responder network as well as emergency dispatch units in East London but, as discussed in section 2.7.3, these are not integrated and the responsibilities of the variuos authorities are unclear. However, a virtual command centre would solve this problem. In addition the city does not use CCTV cameras at present and, thus, does not have access to real-time public safety information.

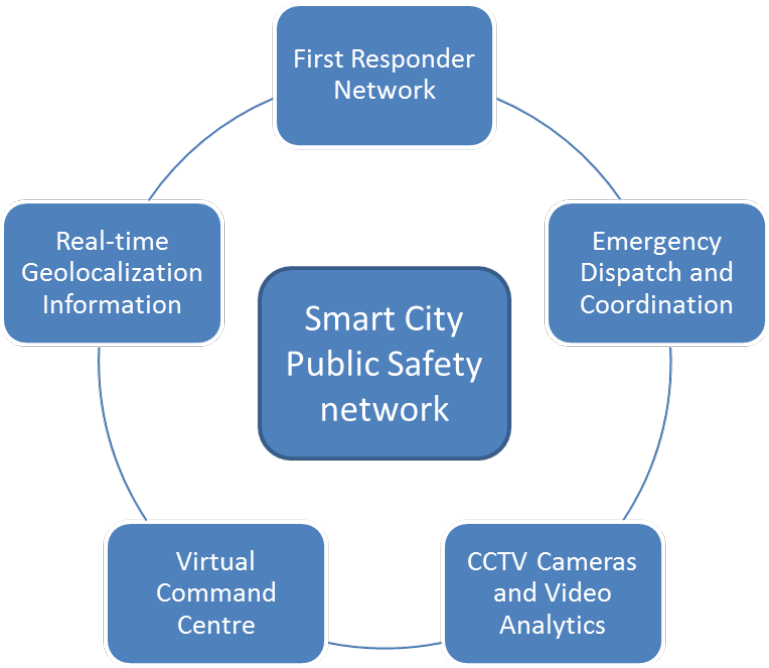


Figure 3.5: Conceptual Representation of a Smart City Public Safety Network (Washburn & Sindhu, 2010)

Three smart city public safety projects, located in Europe, the United States of America and Brazil, are discussed below (McConnachie, 2012; Perez, 2011). A brief overview of the three public safety projects is provided in order to illustrate the importance and value of smart technology in the area of public safety. The first project that will be discussed is the SafeCity Project in Europe.

3.6.1. SafeCity Project

The SafeCity Project was launched in Europe during 2011 with the aim of improving public safety by making use of smart technologies (Gimenez et al., 2013). The motivation behind the project was the increasing crime rate which was attributed to the growing urban populations which had impacted negatively on the lifestyle of European citizens (Agarwal et al., 2011; Pertejo, 2012). The countries participating in the project include Spain, Greece, Portugal, Israel, Sweden, Italy and Romania (Perez, 2011).

The project targets three specific areas in the public safety domain, namely, personal, transport and environmental safety. The various tools used include video surveillance, hybrid clouds, early traffic incident detection and collaboration which makes use of crowdsourcing and real-time sensors to detect pollution and allergens. The services on which the project focuses include situational awareness, alerting the population to a possible public safety threat, command and control functions and ad hoc networks in emergency or disaster areas (Pertejo, 2012).

The SafeCity Project studied specific scenarios in various European cities to determine their capability in the area of public safety. In order to do this, the researchers had to identify the initial set of enablers as well as the key users and public authorities at the various levels that had to be present to provide smart public safety capabilities. Once the initial analysis had been completed, conceptual prototypes were developed and tested. These prototypes made use of an open ICT platform in order to demonstrate the impact of smart solutions on the sustainable development of a city. The initial results indicated that citizen awareness is extremely important if smart public safety is to be effective (Perez, 2011).

During the SafeCity Project two types of data collection methods were utilised. The first such method was video surveillance which was used to detect potential risks based on video analytics, for example face recognition in order to identify wanted individuals or traffic congestion (Gimenez et al., 2013). Although the system was already in place in some cities, the project detected limitations that impacted on the effectiveness of the system. These included insufficient coverage, interrupted monitoring as well as an inadequate number of staff members to operate the system. Further technical limitations of the system included a lack of reasoning engines and knowledge databases, as well as real-time processing and learning. Ethical issues associated with the CCTV system included trust, security and the reliability and protection of sensitive data (Pertejo, 2012). Gutierrez (2012) discussed the following two major concerns in respect of the ethical issues relevant to the SafeCity initiative, namely, that the technology solution must match the demand of the society and, secondly, it must be compliant with the relevant legal framework. The solution which was proposed to address to these two concerns included a proactive approach and identifying a set business purpose for the collection of data.

The second data collection method used in the SafeCity Project involved participants or sensors in order to enhance situational awareness. For the system to be effective, it was essential that an effective gateway and also pre-processing capabilities be available in order to collect and process large amounts of data. It was found that the current system lacked the capability to anticipate and prevent public safety situations as a result of a lack of pre-processing capabilities and access communication networks, e.g. multimodal input on heterogeneous devices (Gimenez et al., 2013; Pertejo, 2012). The second project will be discussed in the next section.

3.6.2. BLUE CRUSH

The second project involved the Memphis Police Department (MPD) in the United States of America which has implemented advanced technology in order to address the rising crime statistics in the city. The MPD was facing a dire situation as the crime rate was increasing while budgets and other resources were dwindling. The department needed an additional 500 patrol officers to offset the growth in criminal activity but, as a result of fiscal constraints, this would have taken six years to accomplish. Instead, the MPD chose to make use of ICT to align police resources with problem areas in order to close this manpower gap. The programme became known as BLUE CRUSH (Criminal Reduction Utilising Statistical History).

BLUE CRUSH enables the MPD to respond faster to emergencies and also to understand the long-term factors that affect crime trends. The programme makes use of direct feeds from the MPD's record management system and other reports as well as robust statistical modelling and analysis in conjunction with Geographical Information Systems (GIS). This enables the recognition of crime trends as they happen, thus making it possible to redirect resources appropriately and respond in a timely manner. The crime volume in Memphis decreased by 30%, violent crime dropped by 15% and the cases that were solved by the MPD's Felonly Assault Unit quadrupled (from 16% to 70%) (IBM, 2011B). The third project will be discussed in the next section.

3.6.3. Command Centre

The third project is based in Rio de Janeiro, Brazil, where a centralised command centre was established. This command centre integrates more than 30 city agencies. The main purpose of the command centre is to improve public safety in the city through improved emergency response coordination, addressing increased traffic volumes, and predicting and responding to natural disasters. The command centre makes it possible to alert citizens to impending danger in time as the data from sensors and live video feeds around the city is used to create real-time maps and graphs. Prior to the establishment of the command centre, emergency responses happened using radios. However, ICT has now been able to increase the effectiveness of the public safety response in the city (McConnachie, 2012).

It is clear from these examples that ICT has an extremely important role to play in improving public safety. Table 3.2 summarises the three projects discussed above as well as the public safety, participatory crowdsourcing smart city project implemented in East

London. A comparison between the projects are then presented. As may be seen this research project addresses all the areas and services in the public safety domain while making use of participatory crowdsourcing as a data collection technique.

Table 3.2: Comparison of Worldwide Public Safety Projects

		Areas of public safety			**Public safety services provided**				**Types of data collection used**	
	Developed city	Personal safety	Transport safety	Environmental Safety	Situational awareness	Warning systems	Command and control functions	Ad-hoc emergency networks	Crowdsensing	Crowdsourcing
SafeCity	X	X	X	X	X	X	X	X	X	X
BLUE CRUSH	X			X	X		X		X	
Command centre			X	X	X	X	X	X	X	
East London smart city project		X	X	X	X	X	X	X		X

This section discussed three public safety projects which have been implemented in various cities in the world. The next section provides insights into how to become a smart city.

3.7. How to Become a Smart City

It has already been mentioned the growing urban movement and increasing energy needs pose specific challenges to local government services and infrastructure (Washburn & Sindhu, 2010; Alusi et al., 2011). It is not easy for East London to increase the revenue required to provide these services because of a poor constituency that cannot afford to pay for municipal services and a small industrial tax base. Accordingly, the city has to find alternative ways, for example, a smart city, to enable it to use existing resources more effectively and efficiently. In order to realise the benefits of smart technology, a city must have very specific infrastructure in place. Thus, as may be seen in Figure 3.6, the city

needs to invest in smart city infrastructure. According to Chourabi et al. (2012) there are three pivotal elements that must be in place before the implementation of a smart city. These elements include technology, policy and organisational commitment. These three elements are supported by the community which makes use of or benefits from the system, the economy, the built infrastructure and the natural environment as well as local government commitment.

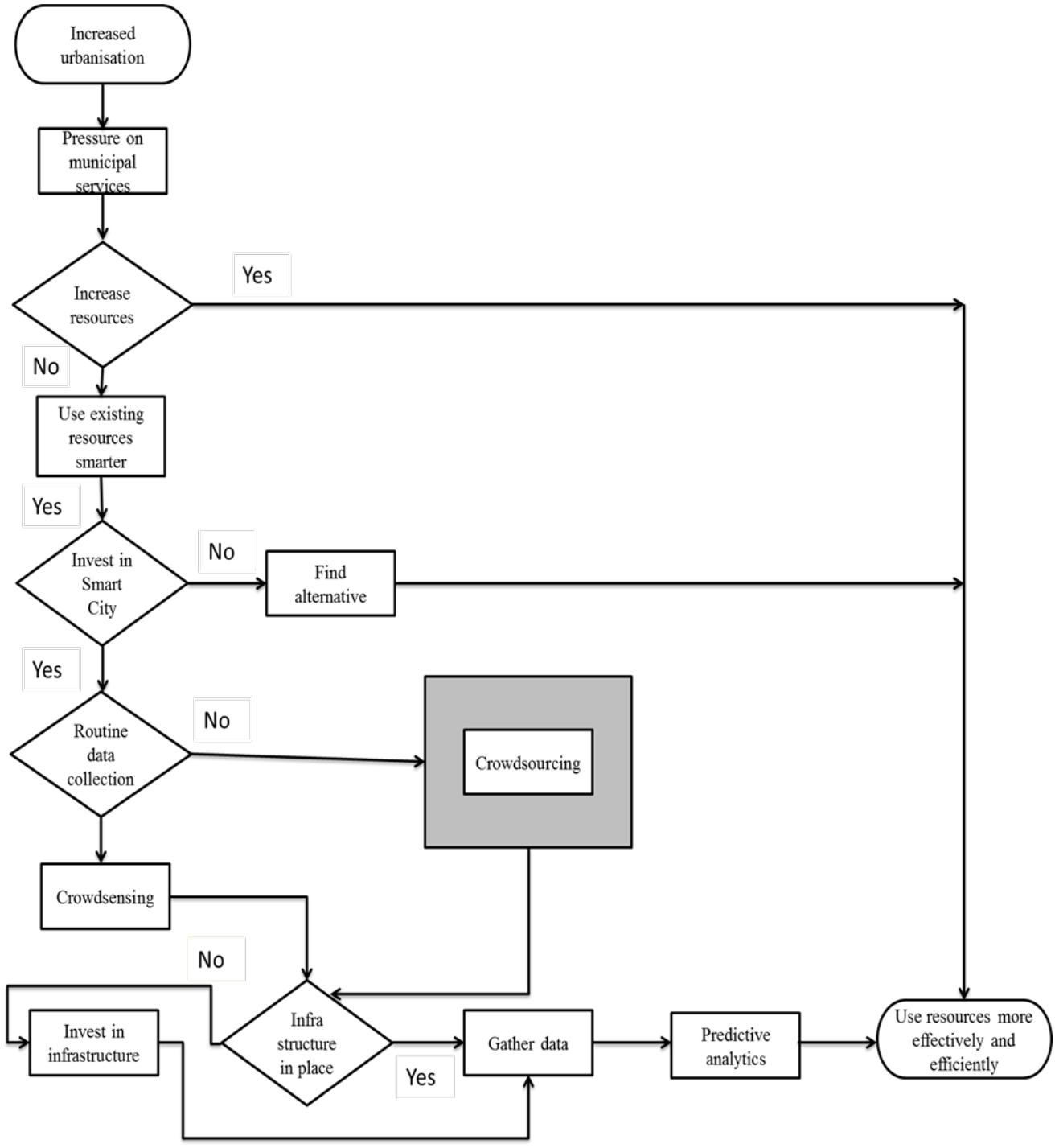


Figure 3.6: System Hierarchy for a Smart City project

As can be seen in Figure 3.6 drawn from this project, the type of data that must be collected will determine the infrastructure (crowdsensing or crowdsourcing) that the city of East London will require. In a crowdsensing environment, the technology required includes a rich environment of high connectivity broadband networks that support digital applications. These applications must combine cable, optical fibre and wireless networks (Schaffers, 2010). These complex systems may include utility lines, water pipes, roads and buildings (Alusi et al., 2011). While these technologies may be costly to instal, recent technological developments, such as cloud computing and IoT, are decreasing the cost of infrastructure while accelerating the learning curve for smart cities (Schaffers, 2010). As discussed previously, participatory crowdsourcing requires only a telephony infrastructure to be in place and, thus, the entry level costs are much lower than establishing a crowdsensing network.

Infrastructure development is influenced by the policies and governance of the local authority in specific cities. Di Maio (2012) discusses the policy differences as regards to the way in which cities provide services. In some cities the local government is responsible for operating public serves while, in other cities, an external service provider is used to provide such services. The way in which smart technology will be implemented in these two scenarios must be approached differently. If the local government is responsible for all services, then it could establish a common programme and infrastructure for all the domains that must comply with the smart objectives. However, if an outside service provider is used, the process becomes more complicated as cooperation between the local government and the service provider is essential. Either way, pragmatism is required to ensure that any smart development is sustainable and affordable after the investment money has been spent.

The applications which are required to run a smart city are still in the innovation phase. A recent report from Forresters pointed out that these applications are still in the technology push phase and that the research agenda is currently more vendor pushed than government pulled based (Schaffers, 2010). This viewpoint is supported by Washburn and Sindhu (2010) who also state that the full potential of this new technology is yet to be realised.

Washburn and Sindhu (2010) have identified definite steps that a local authority must follow in order to make their city smarter. These steps may be divided into the planning, implementation and delivery phases and are discussed briefly below (Washburn & Sindhu, 2010).

1. Planning
    a. Be up to date with smart city developments and best practices;
    b. Develop a strategic plan to become a smart city which includes the vision, road map and stakeholders involved;
    c. Conduct a situational assessment of how smart your city infrastructure currently is, including the current smart project;
    d. Make smart projects a priority;
    e. Develop new business models, technology plans and funding options, including the financial incentives available for smart city investments, and
    f. Identify skills gaps in the Human Resource department.

2. Implementation
    a. Budget to purchase and implement smart technologies;
    b. Modernise existing infrastructure and network;
    c. Competent staff is necessary – appoint or develop staff;
    d. Partner with industry stakeholders as well as system and technology integrators;
    e. Develop metrics to measure the progress and value of smart city investments, and
    f. Align people, processes and incentives to take advantage of smart city investments.

3. Delivery
    a. Roll out smart city administration and general services;
    b. Educate stakeholders on the smart city benefits and how to take advantage of these benefits;
    c. Continue to develop business models to fund smart city initiatives, and
    d. Continue to measure the progress and value derived from the smart city investments.

From the discussion above it is clear that the decision to become a smart city must not be taken lightly. Although the benefits of a smart city may be numerous, the financial and political will to make the changes required must be taken into account (Washburn & Sindhu, 2010). The three steps discussed above were included in the PSPC smart city model for a developing country proposed in this project.

3.8. Conclusion

Chapter 3 introduced the smart city project that was implemented in East London. The chapter also addressed the first research sub-question, namely, **How can a smart city improve public safety in a developing country?** and then provided insight into two of the areas of the PCPS smart city model for developing countries – technology and the city.

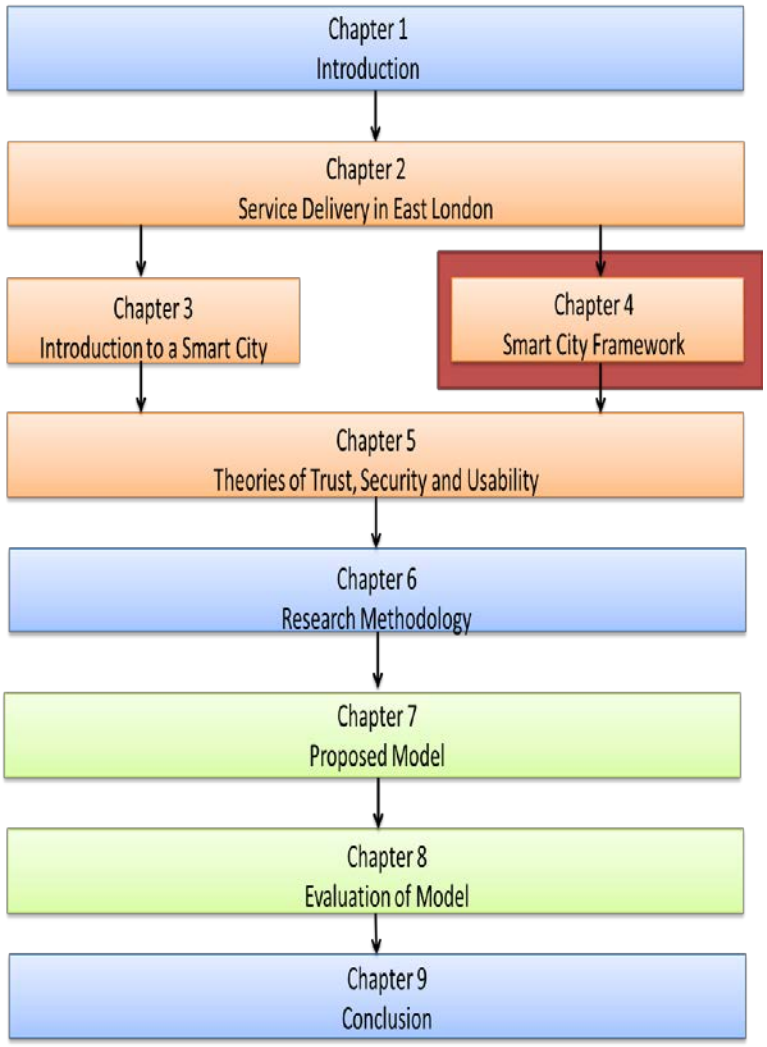
Advances in various types of technologies have enabled local authorities to make use of their natural resources and city infrastructure in a more effective manner. This has been possible because technology is able to provide real-time data that may be used for the purposes of analytics in order to provide relevant information which the local authorities may use to make decisions. The chapter provided an overview of the various definitions for a smart city. The variety of definitions for this term point to the immaturity of this research field. The various design considerations and iterations of the crowdsouring system were also discussed.

The various benefits of a smart city was described. These include the smart economy, smart people, smart governance, smart mobility, smart environment and smart living. The latter, namely, smart living, was discussed in detail with the use of public safety examples from around the world. The services provided by the various public safety projects include situational awareness, warning systems, command and control services and ad hoc emergency networks.

The two methods of collecting data in smart cities were also discussed. Crowdsensing makes use of sensors in order to collect data. However, there are privacy concerns for the citizens. Nevertheless, many of these concerns may be overcome by using participatory crowdsourcing. In terms of this method, participants are able to choose what and when to report information and more detail can be provided. Crowdsourcing was subsequently adopted for the purposes of this research project.

The chapter finished with a discussion about the steps that are required if a city is to become smarter. The different steps that must be followed was identified including the governance, political will, infrastructure and the financial investment that is necessary. The next chapter will introduce some of the theories on smart cities and have been published in recent literature.

Chapter 4
Smart City Framework



4.1 Introduction

4.2 Lack of Research

4.3 Fundamental Elements of a Smart City

4.4 Smart City Initiatives Framework

4.5 Conclusion

4.1. Introduction

The primary objective of this research project is to produce a model that may be used to implement a public safety, participatory crowdsourcing, smart city project in a developing country. Chapter 3 introduced the concept of smart cities and discussed the way in which local government may use smart city initiatives to manage existing resources more effectively and efficiently. Crowdsourcing, the data collection method chosen for this research project, was also discussed. The data which was collected by making use of crowdsourcing may be used for analytical purposes in order to provide information to the local authorities and, thus, to enable them to make informed decisions.

Chapter 2 introduced the city of East London which is part of the BCMM. The citizens of East London were recruited to participate in a participatory crowdsourcing system in order to report public safety matters by making use of an IVR system. The various problems facing East London, in common with many other developing cities, were discussed in detail. These problems also extend to the public safety domain of East London and had to be considered in the context of this study.

This chapter makes use of the framework proposed by Chourabi et al. (2012) in order to introduce the various areas that must be considered when implementing a smart city. The areas identified in the framework include technology, policy, people/communities, the organisation, economy, the built environment, the natural environment and governance.

This chapter provides a detailed overview of three of the areas which were incorporated into the model proposed in section 1.6. These three areas include **technology, the city** and the **people/community**. The chapter also provides more of the evidence required to answer the first research question: **How can a smart city improve public safety in a developing country?** The next section provides an overview of the smart city research that is available in the literature.

4.2. Lack of Research

As discussed in Chapter 3, the term '*smart city'* is relatively new and, thus, there is, as yet, no common understanding of the concept among academics and practitioners. This is evident from both the variety of smart city definitions available and which were discussed in section 3.3 and also the limited number of studies that have been undertaken to investigate and consider questions related to smart cities (Chourabi et al., 2012). Nam and Pardo (2011) and Sharma (2010) concur with this statement when they report that the practical implementation of a smart city has not received much attention from academics.

Crowdsourcing is considered to be a dynamic and emerging research area. However, while crowdsourcing has been implemented in industry it is, nevertheless, not very well understood. Zhao and Zhu (2012) conducted a meta-study of crowdsourcing studies found in literature and evaluated 55 relevant academic publications for the period 2006 to 2012. The findings from the meta-study included the fact that there were relatively few published journal articles as compared to the short reports, letters and announcements on crowdsourcing. This lack of theoretical orientation, in turn, points to the immaturity of the

research area. A second interesting finding was that 18% of the articles found had been written by authors in industry with no ties to academia, while a further 18% of the papers had been co-authored by both academics and industry (Brabham, 2009). This is, in fact, also the case in this research project as academics from the University of Fort Hare and representatives from IBM (industry) partnered in order to determine the factors that are necessary to implement a public safety, participatory crowdsourcing, smart city project in a developing country.

The immaturity of the research field means that, despite the fact that there are several different disciplines making a contribution to the smart city knowledge base, the various elements of theory and practice have not yet converged (Ciaghi & Villafiorita, 2011). As discussed in section 3.6, smart city projects have been undertaken in certain developed countries. However, Sharma (2010) warns that, while following a structured project approach may reduce the implementation failure rate, it is not appropriate to '*copy and paste*' recommendations from the developed countries to projects in the developing countries. The reason for this is that the characteristics of developing countries differ as compared to those of the developed countries and these characteristics of the developing countries will pose unique challenges to the successful implementation of a crowdsourcing system. Some of the characteristics of developing countries identified in section 2.2 included a low literacy rate, high unemployment and high poverty rates as well as the unavailability and cost of technology (Kumar et al., 2010). From the discussion in section 2.8 it is clear that the city of East London exhibits all these characteristics and it may, therefore, be classified as a developing city.

Thus, the decision to implement a smart city initiative in order to provide the BCMM with a more efficient way to use existing public resources – a decision that had emerged from the conversational analysis – was taken despite the lack of evidence that this initiative would work in a developing city. However, it was felt that such a study would contribute the existing body of knowledge.

Recently there have been attempts to introduce frameworks that would assist with the conceptualisation of smart city initiatives. Nam and Pardo (2011), as well as Chourabi et al. (2012), have published smart city frameworks that highlight the various areas that must be considered when implementing a smart city. These frameworks will be discussed in the next section.

4.3. Fundamental Elements of a Smart City

Nam and Pardo (2011) suggest that a smart city consists of three fundamental areas, namely, technology, institutional elements and human (see Figure 4.1 below). The technology area include the physical infrastructure; smart and mobile technologies; virtual technologies and digital networks while the institutional area encompass the governance of a smart city, including the policies and regulations that provide the direction for the smart city. On the other hand, the human area includes both the human infrastructure and social capital.

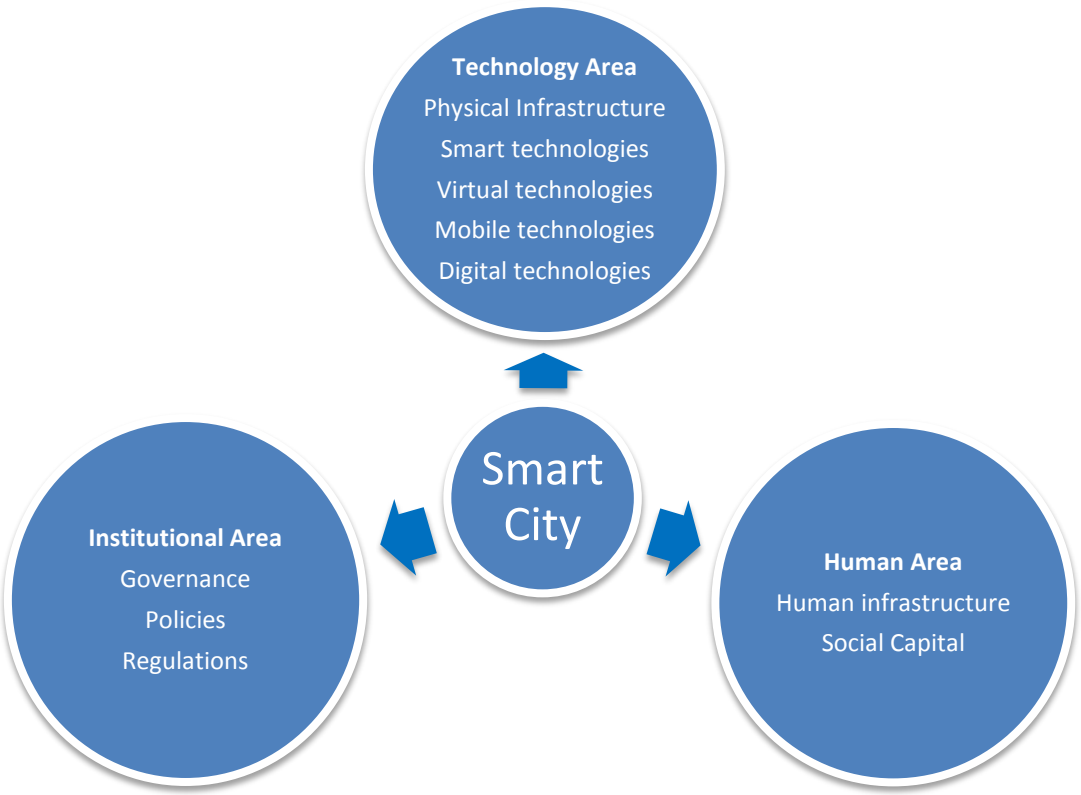


Figure 4.1: Fundamental Components of a Smart City (Nam & Pardo, 2011

Hollands (2008) explained that, instead of expecting ICT to possess the capability to bridge the digital divide, cognisance must be taken of human capital and of the way in which citizens interact with each other and with government. The digital divide in a city may be overcome if awareness of ICT, education and leadership are prioritised. The benefits of bridging the digital divide include the development of ICT skills, nurturing knowledge workers, facilitating an environment of social learning and improving ICT training in schools and industry. The framework proposed by Chourabi et al. (2012) will be discussed in the next section.

4.4. Smart City Initiatives Framework

Chourabi et al. (2012) have developed a smart city framework that may be used to unpack the impact of the organisational, technical and contextual areas both during and after the implementation of the smart city. The framework is depicted in Figure 4.2.

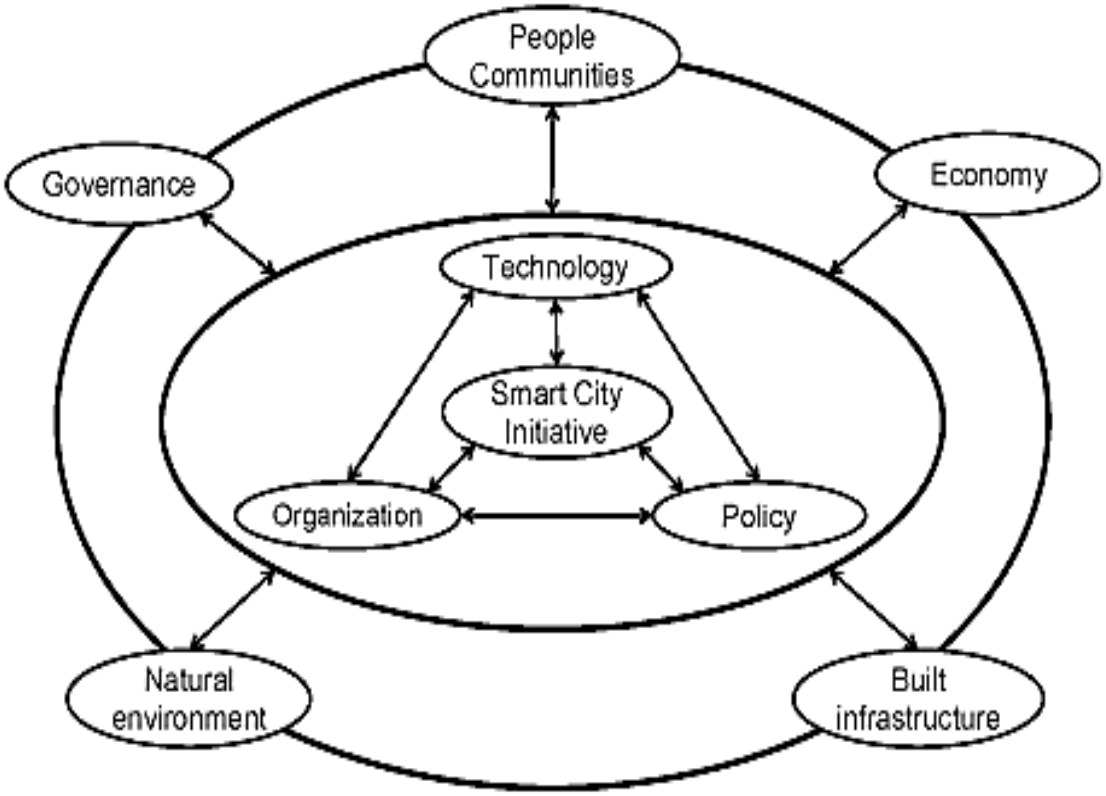


Figure 4.2: Smart City Framework (Chourabi et al., 2012)

According to Chourabi et al. (2012), the inner layer of the framework (technology, city and policy) will impact on the success of a smart city initiative more than the outer layers (people/communities, economy, built infrastructure, natural environment and governance). It is important to note, however, that all the areas will have some kind of impact on the smart city initiative, depending on the context of the project. The core areas found in the framework are explained in Table 4.1 below.

Table 4.1: Core Areas of the Smart City Initiative Framework (Adapted from Chourabi et al., 2012)

Core Area	Explanation	References
City	The city has been identified in ICT initiatives and projects literature as a very important part of the ultimate success or failure of an ICT project. The city in this study, the BCMM, was discussed in Section 2.3 – 2.6.	Scholl, Barzilai-Nahon, Ahn, Olga and Barbara (2009)
Technology	When implementing Smart City projects, ICTs must be considered as one of the key drivers to change the urban landscape of a city and provide new opportunities to improve the functioning of the city. The technology that makes a smart city possible was discussed in detail in Section 3.4.1 – 4.	Hollands (2008), Vasseur (2010)
Policy	Institutional readiness to make use of smart cities must take into consideration the removal of legal and regulatory barriers to implement new technology.	Chourabi *et al*. (2012)
People/ Communities	As discussed in Section 2.6, the lack of citizen participation in the governance of a city is one of the main obstacles in the running of South African Municipalities. If authorities allow citizens to become more active in the governance of the municipality, it will foster a culture of informed, educated and voluntary participation from citizens.	Chourabi *et al*. (2012)
Economy	The economy is one of the major drivers of a smart city. A smart economy includes innovation, entrepreneurship, trademarks, productivity and flexibility of the labour markets as well as integration in the national and global market.	Giffinger *et al.* (2007)
Built infrastructure	Smart cities rely heavily on both the quality and availability of the ICT infrastructure in the city. The built infrastructure can be divided into three dimensions: ICT infrastructure; security and privacy, and operational cost.	Chourabi *et al*. (2012)
Natural environment	In smart cities, ICT is used to increase the sustainability of a city by better managing the natural resources and related infrastructures.	Chourabi *et al*. (2012)
Governance	Smart governance is a collection of technologies, people, policies, practices, resources, social norms and information that interact to support city governing activities. To date, the issue of governance has not received much attention in the literature on smart cities.	Chourabi *et al*. (2012)

The two frameworks discussed above will be used in the discussion of the various challenges facing the implementation of smart city projects and that have been reported in literature. The eight core areas, as found in the framework of Chourabi et al. (2012), will be used during the discussion in order to group the challenges into logical units, although the main focus of the discussion will be on public safety. The reason for the focus on public safety is that the aim of this research project is to produce a model that may be used to implement a public safety, participatory crowdsourcing, smart city project in a developing country. The first factor that will be discussed is the city.

4.4.1. City

The California Institute for Smart Communities defines a smart city as follow (Nam & Pardo, 2011, p. 286): "*A community in which government, business, and residents understand the potential of information technology, and make a conscious decision to use that technology to transform life and work in their region in significant and positive ways*."

With the increasing trend towards urbanisation, municipalities have been placed under intense pressure to provide services, despite the finite resources and deteriorating infrastructures (McConnachie, 2012; Di Maio, 2012). As discussed in Chapter 3, smart cities may be used as a problem-solving tool for government (Sharma, 2010). While the city and its management of ICT projects has previously been identified in the literature as an extremely important factor that will determine the success or failure of an ICT project, little has been reported about this in smart city literature (Chourabi et al., 2012; Scholl et al., 2009). Nam and Pardo (2011) identified three elements that are important in the city factor, namely, governance, policy and regulations.

Governance will be discussed in detail in section 4.4.3 but, for the moment, it is important to consider that smart city initatives must be based on governance with multiple stakeholders in order to promote transparency and accountability. The fact that the departments in the East London Directorate of of Health and Public Safety function in silos, as pointed out in section 2.7, becomes a serious challenge both to providing adequate public safety services and implementing smart city intiatives. Smart cities require collaboration and communication between the various departments if a shared goal is to be attained – in this research project the promotion of public safety in East London (Alawadhi, Aldama-Nalda, Chourabi, Gil-Garcia, Leung, Mellouli et al., 2012; Nam & Pardo, 2011). Although either a top down or a bottom up approach may be taken to implementing a smart city, in either approach the active involvement of every sector of the community is essential. These united efforts will foster the collaboration which would allow

projects to be completed faster and create informed participants who would be willing to transform the way in which the entire community carried out its work (Nam & Pardo, 2011). This is especially important in the case of East London where the ward committees are not functional, thus leaving citizens without an avenue to use to to participate in local government (Managa, 2012). The frustration of the citizens is evident in the frequent service delivery protests which are staged around East London (Municipal IQ, 2011).

If a smart city initiative is to be succesful, it is essential that an administrative policy environment be in place. Such an environment would include the removal of legal and regulatory barriers, promotional activities to introduce the smart city, networking and partnerships to the external stakeholders and transitional components such as the leadership, vision and organisational change to make optimal use of a smart city (Alawadhi et al., 2012; Nam & Pardo, 2011). Organisational change is necessary as the smart city initative will change organisational culture. In addition, leadership was found to be of critical importance as literature has reported funding for smart city initiatives are an ongoing problem in smart city projects around the world (Alawadhi, et al., 2012). The elements mentioned thus far in this section, are all included in the first two phases, namely, planning and implementation, of a smart city initiative (see section 3.7). The next section will introduce the problems reported in literature regarding the technology used in smart cities in order to improve public safety.

4.4.2. Technology

Any discussion about the implementation of smart cities would not be complete if the technology used to accomplish this were not considered. A comprehensive discussion of the technology that has been identified as the main drivers in smart cities was contained in section 3.4.

As discussed in section 2.2 developing countries often lack proper ICT infrastructure and are also characterised by low literacy rates, high unemployment and high poverty rates (Kumar et al., 2010). East London, which was discussed in Chapter 2, is a developing city with these problems. The lack of ICT infrastructure and skilled staff was also mentioned as a possible challenge to the successful implementation of a smart city in East London.

Several writers have attempted to divide the technology problems of a smart city into various elements. According to Chourabi et al. (2012), there are three elements that would influence the infrastructure of a smart city, namely, ICT infrastructure, security and privacy, and operational cost.

The ICT infrastructure problems that must be addressed include the lack of integration across various systems, limited integration with existing systems, lack of knowledge regarding interoperability and the availability and compatibility of software, systems and applications. As discussed in section 3.4.4, the crowdsourcing system that was developed by IBM and which was used in this project did not have any of these problems as the iterations during the building of the IVR prototype were used to detect and fix any technological problems.

The security and privacy element includes threats from hackers, intruders, viruses, worms and Trojans while the privacy and accessibility of personal data and the high cost of security applications and solutions constitute further barriers in this element. The researchers in this study considered this element in detail as privacy concerns could be a barrier to the successful implementation of a public safety, participatory crowdsourcing, smart city in a developing country. These concerns were discussed in section 3.4.6.

The third element, operational cost, includes the high cost of ICT professionals and infrastructure. These costs were identified as typical problems in a developing country and that must be taken into consideration when a smart city is implemented (Kumar, Agarwal, & Manwani, 2010). It was indicated in section 2.6.1 that the the BCMM does have an acute shortage of skilled ICT personel, thus making this a valid concern as regards the implementation of a smart city.

Similarly, Ebrahim and Irani (2005) identified two elements of technological challenges facing the implementation of smart city initiative, namely, ICT skills and organisational factors. The first element includes the lack of employees with the requisite skills to integrate the functions of a city into a smart city initiative as well as a lack of ICT training programs to educate the workers. The second element, organisational factors, includes a lack of cross-sectoral and inter-departmental coordination, unclear vision on the part of the ICT management, internal politics and cultural issues. The research of Ebrahim and Irani (2005) is supported by Demirbas et al. (2011) who also identified ICT skills, including resource availability and capacity, as potential challenges to the implementation of a smart city. The second element, organisational factors, was discussed in section 4.4.1.

This section discussed some of the problems associated with technology when implementing smart city initiatives. The next section will discuss the governance issues associated with these initiatives.

4.4.3. Governance

According to the Forrester Research report, smart governance is one of the core activities of a smart city initiative (Chourabi et al., 2012; Giffinger et al., 2007). Smart governance refers to a collection of technologies, people, policies, practices, resources, social norms and information that all interact in order to support the governing activities of the city. However, as little is known about governance in smart cities, it has become extremely important to understand the concept better (Chourabi et al., 2012).

There are several factors that must be taken into account when governance in a smart city is investigated. For example, the European Union has proposed five pillars in terms of which to measure governance, namely, openness, participation, accountability, effectiveness and coherence. These pillars would assure that corruption is minimised, the views of minorities are taken into account and the voices of the most vulnerable in society are heard in the decision-making process (Ferro et al., 2013).

Ferro et al. (2013) made use of the definitions discussed above and also other relevant literature to devise a synoptic framework in terms of which to discuss the role of ICT in the governance of smart cities. This framework provides for the technological infrastructure in a smart city to be turned into value for society (see Figure 4.4).

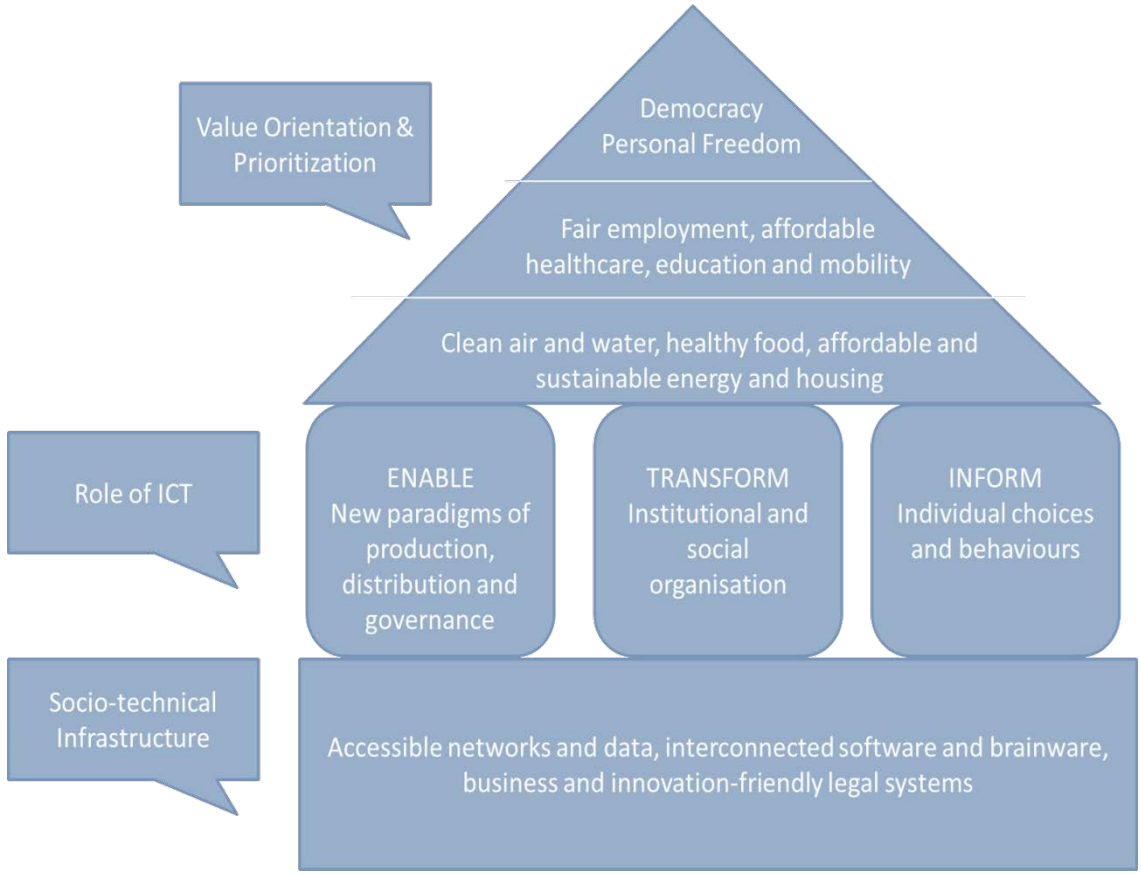


Figure 4.4: The Smart City House: ICT in Smart City Governance (Ferro et al., 2013)

The model provides an analogy between the process of building a house and that of value creation. The foundation of the house refers to the socio-technical infrastructure which encompasses the contextual factors that must be present in order to take full advantage of ICTs (Lock & Sommerville, 2010). These contextual factors include networks, data, software, people and appropriate laws. The links and connections between these resources represent a key value driver for society.

The three pillars of the house (enable, transform and inform) represent the key strategic contributions that ICT may make both to the creation of value and to the transformation of cities into smart cities. The first pillar, enable, provides for new paradigms of production, distribution and governance. An example of this may the way in which ICT may contribute to smart cities in terms of the management, planning and control of public safety. The second pillar, transform, pertains to ways in which the many daily activities are conducted. An example of this would be the use of CCTV cameras to monitor cities. The third pillar, inform, refers to the role of ICT in informing individual choices and behaviours. The use of social media to promote safer behaviour and share stories related to public safety may contribute to a greater awareness of unsafe behaviour and this, in turn, may lead to the

emergence of the desired social behaviours. The last section of the house, the roof, represents the value orientation or outcome that the smart city initiative hopes to achieve. The triangular shape of the roof represents different layers which generate a stack configuration with diverse and interrelated levels, similar to that of Maslow's Hierarchy of Needs (Ferro, Caroleo, Leo, Osella, & Pautasso, 2013).

Thus, the framework provides a representation of the way in which ICT infrastructures may be turned into value within urban areas and, thus, it was deemed suitable to be used in East London. The next section will discuss a subject closely related to governance, namely, the policy that is needed to guide local authorities in their decision making processes.

4.4.4. Policy

The most interesting aspect of crowdsourcing is its ability to transcend geographic, political and economic barriers by means of virtual integration. However, while this ensures that crowdsourcing is a useful tool, it does also have serious legal implications.

The macro environment that must be considered when policies regarding smart city projects are implemented include governance support, the business and economic environment, the living environment and the risk profile of the country concerned (Sharma, 2010). While the implementation of technology in a smart city may easily be observed and measured, the changes that are required in the policies of a city in order to accommodate these technological advances are more ambiguous (Chourabi et al., 2012). As mentioned in the previous sections, it is essential that government support include a favourable regulatory environment in order to minimise bureaucratic hassles (Sharma, 2010). This, in turn, includes the removal of legal and regulatory barriers to the implementation of new technology. The removal of these barriers must be agreed upon by all the various political role players (Chourabi et al., 2012). In addition, the tasks associated with crowdsourcing must be compatible with the prevailing business practices and cultural norms.

Citizens must also be able to relate the goal of the crowdsourcing initiative, i.e. to improve public safety in the city, to their living environment (Sharma, 2010). It is recommended that a risk assessment of the prospective risks in a country commence with an analysis of the living environment (Oshri, Kotlarsky, & Willcocks, 2009). The result of such a risk analysis will play an important role in affecting the motivation of the citizens with the long-term objective of the crowdsourcing initiative (Sharma, 2010). In East London, an

extremely high crime rate was identified. In view of the fact that crime affects the quality of life of all citizens, this was seen as an appropriate area in which to implement the participatory crowdsourcing system, smart city project. The next section will discuss the problems which may be identified with the fifth core factor, people and communities, when implementing a public safety, participatory crowdsourcing, smart city project in a developing country.

4.4.5. People and Communities

One of the most important aspects of a smart city is that the smart city involves the citizens in the management and governance of the city. However, despite the importance of this factor, it is often neglected in favour of the technological factor discussed in section 4.4.2. Allowing citizens to participate and become more active in the management of the city will lead to more informed and educated citizens. This is important as the community is vital to the success or failure of the smart city project (Chourabi et al., 2012).

Sharma (2010) has proposed a model that indicates the critical success factors in the motive alignment of the participants when taking part in a crowdsourcing project. The definition of motive alignment in the context of crowdsourcing is the extent to which citizens are able to associate with the long-term objective of crowdsourcing initiatives, thereby encouraging the wider participation of the citizens. There are five elements that will determine the motive alignment of the crowd. These include vision and strategy, human capital, infrastructure, linkages and trust and the external environment (Figure 4.5). These five elements will directly affect user participation and, hence, the relationship between motive alignment and crowdsourcing success is bidirectional.

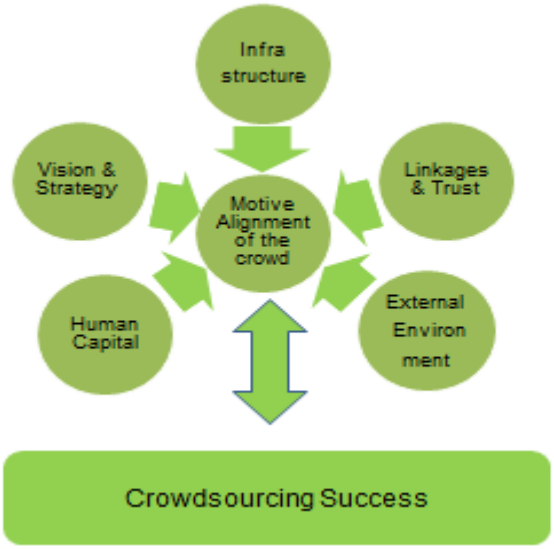


Figure 4.5: Crowdsourcing Critical Success Factor Model (Sharma, 2010)

Zhao and Zhu (2012) evaluated the elements as proposed by Sharma (2010) and stated that these elements are still in need of testing which would provide the opportunity to improve and refine them. A more detailed description and testing of each element may, ultimately, lead to specific theoretical models for each of the elements, while further case studies would verify the model.

The vision of a smart city project is often not properly communicated to the participants. While it is essential that this vision be flexible because of the dynamic nature of smart city projects, proper management of the vision and strategy of the project must be in place. Local authorities must also have the added support of government and this, in turn, includes a trust factor in the project. The project is likely to be service delivery orientated, which will affect all citizens and improve the visibility of and participation in the project (Sharma, 2010).

Human capital includes the collective characteristics, skills and abilities of the crowd and includes, but is not limited to, language and managerial skills, national orientation, traditions and level of education (Carmel, 2003). The success of participatory crowdsourcing depends on the number of people who participate in the initiative. Accordingly, the amount of human capital or number of people needed to provide information must also be considered (Alonso, Rose, & Stewart, 2008).

Sharma (2010) identified that the skill set of those providing the smart city technology and also the participants must be in place. The illiteracy levels in developing countries are often extremely high (Kumar et al., 2010). However, in order not to exclude illiterate

citizens, as was the case in this research project, an IVR system may be used to collect the data in a crowdsourcing project. As reported by Kumar et al. (2010), participants have no difficulty in navigating the IVR system, regardless of their literacy levels. Further advantages when making use of the IVR system include the overcoming of traditional linguistic and cultural barriers as the end user is screened from the complexity of the technology through an intuitive user interface. On the other hand, it is essential that the operators of the participatory crowdsourcing initiative possess the proper skill set, abilities and expertise to develop and market the technology (Sharma, 2010). Crowdsourcing also requires abundant, reliable and cheap telephone or mobile access for its communication needs in order to ensure the participation of the crowd (Donner , 2009). Accordingly, the ease of accessibility, reliability and quality of the communication technologies (or technology infrastructure) are all imperative for crowd participation (Sharma, 2010)

Brabham (2009) reported that the purpose of the smart city initiative is extremely important and that it must be perceived as valuable and benevolent by the participants if they are to be motivated to participate. Participatory crowdsourcing requires more resources from the participants than does crowdsensing. These resources may include time as well as mental and physical effort. For this reason the motivation mechanisms become more relevant when crowdsourcing is used (Thebault-Spieker, 2012). However, the motivation of a crowd to participate in crowdsourcing projects has not been investigated in any depth. In the meta-study Zhao and Zhu (2012) conducted only 2 out of the 55 studies had investigated the crowd's motivation to participate in various contexts. Sharma (2010) advocates that, in order to ensure participation, the incentive should be tailored to attract the greatest number of collaborators. This is particularly important as crowdsourcing projects require mass participation in order to be successful.

Zhao and Zhu (2012) further reported that both the crowdsourcing application context and the granularity of the tasks would contribute to the motivation of citizens to participate in the project. For example, the motivation to report public safety matters and to participate in a business orientated crowdsourcing contest would be different. In the first example a sense of collaboration would be a motivating factor while, in the latter example, financial reward may be the motivating factor. A further consideration is the way in which the participant chooses which tasks to compete or collaborate on with other participants. These are important if considering that a small fraction of participants only will account for the vast majority of feedback as it is expected that most participants will become inactive after only a few submissions.

The safety need of the participants (citizens of East London) in the smart city initiative (public safety, participatory crowdsourcing system) must remain the most important consideration when a smart city initiative is implemented (Sharma, 2010). Zhao and Zhu (2012) and also Liu, Lehdonvirta, Alexandrova, Liu and Nakajima (2011) concur with this view with their recommendation that future research should focus on the crowd participation and motivation in smart city projects. In order to motivate the citizens of East London to participate this research project made use of a lucky draw in terms of which the study participants could win an iPad. However, making use of conversational analysis, it was felt that the competition did not work well as the participants were not motivated to participate in the project. They simply did not believe that they would win the prize. It was felt that, in the future, a system where the participants received an instant prize, such as airtime, immediately after reporting a public safety matter would be more useful in order to motivate the citizens of East London to participate in similar projects.

While the public safety, participatory crowdsourcing system does not explicitly impact on the motivation mechanisms of the participant, it does have the potential to impact on the social experience of the participants and this, in turn, may affect their motivation. The social experience in this context may be as simple as demonstrating to the participants the value of their contribution, i.e. feedback of where crime hotspots are or where infrastructure maintenance was carried out in a public safety crowdsourcing initiative (Reed, 2007). A few studies only have explored the relationship between the effort of the participant and quantity of their contribution. If this link were better understood, this would help with the identification of specific groups of participants and the design of appropriate incentive strategies (Zhao & Zhu, 2012). The next section will discuss the way in which the economy of a country may influence participatory crowdsourcing initiatives.

4.4.6. The Economy

The smart economy include elements such as innovation, entrepreneurship, trademarks, productivity and the flexibility of the labour markets as well as integration in the national and global market (Giffinger et al., 2007). At the same time, the economy is one of the major drivers in a smart city as businesses make use of ICT and new smart business processes in order to stay competitive (Chourabi et al., 2012).

When crowdsourcing is used in the commercial arena, the cities are able to utilise the knowledge of the external entities which create cost effective and creative solutions to business problems. In this way, rich content and better solutions are sourced from a

diverse crowd and this, in turn, may provide a company with a competitive advantage. An example of such a company is Amazon Mechanical Turk (Zhao & Zhu, 2012).

Thus far the adoption of crowdsourcing systems by companies has received little attention (Leimeister, 2010). Schenk and Guittard (2009) reported four main reasons why a company would decide to use crowdsourcing. These reasons include quality of output, risk reduction, problem solving, and organisational core competences. Maiolini and Naggi (2010) focused on the link between SMEs and crowdsourcing. The advantages of adopting and making use of crowdsourcing for SMEs included the building up of new competences that would not otherwise have been possible as a result of a lack of expertise or available investments. Zhao and Zhu (2012) maintain that future research on the topic will have to focus on the relationship between the objectives of crowdsourcing projects, the types of tasks (simple, moderate, or sophisticated), and platform selection (self-developed or third party). This is especially important as a more active approach to data collection would require greater participation in order to be successful. The different incentive and organisational structures for such a system will have to be investigated (Thebault-Spieker, 2012). In this research project, the public safety, participatory crowdsourcing system will not be used for financial purposes as it will be implemented by the government in order to improve public safety. The next section discusses the built infrastructure that must be considered when implementing a smart city initiative.

4.4.7. Built Infrastructure

Smart cities rely heavily on both the quality and availability of the ICT infrastructure (Chourabi et al., 2012). The problems that may influence the infrastructure of a smart city may be divided into the following: ICT infrastructure, security and privacy, and operational cost.

Although capital sources are needed for the development of crowdsourcing initiatives, the actual projects are not capital intensive (Sharma, 2010). However, the investment required will often have to be directed towards the improvement of existing ICT infrastructure. Problems that may have to be addressed include the lack of integration across various systems, limited integration with existing systems, lack of knowledge regarding interoperability, and the availability and compatibility of software, systems and applications (Chourabi et al., 2012). Most of the crowdsourcing initiatives are either mobile or web based (Sharma, 2010). However, it is not always possible for mobile phones to adapt to a heterogeneous infrastructure, despite the use of multi-channels and targeting low-end mobile phones. Further problems with mobile infrastructure may include

a lack of quality control and standardisation as well as irregular updates from the data sources (Ciaghi & Villafiorita, 2011).

As discussed in section 3.4.5, the use of sensors with mobile phones may create privacy concerns for the participants in crowdsensing projects as location data and date and time stamps may compromise the safety of the user. The data is usually archived in a database which is centralised and which provides a single point of access. However, if a malicious entity, such as a hacker, were to gain access to the database, the privacy of the participants would be compromised (Thebault-Spieker, 2012). While there are mechanisms, such as cleaning data, selective hiding and deletion that may be introduced in order to mitigate these risks, more research is needed to establish the effectiveness of such measures.

The third problem, operational cost, includes the high cost of ICT professionals and infrastructure as well as training. One way in which to decrease the cost of smart technology is to make use of mobile phones which are able to utilise existing infrastructure. This is especially useful in developing countries where mobile phone infrastructure is usually already in place (Kumar et al., 2010).

Businesses often develop linkages in order to minimise the perceived cost of doing business (Sharma, 2010). Carmel (2003, p. 8) defines a linkage as "*something which emerges between individuals, between work groups, between firms or between nations due to geographic, cultural, linguistic, or ethnic connections*".

Linkages are especially important in people centric operational models, such as crowdsourcing, as they facilitate the knowledge transfer of best practices and help to pool the resources required to develop the smart city initiative. This, in turn, enables the implementation of feasible crowdsourcing initiatives to which the crowd may comfortably relate (Sharma, 2010). In addition, proper linkages with previous successful crowdsourcing initiatives may contribute a substantial trust aspect to the current crowdsourcing initiative (Brabham, 2009). The last section will discuss the natural environment that must be considered when implementing a participatory crowdsourcing system in a developing country.

4.4.8. The Natural Environment

ICT is used in smart cities to increase the sustainability of a city by improving the management of the natural resources and related infrastructures (Chourabi et al., 2012).

The protection of the natural resources and the related infrastructures is of particular interest in this context. Together, the natural resources and related infrastructure have an impact on the sustainability and viability of a city and, thus, they should be taken into consideration when smart city initiatives are examined. The next section contains a summary of the three areas that are included in this research project, namely, city, technology and people and community.

4.4.9. Summary of the City, Technology and People/Community Factors

This section provides a brief overview of three of the aeas, namely, city, technology and people/community, in the framework of Chourabi et al. (2012). These three areas also represent the three sides of the model that was introduced in section 1.9.

The following frameworks were identified in the literature and were chosen to represent each of the above three factors. The technology areas is contained in the framework of Chourabi et al. (2012), as discussed in section 4.4.2. The critical areas in the people and community factor are contained in the model proposed by Sharma (2010), as discussed in section 4.4.5 while the governance model suggested by Ferro et al. (2013) and discussed in section 4.4.3 is used for the third area, the city.

Table 4.2: Summary of People/Community, Technology and City factors

	Enable	Transform	Inform	ICT infrastrucutre	Security and Privacy	Opoerational cost	Infrastructure	Vision and strategy	Human capital	Linkgaes and trust	External environment
City	X	X	X					X	X	X	
Technology		X		X	X	X	X	X			X
People/Community				X	X		X	X	X	X	X

Table 4.2 provides an overview of the different items that must be considered for each area. As may be seen, several of the items are found in more than one area. This, in turn, strengthens the significance of the individual items to be included in the three areas and also demonstrates the complexity of a smart city as one of the items would affect the entire project on mulitple levels.

4.5 Conclusion

This chapter provided an insight into all of the areas that are present in the PSPC smart city model for developing countries, namely, the city, technology and the citizens. The chapter also provided an answer to the first research sub-question as to **how a smart city could be used to increase public safety in a developing country?**

Smart cities have not yet received much attention in academic literature. The immaturity of the research field is obvious in the lack of consensus regarding a definition of a smart city and also in the relatively few articles that have been published in literature about the topic. However, smart cities have found their way into industry. These smart city projects tend to be implemented in the developed countries and, while such projects provide valuable insights into the process of smart city development, it is not possible to '*copy and paste*' the recommendations to developing countries. The main reason for this is that the characteristics of a developed and a developing country differ.

This chapter also provided an overview of the literature that is available on how to implement a smart city. Using the Smart City Framework of Chourabi et al. (2012), the areas that have been reported as being pertinent to the implementation of a smart city initiative were discussed.

Therefore, it is essential that the organisation ensure user participation in the way in which the city is governed. This may be done by making use of crowdsourcing which enables citizens to report public safety matters. However, the main concern is whether the information that is reported is of a sufficient quality to be useful.

The technology that is used in smart cities has been used in industry. However, relevant academic research about these projects lags behind. In developing countries that lack the technological infrastructure required to make use of crowdsensing, the media has been mentioned as a possible alternative. Unfortunately, the organisations that specialise in emergency response and care are often not able to make use of media platforms as they are not compatible with their own systems.

The governance of smart cities has received some attention in the literature. The Model of Smart City Governance of Ferro et al. (2013) was used as an example of a governance model for smart cities.

Smart cities often make use of technology that trancends international borders. However, the regulatory framework to handle this and other pressing issues, such as the privacy of the individual, has not yet caught up with the technology.

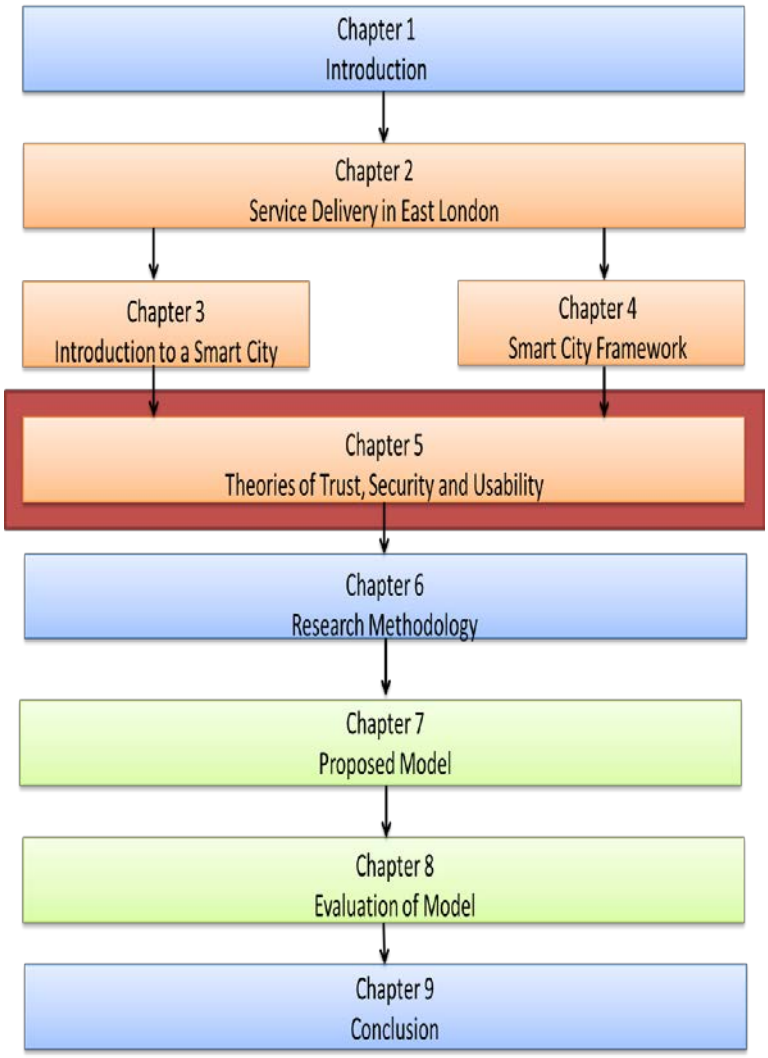
Sharma's model was used to illustrate the five elements that influence user participation in a smart city project. These include the vision and strategy, human capital, infrastructure, external environment and linkages and trust. A sixth element was also discussed, namely, the motivation of the user to participate in a crowdsourcing project.

The economy is seen as one of the major drivers of a smart city. In addition, the economy may provide the city with a competitive advantage that may be used to attract skilled knowledge workers while upgrading the living conditions of the citizens.

The built environment area focuses on the quality and availability of the ICT infrastructure in a city. Three element were identified as important, namely, ICT infrastructure, security and privacy and operational cost.

The last area is the natural environment. Smart cities may be used to protect the natural resources and other related infrastructure within the city. The next chapter will investigate the way in which the trust of the citizins in the public safety, participatory crowdsourcing system would influence the implementation of the system in a developing country. The chapter will also introduce the theories that was used in this study.

Chapter 5
Theories of Trust, Security and Usability



5.1 Introduction

5.2 Theory of Trust

5.3 Theory of Information Security

5.4 Theory of Usability

5.5 Conclusion

5.1. Introduction

As discussed in the previous chapter, the concept of '*smart cities*' is still relatively new (Chourabi et al., 2012). This is confirmed by the lack of studies that have been undertaken in the field (Chourabi et al., 2012; Nam & Pardo, 2011). While researchers have made efforts to identify the fundamental factors that must be present when a smart city is implemented, the relationship between these factors has not received

much attention to date. Thus, this research project focuses on the relationship and interaction between three of these areas as proposed by Chourabi et al. (2012), namely, **technology, the city** and the **people/community**. The relationships between these three areas are investigated in order to identify the factors which are necessary for the successful implementation of a public safety, participatory crowdsourcing smart city in a developing country. The chapter also provides answers to the remaining research sub-questions. These include:

- **How does the trust factor effect the implementation of a public safety, participatory crowdsourcing smart city project in a developing country?**

- **How does the information security factor effect the implementation of a public safety, participatory crowdsourcing smart city project in a developing country?**

- **How does the usability factor effect the implementation of a public safety, participatory crowdsourcing smart city project in a developing country?**

Crowdsourcing is efficient and effective only if a large amount of people participate in the project and provide information. Research has shown that trust and the perception of trustworthiness will influence the participation of citizens in government introduced projects (Fjeldstad, 2003). Scholz (1998) further states that, without trust, there is little basis for social cooperation and voluntary compliance with laws and regulations. This is true even if the end result of the participation would be beneficial for the community (Fjeldstad, 2003). Thus, if the citizens of East London do not believe that the public safety, participatory crowdsourcing system is trustworthy, they will not make use of it.

Information security helps to safeguard trust in the crowdsourcing system and is essential for the establishment of confidence in the system. This confidence may be measured through the user satisfaction with the public safety, participatory crowdsourcing system. If the citizens of East London perceive the system as useful, this will contribute to the confidence that is needed for them to make use of the participatory crowdsourcing system in the future.

As mentioned earlier, trust and the perception of trustworthiness will determine the participation of citizens in a crowdsourcing project. Accordingly, what trust is and the way in which trustworthiness may be determined will be discussed. The discussion will make use of Mayer et al.'s (1995) Model of Trust. This model will be used throughout this

research project as it is often cited in literature and it has been applied to a wide variety of organisational trust relationships.

Risk and uncertainty are inherent in new innovations such as a public safety participatory crowdsourcing system (Souza, Ramos, & Esteves, 2009). Trust is, however, necessary when there is a degree of uncertainty as, without risk, there is no need to trust (Mayer et al., 1995). This relationship between trust and risk is explained in terms of the Risk Reduction Theory (Berger & Calabrese, 1975).

This chapter focuses on the different characteristics that are referred to in the crowdsourcing and citizen factors of the PSPC smart city model for developing countries and which is depicted in Figure 1.6. The nine characteristics listed include the confidentiality, integrity and availability of information, the quality of the system and interface, the usefulness of the system and the trustworthiness of the system as depicted by the ability, reliability and benevolence. Each of these characteristics will be investigated in this chapter.

The remainder of the chapter is divided into three sections. The first section on trust contains the definition of trust and describes the way in which the issue of trust relates to crowdsourcing projects. The chapter also discusses the benefits of trust, specifically in relation to the decision making process while two of the most influential trust models relevant to this research project are introduced. The relationship between trust and risk is discussed in terms of the Uncertainty Reduction Theory. The second section on controls, contains an explanation of the way in which the information security CIA triad was used as a guideline for reducing risk and improving the participation of the citizens of East London in the public safety, participatory crowdsourcing system. The ISO/IEC 27002: 2005 standard is also discussed as it relates to the participatory crowdsourcing system. The third section on user satisfaction determines whether the citizens of East London perceive the public safety crowdsourcing system as useful and how this perception could be used to improve the confidence and participation of the user in the crowdsourcing system.

5.2. Theory of Trust

The first section on the theory of trust will provide an overview of the various definitions of trust. It will also discuss some of the characteristics associated with trust.

5.2.1. Definition of Trust

The concept of trust is becoming more complex as new information systems and ideas are introduced. Although Sodano (2002) and Green (2007) regard trust as an elusive concept researchers have, nevertheless, made attempts to provide a definition of the concept. These definitions are often based on reputation with a specific focus on the individual rather than on the organisational level (Han, Liu, Sun, & Yu, 2006; Saunders, Wu, Li, & Weisfeld, 2004). An example of a definition focusing on the individual level of trust is provided by Shaw (1997, p. 21) who defines trust as the "*belief that the people in whom you trust will measure up to your expectations*". Shaw (1997, p. 21) maintains that trust is built on the "*degree to which those expectations are actualized and the degree of integrity within a relationship*".

There are also definitions of trust in the organizational or business context, for example, definitions suggested by Masuku and Kirsten (2004) and Smeltzer (1997). Masuku and Kirsten (2004) theorise that trust exists in an organisational relationship if one party believes the other to be either honest or benevolent. This view is supported by Smeltzer (1997, p. 41) who makes use of organisational theory and philosophy in order to provide the following definition:

> Trust is the expectation by one person, group, or firm of ethically justifiable behaviour – that is, morally correct decisions and actions based upon ethical principles of analysis – on the part of the other person, group or firm in a joint endeavour or economic exchange.

As indicated in the following definition of trust of Tschannen-Moran and Hoy (2000, p. 556) trust may also be regarded as a multidimensional construct "*Trust is one party's willingness to be vulnerable to another party based on the confidence that the latter party is (a) benevolent, (b) reliable, (c) competent, (d) honest, and (e) open."* This view of trust is based on the confidence that the other party's action in the relationship will be predictable. This definition implies that trust comprises the following (Bussing, 2002):

- Cognitive base – belief about another's trustworthiness;
- Affective base – role of emotions in the trust process, and
- Behavioural base – relying on another and disclosing sensitive information.

In an organisational relationship, the risk that may arise from the other party's actions may be mitigated through control mechanisms. Smeltzer (1997) concludes that the control mechanisms commonly used in an organisational relationship include guarantees, insurance or the law. The use of controls is discussed further in section 5.3.

In contrast to the view, of Smeltzer, there are some who believe that it is possible to achieve trust without the use of control mechanisms. Moorman, Zaltman and Deshpande (1992, p. 45) define trust as the "*willingness to rely on an exchange partner in whom one has confidence"*. Thus, the trustor believes the trustee will consistently fulfil his/her obligations in the relationship (Thomas & Skinner, 2010). The following definition of Mayer et al. (1995, p. 712) supports the previous definition:

> Willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party.

This is one of the most commonly cited definitions of trust and will be adopted as the definition of trust for the purposes of this study. If a trust relationship between the government and the citizens of a country is to be built, both parties need the assurances that the other's action will enable them to achieve their interdependent objectives (Fjeldstad, 2003). In the conversational analysis it was pointed out that the citizens of East London will make use of the participatory crowdsourcing system to provide information about public safety matters to the BCMM. However, this indicates a level of vulnerability as the citizens have no control over the information once it has been recorded. It is, thus, essential that the citizens trust that the crowdsourcing system will reflect their public safety matters correctly and also that they trust the intentions of the BCMM when the BCMM uses the information provided in future.

Despite the fact that there is no consensus as regards a definition of trust, it is possible to identify some common characteristics of trust in all the definitions of the concept of trust provided thus far in this study. Saunders et al*.* (2004) list these common properties as follows:

- At least two parties are involved in the relationship;
- The possibility exists that the one party (trustee) may act opportunistically;
- The risk exists that the potential opportunism will negatively affect the other party (trustor);

- The trustor believes that the trustee will act in the trustor's best interests, and
- The trustor is willing to take a risk.

These characteristics of trust were originally suggested in the context of interpersonal relationships but they are also appropriate for the purposes of this study as it is possible to apply them to the issue of trust in organisational relationships (Saunders et al., 2004). The two parties involved in the participatory crowdsourcing system in this study are the BCMM (trustee) and the citizens of East London (trustor). There is a possibility that BCMM, once they receive the information, may use the information provided for opportunistic or malicious purposes which would be to the detriment of the trustors, for example, to invade the privacy of the trustor and/or to identify theft or fraud. However, if the participatory crowdsourcing system is to operate effectively it is essential that each party believe that the other will act in his/her best interests. This is especially important as private information which could be used to identify victims of crime may be reported via the crowdsourcing system. In addition, in order to ensure participation, the citizens of East London had to be willing to take the risk of engaging in the crowdsourcing system and, thereby, expose themselves to potential opportunistic behaviour on the part of the BCMM or the trustee. This is possible only if the perceived benefit to be received from providing the information outweighs the cost of the potential risk.

It is clear from the discussion above that there had to be trust present in the process of information sharing between the citizens of East London (trustor) and the BCMM (trustee). Making use of conversational analysis, it was pointed out that the sharing of accurate, complete and timely information in the public safety domain was a central theme in this research project. If the citizens of East London did not trust the participatory crowdsourcing system, they would either not make use of it or they would not provide the correct information when they did make use of it. Thus, trust is essential in order to promote participation and information sharing.

Relevant literature indicates that trust in information systems would be enhanced by the following: Firstly, the risk associated with the system must be minimised and, secondly, the user must make use of the system and receive positive feedback from it (Kelley, 2009). There is always some degree of uncertainty in organisational relationships. Todd (2005) maintains that the lower the level of uncertainty in the relationship between the two parties in an organisational relationship, the more likely it is for trust to exist in the relationship. In order to reduce the risk, control measures must be put in place (Kelley, 2009). This concept will be further explained in section 5.2.5.

This section provided a comprehensive overview of the various definitions of trust as it refers to both the individual and organisational level. The next section will explore the need for trust in a participatory crowdsourcing system further.

5.2.2. The Need for Trust in a Participatory Crowdsourcing System

Trust is considered to be a key factor in the development of modern societies (Freitag & Buhlmann, 2009). Stein and Harper (2003) maintain that trust between citizens and government is necessary if decisions are to be made that are in the interests of both parties. Thus, trust is necessary in order to promote information sharing between different partners (Ghosh & Fedorowicz, 2008). In view of the fact that this research project aims to investigate the factors which would contribute to the successful implementation of a public safety, participatory crowdsourcing, smart city project in a developing country, it is essential to consider the issue of trust in this context.

The degree of information exchange between two parties may be used in order to test the strength of a relationship. However, as regards to the crowdsourcing system, this information exchange is not possible as the system does not provide any direct feedback to the user (Nam & Pardo, 2011). A degree of trust is, therefore, necessary on the part of the user as a result of the lack of immediate information exchange between the two parties (Schmandt & Hulteen, 1981). Thus, the BCMM is responsible for providing feedback to the citizens of East London once the information has been collated and used to improve public safety in the city.

According to the definition of trust, proposed by Mayer et al. (1995) and that was adopted for the purposes of this study, there is a need for one party (trustor) to depend on another party (trustee). Two of the benefits of trust in organisational relationships have been identified as speed and cost. These are briefly discussed in the next section.

5.2.3. Benefits of Trust

Covey (2006) proposes that trust will affect two outcomes in a system, namely, speed and cost. If trust is not present in a relationship, costly control measures would have to be put in place and these would decrease the efficiency of the system. Thus, the speed of the system decreases while the cost increases. These costs include the monitoring and enforcement costs which are associated with the control mechanisms (Dyer & Chu, 2002). Similarly, if the degree of trust in the relationship is high, there is no need for

control measures and, thus, the result would be that, while the speed of the system improves, the cost would decrease.

An example of the decreased speed of the system is the stringent security measures that were put in place in all airports in the United States of America after the 9/11 terrorist attacks. After the attacks the public did not trust flying as a mode of transport as the perceived risk of similar terrorist attacks was extremely high. In order to address this situation, the airport companies implemented stringent security measures to which all passengers were subjected. These security measures increased the time passengers had to spend in the airport terminals prior to departure and resulted in an increased cost, both for the company and the passengers who had to pay a security tax. Thus, in view of the fact that the level of trust was low, control measures were put in place to increase the trust, but resulting in a lower speed (less efficient system) and increased cost to both the public and the airport companies (Covey, 2006).

This research project is concerned with the implementation of a public safety, participatory crowdsourcing, smart city project in a developing city. While the system was not be in a competitive market environment, it did still need to be efficient in order not to waste resources and, thus, it was necessary to increase the trust of the citizens in the crowdsourcing system.

As mentioned before, trust will increase because of two factors, namely, positive feedback and mitigated risk. Akkermans, Bogerd and Van Doremalen (2004) provide a graphical explanation of the first factor. This is depicted in Figure 5.1 below:

Figure 5.1: Trust in a Participatory Crowdsourcing System (Akkermans et al., 2004)

As indicated in this diagram, Akkermans et al. (2004) view the trust in a participatory crowdsourcing system as being determined by previous interactions with the system (History of Successful Collaboration). Thus, for the purposes of this research project, the establishment of trust would improve the participation of the citizens of East London in the system and this, in turn, would improve the quantity of the information that was made available. The extent to which either party in an inter-organisational relationship shares information signals good faith to the other party and determines the level of trust between the parties (Sahay, 2003). The information provided by the participants in this study could be used by the BCMM to make quality decisions about how to improve the public safety in the city of East London. Thus, the improved performance of the BCMM would then provide a basis on which future trust could be established. Therefore, it may be argued that improved trust would lead to improved performance of the participatory crowdsourcing system.

However, literature has shown that, although information sharing is equally beneficial to all parties in an inter-organisational relationship, there is no guarantee that the parties will share information (Premkumar, Ramamurthy, & Saunders, 2005). This shows clearly that an important relationship exists between trust and information sharing.

This section has discussed the importance of information sharing in an inter-organisational relationship. In order to understand fully the role of trust in inter-organisational relationships, it is necessary to explore some of the key trust models that are relevant to this study. Two of these models will be discussed in the next section.

5.2.4. Trust Models

Several trust models were considered for use in this research project. These included Mayer et al.'s (1995) Model of Trust; McKnight et al.'s (2002) Initial Trust Model; Li's (2004) Initial Trust Formation Model; and Han et al.'s (2006) Relationship Among Trust Constructs. However, two models were included in this study as they could be used to investigate trust in an organisational relationship and are cited extensively in literature. These two models identify components of trust which are relevant to this research project, in particular, institution-based trust which is determined by the disposition to trust. Both of these components, namely, institution-based trust and the disposition to trust, are believed to directly influence trusting beliefs and trusting intention which will be discussed in the subsequent sections. The models that will be used for the purposes of this study are Mayer et al.'s (1995) Model of Trust and McKnight et al.'s (2002) Initial Trust Model.

5.2.4.1. Model of Trust

Mayer et al. (1995) used literature in the management domain in order to develop their model of trust. In this model, trust is viewed as a trait that leads to a generalised expectation about the trustworthiness of others with the Model of Trust being developed on this basis. The model is depicted in Figure 5.2 below:

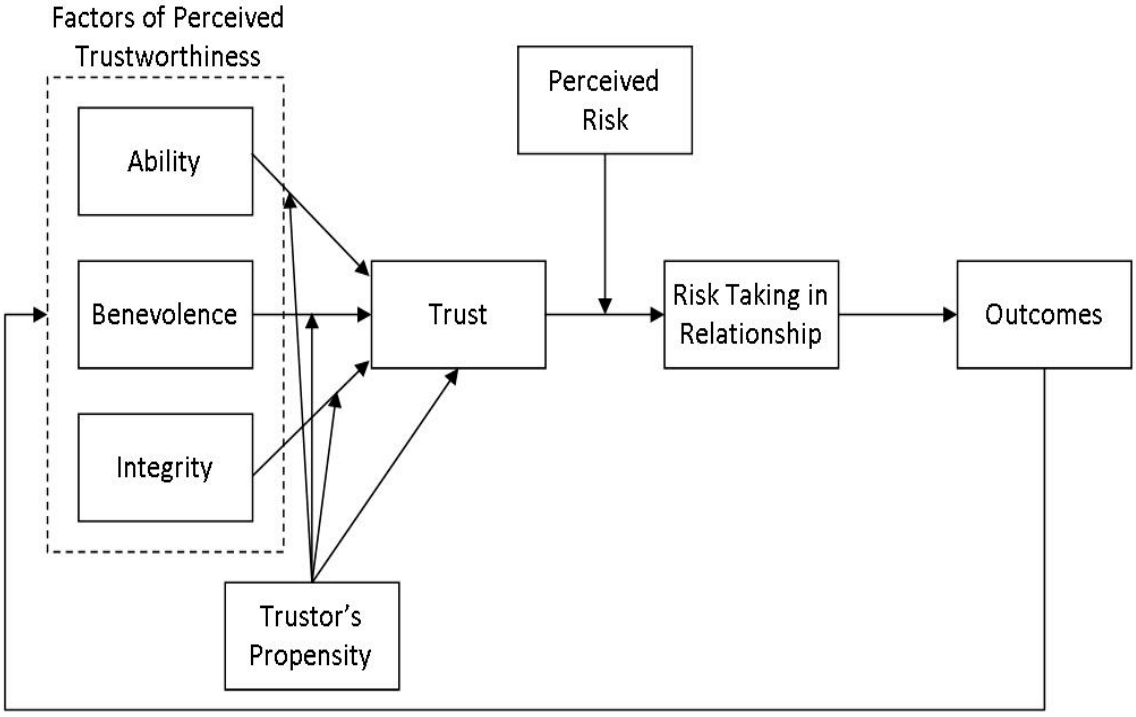


Figure 5.2: Model of Trust (Mayer et al., 1995)

In the model, Mayer et al. (1995) distinguish between the trustor and trustee characteristics that will foster a trusting relationship. As discussed in section 5.2.1, trust is a core attribute in an inter-organisational relationship which exists when one party (the trustor) has confidence in the other party's (the trustee's) reliability and integrity. Thus, the trustor believes the trustee will consistently fulfil his/her obligations in the relationship (Thomas & Skinner, 2010). The characteristics that determine trust in a relationship, as identified by Mayer et al. (1995), are discussed further in the next section.

5.2.4.1.1. Characteristics of the Trustor (Trustor's Propensity)

Several writers have tended to regard trust as a personality trait of an individual. In the context of the model of trust propensity may be regarded as a general willingness to trust others (Mayer et al., 1995). If propensity is perceived as a personality trait, it follows that

the willingness to trust will be influenced by the different developmental experiences, personality type and cultural backgrounds of the individual (Hofstede, 1980).

In the Model of Trust (see Figure 5.2), this willingness to trust is termed the *Trustor's Propensity*. The concept of blind trust may be seen as an example of this propensity trait. Some individuals may repeatedly manifest trust in situations that most people would agree do not warrant trust (Mayer et al., 1995). Thus, Mayer et al. (1995) propose that the higher a trustor's propensity to trust, the higher the level of trust for a trustee would be prior to the availability of information about the trustee. If information about the trustee's characteristics is available, this may further influence the decision of the trustor to trust the trustee. In the next section, trustee characteristics are discussed.

5.2.4.1.2. Trustee Characteristics (Trustworthiness)

Mayer et al. (1995) proposed three characteristics that are often cited in the literature as forming a foundation for the development of trustworthiness, namely, ability, benevolence and integrity. Each of these characteristics offers a unique perspective that may be used to consider the trustworthiness of the trustee.

Ability in this context is defined as the skills, competencies and characteristics that ensure the trustee has influence in the relationship (Mayer et al., 1995). Thus, this characteristic implies credibility, which indicates the ability to perform the functions required efficiently and reliably (Mallalieu, 2005). Similar terms include competence, perceived expertise, interpersonal competence, business sense and judgement (Mayer et al., 1995).

According to Bhattacherjee (2002), this dimension of trust is domain specific. This, in turn, means that trust in one domain of expertise does not necessarily transfer to other domains. For example, the ability of the BCMM to use the information provided via the crowdsourcing system to improve public safety in East London may be regarded by the citizens as satisfactory. However, the trust in the ability of the BCMM to improve public safety would not be transferred if the purpose of the system changed, for example, to improve health care.

The second characteristic, benevolence, is defined as the extent to which the trustee is believed to want to act in the trustor's best interests (Mallalieu, 2005). Benevolence also suggests that the trustee has some specific attachment to the trustor (Mayer et al., 1995). Mayer et al. (1995) used the example of the relationship between a mentor (the trustee)

and a protégé (the trustor). Although the mentor is not receiving an extrinsic reward for helping the protégé, the mentor has a positive orientation towards the protégé and, therefore, the mentor wants to be helpful. In this study the BCMM has been elected by the citizens of East London to that position and, therefore, it is incumbent on the BCMM to act in the best interests of the citizens.

Perceived benevolence plays an important role in the assessment of trustworthiness, and is inversely related to negative behaviours such as the motivation to lie (Mayer et al., 1995). This is especially important as new technologies are increasingly requiring citizens to disclose personal information. It is particularly important in a public safety context that the information provided be accurate and complete if it is to be useful. However, the disclosure of information to a third party without the knowledge or consent of the citizen would clearly raise privacy concerns.

The last characteristic, integrity, refers to the belief that the person or institution concerned will act in an honest, reliable, and credible manner. This characteristic would be more relevant early in the relationship between the two parties before any information about the benevolence of the other party had been obtained (Mayer et al., 1995). Factors that influence the degree of integrity attributed to a trustee include the consistency of the party's actions in the past, credible communications about the trustee from other parties, the belief that the trustee possesses a strong sense of justice, and the extent to which the trustee's actions are congruent with his/her words (Mallalieu, 2005).

A number of researchers have identified similar terms to integrity, namely, reliability, value congruence, consistency, fairness and openness (Mayer et al., 1995) . The term used for this characteristic is similar to the term used for one of the characteristics found in the CIA triad. Where integrity in the context of information security refers to the completeness of information, integrity in the context of trust refers to the belief that the person or institution concerned will act in an honest, reliable and credible manner. Thus, this characteristic will be renamed '*reliability*' for the purposes of this study in order to distinguish between the two.

Mayer et al. (1995) do, however, caution that, when making judgments about the level of trustworthiness, it is the perceived level of reliability that must be considered and not the reasons that played a role in reaching that conclusion. In a participatory crowdsourcing system, reliability would refer to the belief that both the BCMM and the fellow citizens reporting public safety matters are honest, reliable and will keep their promises. It is

essential that the BCMM be able to guarantee the reliability of information that is reported, while it is incumbent on fellow citizens to report accurate information in order to ensure the reliability of the information.

Thus, based on the above, citizens would view the BCMM as trustworthy only to the extent that they believe that the BCMM will act in their best interests, that its procedures are fair and reasonable, and that their trust is reciprocated. The combination of these would, in turn, persuade citizens to become more active in local governance and to co-operate with government initiatives.

In conclusion, Mayer et al.'s (1995) model identifies three key characteristics of trust which are important for the purposes of this research project. The level of trustworthiness in the ability of the BCMM to improve public safety by making use of a participatory crowdsourcing system would be determined by the level of ability, benevolence and reliability of the BCMM as perceived by the citizens of East London.

Rusman, Van Bruggen and Valcke (2009) criticised the Model of Trust as it is based on a literature survey and common sense approach only. However, several researchers have provided empirical evidence to confirm the characteristics identified in the model. For example, McKnight et al. (2002) reported empirical evidence for the Model of Trust while developing their own model and, thus, may be said to have validated the model. The model of McKnight et al.'s (2002) will be discussed next.

5.2.4.2. Initial Trust Model

While the Model of Trust was developed in the management domain, the Initial Trust Model of McKnight et al. (2002) was originally developed in an electronic commerce context. However, the model does incorporate concepts of trust from other disciplines. It was also based on the model of Mayer et al. (1995). The model will be discussed in this chapter. The Initial Trust Model is depicted in Figure 5.3 below.

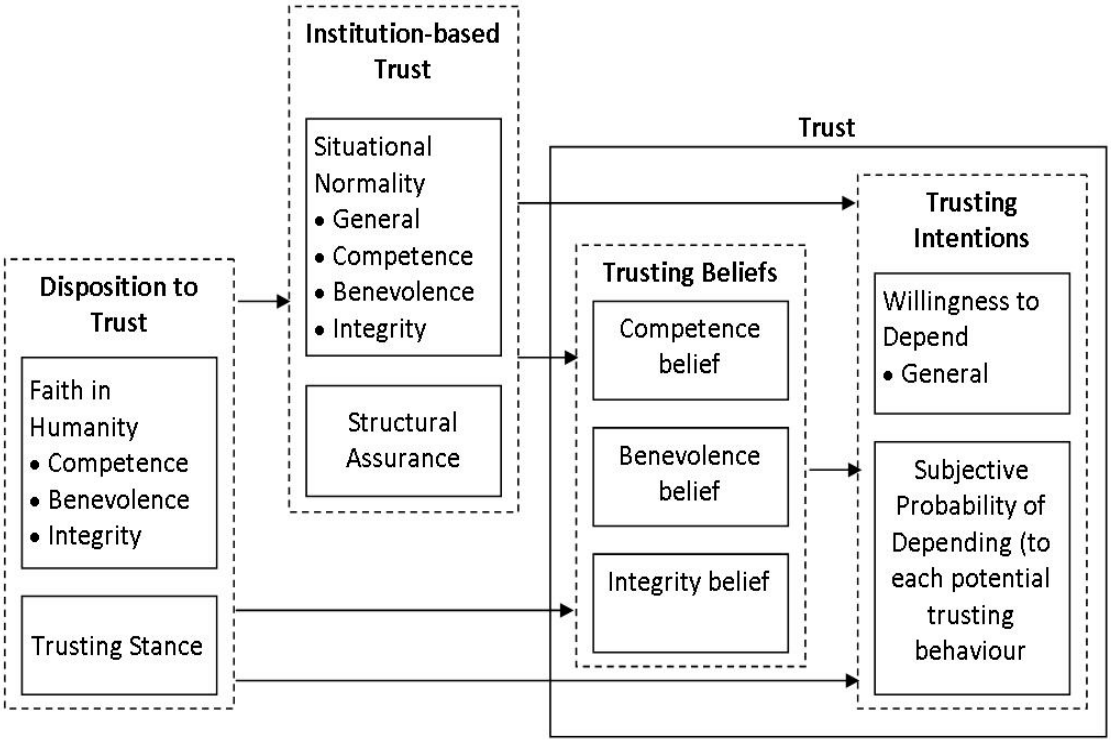


Figure 5.3: Initial Trust Model (McKnight et al., 2002)

As may be seen in Figure 5.3, the model divides trust into two components, namely, trusting beliefs and trusting intention.

Trusting beliefs refer to the trustor's belief that the trustee possesses attributes that are beneficial to the trustor and is based on Mayer et al.'s (1995) factors of perceived trustworthiness as discussed in the previous section. *Trusting intention* may be defined as the trustor's willingness to depend on the trustee. Trusting intention may be equated to Mayer et al.'s (1995) propensity and is influenced by the trusting beliefs.

In addition to these two components, McKnight et al. (2002) define disposition to trust and institution-based trust as the precursors to the trusting beliefs and trusting intentions described above.

Disposition to trust refers to the trustor's willingness to depend and is based upon *Faith in humanity*, which is an assumption that each party is honest and dependable; and *Trusting stance*, which refers to the belief that better outcomes will result from dealing with the trustee as if they were honest and dependable, regardless of the trustor's perception of the trustee's attributes.

Institution-based trust refers to the belief in the structural conditions that need to exist in order to improve the probability of a successful outcome in the relationship and is based

on *Structural assurance*, which is a belief that structures such as guarantees, regulations, legal recourse or procedures, promote success in a relationship; and *Situational normality*, which refers to a belief that the environment in which the interaction occurs is in the required state to ensure success, i.e. in a normal state.

In this model, institution-based trust is determined by the disposition to trust while both of these components are believed to directly influence trusting beliefs and trusting intention. As mentioned previously, the model includes Mayer et al.'s (1995) characteristics of ability, benevolence and reliability. In addition, the inclusion of structural assurance in the model emphasises the need to achieve a balance between trust and controls. Thus, this model was deemed to be relevant for this research project.

The use of controls in inter-organisational relationships has emerged in the two models discussed above. However, in order to understand the need for controls, it is necessary to analyse the relationship between trust and risk (see next section).

5.2.5. Trust and Risk

The need for trust in a relationship arises only when risk exists (Schoorman, Mayer, & Davis, 2007). As mentioned in section 5.2.1, there is an element of vulnerability in any inter-organisational relationship. This vulnerability is related to the behaviour of the trustee and the uncertainty about how the trustee will participate in the relationship (Mayer et al., 1995).

According to Mayer et al. (1995), risk appetite, or risk propensity, has a moderating effect on people as the decision as to whether a situation is risky or not is taken quickly and intuitively. The decision will be influenced by both previous experiences and the level of involvement of the individual (Wiedmann, Hennings, Varelmann & Reeh, 2010). Thus, the need for trust increases as the risk associated with the system or action increases (Pennanen, Tiainen & Luomala, 2007).

In a smart city environment the need to collect information must be weighed against the level of privacy that the citizens expect. The individual risk appetite of citizens will determine this expectation. As discussed in section 5.2.1, there is the risk that government may use the information provided to the detriment of the citizens. However, if the public safety participatory crowdsourcing system is to operate effectively and efficiently, it is essential that each party believe that the other will act in his/her best interests.

5.2.6. Uncertainty Reduction Theory

Risk and uncertainty are inherent in new innovations such as smart technologies (Souza et al., 2009). Berger and Calabrese (1975, p. 41) define uncertainty as the *"(in)ability to predict and explain actions*" of another party*.* From the user perspective, new technologies promote a feeling of uncertainty. This is especially true when the technology affects the daily activities of the user, for example, a public safety, participatory crowdsourcing system (Wiedmann, Hennings, Varelmann & Reeh, 2010).

The Theory of Uncertainty Reduction, as proposed by Berger and Calabrese (1975), provides for the potential influence of uncertainty as well as the reduction of uncertainty at the beginning of a relationship. There will always be a degree of uncertainty in our interactions with others. However, this uncertainty may be reduced by generating and confirming predictions about the behaviour of the other party by making use of an exchange of information about each party (Berger & Calabrese, 1975).

It may, thus, be assumed that, when the BCMM reaches a certain level of predictability regarding the actions that are taken and which are based on the information that has been reported making use of the participatory crowdsourcing system, uncertainty will be reduced. The BCMM should, therefore, provide feedback to the citizens regarding the outcomes of the public safety information that has been reported in order to ensure the trust of the citizens in the participatory crowdsourcing system. The next section will discuss the control measures that are necessary to mitigate the risk in an inter-organisational relationship.

5.3. Theory of Information Security

Both trust and control measures may be used to help manage risk in an inter-organisational relationship. Covey (1989) stated that, in order to enhance the trust of the citizens in a public safety, participatory crowdsourcing system, it is essential that control measures be put in place to reduce the associated risk which would, in turn, decrease the speed (or efficiency) of the system. One may, therefore, reason that, if the level of risk in a relationship exceeds the level of trust, then a control system would bridge this gap and reduce the risk to an acceptable level. When this happens, a trust-based relationship is established as the existence of trust is expected. In the context of this study, the assurances provided by the BCMM should include information about the controls that

have been put in place in order to secure the information provided via the participatory crowdsourcing system. If, however, the control system that is put in place is too rigid, no risk will be perceived in the relationship, and any trustworthiness would be the result of the control system and not the efforts of the trustee (Flowerday & Von Solms, 2006). It is, thus, essential that the balance between trust and the control systems be carefully managed so as not to detract from the efficiency of the system (Mayer et al., 1995; Covey, 1989). In the next section the security of the system will be introduced as a control system that may be used to enhance trust.

5.3.1. Trust and Control Measures

Camp (2002) stresses that '*security is not a separable element of trust'.* While both trust and security-based mechanisms are classified as safeguarding protective measures, the presence of these mechanisms will not build trust on its own (Flowerday & Von Solms, 2006). Security-based mechanisms does, however, hold technological, organisational and relationship benefits for the various stakeholders of a participatory crowdsourcing system.

Camp (2002, p. 16) further advocates that both *"technical competence"* and *"good intent"* are required to ensure information security. The technical competence of a crowdsourcing system will be illustrated by the networks, protocols, machines and policies that are in place, while good intent takes into account the way in which social agents (BCMM and the citizens of East London) participate in and contribute to trust.

However, even if security is in place, it is commonly accepted that it is not possible to eliminate all risk (Greenstein & Vasarhelyi, 2002). This inherent risk is based on the notion that additional investments in controls or safeguards would not eliminate the risk completely. The trust relationship between the citizens and the city is affected by both the level of trustworthiness attributed to the city that is providing the system (the BCMM) and the perception of the degree of adequacy of the system's controls that have been put in place to safeguard the information provided to the system. In order to optimise the relationship between the user and the participatory crowdsourcing system, it is essential that the correct balance between this trust and the controls be found (Cox & Marriott, 2003).

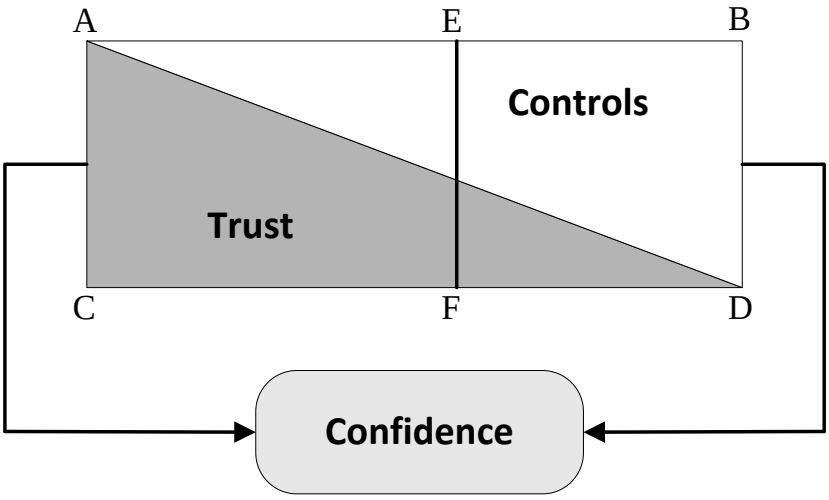


Figure 5.4: The Relationship Between Trust, Controls and Confidence (Flowerday & Von Solms, 2006)

Figure 5.4 illustrates how trust and controls work together to create the security of a participatory crowdsourcing system. The rectangular area, A, B, D, C, represents the reporting of public safety information by the East London citizen and the public safety participatory crowdsourcing system. Triangle A, B, D represents the control area (controls put in place to safeguard the information) while triangle A, D, C represents the trust of the citizens in the crowdsourcing system. The line E-F is the hypothetical positioning of the individual's risk appetite. The position of this line may be influenced by the individual's propensity to accept risk (Cox & Marriott, 2003). It is, therefore, essential that the correct balance between the controls (which comes at a cost) and level of trust be found in order not to decrease the efficiency of the system.

In short, absolute trust and absolute controls may be seen as two opposing points on the confidence scale (Flowerday & Von Solms, 2006). However, as it is not possible to achieve either 100%, the solution is somewhere in the middle. Di Maio (2001) suggests that one should try to create an environment in which each party is willing and able to demonstrate continuously to the other party that all dealings are honest, open, and that the rules are being followed. However, practicalities such as the cost and speed of the crowdsourcing system are forces that propel this solution towards the control end of the spectrum (Flowerday & Von Solms, 2006). The next section will introduce the security that needs to be in place in order to promote the confidence of the citizens of East London in the participatory crowdsourcing system.

5.3.2. Security

Karnouskos, Hondroudaki, Vilmos and Csik (2004) have identified three requirements for the user to adopt an information system. These requirements include trust and also the security and privacy of the system. Trust was discussed extensively in the previous sections and security and privacy will be discussed in the following sections.

Kainda, Flechais and Roscoe (2010) maintain that the natural way in which a user interacts with any information system should be considered as a secure way. However, the fact is that many information systems are not secure. As mentioned in the previous section, a 100% secure system is not practical. It is essential that the crowdsourcing system make use of technology which is secure and also that the system provides adequate procedural information to ensure the confidentiality, integrity and availability of the information reported via the public safety, participatory crowdsourcing system. In addition, appropriate policies and procedures must be in place to support these technologies (Whitman & Mattord, 2005; Karnouskos et al., 2004). These security mechanisms protect systems and information from being adversely affected by malicious and unauthorised parties. Secured systems are, thus, considered to be more reliable and, thus, more trustworthy as compared to unsecured systems and, therefore, such secure systems are one of the key technology drivers of the future success of public safety, participatory crowdsourcing systems (Wiedmann, Hennings, Varelmann & Reeh, 2010). The next section will introduce the controls that are necessary to provide adequate protection to the information reported via the public safety participatory crowdsourcing system.

5.3.3. Information Security

Information security involves achieving and maintaining the confidentiality, integrity and availability of information (ISO/IEC 27002, 2005). These three characteristics, which are known as the CIA triad, constitute one of the most frequently cited frameworks in security literature and must, therefore, be considered in any discussion involving the protection of information in a crowdsourcing system (Kainda et al., 2010).

The CIA triad is able to ensure the safety of a variety of information systems, including paper-and-computer based systems, emails, Web browsers, and telephonic communications. It would, thus, be possible to use the CIA triad to secure the information within the participatory crowdsourcing system. This is made possible by the provisions for

the confidentiality, integrity and availability of the information (Kelley, 2009). The following section will discuss the CIA triad.

5.3.3.1. Confidentiality of Information

The confidentiality of information refers to the prevention of disclosure or the exposure of information to unauthorised individuals or systems (Whitman & Mattord, 2005). Thus, confidentiality would ensure that authorised people only would have access to the information reported via a public safety, participatory crowdsourcing system (Kelley, 2009). As discussed previously, the information reported via a public safety participatory crowdsourcing system may be used to breach the privacy of the individual as it may identify victims of crime or be used for malicious purposes such as fraud. However, in order to mitigate this risk, a number of measures may be taken to protect the confidentiality of the information. These include the following (Whitman & Mattord, 2005):

- Information classification;
- Secure document storage;
- Application of general security policies, and
- Education of information custodians and end users.

The confidentiality of the public safety, participatory crowdsourcing system would help to protect the privacy of the citizens of East London. The next section will discuss the integrity of the information.

5.3.3.2. Integrity of Information

Information is regarded to have integrity when it is whole, complete and uncorrupted. Threats to the integrity of information include exposure to corruption, damage and destruction. Possible sources of these threats include external forces such as hackers or viruses and/or internal considerations such as theft (Whitman & Mattord, 2005). Once the information has been reported using the crowdsourcing system, the citizens have no control over what happens to the information. The BCCM is, thus, responsible for ensuring that adequate controls are in place to safeguard the integrity of the information.

The integrity of information security is similar to the integrity characteristic found in trust. The differences between the two were discussed in section 5.2.4.1 and the integrity

characteristic of trust was subsequently renamed reliability in order to avoid confusion. The next section will discuss the availability of the information reported via the public safety, participatory crowdsourcing system.

5.3.3.3. Availability of Information

The availability of information enables authorised users to access information without interference or obstruction, and to receive the information in the required format (Whitman & Mattord, 2005). This crowdsourcing system will collect information regarding public safety matters. Thus, in order to provide the correct response timeously, it is important that the authorities such as the police and emergency services have access to the information that has been reported.

If the three CIA characteristics are perceived favourably, the user will regard the information security controls of the public safety participatory crowdsourcing system as satisfactory and will consider the crowdsourcing system to be trustworthy (Kim, Tao, Shin & Kim, 2010). The International Organisation for Standardisation (ISO) has produced a standard that may be used to implement information security. This standard, the ISO/IEC 27002: 2005, is an internationally accepted standard of good practice for information security. The aim of the standard is to provide a set of suggested controls designed to address information security risks, including confidentiality, integrity and availability, within the crowdsourcing system (ISO/IEC 27002, 2005). This standard indicate suitable information security controls, but are used as a code of practice/guideline rather than a certification standard.

Organisations that adopt ISO/IEC 27002: 2005 are expected to assess their own information security risks and apply suitable controls, using the standard for guidance. Thousands of organisations worldwide make use of ISO/IEC 27002: 2005 and it is, therefore, the most widely recognised information security standard. The ISO/IEC 27002: 2005 standards are influenced by an organisation's needs and objectives, security requirements, the processes employed and its size and structure (Whitman & Mattord, 2005).

The ISO/IEC 27002: 2005 may be used by all types of organisations that deal with and depend on information, e.g. commercial enterprises of all sizes, charities and government. This, in turn, renders it suitable for a participatory crowdsourcing system in which both government and citizens will participate in information sharing as the standard is flexible

enough to allow organisations to choose what controls to include according to the individual need (Lineman, 2008).

The ISO/IEC 27002: 2005 standard cannot be used to obtain a formal security certification. This is as a result of the fact that the flexibility of the standatd makes it is difficult for the certification bodies to assess whether an organisation is fully compliant with the standard. Instead, organisations may apply for the certification of the Information Security Management System as a whole, as certified against the ISO/IEC 27001 standard (ISO/IEC 27001, 2005).

The ISO/IEC 27002: 2005 standards described in this section may be used as a benchmark for the information security considerations of a public safety, participatory crowdsourcing system. These standards are internationally recognised and accepted. This, in turn, means that they may be used in various countries around the world in order to safeguard the information provided via a participatory crowdsourcing system. The final category that will be discussed is user satisfaction

5.4. Theory of Usability

As mentioned earlier, the trust in an information system will increase either if the risk associated with the information systems decreases or if the user receives positive feedback from the system (Kelley, 2009). The category of user satisfaction is used to investigate the second factor, positive feedback.

The usability of a system is influenced by user-centric beliefs and attitudes (Wiedmann, Hennings, Varelmann & Reeh, 2010). The user-centric beliefs and attitudes in turn will influence ICT usage behaviour as the user gains first-hand experience with the technology. The perceived usability of a system may be defined as the degree to which an individual believes that using a particular system, such as a participatory crowdsourcing system, will enhance a specific goal, i.e. public safety. Appearance and ease of use are prerequisites for crowdsourcing systems. For example, if a participatory crowdsourcing system is well designed, it will be easy to use. As a result, if the crowdsourcing system is perceived as reliable the user's confidence in the system will increase.

5.4.1. Usability

Usability standards for Human Computer Interaction (HCI) are used to ensure consistency in the usability of a system and, thus, predictability as regards to the interaction of the user with the system (Bevan, 2001). Thus, in the crowdsourcing context, the usability of the system will also determine the crowdsourcing system's use, efficiency, user acceptance and productivity (Madan & Dubey, 2012; Abran, Khelifi, Suryn, & Seffah, 2003). As regards the crowdsourcing system that was used in this research project, three aspects were identified that will be considered in relation to its usability. These three aspects include system quality, interface quality and usefulness of the system and will be discussed in subsequent sections. If the usability of these three aspects of the system is found to be positive, the risk associated with the participatory crowdsourcing system would be decreased while the confidence in the system would increase (Madan & Dubey, 2012; Abran et al., 2003). The next section will provide an overview of both the definition of the term usability and also of the various models which may be used to explain usability.

5.4.2. Definition of Usability

Usability is an abstract concept which is difficult to define as it is dependent on the characteristics and attributes of the information system concerned and dependent on the context in which the system is developed (Madan & Dubey, 2012; Abran et al., 2003). For this reason, it is possible to find various definitions of usability in literature (Abran et al., 2003). Some of these definitions are listed in Table 5.1.

Table 5.1: Definitions of Usability

Definition	Author
Usability may be defined as a product attribute that influences the quality of a software system.	(Madan & Dubey, 2012)
Usability may be understood as the degree to which software is usable by specified users with ease and comfort.	(Dubey, Gulati & Rana, 2012)
The ease with which a user is able to learn to operate, prepare inputs for, and interpret the outputs of a system or component.	IEEE std. 610. 12-1990
The capability of the software product to be understood, learned and used by the user and to be attractive to the user, when used under specified conditions.	ISO/IEC 9126-1, 2000
The extent to which a product may be used by specified users to achieve specified goals within effectiveness, efficiency and satisfaction in a specified context of use.	ISO/IEC 9241-11, 1998

The last definition, as contained in the ISO/IEC 9241-11, 1998, is widely accepted in the HCI community (Wallace, Reid, Clinciu & Kang, 2013). This definition of usability will be adopted for the purposes of this research project as the three characteristics that are mentioned (efficiency/effectives/satisfaction) are relevant to the functions of a public safety, participatory crowdsourcing system. The next section contains an analysis of some of the characteristics that are found in usability models.

5.4.3. Usability Models

The following models, as is evident in Table 5.2, indicate a number of characteristics of the information system that must be taken into account when determining the usability of the system. This table is adopted from the work Madan and Dubey (2012) and Wallace, Reid, Clinciu and Kang (2013).

Table 5.2: Various Usability Models and Related Characteristics

MODEL	Learnability	Efficiency	Memorability	Recover from Errors	Satisfaction	Effectiveness	Flexibility	User attitude	Consistency	Ease of Use	Controllability	Usefulness	Expectability	Naturalness	Productivity	Compliance	Attractiveness	Safety
Nielson Heuristics (1993)	x	x	x	x	x													
Shackel Model (1991)	x					x	x	x										
McGee *et al.*, (2004)		x				x			x	x	x	x	x	x				
ISO/IEC 9241		x			x	x												
Abran *et al.*, (2003)	x	x			x	x												x
ISO/IEC 9126	x									x				x		x	x	
Bevan (1995)								x		x				x				
Preece *et al*., (1993)	x	x			x	x	x	x										x
QUIM	x	x			x	x		x				x			x	x		x
Total	**6**	**6**	**1**	**1**	**5**	**6**	**2**	**4**	**1**	**3**	**1**	**2**	**1**	**3**	**1**	**2**	**1**	**3**

It is clear from Table 5.2 that the characteristics of learnability, efficiency, satisfaction and effectiveness are the most commonly cited in usability models. Three of the four characteristics mentioned are included in the ISO/IEC 9241-11, 1998 definition of usability as adopted for the purposes of this study. The three characteristics as per the ISO/IEC 9241-11, 1998 standards are defined below (Wallace, Reid, Clinciu & Kang, 2013):

- Effectiveness: the accuracy and completeness with which users achieve specified goals;
- Efficiency: the resources expended in relation to the accuracy and completeness with which users achieve goals, and

- Satisfaction: the comfort and acceptability of use.

The next sections provide a brief overview of each of these characteristics.

5.4.3.1. Effectiveness and Efficiency

There first two characteristics, Effectiveness and Efficiency, are described by Covey (1989) as follows:

- Effective – Adequate to accomplish a purpose, producing the intended or expected result.

- Efficient – Performing or functioning in the best possible manner with the least waste of time and effort.

The following scenario may be used to illustrate the difference between effectiveness and efficiency. Suppose the citizens of East London use a participatory crowdsourcing system in order to report public safety matters. If a citizen witnesses a motor vehicle accident, he/she will be required to make a call to the crowdsourcing system and report what they have seen in order for the emergency services to be alerted. However, if the citizen is not familiar with the crowdsourcing system, navigating the system by making use of the voice prompts may take a long time. This means that the system is effective as the expected result, alerting the emergency services, will be achieved. On the other hand, the system is not efficient as the citizen had to waste time navigating an unfamiliar system.

If the citizen is familiar with the crowdsourcing system and is able to navigate it quickly in order to report the information, the system will be an efficient system. However, if the citizen uses the system to report the wrong information, e.g. complaints about the poor quality of education in the city, the system will not be effective as the desired goal, namely, to improve the education in the city, is not included in the crowdsourcing system's functions.

To sum up, Covey (1989, p. 105) explains the difference between effectiveness and efficiency as follows: "*being effective is about doing the right things, while being efficient is about doing things in the right manner*". Effectiveness and efficiency are both objective in nature and, thus, the quantitative measurements related to the operations of the crowdsourcing system were considered appropriate to measure these characteristics of the crowdsourcing system (Bevan, 2001). In this study, effectiveness and efficiency were

included under system quality in the investigation into the usability of the public safety, participatory crowdsourcing system.

Interface quality was used in order determine the efficiency of the crowdsourcing system. Contingency of the crowdsourcing system refers to the extent to which one person's queries, responses and comments are dependent on prior queries, responses and comments (Paine Schofield & Joinson, 2008). In the IVR system contingency is important as the response of the user will determine the next voice prompt to be cued. It is essential that the system understand the root of the problem, a wrong answer or if the user is not speaking clearly, and respond accordingly (Schmandt & Hulteen, 1981). If the responses are unclear or do not provide enough information, the crowdsourcing system will not be deemed usable by the BCMM and, this, in turn, would decrease the participation of the citizens of East London in the public safety project as no response will be provided by the BCMM. The problem regarding the responses not being understood by the IVR system was solved by testing the prototype extensively before it went operational. More than 20 iterations were necessary in order to make sure that all accents would be recognised by the speech software. Alternatively, callers were given the option to input their responses by making use of the touch pad if the system did not recognise their responses.

Barth and Merelles (2011) stated that the user often perceives a standard textual interface as indifferent while the speech based interface provides a sense of engagement in the interaction. This, in turn, means that the user would be more likely to disclose information when making use of an IVR system than a SMS based system. In the context of this study, where accurate, complete and timely information was needed to provide an appropriate response, it was important that the user was made to feel comfortable so as to encourage the user to disclose as much information as possible. A further reason why an IVR system was chosen for the purposes of this study was that this meant that illiterate users would also be able to participate in the study. Kumar et al. (2010) had previously reported that users were able to make use of an IVR system regardless of their literacy level. However, they also found that the spelling in text messages was confusing and could not be used in predictive analytics. Accordingly, the calls that were made to the IVR system had to be transcribed by one person in order to standardise the spelling of the messages.

Synchronicity determines whether the interaction between the caller and IVR system is in real-time. This, in turn, makes possible immediate bidirectional feedback. In contrast, asynchronous means that the feedback is provided later (Paine Schofield & Joinson, 2008). In view of the fact that an asynchronous crowdsourcing system was used in this

study, the only information the user received from the system was via the voice prompts. This means that the interface quality had to be sufficient to provide the user with enough information to navigate the crowdsourcing system so as to obviate the frustration which may have decreased the participation rate of the citizens making use of the public safety participatory crowdsourcing system. The next section will discuss the final aspect of the participatory crowdsourcing system, the usefulness of the system.

5.4.3.2. Usefulness of the Crowdsourcing System

If the user felt that the crowdsourcing system was useful and would yield positive results, the confidence of the user in the system will increase. Further elements that have been found to be associated with the degree of task outcomes entrusted to the system include dependability, expertise, trust and task attraction (Paine Schofield & Joinson, 2008).

Abran et al. (2003) maintain that the most important consideration when designing a usable system is the end-user. Bevan (2001) agrees with this point of view and states that end-user interaction is a prerequisite for designing and developing an appropriate interface and interaction with an information system. One of the most common ways in which to involve users in the software design process is through usability testing. In order to verify whether or not the required level of usability has been achieved, it is necessary to measure the interaction and the satisfaction of users working with the product. This measurement of usability is a complex interaction between the users and the context of use and it may produce different levels of usability performance for the same product when it is used in different contexts (Abran et al., 2003). If the system is considered to be user-friendly, the interaction of the system becomes predictable and, in the context of the crowdsourcing system, this would decrease the risk associated with using the system to report public safety matters.

5.5. Conclusion

This chapter forms part of the theoretical foundation of this research project. While the previous chapters introduced the smart city concept and the public safety problems of East London to the reader, this chapter presented an overview of the various aspects that must be considered when implementing a public safety, participatory crowdsourcing model. The literature suggests two reasons why trust in an information system, such as

crowdsourcing, would be increased, namely, the reduction of the risk associated with the system and user satisfaction with the system.

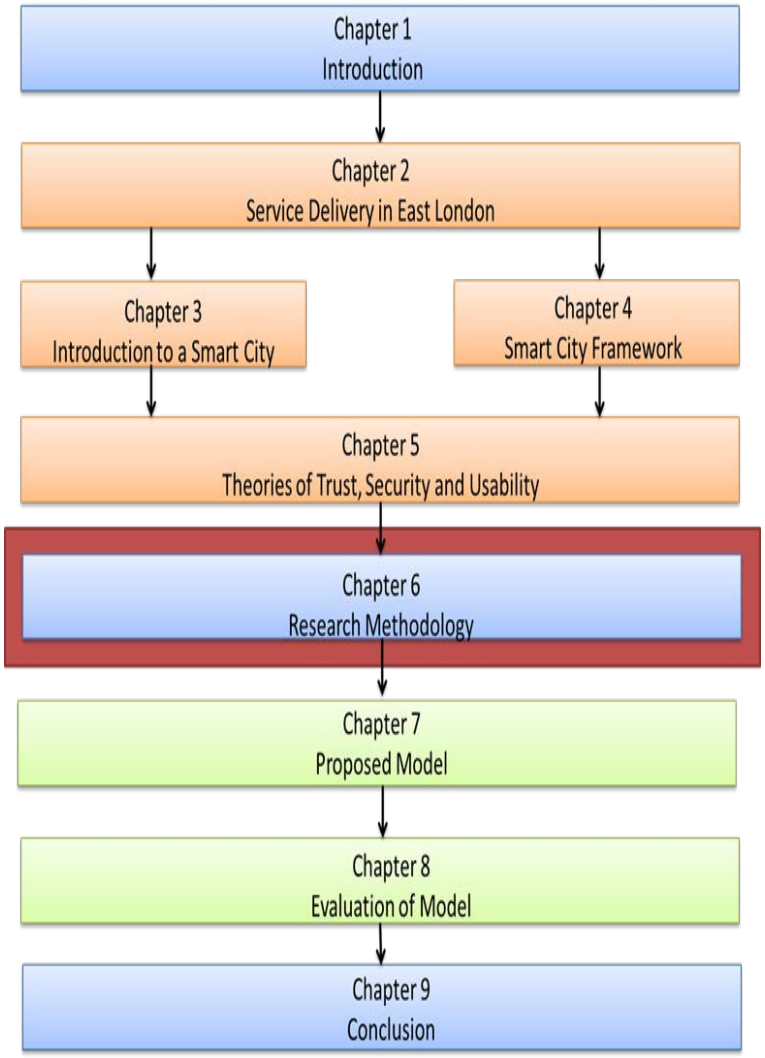
The chapter discussed the trust, information security and usability factors. The Model of Trust as proposed by Mayer et al. (1995) was used to identify the factors that had to be considered when the trustworthiness of the two parties – in this research project the citizens of East London and the BCMM – were determined. Ability is defined as the skills, competencies and characteristics that ensure the trustee has influence in the relationship between the crowdsourcing system and citizens. In this study the ability of local government to use the information provided via the crowdsourcing system in order to improve public safety could be used by the citizens of East London in order to determine the trustworthiness of the city management. On the other hand, benevolence is defined as the extent to which the trustee is believed to want to act in the trustor's best interests while, the last characteristic, reliability, refers to the belief that the person or institution will act in an honest, reliable and credible manner. In the context of a participatory crowdsourcing system, reliability would refer to the belief that both the government and the fellow citizens reporting public safety matters are honest, reliable and will keep their promises. The Model of Trust used '*integrity*' as one of the characteristics. However, this term is similar to the CIA triad, and was renamed '*reliability*'. It is essential that local government be able to guarantee the reliability of the information that is reported while the citizens must report accurate information in order to ensure the reliability of the information.

The next section provided an explanation of why trust in a relationship is necessary if risk is present. With new technologies, such as crowdsourcing systems, there is always risk present. Uncertainty Reduction Theory was used to illustrate the way in which control measures may be used to mitigate risk and increase trust at the same time. One of the factors in a smart city project that was discussed in detail was the information security of the system. The ISO/IEC 27002 standard was discussed briefly and, finally, the CIA triad was used to explain the information security of the crowdsourcing system. Confidentiality ensures that authorised people only have access to the information reported via a public safety participatory crowdsourcing system. In this study authorised people referred to the emergency authorities that had to respond correctly and timeously. Information is said to have integrity when it is whole, complete and uncorrupted. Once the information has been reported via the crowdsourcing system, the citizen has no control over what happens to this information. The availability of information enables authorised users to access information without interference or obstruction, and to receive the information in the required format. In the context of this study this crowdsourcing system collected

information on public safety matters. In order to provide the correct response timeously, it is important that authorities such as the police and emergency services have access to the information that has been reported.

Finally, the usability of the system was discussed as it would influence the confidence of the citizens in the public safety, participatory crowdsourcing system. Three aspects were identified as referring to the usability of the system, namely, interface quality, system quality and the usefulness of the system. The definition of usability as contained in the ISO/IEC 9241-11, 1998 was adopted for the purposes of the study. This definition refers to the characteristics of effectiveness, efficiency and satisfaction. If the user felt that the crowdsourcing system was useful and would yield positive results, this would increase confidence in the system. The next chapter discusses the research methodology used in this project.

Chapter 6
Research Methodology



6.1 Introduction

6.2 Philosophical Research Paradigm

6.3 Research Approach

6.4 Research Methodology

6.5 Data Collection Methods

6.6 Study Population

6.7 Data Analysis

6.8 Research Evaluation

6.9 Ethical Considerations of the Study

6.10 Conclusion

6.1. Introduction

Research is a process of finding out about a phenomenon by critically looking at its significant attributes and behaviours. It, thus, encompasses the application of a systematic and objective investigation to provide answers to an identified problem (Burnes & West, 2000, p. 59).

Saunders, Lewis and Thornhill (2009) explain that the research methodology section of a thesis provides the researcher with an opportunity to present and justify the research

methods that were used to arrive at the research results pertaining to the research problem which has been identified. Hofstee (2006) concurs with this statement when he appeals to the researcher to think carefully when choosing an appropriate research method as the research method is critical to the success of a research project. If the incorrect research method is used this would result in time being wasted as well as unnecessary frustration and effort on the part of the researcher.

Research may be regarded as the accumulation of a series of stages. Saunders et al. (2009) have identified six research stages. They termed the figure representing these stages a '*research onion*'. These six stages include philosophies, approaches, strategies, choices, time horizons, techniques and procedures. Figure 6.1 illustrates the different components of the research onion.

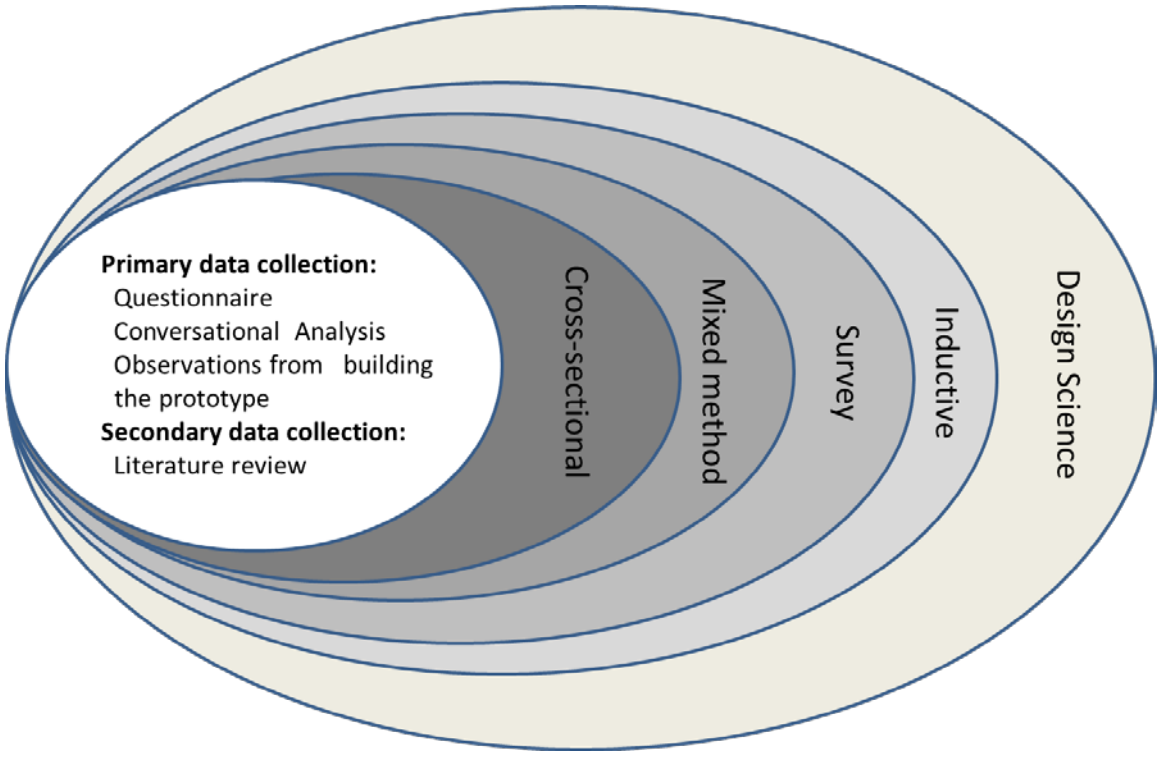


Figure 6.1: The Research 'Onion' (Adapted from Saunders et al., 2009)

This chapter follows the '*research onion*' approach. The chapter starts with an explanation of the various research paradigms or philosophies (Positivism, Realism, Interpretivism and Pragmatism) that are found in literature. A fifth paradigm, Design Science Research, is also included in the discussion and was subsequently adopted for this research project. The research methodology, approach and strategy are discussed in the next section. In this research project an inductive logic approach was followed, making use of a mixed method strategy. The cross-sectional time horizon was also used in this project. The data collection methods used in the research project included conversational analysis,

observations from the development of the crowdsourcing system prototype, a questionnaire and a literature review. Section 6.8 explains how the integrity of the results of the study was evaluated. The chapter concludes with a section discussing the ethical aspects that were considered for the purposes of the study. The next section discusses the various philosophical research paradigms that are available to the researcher.

6.2. Philosophical Research Paradigm

A research paradigm may be defined as an overall philosophical framework of the way in which scientific knowledge is produced (Collis & Hussey, 2009). It provides a set of assumptions about reality (ontology), how that reality is understood (epistemology) and the particular ways of knowing about that reality (methodology) (Saunders et al., 2009; Maxwell, 2005).

It is not possible for researchers to work in isolation from each other as the nature, domain and structure of research is shared with the broader research community. Each discipline in the social sciences consists of a variety of paradigms as can be seen in Figure 6.2 (De Vos, Strydom, Fouche & Delport, 2005).

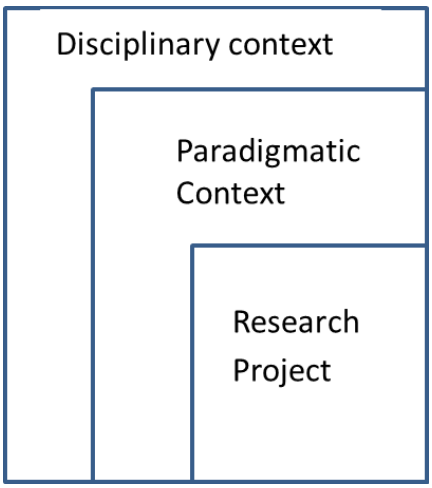


Figure 6.2: Research Context (De Vos et al., 2005)

The philosophical research paradigm was first described in 1962 by Kuhn in his work, *The structure of scientific revolutions*. In this book, Kuhn explains that physical science displayed a distinct cycle of periods of normal science followed by scientific revolutions (Mouton, 2001). Following this work, a comparative study of the paradigms in the social sciences was conducted. The conclusion reached was that, unlike the physical sciences, there are no disciplines in the social sciences in which a single, dominant paradigm could

be found (Mouton, 2001). This parallel comparison between the physical and social sciences has subsequently been criticised as the function of problem solving is not the same in these two sciences. In natural sciences, problem solving has a clear and specific meaning while, in the social sciences, it is most often associated with the in-depth understanding, explanation, analysis and interpretation of a problem (Mouton, 2001).

Even though there are no dominant paradigms in the social sciences, the researcher must choose and prescribe to a specific research paradigm with particular philosophical assumptions (Collis & Hussey, 2009). The reason for this, according to Easterby-Smith, Thorpe and Lowe (2002) and Maxwell (2005), is that a well-chosen philosophy will assist the researcher to evaluate the available methodologies early on in the research process and to select the most suitable one for the specific project. The research methods will determine what evidence is to be gathered, from what source, as well as how it will be interpreted in order to address the research question.

There are several paradigms at the disposal of the social science researcher. These paradigms may be distinguished according to the underlying philosophical assumptions on which they are based. There is, however, disagreement regarding which of the philosophical paradigms is appropriate for Information Systems research (Collis & Hussey, 2009; Klein & Richey, 2007; Saunders et al., 2009).

Oates (2006) argues that a common problem in Information Systems research is the fact that artefacts are produced with no consideration for the underlying research philosophy. This oversight will, in turn, influence the correct methodology that should be used during the research process (Oates, 2006). A further concern is that, if Information Systems accepts a paradigm as its own, this does not guarantee a universal best way of conducting research or reconciling humanitarian attitudes with scientific education (Feyerabend, 2010). Several researchers have warned that strict adherence to a particular paradigm may lead to the delay of scientific progress (Hofstee, 2006; Brink, Van der Walt & Van Rensburg, 2006; Wilson, 1989). For this reason Collis and Hussey (2009) urge researchers not to make use of a purely Positivist or Phenomenologist approach in their research. They argue that using a combination of both enables researchers to adopt a broader and often complementary view of the research problem. These two paradigms are depicted in Figure 6.3.

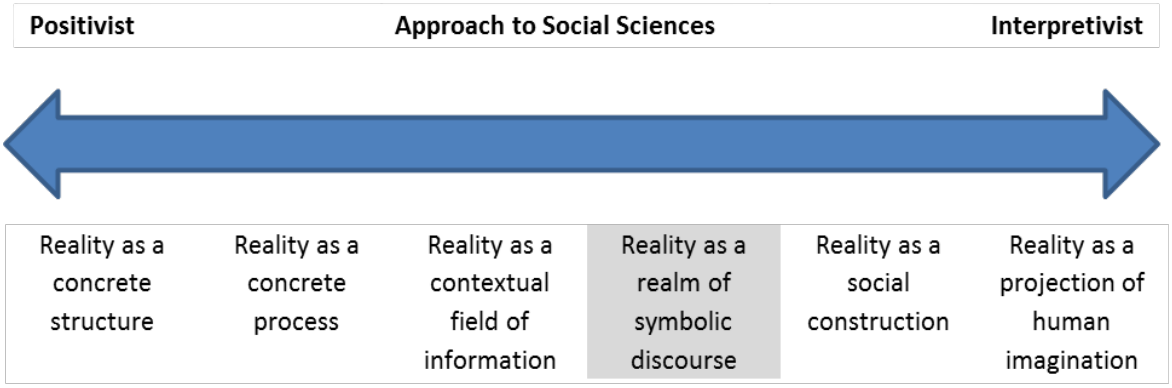


Figure 6.3: Continuum of Core Ontological Assumptions (Collis & Hussey, 2009)

As depicted in Figure 6.3, Collis and Hussey (2009) recognise two main philosophical paradigms – Positivist and Interpretivist – in the context of Information Systems research. Within these two paradigms, several different realities may be distinguished according to the approach researchers choose for their specific study. This research project will make use of an Interpretivist approach in terms of which reality is perceived as a Realm of Symbolic Discourse. Other paradigms that are available to the researcher include Critical Research, Design Science Research and Pragmatism. All five of these philosophical paradigms are briefly explained below. This is followed by a comparison of the fundamental differences between the paradigms and a discussion of the motivation behind the selection of the research paradigm which was deemed appropriate for the purposes of this study.

6.2.1. Positivism

The Positivist paradigm is considered to be the oldest research paradigm and is traditionally found in natural science studies (De Vos et al., 2005). While a Positivistic study will produce results that are easily generalisable, one of the limitations of this approach for the social researcher is that it considers social reality to be external and objective and, thus, it does not seek to explore the social world of people, organisations or culture. This objective is achieved by the researcher prescribing to an outsider perspective stance (Oates, 2006; Wahyuni, 2012). Positivistic researchers believe that it is possible to make a common, universal generalisation if a large sample is investigated by different researchers making use of similar research approaches and statistical tests. The results obtained may then be applied across various contexts (Wahyuni, 2012).

The assumptions on which Positivism is based on are further explained by Oates (2006), Easterby-Smith et al. (2002), and Saunders et al. (2009). These assumptions are discussed below.

- *The world exists independently of humans*: All people and things are considered to be alike and there is an existing physical and social world that may be studied, captured and measured.

- *Measurement and modelling*: The world may be observed and measured in order to produce models, hypotheses or theories of how it works.

- *Objectivity*: The researcher acts as an impartial observer and the facts are discovered independently of the researcher's personal values and beliefs.

- *Hypothesis testing*: The research is based on the empirical testing of hypotheses which are either confirmed or refuted (deductive logic).

- *Quantitative data analysis*: Mathematical modelling and statistical analysis provide a logical and objective means of analysing observations and results.

- *Universal laws*: Positivist researchers aim to produce generalisations that are shown to be true, regardless of the researcher and occasion.

This study explores the factors that must be in place in order to implement a public safety, participatory crowdsourcing, smart city project in a developing country. The crowdsourcing system was used by the citizens of East London and, therefore, the social nature of humans had to be included in the study. Thus, an appropriate paradigm would have to be more subjective than Positivism and rely on the researcher's social context. This, in turn, meant that that a pure Positivism paradigm was unsuitable for this research project. The Interpretivism paradigm is discussed in the next section.

6.2.2. Interpretivism

Interpretivism does not aim either to prove or disprove hypotheses as does Positivist research but, instead, it seeks to identify, explore and explain how the factors in a social setting are related and interdependent (Oates, 2006; Klein & Richey, 2007). In view of the fact that Interpretivistic research is relatively subjective in comparison to Positivism, it may

be influenced by the researcher's beliefs, values and actions (Olivier, 2004). Interpretivists also maintain that, as the human perspectives and experiences studied are subjective, social reality may change and may have multiple perspectives (Wahyuni, 2012). As a result Interpretivists reject both objectivism and a single universal truth. The objective of Interpretivistic research is to uncover either inside perspectives or the real meaning of social phenomena and not to produce a universal, generalisable result as is the case with Positivism.

This paradigm emerged in response to criticism of Positivism and is based on the following assumptions (Collis & Hussey, 2009; Oates, 2006):

- *Multiple subjective realities*: There is no single version of the truth as each person perceives the world in a different way.

- *Dynamic, socially constructed meaning*: Language and shared meanings are used to transmit the understanding of reality and these differ across groups and time.

- *Researcher reflexivity*: The assumptions, beliefs, values and actions of the researcher inevitably affect the research process. It is, thus, essential that researchers acknowledge their influence on the research.

- *Study of people in their natural social Settings*: People are studied in their natural setting and not in an artificial environment. It is also vital that neither the researcher's previous understanding or nor the researcher's expectations be imposed on the participants of the study.

- *Qualitative data analysis*: There is a strong preference in this paradigm for the generation and analysis of qualitative data.

- *Multiple interpretations*: Researchers usually arrive at more than one explanation in their study, but they discuss and motivate the explanation that appears the most relevant.

This paradigm is appropriate for most Information Systems research as it seeks to construct and develop the social context of Information Systems (Oates, 2006). While this research project did focus on the human element, it also incorporated quantitative data analysis to support the results of the literature survey, observations from the building of the prototype and conversational analysis. Accordingly, a purely Interpretivistic stance was also not deemed suitable for this research project.

Critical theory researchers criticised Interpretivism for failing to analyse the patterns of power and control that regulate views of reality in society. Critical theory further stated that the economic, political and cultural influences must be included in the research environment (Oates, 2006). Critical theory is discussed in the next section.

6.2.3. Critical Theory

Critical theory provides a framework with which to approach research from a political stance. Critical theory has its roots in Marxism as the goal of both is not only to study and understand society, but also to critique and change it (De Vos et al., 2005). The departure point for this paradigm is the fact that that social reality is historically formed and may be produced and reproduced by people. The assumption is, thus, that although people are able to knowingly choose to change their circumstances, they are held back by social, cultural and political factors (Myers & Klein, 2011; Klein & Richey, 2007; Oates, 2006). Critical research studies are characterised by the following:

- *Emancipation*: The primary aim of critical researchers is to empower people by enabling them to make use of the research that has been conducted.

- *Critique of tradition*: Critical researchers do not accept the current situation, but rather challenge existing patterns of power and *status-quo* assumptions.

- *Non-performative intent*: Critical researchers focus on maximising profits and enhancing the power and control of managers.

- *Critique of technological determinism*: Critical researchers reject the notion that people need to adapt to technology, but rather argue that people and society should shape the way in which technology is created.

- *Reflexivity*: As with Interpretivist research, Critical researchers acknowledge the influence which their own values, beliefs and actions have on the research they conduct.

The primary objective of critical research is, therefore, to create knowledge with an emancipatory intent by focusing on conflicts, contradictions and oppositions (Myers & Klein, 2011). However, as it was not anticipated that this study would focus on conflicting,

contradicting or opposing issues, this paradigm was not deemed appropriate. The fourth paradigm, Pragmatism, is discussed in the next section.

6.2.4. Pragmatism

Pragmatism is the fourth paradigm that will be discussed. This paradigm has refused to join the '*paradigm war*' between the Positivist and Interpretivist research philosophies and, instead, it has found a middle ground between these philosophical dogmatisms and provided researchers with a workable solution to many longstanding philosophical dualisms (Wahyuni, 2012; Johnson & Anthony, 2004). Pragmatism recognises both the natural and physical worlds, as well as the emergent social and psychological worlds. It views knowledge as being constructed and also as being based on the reality of the world we experience and in which we live. Pragmatism is found on the principle of fallibilism or the belief that research conclusions are rarely, if ever, considered to be either certain or absolute (Johnson & Anthony, 2004).

In Pragmatism a researcher is given the opportunity to state his/her research question and then to determine the research framework that would be the most appropriate to answer this research question. This approach encourages the researcher to view the research philosophy as a continuum rather than as two extremes (Interprevistism and Positivism) (Wahyuni, 2012; Johnson & Anthony, 2004). This, in turn, means that a mixture of ontology, epistemology and axiology is acceptable to approaching and understanding social phenomena. Researchers may use both quantitative and qualitative data collection methods as the emphasis is on what works the best to address the current research problem. This approach is also known as mixed method research and is defined as "*the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study*" (Johnson & Anthony, 2004). Pragmatism is considered to be an expansive and creative form of research which invites the researcher to take an eclectic approach to method selection in order to produce research that is inclusive, pluralistic and complementary (Wahyuni, 2012). To an extent this study adopted a pragmatic view and could be described as adhering to pragmatism. However, it was felt that the creation of a prototype in the form of a model is part of the research paradigm, Design Science Research. Accordingly, this paradigm will be discussed in the next section.

6.2.5. Design Science Research

Design Science Research has become an important paradigm in the Information Systems research field (Hevner & Chatterjee, 2010). Design Science is a problem-solving paradigm which ensures that knowledge and understanding of a problem are achieved through the building and application of an artefact (Gregor & Hevner, 2013). Such artefacts generally take the form of constructs, models, methods or instantiations.

There are two broad aims to the creation of an artefact. Firstly, it enables the understanding of the problem in question and, secondly, it confirms that the solution is feasible. The four categories of artefacts may be described as follows (Hevner et al., 2004):

- Constructs provide the language in which problems and solutions are defined and communicated;
- Models are used to represent the real-world situation while assisting in the understanding of the problem and the solution to the problem;.
- Methods define processes and provide guidance to solving problems, and
- Instantiations show that constructs, models or methods may be implemented in a working system.

Gregor and Hevner (2013) proposed a knowledge contribution framework that may be used by the researcher to position the contribution or artefact of a Design Science Research project. In the past this contribution of Design Science Research was difficult to determine as the nature of the artefact designed, the state of the field of knowledge, the audience or journal via which it was communicated would all exert some influence on the process.

Gregor and Hevner (2013) postulate that no research contribution is completely '*new*', but that contributions are rather built on some previous idea or else is composed of something else that existed before. It thus follows that the contribution of Design Science Research will depend on the starting point in terms of the problem and solution maturity. The Design Science Research Knowledge Framework consists of a 2 x 2 matrix with 4 quadrants in which the artefact may be placed according to the knowledge and solution maturity (see Figure 6.4).

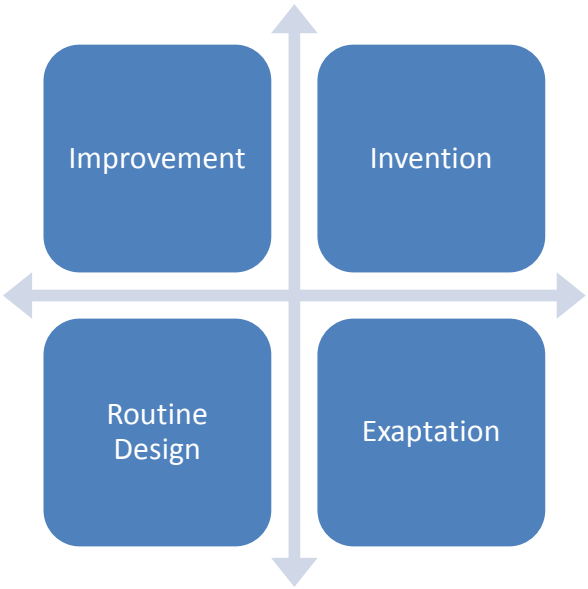


Figure 6.4: Design Science Research Knowledge Contribution Framework (Gregor & Hevner, 2013)

A short description of the various quadrants of the Design Science Research Knowledge Contribution Framework is provided below.

- Improvement – in this quadrant the researcher will develop new solutions for known opportunities and will contribute to both the research opportunity and the knowledge base. The artefacts developed are considered to be more efficient and effective than previous solutions and may take the form of products, processes, services, technologies or ideas.

- Invention – this quadrant invents new solutions for new problems and contributes to both the research opportunity and the knowledge base. This type of research will contribute to new and interesting applications where no effective artefacts are yet available because of a lack of understanding of the problem context.

- Exaptation – extends a known solution from another field to a new problem and will contribute to both the research opportunity and knowledge base. In this quadrant the researcher must demonstrate that the extension of known design knowledge into a new field is nontrivial and interesting and, thereby, produce an effective artefact from a related problem area to fit the current research context.

- Routine Design – will happen when a known solution is applied to a known problem and, therefore, no major knowledge contribution is expected. If a

discovery is made during the research, this would probably move the research project into one of the other quadrants.

This research project will involve the improvement quadrant. The primary objective of this research project was to produce a model that may be used to implement a public safety, participatory crowdsourcing, smart city project in a developing country. This model, or artefact, was applied to a known problem, namely, the lack of resources to effectively manage public safety in developing countries. In the next section the appropriate research paradigm for this research project will be selected and justified.

6.2.6. Selecting an Appropriate Research Paradigm

As discussed in section 6.2, very few researchers make use of a purely Positivistic or purely Interpretivistic stance in their research approach. The use of a combination of these two paradigms enables the researcher to take a broader and often complementary view of the research problem (Collis & Hussey, 2009). The conclusions based on the various paradigms discussed in sections 6.2.1 to 6.2.5 are briefly reviewed below:

- *Positivism*. This research paradigm provides for a single, objective reality, but does not take into account the social nature of humans as an important factor when conducting research. Thus, the results from Positivistic studies may easily be generalised. In view of the fact that the social behaviour of the citizens of East London would contribute to the acceptance of the crowdsourcing model, this had to be taken into account by the researcher. A purely Positivistic paradigm was, thus, not deemed appropriate for the purposes of this study.

- *Interpretivism*. This paradigm is subjective in nature and allows for values and knowledge to emerge from the researcher-participant interaction. This paradigm is strongly influenced by the qualitative data collection methods that enable the researcher to understand and analyse the phenomenon that is being investigated. The model will be evaluated by means of a questionnaire. The results will then be analysed using descriptive and inferential statistical methods. Thus, a purely Interpretivistic research paradigm was not deemed appropriate for the purposes of this research project.

- *Critical theory*. The primary objective of critical research is to create knowledge with an emancipatory intent by focusing on conflicts, contradictions and

oppositions (Myers & Klein, 2011). However, it was not anticipated that this study would focus on specific conflicting, contradicting or opposing issues and, thus, this paradigm was not suitable.

- *Pragmatism*. Pragmatism recognises both the natural and physical worlds as well as the emergent social and psychological worlds. It also views knowledge as being constructed and based on the reality of the world we experience and in which we live. In addition, it offers the researcher the opportunity to make use of a combination of both quantitative and qualitative methods in order to investigate the research problem. Thus, in view of the fact that this research project would make use of both quantitative and qualitative methods, this research paradigm could have been considered suitable for the project although the lack of focus on the research artefact would be a disadvantage if this paradigm were used.

- *Design Science Research*. Design Science is a problem-solving paradigm which ensures that knowledge and understanding of a problem are achieved through the building and application of an artefact. This research paradigm enables the researcher to make use of both quantitative and qualitative methods while also directing the focus of the research on the artefact that is produced. The lack of focus on the artefact in the Pragmatism paradigm meant that this paradigm was deemed to be the most appropriate for the purposes of this research project.

The section identified the Design Science Research paradigm as the most appropriate for this research project. The next section will briefly discuss the research approach that was followed in the research project.

6.3. Research Approach

The research approach adopted may be classified as either inductive or deductive (Collis & Hussey, 2009). Inductive reasoning involves the formulation of recommendations based on the empirical observations in terms of which generalised conclusions are reached (Collis & Hussey, 2009). On the other hand, deductive research involves the development of a theoretical structure that is then tested empirically (Collis & Hussey, 2009). These two approaches are illustrated in Figure 6.5.

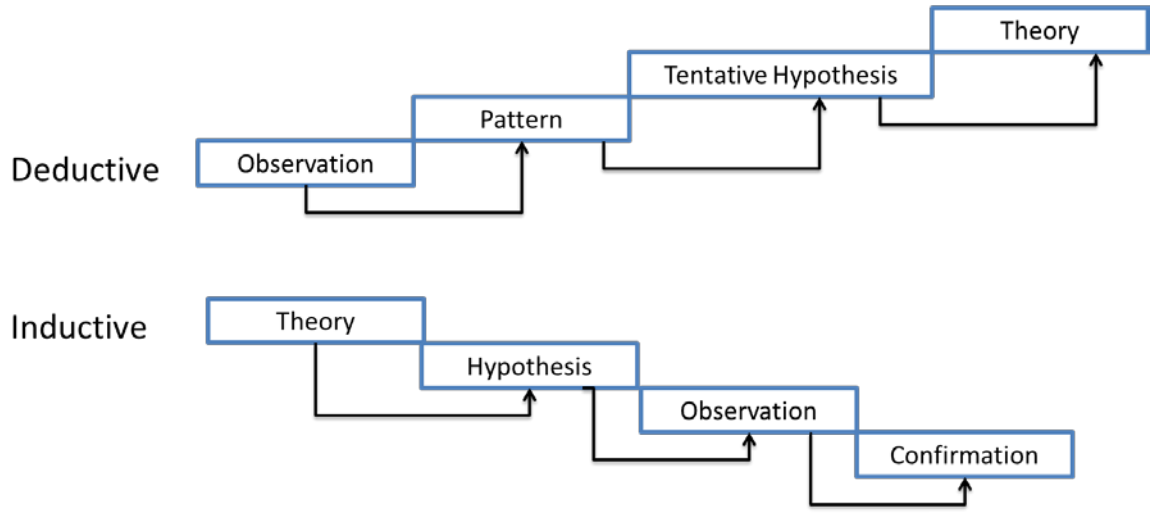


Figure 6.5: Differences between Inductive and Deductive Logic (Trochim, 2006)

The approach adopted in this research project was based on inductive reasoning. This implies that the researcher begins the research project with a detailed literature review on the basis of which specific research questions and sub-questions are formulated. The researcher then uses both primary and secondary data collection methods in order to obtain evidence to answer these questions. In this research project the culmination of the process was general conclusions that could be used to implement a public safety, participatory crowdsourcing, smart city project in any developing country.

6.4. Research Methodology

Collis and Hussey (2009) point out that it is essential that the researcher select a research methodology that reflects the philosophical assumptions of the paradigm chosen – in this research project the Design Science Research paradigm. As described previously, the goal of Design Science Research is to create and evaluate artefacts in order to solve the organisational problems which have been identified (Hevner et al., 2004). Figure 6.6 depicts Hevner et al.'s (2004) conceptual framework for Information Systems research. This framework combines Design Science and Behavioural Science.

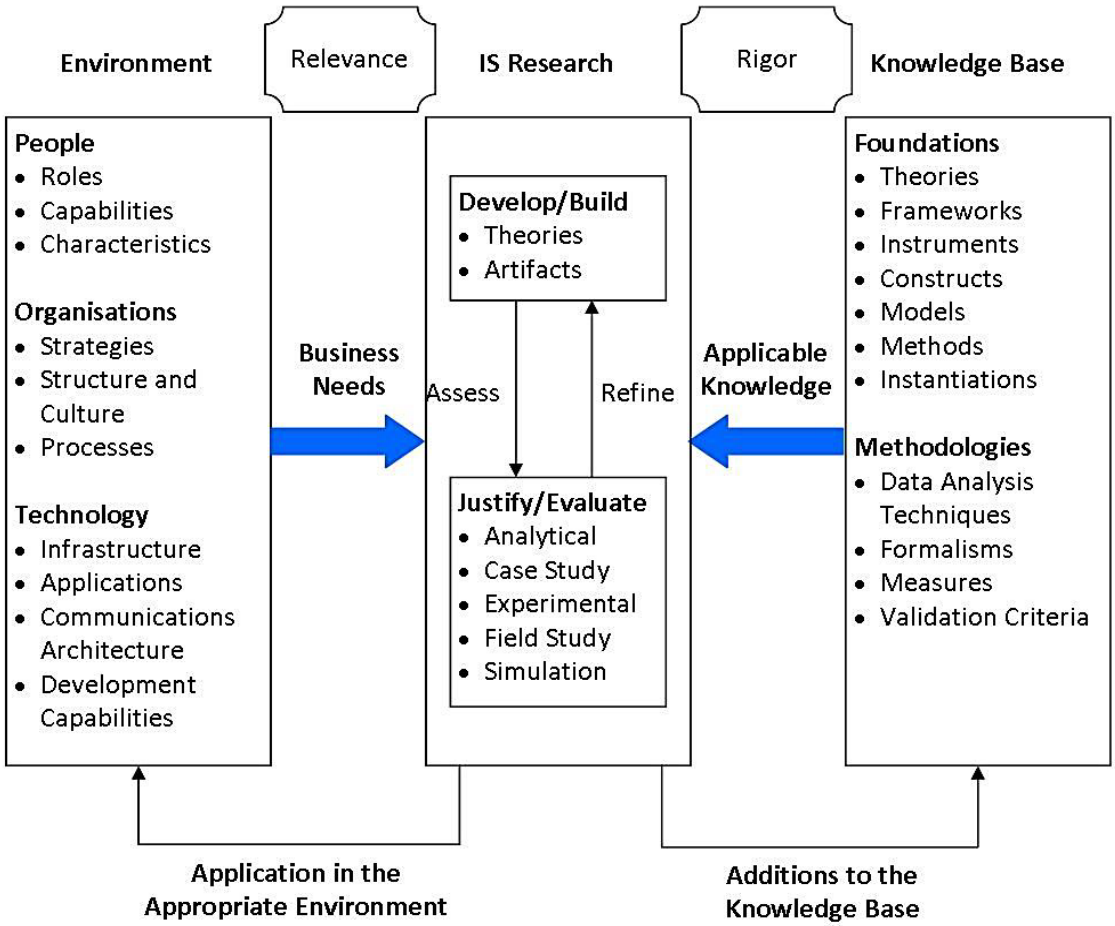


Figure 6.6: Information Systems Research Framework (Hevner et al., 2004)

In their research framework, Hevner et al. (2004) recognise the impact of both the environment and the existing knowledge base on Information Systems research. The environment refers to the context of the research, in this case, public safety in East London. This environment comprises the people (citizens of East London), the city (BCMM) and technology (participatory crowdsourcing system) which, together, define the research problem or business need. On the other hand, the knowledge base is composed of the existing theories and methodologies that are used in the development of the research artefact. The use of existing information in the knowledge base helps to enhance the rigour of the study. While taking into account the business need (environmental aspect) and the existing theories and methodologies (knowledge base aspect), Information Systems research is conducted in two stages, namely, build and evaluate. This is an iterative process which is concluded when the researcher makes a contribution to the existing knowledge base and provides a solution appropriate to the environment in order to meet the original business need (Hevner et al., 2004). In this research project a user review was used to evaluate the proposed model in order to refine it.

There are guidelines available to assist the researcher who conducts Design Science Research. The most widely cited set of guidelines for Design Science Research is the seven guidelines proposed by Hevner et al. (2004). While these guidelines provide a foundation for the researcher wishing to conduct Design Science Research, there is no particular order in which the guidelines must be applied. The remainder of this section contains a description of the guidelines which are described and also an overview of the way in which this research project adhered to each of these guidelines.

Guideline 1: Design as an Artefact

Design Science states that the research must produce a viable artefact in the form of a construct, model, method or instantiation (Hevner et al., 2004). These four concepts were discussed in section 6.2.5.

After a thorough evaluation of the four types of artefacts in the context of this research project, it was decided that the most appropriate artefact was a model. It was anticipated that this model would visually represent the way in which a public safety, participatory crowdsourcing, smart city project could be implemented in a developing country. The next section discusses the problem relevance of the study.

Guideline 2: Problem Relevance

The research problem investigated in this study was how to implement a public safety, participatory crowdsourcing, smart city project in a developing country. As discussed in section 4.2, the concept of smart cities is still relatively new and, thus, there is not much literature available on this subject. Smart city projects are also typically implemented in developed countries. However, there are specific problems in developing countries that would influence the implementation of a public safety, participatory crowdsourcing smart city. These problems include low literacy rates and income levels, high unemployment and the cost and unavailability of technology (Kumar et al., 2010). Thus, it is not feasible to use the lessons learned from developed countries to smart city projects in developing countries. The next guideline will explain how the artefact is evaluated.

Guideline 3: Design Evaluation

The purpose of design evaluation is to produce an artefact that has been rigorously assessed in order to ensure the utility, quality and efficacy of the artefact. The evaluation method chosen is influenced by the design of the artefact (Hevner et al., 2004). Ahmed and Sundaram (2011) suggest a number of evaluation methods, including research consortiums, research symposiums, seminars and conferences, as well as feedback from

peers, industry experts, system architects, conferences and journal reviewers, domain experts, academics and modellers (Figure 6.7).

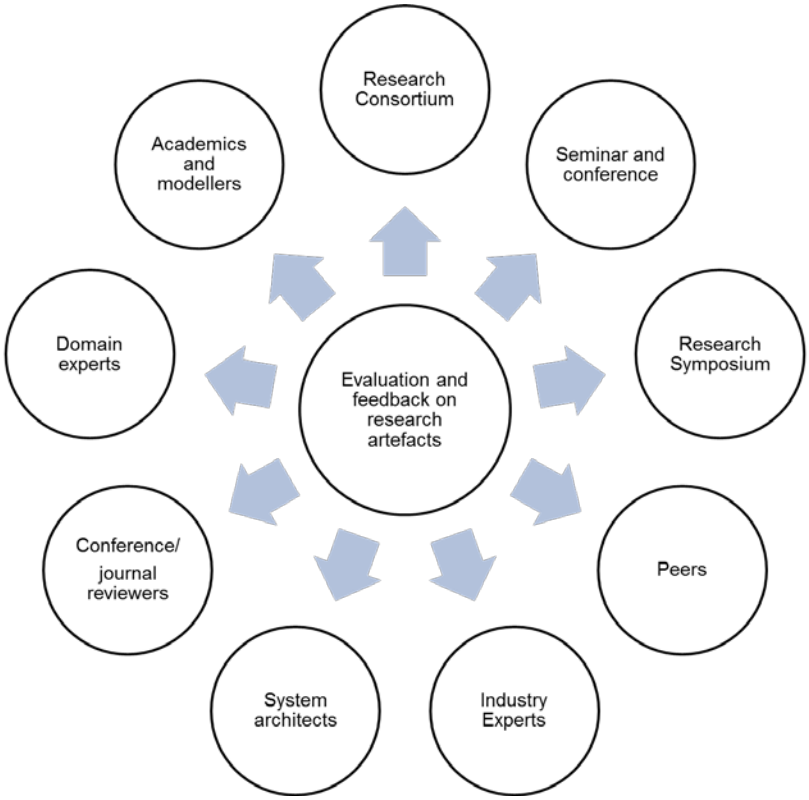


Figure 6.7: Expert Groups for Evaluation (Ahmed & Sundaram, 2011)

For the purposes of this study the most appropriate method to evaluate the artefact was found to be a user review. The user review is an evaluation method which uses peers to criticise the design artefact (Molich & Jeffries, 2003). The peers offer comments on the material presented and these comments are then used to refine the model. In this research project, the user review was conducted by the citizens of East London. A questionnaire was compiled to test the various factors and items of the model after which the questionnaire was sent to the participants in the smart city project who were asked to comment on the model. The results from the questionnaire were then used to refine the model. The results of the user reviews are contained in Chapter 8. The research contribution of the study will be discussed in the next section.

Guideline 4: Research Contribution

According to Hevner et al. (2004), all Design Science Research must contribute to the specified area of the artefact designed. These contributions may be to the research artefact as well as the design artefact's novelty, generality and significance. The research artefact is the most common contribution in Design Science Research and it is directly

linked to Guideline 1. The artefact designed must either provide a solution to an unsolved problem or provide an alternative solution to a problem which has been previously solved. The contribution to the research foundation refers to the contribution to Design Science knowledge base contained in the four different forms of the artefact, namely, constructs, models, methods or instantiations. Lastly, the research methodology refers to the development and expressed use of the evaluation methods. These methods may include experiments, analysis, tests, informed arguments and case studies or scenarios.

This research project will focus on the development of a design artefact – the PSPC smart city model for a developing country. As discussed in section 6.2.5, the artefact contributes to both the knowledge base and the research opportunity indicated in the improvement quadrant. The artefact that will be developed for the purposes of this research project represents a new solution to a problem. This solution will be applied to a known problem, namely, the lack of resources to effectively and efficiently manage public safety in developing countries. In the next section the steps that should be followed in a Design Science approach will be discussed. Guideline 5 will introduce the different steps that may be taken to ensure the rigour of the research.

Guideline 5: Research Rigour

Rigorous methods must be applied in the construction and evaluation of the artefact as this will ensure that valid research is conducted in a thorough way and there will be no doubt that the artefact design is correct (Hevner et al., 2004).

Research rigour must be proved during both the construction of the artefact and the evaluation of the artefact. The following steps were taken in this project to ensure research rigour during the construction of the artefact:

- Theories were used to guide the research and to validate any assumptions;
- A detailed literature search was conducted in order to identify all related research that could be used to guide the direction of the study;
- The research design adopted for this study conformed to the most appropriate philosophical view;
- Conversational analysis with the various stakeholders (IBM India, IBM Israel and UFH) was recorded to provide relevant information throughout the study, and
- The questionnaire used was formulated after a search of the relevant literature had uncovered questionnaires that had been tested and validated in various fields to ensure validity.

In order to ensure rigour during the evaluation of the artefact, several different strategies were used. These included seminars, conferences and research symposiums as well as feedback from peers, industry experts, conference reviewers and academics (Ahmed & Sundaram, 2011). The researcher attended two conferences – the Annual Conference on World Wide Web Application 2013 (ZA-WWW 2013) and the Joint Annual Conference on Engineering Education and Research and International Conference on Information Technology (ICEE/ICIT 2013) – in order to present two papers that were accepted and published as part of the conference proceedings. Feedback from the double blind reviewers who assessed these two papers was incorporated into the research thesis and articles (see Appendix B). A third article has been submitted to an international journal and the researcher is awaiting feedback from the double blind, peer review process (see Appendix B).

Three research symposiums were conducted at the University of Fort Hare during which the researcher had the opportunity to present the research project and to receive feedback from the academics who attended these events. Feedback from peers was received during the pilot phase and was incorporated into the final questionnaire that was used in the study. Industry experts were asked to provide input throughout the research project via telephone conferences. The input from the industry experts was especially valuable as to regards providing guidance in respect of the final artefact that was developed. The next section will discuss Guideline 6 – Design as a Search Problem – as well the process that was followed during this research project.

Guideline 6: Design as a Search Problem

This guideline entails the description of the research process which is followed and which leads to the development of an effective solution to a problem. Figure 6.8 below illustrates the four phases of the project as well as the way in which these phases relate to the seven guidelines outlined in Design Science. Guideline 6, Design as a search problem, starts in Phase 1 with the literature review and continues into Phase 2 with the preparation of the research instrument. Once the data had been collected it was analysed in Phase 2, and an appropriate artefact is presented in Phase 3.

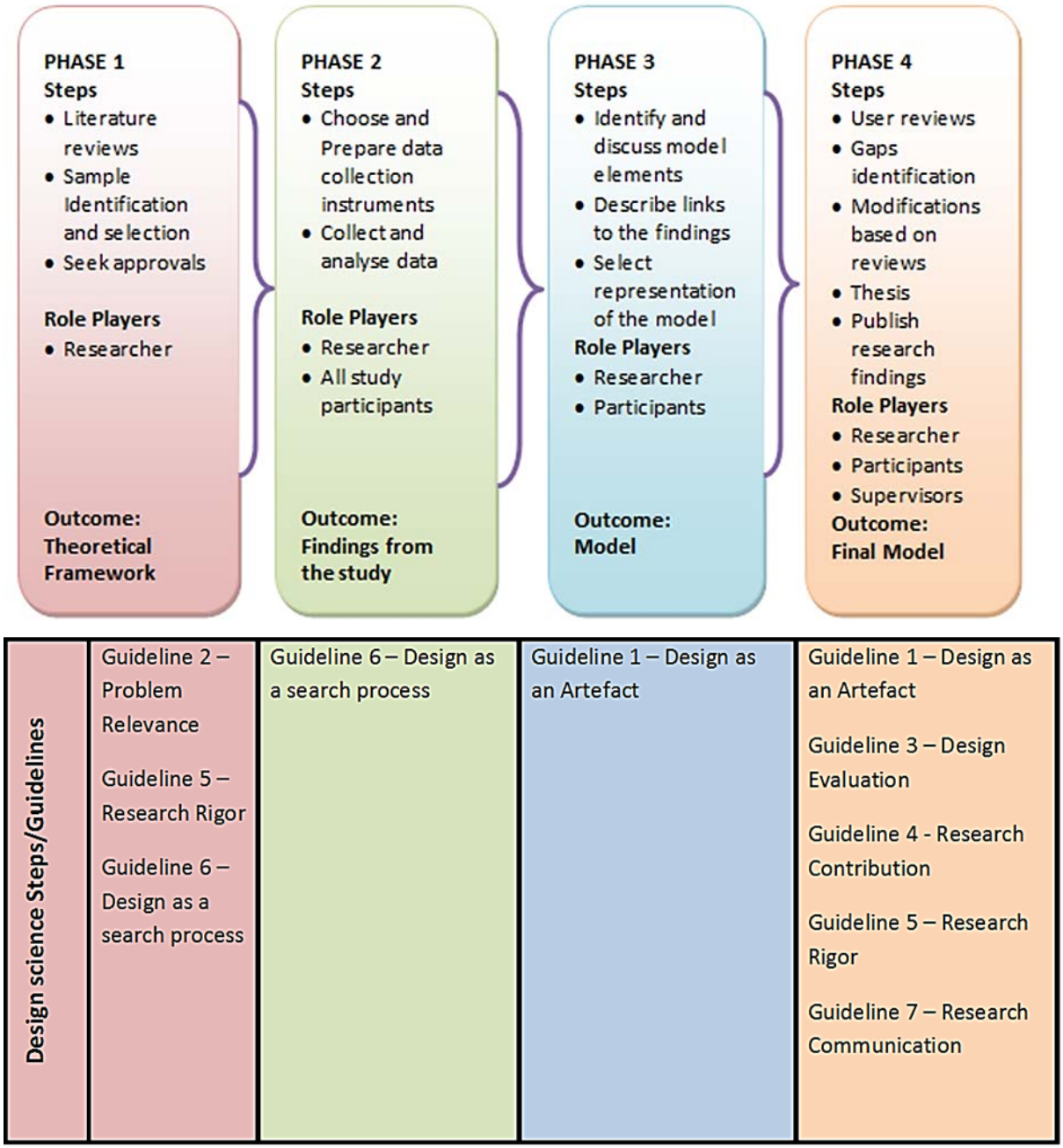


Figure 6.8: Research Methodology used in Research Project

The last guideline will discuss the communication of the results of the research project.

Guideline 7: Communication of Research

This guideline is concerned with the manner in which the researcher communicates the research findings to outside stakeholders. There are two types of audiences that must be considered, namely, technical and management audiences. Technical audiences require a detailed description of the artefact in order to replicate and effectively implement the artefact in relevant contexts. This is made possible by a detailed explanation of the

construction and evaluation processes. On the other hand, the management audience requires an explanation of how the artefact will solve the research problem identified in order to ascertain whether the solution is feasible. Management audiences are concerned with whether the resources required for implementation are available and acceptable.

This research project ensured effective communication in the following ways:

- The findings were published in both conferences and an academic journal;
- The completed dissertation will be sent to the library at the Fort Hare University and made available on the Internet and,
- The findings of this research project will be presented to IBM and BCMM for future research purposes.

In order to meet the demands of the technological audience, the PSPC smart city model for developing countries was presented to explain how a smart, city project may be successfully implemented in a developing country. A thorough detailed of the research methodology used was also provided to enable other researchers to replicate and implement the study elsewhere. On the other hand, the management audience was made aware of the importance of smart city initiatives and how they may be used to manage finite resources effectively. The assurance that the seven Design Science guidelines had been adhered to reinforced the fact that valid conclusions had been reached. These data collection methods employed to gather both the primary and secondary data for the purposes of this research project will be discussed in the next section.

6.5. Data Collection Methods

This research project made use of a mixed method approach to the data collection. The quantitative data collection methods used included a questionnaire while the qualitative data collection methods included a literature review, conversational analysis and observations from the crowdsourcing system prototype development. The goal of mixed method research is not to replace either quantitative or qualitative data collection methods, but rather to make use of the strengths of both methods in a single research project (Burke et al., 2006).

The two main considerations in a mixed method design is whether or not to operate in one dominant paradigm and whether to conduct the qualitative and quantitative phases concurrently or sequentially. Regardless of which mixed method design is used, it is

essential that the findings be integrated at some point during the research project (Burke et al., 2006). Figure 6.9 depicts these two considerations visually. In this research project, the Design Science Research paradigm was the dominant paradigm used. The qualitative data collection methods were used to inform the theoretical foundation of the model while the quantitative methods were used to review and refine the model. The decision was that the qualitative and quantitative methods would be implemented in sequential order while decision regarding the emphasis on the dominant paradigm meant that the qualitative data was more prominent than the quantitative data in the study. Accordingly, the bottom right hand quadrant (QUAL → quan) was applicable to this study.

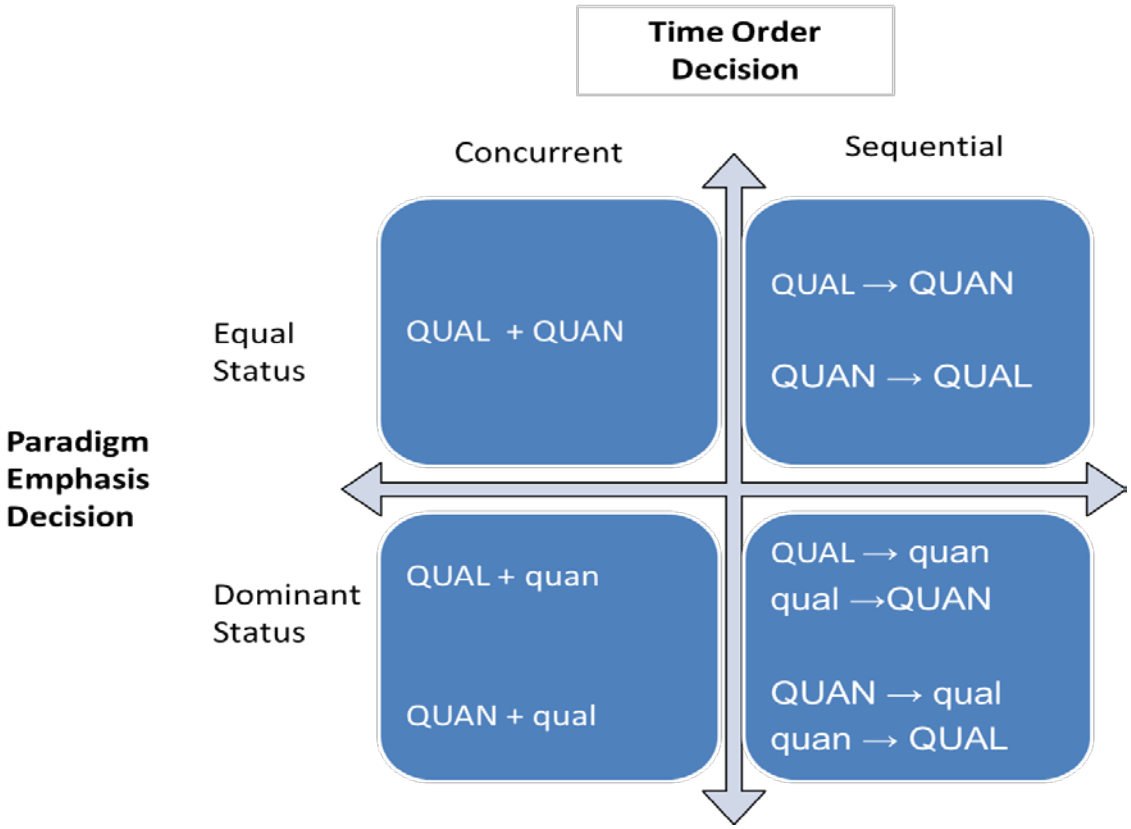


Figure 6.9: Mixed Method Design Matrix with Mixed-Method Research Designs Shown in the Four Cells (Burke et al., 2006) (Please note: Qual – qualitative and Quan – quantitative)

The data collection for the study was conducted from November 2012 to April 2013. Newspaper advertisements, flyers and e-mails (see Appendix D) were used to recruit the participants. The participants were directed to visit a web page (www.csi.ufh.org.za) to enable them to access the terms and conditions of the research project (see Appendix C). This was a legal and ethical requirement. Once they had accepted the terms and conditions, a telephone number, 043 704 7390, was made available to them. The participants were required to call this number to report public safety matters by making use of the voice prompts that guided them through the IVR system (see Figure 6.10).

After the conversational analysis it was decided to use English as the primary language for the voice prompts. Despite the fact that there are eleven different languages in South Africa, it was felt that English is the official business language in the country and, therefore, most citizens are conversant with English. It was further noted that, in order to facilitate the analytical analysis of the reported messages, the voice prompts should be in one language. Thus, ensuring that the voice prompts were in English also encouraged the citizens to provide their reports in the same language. If the participants registered their personal details on the website, they were entered into a lucky draw to win one of the three iPads that were used an in incentive to encourage the participants to register. Once the participants had registered on the website and made a call to report a public safety event, some of them were contacted via e-mail and asked to complete a short questionnaire about their experiences with the IVR system. The steps in the process described above are visually represented in Figure 6.10.

Figure 6.10: Visual Representation of the Steps Necessary to Participate in the Study (UFH, 2013)

Figure 6.11 provides a detailed description of the voice prompts that the participant would encounter when placing a call to report a public safety event. The first prompt welcomes the caller and asks if the caller has accepted the terms and conditions of the project. This is important from a legal point of view as it was essential that the callers be aware that

they were participating in a research project. It was made clear in the terms and conditions on the website and in the advertisements distributed that if the caller was reporting a public safety event that required immediate emergency assistance, none would be provided. If the caller answered that he/she had not accepted the terms and conditions of the project the caller was instructed to visit the website in order to do so and the call was terminated. However, if the caller answered in the affirmative, the next prompt requested the caller to record the information regarding the public safety event. The caller was asked to record all the information in one segment in order to provide useful data for voice analytics. Once the caller had finished reporting the information, the recording was played back and the caller had to confirm that he/she was satisfied with it. This was done to provide an additional opportunity for the caller to provide more information after he/she had made the initial recording. If the caller was satisfied with the recording, the system thanked the caller for participating and ended the call.

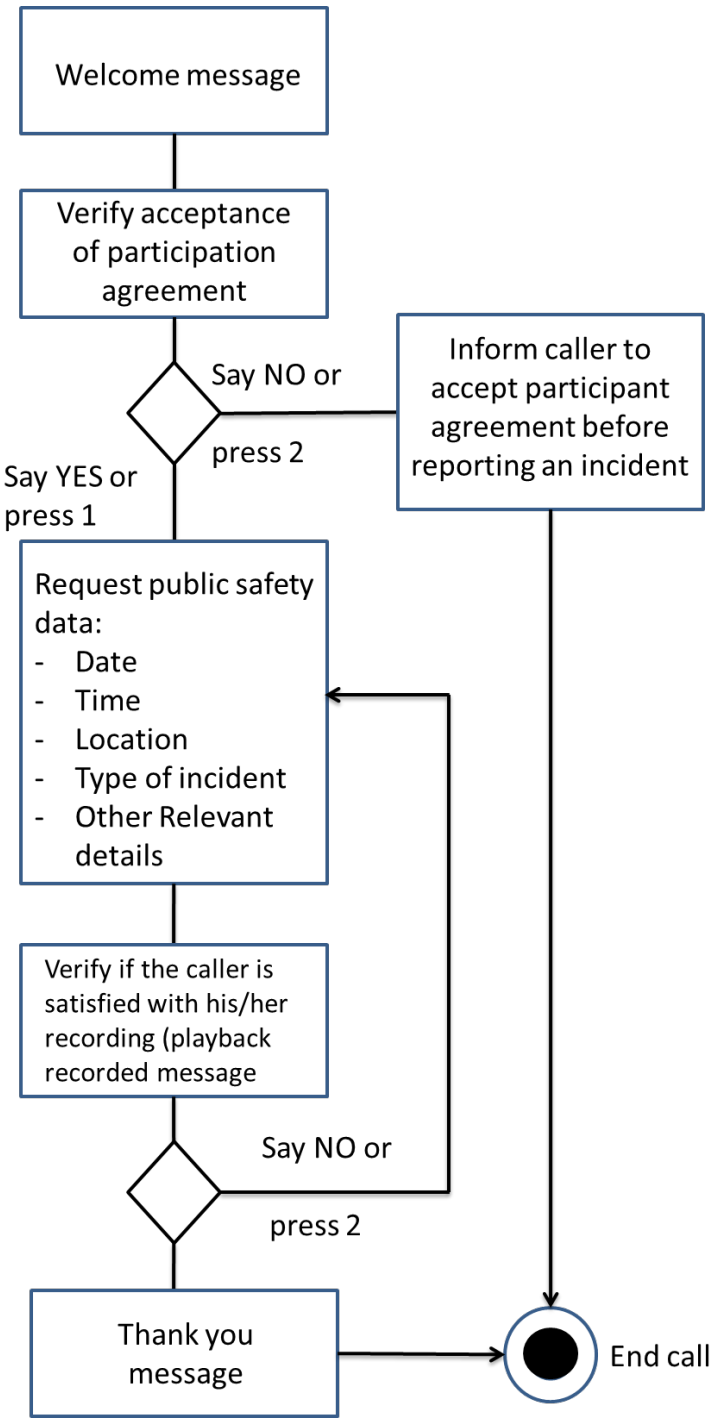


Figure 6.11: Crowdsourcing Message Prompts (UFH, 2013)

The next section provides an overview of the primary and secondary data collection methods used in the study.

6.5.1. Primary and Secondary Data Collection

There are two different types of data that may be collected in a research project, namely, primary and secondary data. Primary data is collected in order to answer a specific

research question. Research methods designed specifically to suit the research project in question are used. The data is gathered directly from the participants or the organisation.

On the other hand, secondary data has been collected for a different purpose and is now being reused to another research question (Myers & Klein, 2011). Examples of secondary data sources include previously published materials such as books, articles and completed studies (Cooper & Schindler, 2003). This study made use of a questionnaire, conversational analysis and observations from the development of the crowdsourcing system prototype as the primary data sources, and a literature review as the secondary data source. Both of these methods are discussed in the next sections.

6.5.1.1. Primary Data Collection Methods

The primary data sources for this research project included a questionnaire, conversational analysis and observations from the development of the crowdsourcing system prototype. These are discussed below.

6.5.1.1.1. Questionnaire

The primary aim of the questionnaire was to validate the PSPC smart city model which had been devised for developing countries. In order to do this, a set of pre-defined questions were assembled in a pre-determined order. The respondents were then asked to complete the questionnaire in order to provide the researcher with data that could be analysed and interpreted (Oates, 2006).

The questionnaire remains a popular option with which to gather information as it is inexpensive to administer, is able to reach a large number of respondents and, when open-ended questions are used, provides rich information (De Vos et al., 2005). However, the traditional limitations of questionnaires include a potentially high non-response rate, the respondents providing untrue but socially acceptable answers, the respondents failing to answer some questions completely and the limited opportunity to clarify questions that may have been misunderstood by the participants (Brink et al., 2006; De Vos et al., 2005).

The response rate in this study was 81.2%. This response rate is extremely high when compared to the 30% which is prescribed as acceptable by Oates (2006). There was, however, a problem with the participants failing to answer all the questions. A total of 394 questionnaires were collected but, of these 33 were incomplete and could not be used for

the data analysis. In other words, 8% of the questionnaires collected could not be used. The most likely reason for this may have been the structure of the online questionnaire. The participants were required to complete the questionnaire on three consecutive pages (see Appendix E). Thus, if their Internet connection was either slow or lost, the participants may have given up before completing the whole questionnaire.

It is important to ensure that the questionnaire is carefully structured in order to meet the needs of the researcher. Open-ended questions may be used to explore specific aspects of the research problem as such questions do not restrict participants in the answers they are able to provide. However, with closed-ended questions, the participant is asked to choose a response from the options provided by the researcher on the questionnaire. One of the advantages of using closed-ended questions is the fact that that responses are easy to quantify and to analyse. It is for this reason that this option was selected for this research project (De Vos et al., 2005).

The questionnaires were sent to the 485 registered participants. The questionnaire had been constructed using previously published questionnaires found in the literature and tested specific constructs (Appendix E). These questionnaires included the IBM questionnaire as developed by Lewis (1993) to test user satisfaction, a questionnaire to test trustworthiness as devised by Mayer et al. (1995), and an Information Protection Risk Assessment questionnaire which made use of the CIA triad. All these questionnaires were adopted to suit the research objectives of this research project and to ensure the reliability of the questionnaire used (Saunders et al., 2009). Different formats of questions and responses were used, for example, yes/no, degree of agreement or disagreement (Likert scale), and rank order questions. The pilot study, response rate and findings from the questionnaire are described in detail in Chapter 8. The second primary collection tool used in this research project was conversational analysis and is discussed next.

6.5.1.1.2. Conversational Analysis

Telecommunication technologies may effectively overcome time and distance barriers (Szucs, Vidal & Bernath, 2009). This technique was used in this study to obtain information from voice technologies experts in the telecommunication industry via teleconferences, e-mails and telephone calls. The advantage of these tools included the fact that they minimised the geographical distances between the various stakeholders (India, Israel and South Africa) in a relatively inexpensive way. Telephone conferences were used to enable the researchers and experts to communicate simultaneously and to

respond to questions immediately while the e-mail was used to clarify any misunderstandings that may have arisen as a result of communication barriers and also to provide a '*to do*' list and documentary evidence for the researchers and experts after the telephonic conversations had ended. This point of view is supported by Shachaf (2005) who concluded that e-mail may be used to mitigate intercultural miscommunication that may arise because of language, verbal cues and non-verbal cues. This is as a result of the fact that the accuracy of the language used may be improved before the message is transmitted as the sender is able to review the message to be send. The analysis and results of the conversational analysis are presented throughout the thesis as they pertain to the various sections of the thesis. The final primary data collection method used was the observations of the researcher during the development of the crowdsourcing system prototype. This method will be discussed in the next section.

5.5.1.1.3. Observations from the Development of the Crowdsourcing System Prototype

The main advantage of direct observations in a research project is that the behaviour which is to be studied is recorded first-hand. Observation is often considered to be a simple research method. There are two different types of sampling in observational research – continuous observation and event sampling. In the first sampling method, the researcher records, by means of a tally, each occurrence of the selected behaviour. This method is appropriate when a large number of behaviours are to be recorded. The second sampling method, event sampling, is more appropriate for non-routine behaviours than continuous sampling. In event sampling, the researcher must always be ready to observe such an event if it does occur and to make the necessary recordings (Welman, Kruger & Mitchell, 2005). This research project made use of event sampling in order to record the researcher's observations during the building of the participatory crowdsourcing system prototype. This type of sampling was deemed appropriate for the purposes of this study as the collaboration in building the prototype took place in three countries – South Africa, India and Israel. As discussed in section 6.5.1.1.2, the researchers communicated via e-mail and telephone conferences which were *ad hoc* and could not be predicted.

In this section the three primary data collection methods used in this study were discussed. In the next section the secondary data collection method used in this study, namely, a literature survey, will be discussed.

6.5.1.2. Secondary Data Collection Methods

According to Myers and Klein (2011), it is possible to use data which has been collected previously by other researchers as long as the data has been archived and is available. The secondary data collected for this study involved an extensive and thorough literature survey of relevant Internet sources, frameworks, methodologies, journal articles, past research, reports and books (Olivier, 2004).

There are certain disadvantages to the use of secondary data. These include the difficulty in searching for and retrieving sources of data that would be useful to the current research problem. In addition, researchers must also evaluate the quality of the data in order to ascertain whether it will meet the research and methodological requirements of the study in question (Myers & Klein, 2011). During the research period for this study all possible efforts were made to ensure that the content of the research remained as current as possible.

In this study, both relevant literature and the citizens of East London were included in the process which was aimed at answering the research question. The PSPC smart city model for a developing country was built making use of the theories that had been discussed during both the literature review and the conversational analyses. The model was then evaluated by the citizens of East London and refined by making use of the observations of the researcher which had arisen during the development of the crowdsourcing system prototype. This process is illustrated in Figure 6.12.

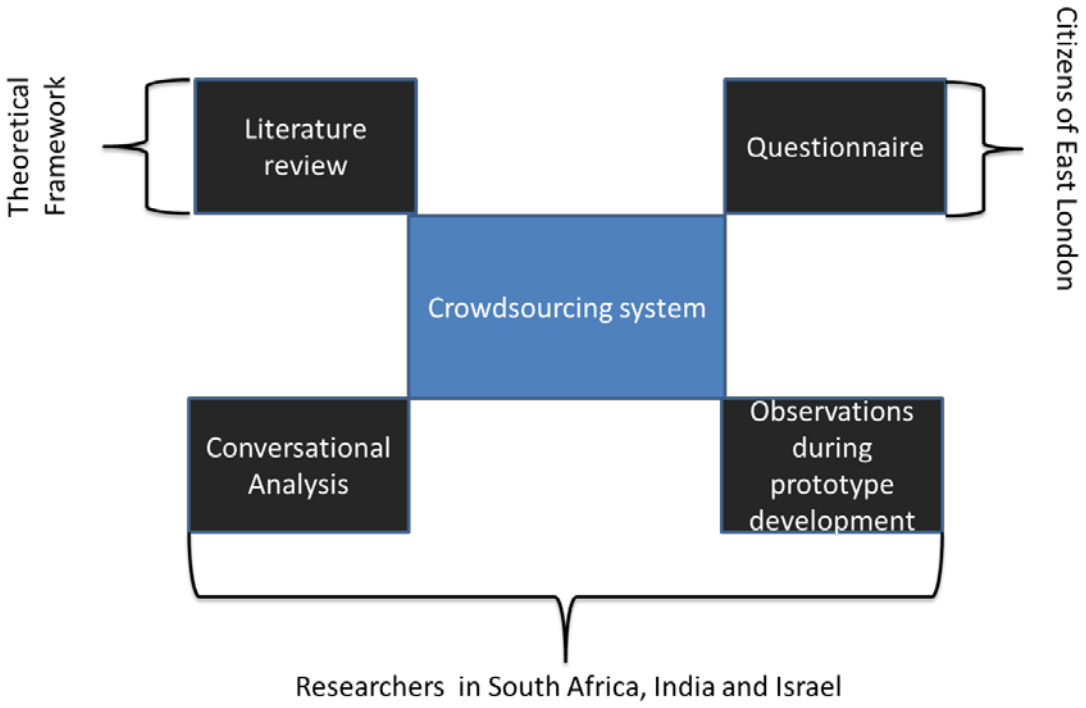


Figure 6.12: Illustration of Data Collection Methods used in this Research Project

This section has introduced the various data collection methods used in this study. In the next section the study population will be discussed.

6.6. Study Population

The study population was selected from the members of the public who had registered on the website and had then made use of the participatory crowdsourcing system to report a public safety matter. Shi (2009) proposed a formula that may be used to determine the sample size required in order to produce an estimate of the population proportion with a certain level of precision.

$$n = P\,(1 - P)\,(1.96 / E)^2$$

Where n = sample size, P the population proportion, Z the confidence level, usually set at 95%, and E the margin of error. If data from a previous pilot study or research project is available, P may be estimated based on this information. However, if no previous data is available, P is usually set to 0.5 to obtain a conservative sample size estimate. The margin of error, E, indicates the maximum error the researcher is willing to risk in the study and is usually set at 95%.

The study population in this study comprised the citizens of East London. As discussed in section 2.4, the population of East London is estimated to be 761 996 and, thus, P = 761 996. The margin of error, E, was set at 95%. Using this formula the sample size of participants to be recruited in order to produce a representative population proportion was 384 participants. Convenience sampling was used to recruit the study sample from the 485 registered participants on the website. The data analysis is discussed in the next section.

6.7. Data Analysis

Once data has been collected it must be analysed in order either to support or reject the answer proposed for the research question. It is essential that the data analysis techniques selected are appropriate for the research paradigm (Tharenou, Donohue & Cooper, 2007).

The first step in the data analysis process involves processing the data which has been collected. This involves the editing, coding, classification and tabulation of the data collected so that the data may be analysed (Leedy & Ormrod, 2009; Cooper & Schindler, 2003). The research instrument used in this study, a questionnaire, was coded during the developmental phase in order to depict various constructs.

The analysis process involves the summarising of the data which has been collected in order to answer the research question. This process involves the inspection of the relationships between constructs, concepts or variables and either determining the elements of data that may be isolated or establishing themes in the data (Leedy & Ormrod, 2009; Cooper & Schindler, 2003).

The reliability of the data collection instrument was confirmed by calculating the Cronbach's Alpha coefficients for each of the factors. Factor analysis was used to check the relationships between the factors that may have influenced the implementation of the crowdsourcing system. The statistical computer programme SPSS 21 was used for this purpose. Descriptive statistics (mean, median and percentages) were also used to report the research results.

The information obtained from the above procedures was used to inform the development of the research artefact – a PSPC smart city model for a developing country. After the model had been completed, comments from the users (citizens of East London) were

elicited via a questionnaire. The quantitative data derived from the questionnaire was summarised and the model refined accordingly. The information obtained from the analysis of the questionnaire is discussed in Chapter 8. The evaluation of the research project in order to improve the credibility of the project is discussed in the next section.

6.8. Research Evaluation

Research integrity may be considered as a general evaluative judgment of the extent of the truth contained in the study (Saunders et al., 2009). As discussed in section 6.5, this research project made used of a mixed method approach with a particular focus on qualitative data collection methods (conversational analysis and observations from building the crowdsourcing prototype). The quantitative data collection method, a questionnaire, was used to validate the PSPC smart city model for developing countries. Therefore, the research evaluation method most suitable to evaluate the integrity of the results from this research project is that of Interpretivistic research. There are five factors that must be considered when Interpretivistic research is evaluated (Wahyuni, 2012; Saunders et al., 2009; Oates, 2006; Easterby-Smith et al., 2002). These factors include trustworthiness, confirmability, dependability, credibility and transferability and are discussed in Table 6.1 below.

Table 6.2: Evaluation of Interpretivist Research (Wahyuni, 2012; Saunders et al., 2009; Oates, 2006; Easterby-Smith et al., 2002)

Evaluating Criteria	Definition	Application in this study
Trustworthiness	Refers to the accuracy of the collected data.	A questionnaire was compiled using verified questionnaires found in literature on the various constructs (see section 6.5.1.1). The data collected was cleaned and verified after been captured. A user review was used to evaluate the artefact produced in the research project. The citizens of East London had made use of the public safety, participatory crowdsourcing system and, thus, the results from the questionnaires completed by the citizens may be considered trustworthy.
Confirmability	Ability to be tested by experiment or observation in order to be either verified or falsified.	Multiple data collection techniques were used in this research project in order to produce the artefact. Conversational analysis, a literature review, observations from the building of the prototype and a questionnaire were used to build and evaluate the model.
Dependability	Refers to the ability to produce the same result if the study were replicated.	This criterion was established based on both the work of recognised writers found in the literature and also the contributions from citizens in the field of study in the form of the user review. The use of established theories and models that have been tested in numerous research projects contributed to the dependability of this project.
Credibility	The accuracy of the research study as regards to reflecting the social phenomena observed.	The case study was carefully selected to meet requirements of a developing city. Mixed method research: questionnaires, conversational analysis, observations and secondary data sources. Credibility was ensured through the use of multiple data collection techniques and the use of user reviews.
Transferability	Level of applicability in other settings or situations.	The study included a detailed explanation of the research sites and characteristics of the case study in order to enhance the transferability (see Chapter 2). Transferability was achieved as the research model may be applied to other inter-organisational settings with similar characteristics.

The application of the criteria discussed above meant that the research methods may be considered credible. The next section presents the ethical considerations that were taken into account in order to address the ethical concerns of the study.

6.9. Ethical Considerations of the Study

According to Saunders et al. (2009), research consists of team work involving various stakeholders and, thus, great care should be taken to ensure that no person is negatively affected by the research. Punch (2006) maintains that it is the researcher's responsibility to ensure academic integrity and honesty, as well as to respect other people.

In order to ensure that ethical principles were fully observed and to guarantee the confidentiality of the study participants who had been recruited to participate in the study, the following measures were taken:

- The Research Ethics Committee (UREC) of the University of Fort Hare approved the study (Certificate Reference Number: FLO011SCIL01).
- Informed consent was obtained by sharing all necessary information about the research project with all the participants. The terms and conditions of the research project were displayed on a website. It was a legal requirement that participants had to agree to the terms and conditions of the research project before they could report public safety matters via the IVR system.
- Participants were guaranteed anonymity by constructing the questionnaires in a manner which ensures no personal information was captured.
- The misuse of results was mitigated by ensuring information gathered from participants was only used for the indented and expressed purpose of the research. This research project made use of crowdsourcing, thus the participants could decide what public safety information to report making use of the IVR system.
- Participants were allowed to refuse participation in the research project at any time.
- The participants were fully informed about the purpose of the study as well as any issues, benefits and risks that may arise from the study.
- All the participants were made aware that the researcher would use the information provided for academic purposes only and were instructed to report any issues to the correct authorities first and then to call the number provided.
- The confidentiality of the participants and of the information provided was assured.

- The raw data was securely stored and proper access control measures were put in place.

The researcher was aware of the above ethical considerations, and all reasonable efforts were taken to conduct the research project without malice or prejudice to the respondents and to present the findings and conclusions honestly.

6.10. Conclusion

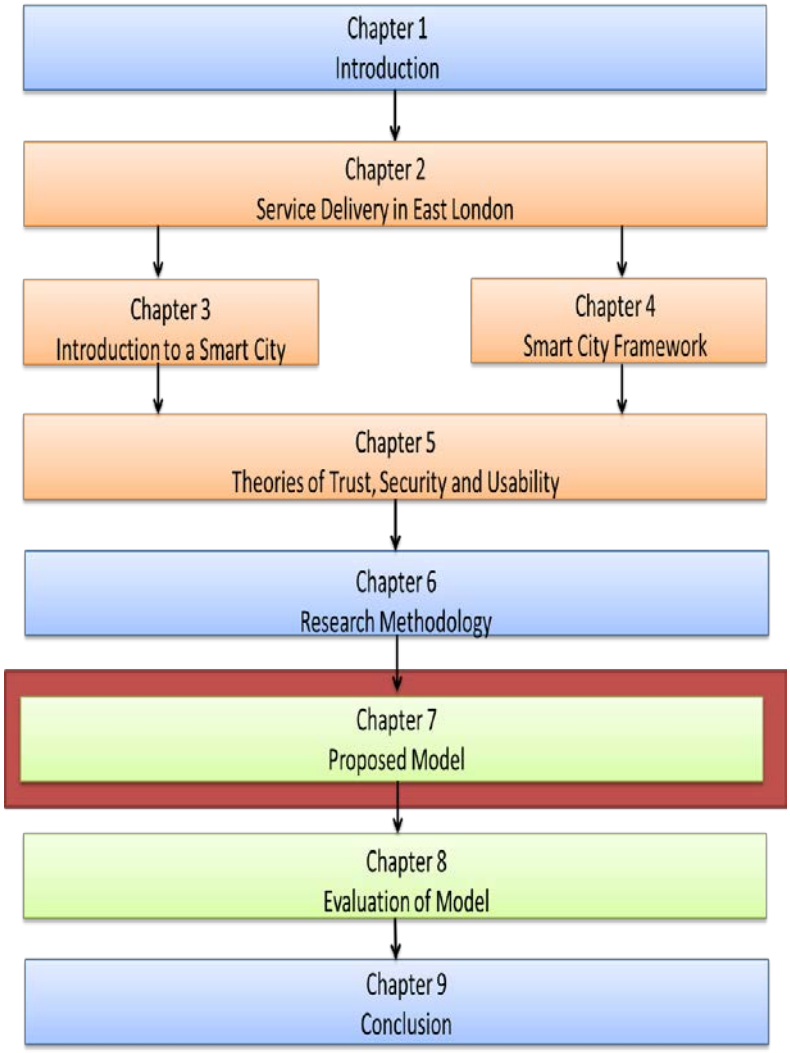
The '*research onion*' was introduced in section 6.1 and will be briefly discussed again as it relates to the research methodology that was discussed in this chapter. The research philosophy underlying the research project was that of Design Science Research. This research paradigm also enables the researcher to make use of both quantitative and qualitative methods. In addition, it places the focus of the research on the artefact that is produced – in this study a PSPC smart city model for developing countries.

The research approach adopted in the research project was based on inductive reasoning. This meant that the researcher began the research project with a thorough literature research from which specific research questions and sub-questions were formulated. Both primary and secondary data collection methods were used throughout the study to collect the evidence required to answer these questions.

The primary research strategy used was that of mixed method approach which included primary data collection methods such as a questionnaire, conversational analysis and observations from the building of the prototype with a detailed literature review as the secondary data collection method. The PSPC smart city model for developing countries was constructed using the theoretical framework which was presented in Chapters 2, 3, 4 and 5. To support the model, conversational analysis and observations from building the crowdsourcing prototype were used. Finally, a questionnaire was sent to the study sample and the users of the crowdsourcing system, the citizens of East London, in order to validate the model that will be presented in the next chapter. The results of the questionnaire will be discussed in Chapter 8.

The integrity of the research project was assured by the trustworthiness, confirmability, dependability, credibility and transferability of the study. These five items were discussed in detail in section 6.8. The next chapter will introduce the PSPC smart city model for developing countries.

Chapter 7
PSCS Smart City Model for Developing Countries



7.1 Introduction

7.2 Introduction to General Systems Theory

7.3 General Systems Theory and this Research Project

7.4 Proposed Model

7.5 Conclusion

7.1. Introduction

The previous chapter discussed the research methodology that was used in this research project. In this chapter, the solution to the research problem – how to implement a public safety, participatory crowdsourcing, smart city project in a developing country – is presented in the form of a model. As explained in Chapter 1, General Systems Theory was used to demonstrate how the model addressed the research problem.

The research model introduced in this chapter makes use of relevant literature and theory (as discussed in Chapters 2 to 5) as a foundation. In addition, conversational analysis and observations from the development of the crowdsourcing system prototype were also used to justify the various factors comprising the model. The empirical findings from the questionnaire that was administered to the study participants are discussed in the next chapter, Chapter 8, as part of the user review.

This chapter starts by explaining how General Systems Theory contributed to the research model. The proposed model is then introduced with an explanation of the various factors and relationships identified in the model. The model aims to address the primary research objective by identifying the various factors that are necessary to implement a public safety, participatory crowdsourcing, smart city project in a developing country. In the next section, a brief overview of General Systems Theory is provided. This is followed by a discussion of the model itself and an explanation of each factor of the research artefact.

7.2. Introduction to General Systems Theory

As discussed in Chapter 1, General Systems Theory subscribes to the notion that the whole is made up of '*more than the sum of its parts*.' This, in turn, introduces the notion of '*the adaptive whole*' in terms of which the entity is able to adapt and survive within the limits of a changing environment (Checkland, 2000; Von Bertalanffy, 1968). Traditional systems theory involves both natural and design systems. Natural systems are biological in nature, while design systems are found in the engineering field (Checkland, 2000).

General Systems Theory subscribes to the notion that systems in the world may be engineered to achieve desirable objectives. Thus, the design systems approach is founded on identifying the correct solution while prescribing that, based on prior experience, it is possible to predict the future with a degree of accuracy, thereby reducing perceived uncertainty by making use of probability and likelihoods (Checkland, 2000). However, one of the limitations of this approach is the fact that the approach does not consider the possibility that human behaviour may cause the system to become unpredictable. In view of the fact that the public safety, participatory crowdsourcing system will be used by the citizens of East London, there is an element of human behaviour, or unpredictability, which would have to be considered when, implementing the crowdsourcing system (Checkland, 2000).

While Soft Systems thinking follows the traditional views on General Systems Theory, Soft Systems thinking also incorporates the principle of human behaviour as guided by conditions, boundaries and rules. Thus, Soft System thinking provides for a way in which to conceptualise the world and the unpredictable actions undertaken by humans (Checkland, 2000).

The relationships between the parts of a system and the events these parts produce through their interaction results in the system elements being rationally connected as regards to a shared purpose (Checkland, 2000). Mele, Pels and Polese (2010) further state that this focus on the interactions between the parts must be considered as the behaviour of a single, autonomous element. It is, thus, important to note that General Systems Theory argues that the researcher is not able to solve a problem by simply breaking the problem up into the basic parts and then reforming the problem. Instead, the research problem must be considered from a holistic perspective in order to fully understand the function of the parts in the whole (Mele et al., 2010). When this is done, it is possible to observe the emergent properties of the system. In this research project, the emergent property, a model to implement a public safety, participatory crowdsourcing, smart city project in a developing country, will enable the BCMM to make use of existing resources more efficient and effectively in order to improve public safety in East London.

When considering the relationships between the various elements in the model, it is important to consider whether the system in which these relationships exist is either open or closed. In open systems there are exchanges of energy, matter, people and information with the external environment while, in closed systems, there are no exchanges with the external environment (Mele et al., 2010). In this study, an open system was used to investigate the relationship between the city (BCMM), the citizens of East London and the smart city, public safety, participatory crowdsourcing system. The next section will briefly discuss the positioning of the research project in the BCMM service delivery process, making use of General Systems Theory.

7.3. General Systems Theory and this Research Project

As discussed in Chapter 1, a system may be placed in a specific hierarchy within a research area (see Figure 7.1). The flow diagram in Figure 7.1 identified the various parts or subsystems that are involved in the decision of local government to become a smart city. The grey block labelled '*Crowdsourcing*' represents the subsystem that was

investigated in this research project. As discussed in section 1.5.1, the subsystem, Crowdsourcing, is separated from the wider environment by a system boundary. The system consists of inputs which are the factors that must be in place in order to implement a public safety, participatory crowdsourcing system in a developing country. The process represents the actual implementation of the system, while the output represents the improved public safety in East London. The feedback loop represents the information that the BCMM would provide to the citizens about the information reported to the crowdsourcing system. The BCMM would use reports, statistics or graphs in order to provide this information to the citizens.

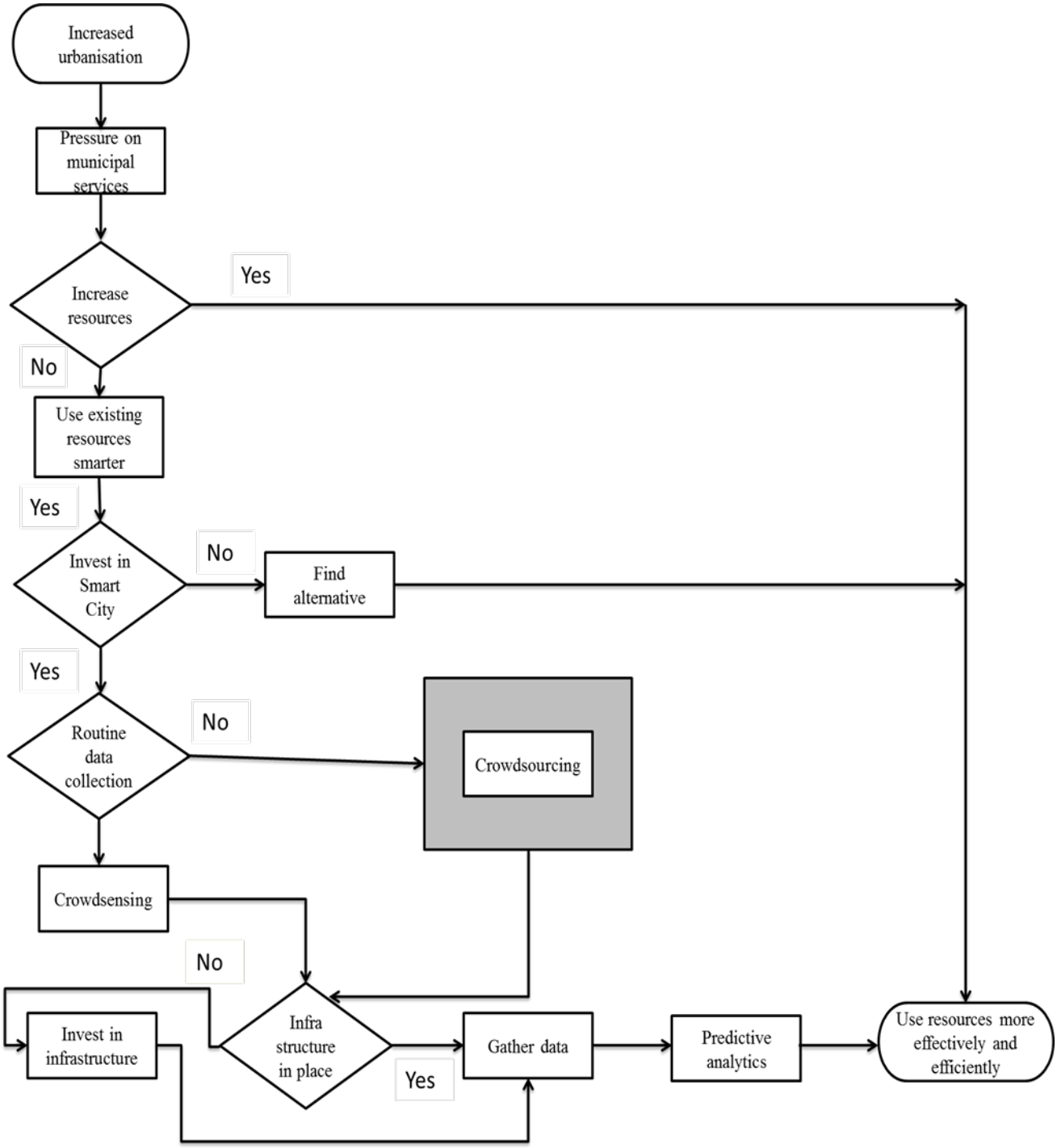


Figure 7.1: System Hierarchy for a Smart City Project

While this chapter provides an overview of the model, the various elements of the model have been discussed throughout the thesis. Thus, this section then forms the part of the whole that is presented as this research project, with the model to implement a public safety, participatory crowdsourcing, smart city project in a developing country, as the main contribution of this research. This model will be discussed in the next section.

7.4. Proposed Model

As mentioned in section 7.2, the *whole* is often made up of many parts. In this thesis, these parts, as well as the relationship between them, have been discussed throughout as sections or chapters with their own emergent properties. Thus, each chapter of the thesis is part of the whole presented in this research project, with the emergent property being a model to implement a public safety, participatory crowdsourcing, smart city project in a developing country.

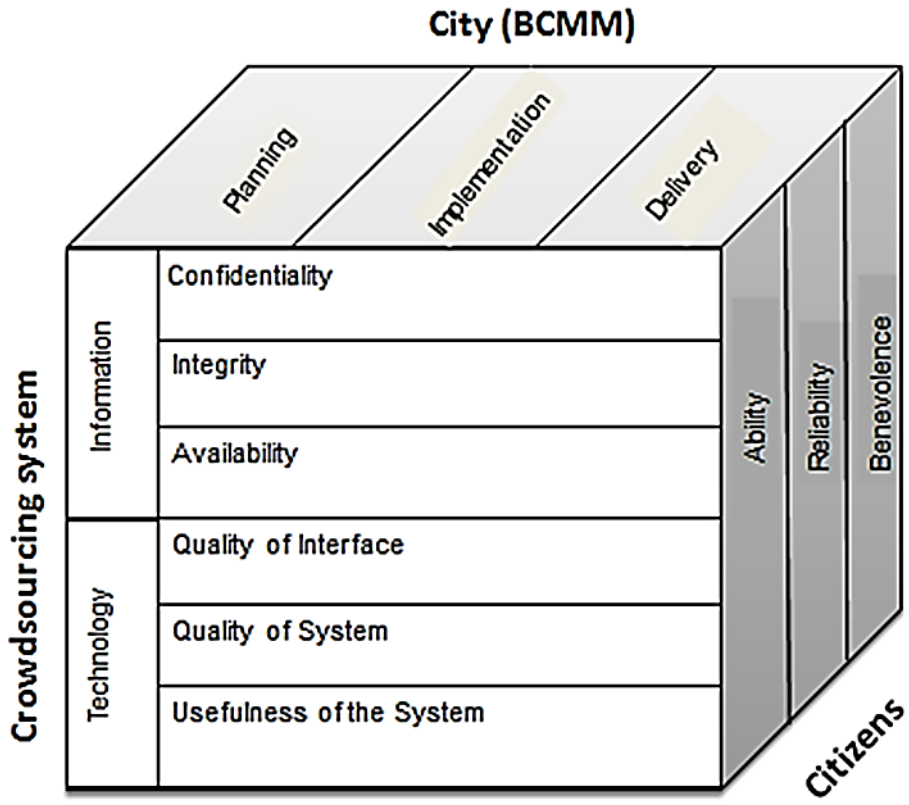


Figure 7.2: PSPC Smart City Model for a Developing Country

The various factors of the model will now be introduced and discussed in more detail. These factors include the crowdsourcing system, the citizens and the city (BCMM). Each of the characteristics comprising these factors will be dissected as well. This will be followed by a discussion on the relationship, in line with General Systems Theory, between the various components. Table 7.1 summarises the argument that is presented in sections 7.4.1 to 7.4.7.

7.4.1. Crowdsourcing

A smart city places the emphasis on the use of smart technologies and intelligent processes in order to solve the problems a developing city would be experiencing and in order to ensure, for example, that public safety would be prioritised. The problems experienced by a developing city include the deteriorating condition of the infrastructure, scarcity of resources, inadequate and poor infrastructure, energy shortages, price instability, global environmental concerns and human health concerns (Washburn & Sindhu, 2010).

In order to realise the benefits of a smart city, a great deal of data must be collected. The two data collection methods that were considered in this study include crowdsensing and crowdsourcing. Making use of conversational analysis, it was decided that crowdsourcing would be a better fit in this research project as the technology has lower entry barriers (existing telephone infrastructure can be used), eliminates privacy concerns of the user and is useful in the public safety context as unusual events in a wider geographical area can be reported making use of mobile phones.

The next decision that was taken on the basis of the conversational analysis involved whether or not to use an IVR or a SMS based system. It was decided that an IVR system would be the best method to use to collect data in this research project as the IVR system enables users unfamiliar with the technology to report public safety matters at their own pace. In addition, a speech based IVR system would not exclude illiterate users from reporting public safety matters, while the text format of SMSs are confusing and cannot be readily used for analytics.

In this study, the study participants were divided about the use of either a IVR or a SMS based crowdsourcing system with 38% support for each. The reason for this may be attributed to the age and qualification level of the participants. Approximately 50% of the participants were less than 30 years of age. This age group has grown up with social media such as Twitter, Mxit and Facebook and is, therefore, accustomed to the convenience of texting. Many have even developed their own texting language. Less than 5% of the participants in the study had not completed Grade 12 and, thus, it was assumed that the majority of the study population was in fact literate. Thus, despite the fact that literacy is one of the deterrents to using a SMS based crowdsourcing systems, this factor was not relevant in this study.

A further consideration was the availability of the Internet to enable the participants to read and accept the terms and condidtions of the research project. This was a legal requirement, but would exclude those citizens in East London who did not have access to the Internet. This was seen as a possible barrier to the participation of citizens in the project. However, mobile penetration in South Africa is high and, therefore, more citizens have access to the Internet than previously.

Although one of the concerns in developing countries is the lack of ICT infrastructure. Mobile networks have expanded and penetrated the South African market sufficiently to make the entry level costs for implementing an IVR system acceptable. The only challenge envisaged by the researchers was the difficulty of training speech recognition software to understand all 11 offical languages and the numerous accents in South Africa. However, this problem was overcome by adopting English (the offical business language of South Africa) for the voice prompts and mapping as many speech examples with different accents as possible before the crowdsourcing system became operational. The decision to use English only was also necessary as the research team was based in three different countries (South Africa, India and Israel). While predicitve analytics is beyond the scope of this research project, the analysis of the reported data would not have been possible if the messages had been recorded in indigenous South African languages, while the meaning of the message may have been lost during translation. In addition, it was felt that the use of the indigenous languages would have excluded members of the research team if they did not understand the indigenous languages.

Smart cities are still a relatively new concept and there is neither a standarised definition nor agreed upon common characteristics. This is evident in the many definitions of smart cities presented in Chapter 3 and also in the limited number of studies that are available in this research area. It was pointed out that a third of the studies that are available are industry orientated, thus pointing to a technology that is still in the innovation phase. A further issue is that the smart city studies reported were implemented in developed countries. While these studies provide valuable insight into smart city projects, it is not possible to generalise the results to the implementation of smart cities in developing countries as the characteristics and requirements of the developing countries differ from those of the developed countries. For example, developing countries often have low literacy rates, high poverty and unemployment rates while technology is either expensive or not available.

During this research project the research team observed that some of these characteristics were valid for the city of East London. The high poverty and

unemployment rates influenced the number of calls that was received during the project as call rates in South Africa are expensive. The solution to this problem was to limit the length of the phone call to less than a minute and this was incorporated during the development of the crowdsourcing prototype. The research team tested the system using different voice prompts and pathways in order to report a public safety matter. These iterations provided valuable as the system was refined (unnecessary information was identified and deleted) and also made affordable for the citizens to report public safety matters. The technology required to develop and host the participatry crowdsourcing system was obtained through a collaboration between IBM and the University of Fort Hare. IBM built and hosted the participatory crowdsourcing system in India.

One of the problems reported by the research teams in Inida and South Africa was the four and a half hour time zone difference between the two countries. The adjustments to the crowdsourcing system had to be done over the course of days because of this time difference and this, in turn, resulted in delays before the system went operational. Technology challenges were also experienced in East London at the start of the project. For example, electricity outages, faulty hardware and problems with the website were all reported at the start of the project with these problems resulting in the citizens of East London not being able to access the website in order to agree to the terms and conditions. These problems were resolved within 48 hours but they did, however, impact on the rollout of the initial system. The aim of this research project was to develop a model to implement a public safety, participatory crowdsourcing, smart city project in a developing country, while taking into consideration all of the factors mentioned above. It is envisaged that the model will contribute to the existing body of knowledge on smart cities. The second component of the model, the city, is discussed in the next section.

7.4.2. City

As discussed in Chapter 3, urbanisation is increasing the pressure on existing resources with local authorities, such as the BCMM, having to provide services to an increasing population in the framework of finite resources and deteriorating infrastructure. This, in turn, means that, as it is not possible to increase resources, more efficient ways must be found to use existing resources in a more effective way.

East London was chosen as the city in which to implement the public safety, participatory crowdsourcing, smart city project. Based on the literature review and conversational analysis, several problems were identified that were contributing to the poor service delivery of the BCMM in the city. These included the mismanagement of resources,

corruption, no community involvement in local government as a result of non-functioning ward committees, a lack of skill and capacity in the BCMM and unfulfilled election promises. The poor state of service delivery in the city has led to both protests and the citizens threatening to withhold their rates and taxes.

The developing state of the Eastern Cape Province is further exacerbated by the vast rural areas in the province. Approximately half of the province is considered to be rural. Many of the people living in these rural areas move to East London in search of employment and better living conditions. The BCMM has to provide infrastructure and services to the peri-urban areas and also to the expanding informal settlements within its boundaries. At the same time the BCMM is not able to increase its revenue because of a small industrial base and the high poverty rate with many of the citizens of East London being unable to afford to pay for municipal services.

In view of the fact that it is metropolitan area, provision is made to address the issue of public safety in East London through the Directorate of Health and Public Safety. While the structures are in place to respond to possible public safety situations, the various departments work alone with no or little integration. In addition, the responsibilities of the various departments within the Directorate are also not clear, resulting in confusion on the part of the citizens of East London. In addition, these departments do not have in place a pro-active, public safety approach but, instead, simply react to emergency situations. The next section will discuss the last component of the model, the citizens.

7.4.3. Citizens

The citizens of East London were asked to report public safety matters via a participatory crowdsourcing system after registering on the project website. Public safety was chosen as the context of the research project after careful consideration as public safety affects the quality of life of all citizens. Increasing crime rates have been attributed to the increase in urbanisation. The BCMM recorded the highest growth rate of all metropolitan areas in 2012 and crime is certainly a major problem in the city (Skenjana, 2013). As mentioned in the previous section, the various departments in the Directorate of Health and Public Safety work in silos with little integration between them while the responsibilities of the various departments are unclear (Managa, 2012). During the conversational analysis, these were all problems that was considered as reasons why public safety would be a good fit for this research project.

Crowdsourcing may assist cities to cope with public safety matters in two ways. Firstly, the system is able to provide real-time information about public safety matters so as to enable the emergency services to respond faster and, secondly, the system also provide information that enables a pro-active approach to public safety matters. This pro-active approach includes altering the environment or changing the conditions that are conducive to public safety disasters and/or criminal activities. This is done by making use of predictive analytics using the information that was reported by the citizens of East London via the participatory crowdsourcing system.

The problems that were identified in Chapter 3 in relation to crowdsourcing include the incompatibility of various crowdsourcing systems, the quality of the data reported and semantic problems with the speech analytics. In Chapter 5 the problem of trust in the crowdsourcing system was discussed. It is not possible for any system to be 100% secure and, thus, there is always room for uncertainty and risk. If the citizens of East London do not trust the participatory crowdsourcing system to reflect their public safety concerns correctly, they will not participate with the system. In order to decrease the risk associated with the participatory crowdsourcing system, it is essential that control measures be put in place. However, such control measures may decrease the speed or efficiency of the crowdsourcing system as a whole as they are often cumbersome. In addition, control measures may also simultanously increase the cost of the system. A balance between trust and risk must then be found in order to promote the efficiency of the entire system. The control measures will be discussed in the next section.

7.4.4. Characteristics of the Crowdsourcing System Factor

The public safety participatory crowdsourcing system may be divided into two categories, namely, information and technology. Information refers to information security while technology is used to explain the usability of the system. These two factors were identified in Chapter 5 on the basis of the literature review.

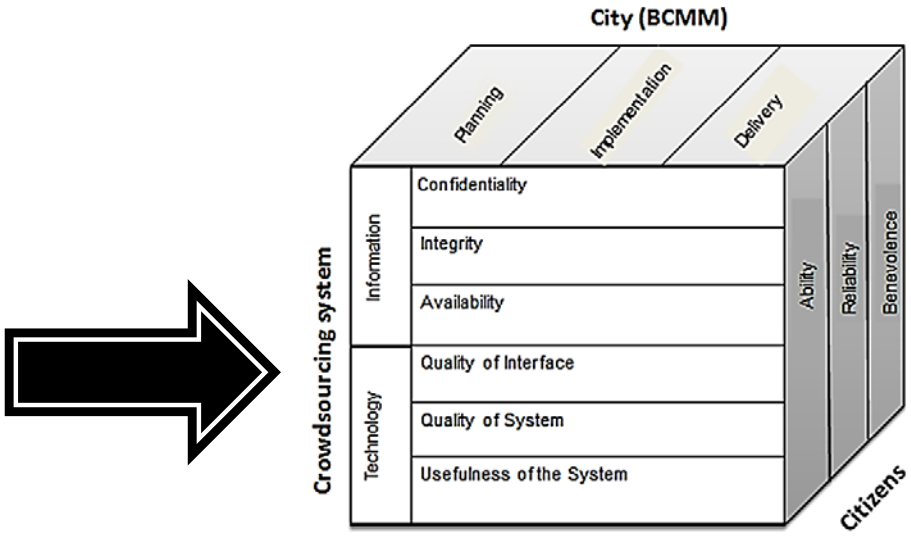


Figure 7.3: PSPC Smart City Model for a Developing Country

As discussed in the previous section, in order to decrease the risk associated with the participatory crowdsourcing system, it is essential that control measures be put in place. The CIA triad represent the pillars of information security. If the control measures are put in place, the result will be that the three pillars of the CIA triad, namely, the confidentiality, integrity and the availability of the information, will be ensured. Each of the pillars will be discussed seperately in the next sections.

7.4.4.1. Information Confidentiality

"*Information has confidentiality when disclosure or exposure to unauthorised individuals or systems is prevented*" (Whitman & Mattord, 2005, p10). There are two factors that must be taken into consideration in respect of information confidentiality. Firstly, confidentiality is closely related to the privacy of the citizen reporting the information and, secondly, confidentiality refers to the status afforded to sensitive information. Accordingly, confidentiality ensures that only those with the requisite rights and privileges may access the information in question. A list of possible ways to manage this risk was provided in Chapter 5, section 5.1.4.

7.4.4.2. Information Integrity

Information integrity refers to the safeguarding of the accuracy and completeness of information and its processing methods. Any information that is transmitted or recorded and entered into the system should reflect actual, reliable and correct records or instances, without corruption. The BCCM is responsible for ensuring that adequate

controls are in place to safeguard the integrity of the information that is reported via a participatory crowdsourcing system. If this factor is addressed, this would increase the trustworthiness of both the information reported and participatory crowdsourcing system.

7.4.4.3. Information Availability

The availability of information enables authorised users to access information without interference or obstruction, and to receive the information in the required format. The reason for why information must be available is that the crowdsourcing system for the purposes of this research project will be used to report public safety matters which may require an immediate response. On the other hand, in order to provide a timely response, it is essential that authorities such as the police and emergency services have access to the information that is reported in a usable format and familiar language.

The next section will discuss the technology category of the model. The confidence of the citizens of East London in the public safety, participatory crowdsourcing system may be measured using the usability of the system. In Chapter 5 it was discussed that the crowdsourcing system may be used as a communication tool between the citizens of East London and the BCMM and it is, thus, essential that the system be perceived as trustworthy. Information security would help safeguard trust in the crowdsourcing system and also establish confidence in the system. This confidence may be measured by measuring user satisfaction with the crowdsourcing system. If the citizens of East London perceive the system as useful, this would contribute to the confidence that is necessary if they were to use the participatory crowdsourcing system in the future.

The definition of usability contained in ISO/IEC 9241-11 identifies three characteristics of usability, namely, efficiency, effectiveness and user satisfaction, which are relevant to the public safety participatory crowdsourcing system. In the next section, the interface quality, system quality and usefulness of the participatory crowdsourcing system will be discussed in relation to the three characteristics.

7.4.4.4. Interface Quality

This factor refers to the usability of the crowdsourcing system when it provides the users with information regarding the way in which to report public safety matters. In view of the fact that an asynchronous crowdsourcing system was used, the only information the user receives from the system is via the voice prompts. If these voice prompts are unclear or

do not provide enough information, the crowdsourcing system would not be deemed usable and this, in turn, would adversely affect the participation of the citizens of East London in the public safety project. The decision was taken to use an IVR system as illiterate users would also be able to make use of the system. This is a concern in East London where the illiteracy level is significantly higher than the national standard (ECSECC, 2012).

Further challenges that was observed during the building of the crowdsourcing system prototype include that the speech recogniser of an IVR system was not completely accurate as the complexities of variable pitch, intonation and co-articulation still need to be mapped and analysed. This was important for this research project as there are eleven official languages and many more regional accents in South Africa. However, the problem was overcome by mapping as many examples of the expected answers in different accents as possible before the crowdsourcing system went operational. Several iterations were necesseary in order to '*train*' the speech recogniser software adequately.

The IVR system lacked the comprehension that is necessary to provide appropriate responses to the user. This challenge was exacerbated by the various accents that occur in South Africa. However, if the crowdsourcing system was not able to identify the response of the caller, a voice prompt would ask the caller to repeat his/her answer or, alternatively, make use of the touch pad to input his/her answer.

An IVR is a system-driven rather than an event-driven interaction system. This, in turn, makes it difficult for the system to complete complicated tasks quickly. However, the voice prompts that was used were kept simple in order to provide the caller with an opportunity to record his/her public safety concern. More than 20 iterations of the IVR system were carried out in order to ensure simplicity of the system. After the caller had made the recording, it was played back to the caller and if he/she were not satisfied with the recording, the caller was able to rerecord his/her message.

7.4.4.5. System Quality

The quality of the crowdsourcing system would be affected by the efficiency and effectiveness of the system. As discussed in Chapter 5, being effective is about doing the right things, while being efficient is about doing things in the right manner (Covey, 1989). The first characteristic, efficiency, that was chosen for this study is measured by the length of the telephone call. This was important because, in general, of the cost of

telephone calls in South Africa is high and, together with the high unemployment and poverty rates in East London, may discourage citizens from making use of the crowdsourcing system.

The second characteristic refers to the effectiveness of the crowdsourcing system. This was measured as the ease of use regarding reporting a public safety matter by making use of the IVR system. As discussed in the previous section, the confidence of the citizens in respect of making use of the public safety, participatory crowdsourcing system would be affected by their experiences when making use of the system.

7.4.4.6. Usefulness of the System

The last characteristic that was included in the model relates to the usefulness of the public safety participatory crowdsourcing system (refer Figure 7.4). The majority of the participants (87.2%) indicated that the crowdsourcing system would save them time when they reported public safety matters. Furthermore, if the user feels that the crowdsourcing system is useful and will yield positive results, this would increase the confidence in the smart city and this, in turn, would increase the participation of the citizens in the public safety, crowdsourcing, smart city project.

7.4.5. Steps of the City Component

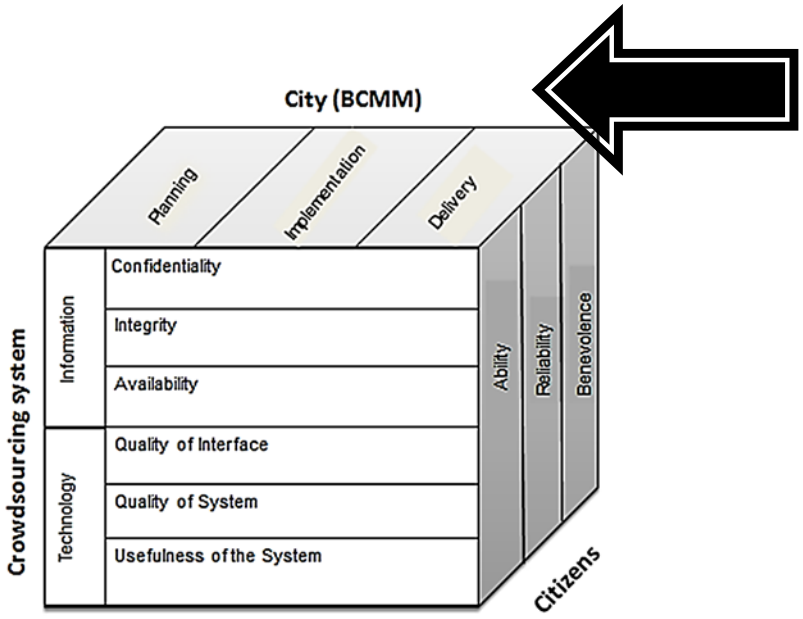


Figure 7.4: PSPC Smart City Model for a Developing Country

The steps in this component were identified based on the literature review discussed in section 3.7. Washburn and Sindhu (2010) provide an extensive explanation of the three

steps which would have to be considered should the BCMM decide to use crowdsourcing as a data collection method in a smart city. These steps involve the planning, implementation and delivery phases while various activities for each phase were indicated in section 3.7. Based on the conversational analysis, the explanation provided by Washburn and Sindhu (2010) was deemed to be an appropriate guide for cities that wish to become smarter.

While these steps fall outside the scope of this research project, they were included as the three factors that must be considered in the city component as comprising a validated guide for how a city may become smarter.

7.4.6. Characteristics of the Citizen component

It was determined in Chapter 5 that the ability, reliability and benevolence of the public safety, participatory crowdsourcing system is important to the user. The Model of Trust, as proposed by Mayer et al. (1995), was used to identify these characteristics as being important as regards the implementation of a public safety, participatory crowdsourcing, smart city project in a developing city.

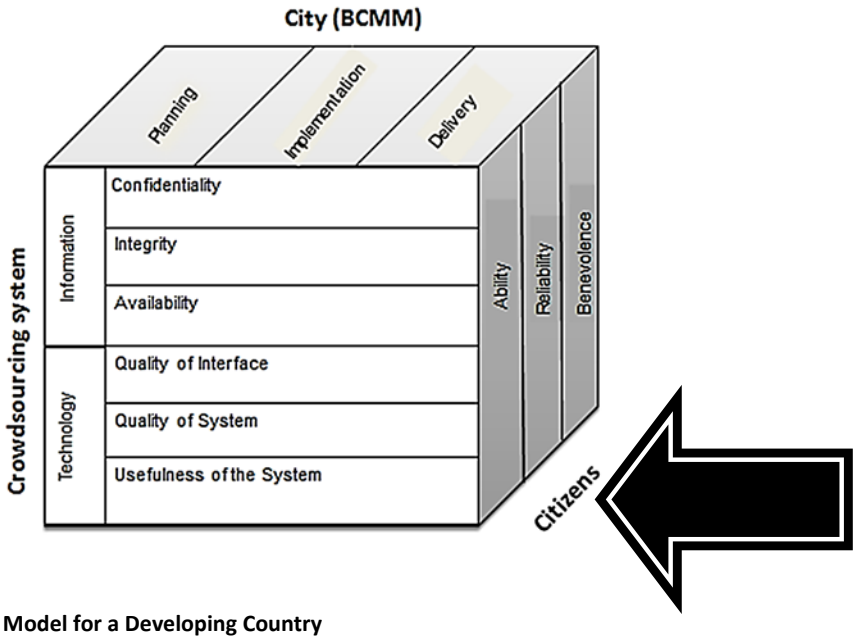


Figure 7.5: PSPC Smart City Model for a Developing Country

Ability may be defined as the skills, competencies and characteristics that ensure that the trustee has influence in the relationship with the trustor. In this study, the ability of government to use the information provided via the crowdsourcing system in order to improve public safety, as illustrated by the feedback loop in Figure 1.3, had to be included

in the model in order to demonstrate to the citizens of East London that the crowdsourcing system would be capable of reflecting their public safety matters correctly.

Benevolence may be defined as the extent to which the trustee is believed to want to act in the trustor's best interests. Privacy concerns may lead to the citizens being fearful that the public safety information provided while making use of the crowdsourcing system would be disclosed to unauthorised parties. The last characteristic, reliability, refers to the belief that the person or institution will act in an honest, reliable and credible manner.

In the context of a participatory crowdsourcing system, reliability refers to a belief that both government and the fellow citizens reporting public safety matters are honest and reliable. It is essential that local government be able to guarantee the reliability of information that is reported, while fellow citizens must report accurate information in order to ensure the reliability of the information. In the next section the relationships between the various components of the model are discussed.

7.4.7. Relationships between the Various Components of the Model

This research project made use of General Systems Theory in order to identify the three main relationships that had to be considered in the model. These include:

- Crowdsourcing system – Citizens;
- Crowdsourcing system – City, and
- City – Citizens.

While many of these relationships have been touched upon in previous sections, they will briefly be discussed in the Table 7.2 again.

Table 7.1: Relationships in the Model

Relationship	Description of relationship	Determining factors	Discussed in which section?
Crowdsourcing system – Citizens	Trust of the citizens in the participatory crowdsourcing system.	Citizen has no control over information once reported Trust will increase if: • Risk associated with the system must be mitigated o Control measures in place o Decrease efficiency of system • User must receive positive feedback when making use of the system o Usability of system o Increase confidence of the user	Section 5.2.5 Section 5.3.1 Section 5.2.3 Section 5.4 Section 5.4.1 Section 5.4
Crowdsourcing system – City	Refers to the implementation of the public safety participatory crowdsourcing smart city by the City, or the BCMM, in this research project.	Three factors: • Planning • Implementation • Delivery Will ensure Information security and the usability of the system will be planned for in initial stages of study.	Section 3.7
City – Citizens	Endeavour to involve the citizens of East London in the planning, implementation and delivery phases of the smart city project	Unique characteristics of developing city influence the development and implementation of the public safety, participatory crowdsourcing smart city project. • Low literacy rate - speech based IVR system • High poverty and unemployment rate - cost of phone call • Unavailability and cost of technology - low entry barrier due to existing telephony infrastructure	Section 2.1 – 2.6

7.5. Conclusion

This chapter presented the proposed model for implementing a public safety, participatory crowdsourcing model in a developing country. As such, the chapter provides the solution to the research question that was presented in Chapter 1. The PSPC smart city model for a developing country will be validated in the next chapter.

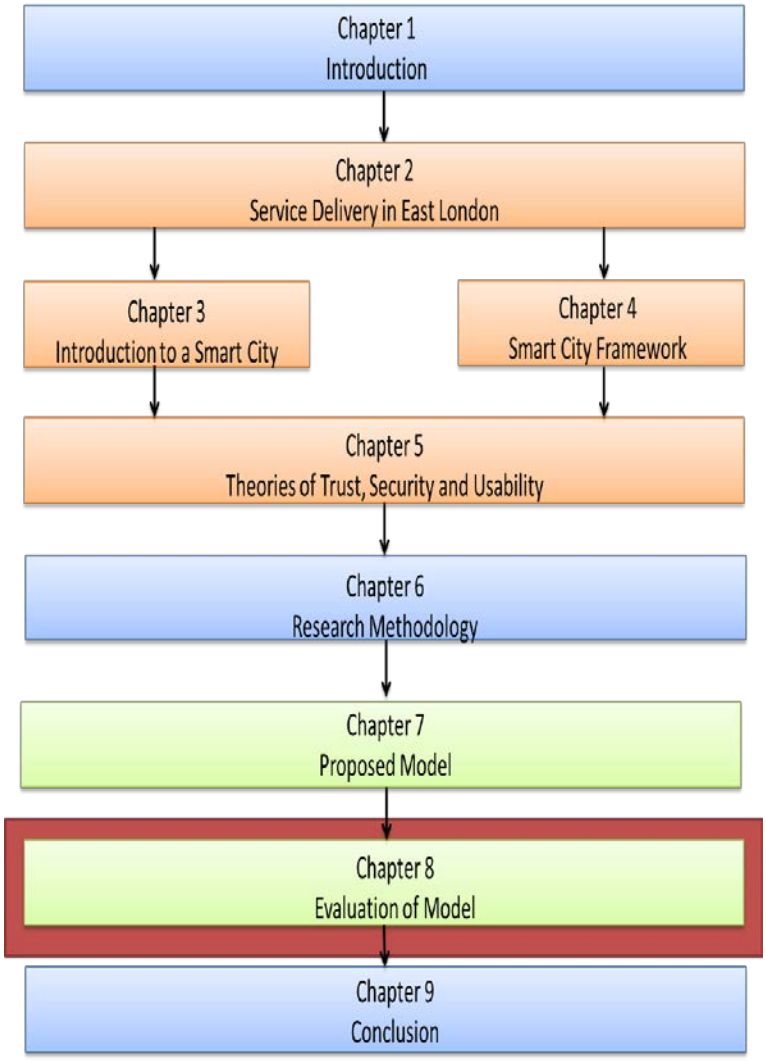
This chapter contained a detailed explanation of the key components of the proposed model. The model was based on the secondary data that was presented in Chapters 2 to 5 and supported by the observations from the building of the crowdsourcing system prototype and the conversational analysis. The categories identified in respect of the

crowdsourcing area included technology and information. The technology category included interface quality, system quality and usefulness of the system, while the information category include the confidentiality, integrity and availability of the information reported via the public safety, participatory crowdsourcing system.

The city was discussed in section 3.7. The three steps that are important in the process of becoming a smart city were identified. These steps were included in the PSPC smart city model for a developing country as they provide a comprehensive overview of the implementation of a smart city for the benefit of local city management.

It is essential that the citizens perceive the crowdsourcing system as trustworthy if they are to make use of it. The characteristics that determine the trustworthiness of the crowdsourcing system were identified by Mayer et al. (1995) as ability, reliability and benevolence. All three these characteristics were included in the model. The next chapter will validate the PSPC smart city model for a developing country.

Chapter 8
Evaluation of the PSPC Smart City Model for Developing Countries



8.1 Introduction

8.2 Pilot Study

8.3 Response Rate

8.4 Demographics

8.5 Questionnaire

8.6 Dependent Variables in the Study

8.7 Validity of the Measuring Instrument

8.8 Reliability of the Measuring Instrument

8.9 The Factors Identified by Means of Factor Analysis

8.10 Correlation

8.11 Multiple Regression Analysis

8.12 Summary of the Validation of the Questionnaire

8.13 Conclusion

8.1. Introduction

The purpose of design evaluation is to ensure an artefact that has been rigorously assessed in order to guarantee its utility, quality and efficacy. The evaluation method selected is influenced by the design of the artefact (Hevner et al., 2004). Ahmed and Sundaram (2011) suggest a number of evaluation methods. However, a user review was selected as the method most appropriate for the purposes of this study (see section 6.4).

The user group provides comments on the material presented and this feedback is then used to refine the artefact. In this research project, the user review was conducted using the participants in the study who had used the public safety, participatory crowdsourcing system. The questionnaire was sent to the population sample that had participated in the smart city project and was asked to comment on the model. The questionnaire findings were used to refine the model. The results of the user review are presented in this chapter.

The next section will present the questionnaire findings, starting with a discussion of the pilot study, response rate and demographics of the participants. This will be followed by the descriptive statistical results and, finally, the results from the factor analysis that was conducted will be presented.

8.2. Pilot Study

A pilot or feasibility study is a small-scale implementation of the planned data collection method which is conducted in order to refine the research instrument. Accordingly, the results from the pilot study are not considered important but, rather, it is the problems reported by the users in respect of the data collection instrument that are of importance. Such problems may include misunderstood questions or unexpected responses from the participants (Olivier, 2013). Thus, the pilot study typically involves a limited number of participants who will not be included in the actual study (Teddlie & Tashakkori, 2003).

Five colleagues of the researcher took part in the pilot study for this research project. They were asked to complete the questionnaire and to comment on both the user-friendliness of the questionnaire itself and the clarity of the questions. The comments received were used to refine the questionnaire so as to ensure that the research instrument would elicit the most appropriate responses.

It emerged from the pilot study that some of the questions were not clear and would require further refinement if the expected responses were to be elicited. The questionnaire was adjusted accordingly. Three of the questions included in the questionnaire tested more than one construct. After the feedback received during the pilot study, these questions were adjusted to test only one construct each. The following sections discuss the response rate of the participants in the study.

8.3. Response Rate

A total of 485 people registered on the smart city website. After they had reported a public safety matter via the participatory crowdsourcing system, they were then asked to complete an online questionnaire. A total of 394 questionnaires were completed (see Appendix E), indicating a response rate of 81.2%. According to Oates (2006), a response rate of 30% or higher is acceptable in a research project. In view of the fact that the response rate in this study was considerably higher than 30%, the response rate was considered acceptable. The high response rate may be attributed to the incentive provided for participating in the study. The participants were entered into a lucky draw when they after they had provided their contact information when registering on the smart city website. The prizes for the lucky draw were 3 iPads. The lucky draw was advertised both on the flyer and on the website on which the participants registered for the research project. The next section discusses the demographics of the participants.

8.4. Demographics

This section discusses the gender, age and highest qualification of the participants. The study sample consisted of 219 (60.7%) males and 142 (39.3%) females. The reported ages of the participants are presented in Table 8.1 below. Almost half of the participants (48.2%) were younger than 30 years of age. The next age group, 30−39 years, made up the second largest group (23.5%), and was followed by the 40−49 years age group (14.7%). The two oldest age groups, 50−59 and 60+, were the smallest groups with the lowest percentages of 10.2% and 3.3%, respectively.

Table 8.1: Age of Participants

	Frequency (n = 361)	**Percentage (%)**
18-29	174	48.2
30-39	85	23.5
40-49	53	14.7
50-59	37	10.3
60+	12	3.3
Total	**361**	**100.00**

The highest qualification of the participants was as follow:

- 4.7% had not completed Grade 12;
- 30.2% had completed Grade 12;
- 10.5% had completed a diploma qualification;
- 32.4% had completed an undergraduate degree and,
- 22.2% had completed a postgraduate degree.

The next section introduces the questionnaire that was used in the data collection process. As discussed in Chapter 5, the various constructs that were included in this study were trust, information security and user satisfaction with the IVR system.

8.5. Questionnaire

According to Creswell (2009), the purpose of analysing data is to create meaning from the raw data which has been collected. The data analysis methods that may be used include comparing and evaluating the raw data as well as analysing the feedback received from the participants. Both of these methods were used in this study to report the findings from the questionnaire.

A detailed discussion of the way in which the literature informed the formulation of the various questions is provided in Chapter 5. Three constructs had been identified in respect of the public safety, participatory crowdsourcing system, namely, trust, security and usability (Figure 8.1).

Figure 8.1: Relationship Between Variables that Influence the Successful Implementation of a Public Safety, Participatory Crowdsourcing Model

The questionnaire was divided into the following 4 categories, namely, demographics, trust, information security and user satisfaction. The remainder of this section will discuss the findings for the three constructs found in the questionnaire. The findings for each construct are discussed separately.

8.5.1. User Satisfaction

Usability has become the most widely used concept in the software engineering field (Madan & Dubey, 2012; Abran et al., 2003). There are several aspects that may be identified in determining the usability and perceived efficiency of an information system. These include three aspects that were identified in Chapter 5 under user satisfaction, namely, system quality, interface quality and the usefulness of the system. The findings for these three aspects are discussed in the next section.

8.5.1.1. System Quality

The IVR system and the interaction between the system and the participants were investigated in this aspect. In order to do this, three items were included in the questionnaire. The first item requested the participant to indicate whether the length of the phone call had been acceptable. The length of the phone call was identified in section 7.4.1 as a possible inhibitor as regards the implementation of a smart city in a developing country. The majority of the participants (82.8%) indicated that they were of the opinion that the length of the call had been acceptable in terms of cost. The mean for this question was 1.9 (Agree strongly) and the median 2. The results for this item are presented in Table 8.2.

Table 8.2: Question 1, System Quality in the User Satisfaction Construct

	Frequency (n = 361)	**Percentage (%)**
18-29	174	48.2
30-39	85	23.5
40-49	53	14.7
50-59	37	10.3
60+	12	3.3
Total	**361**	**100.00**

The second item under system quality asked the participants to consider their navigation of the participatory crowdsourcing system. This item was valuable as it provided an

insight into the ease of use and efficiency of the participatory crowdsourcing system. The use of a participatory crowdsourcing system to report public safety matters in the city of East London is a novel approach and, thus, the insights provided by the answers were extremely useful. The ease of navigation of the participatory crowdsourcing system also supported the previous item about the length of the phone call. The responses of the participants were positive with 83.6% indicating that the voice prompts were an efficient way in which to navigate the participatory crowdsourcing system. The mean for the item was 1.9 (Agree strongly) and the median 2. Below are the results for this item (Table 8.3).

Table 8.3: Item 2, System Quality in the User Satisfaction Construct

	Frequency (n = 361)	**Percentage (%)**
1 (Agree strongly)	107	29.6
2 (Agree)	195	54.0
3 (Neutral)	38	10.5
4 (Disagree)	18	5.1
5 (Disagree strongly)	3	0.8
Total	**361**	**100.0**

The third item, "*The IVR system is an effective way to report a public safety matter*", asked the participants to consider their entire experience when they had reported a public safety matter. Seventy five percent of the participants indicated that they considered the participatory crowdsourcing system to be an effective way to report public safety matters. The mean for this category was 2.0 (Agree) and the median 2. The results for this item are depicted in Table 8.4.

Table 8.4: Item 3, System Quality in the User Satisfaction Construct

	Frequency (n = 361)	**Percentage (%)**
1 (Agree strongly)	80	22.2
2 (Agree)	191	52.9
3 (Neutral)	72	20.0
4 (Disagree)	15	4.1
5 (Disagree strongly)	3	0.8
Total	**361**	**100.0**

The results for this section on the system quality showed that the participatory crowdsourcing system is effective and efficient. The next section will present the results for the items pertaining to the usefulness of the participatory crowdsourcing system.

8.5.1.2. Usefulness of the System

The usefulness of the system in this context refers to the service that the participatory crowdsourcing system provided to the participants when they reported a public safety matter. The service may be measured in terms of cost, time or other similar benefits. In order to measure the anticipated service provided by the participatory crowdsourcing system, one item only for this section was included in the questionnaire.

The item is "*The IVR system is an efficient and effective way to report a public safety matter*". The participants indicated that they believed that the participatory crowdsourcing system would be able to save them time when they reported public safety matters (Table 8.5), with 87% indicating that they believed this would be the case. These results are similar to those reported in the previous section and, thus, they support the conclusion that the public safety, participatory crowdsourcing system is an effective and efficient method to report public safety matters in a developing city. The mean for this item was 1.8 (Agree strongly) and the median 2.

Table 8.5: Item 1, Usefulness of the System in the User Satisfaction Construct

	Frequency (n = 361)	**Percentage (%)**
1 (Agree strongly)	144	39.9
2 (Agree)	171	47.3
3 (Neutral)	32	8.9
4 (Disagree)	12	3.3
5 (Disagree strongly)	2	0.6
Total	**361**	**100.0**

The last category in this construct, interface quality, will be discussed next.

8.5.1.3. Interface Quality

For this category two items were included in the questionnaire. The two items were "*The IVR system provided information/instructions that is clear*" and "*The IVR system provided sufficient information for me to report my public safety matter*". Both of these items received favourable results from the participants at 94.2% and 91.7% respectively. The results for the first item, "*The IVR system provided information/instructions that is clear*" are presented in Table 8.6. The mean for the item is 1.7 (Agree strongly) and the median 2.

Table 8.6: Item 1, Interface Quality in the User Satisfaction Construct

	Frequency (n = 361)	**Percentage (%)**
1 (Agree strongly)	130	36.0
2 (Agree)	210	58.2
3 (Neutral)	15	4.2
4 (Disagree)	4	1.1
5 (Disagree strongly)	2	0.5
Total	**361**	**100.0**

The second item, "*The IVR system provided sufficient information for me to report my public safety matter*", also received positive results from the participants. The mean for this category was 1.73 (Agree strongly) and the median 2. The results for the item are presented in Table 8.7.

Table 8.7: Item 2, Interface Quality in the User Satisfaction Construct

	Frequency (n = 361)	**Percentage (%)**
1 (Agree strongly)	136	37.7
2 (Agree)	195	54.0
3 (Neutral)	23	6.4
4 (Disagree)	5	1.4
5 (Disagree strongly)	2	0.5
Total	**361**	**100.0**

The results in this section confirm that the interface of the participatory crowdsourcing system had been refined sufficiently so as to facilitate the users' reporting their public safety matters effectively and efficiently. This fact is of particular concern as the system makes use of an asynchronous interface. Thus, if the quality of the interface is not sufficient, this may result in the user becoming frustrated and not making use of the public safety, participatory crowdsourcing system in future. The next construct that will be discussed is that of trust.

8.5.3. Trust

The trust model chosen for the purposes of this project was the Model of Trust as proposed by Mayer et al. (1995). Section 5.2.4.1 identified the following three

characteristics as the basis of the perceived trustworthiness between the trustor and trustee, namely, ability, reliability and benevolence (Mayer et al., 1995).

8.5.3.1. Ability

The first characteristic, ability, may be defined as the skills, competencies and variables that ensure the trustee, or citizens, has influence in the relationship (Mayer et al., 1995). This definition implies credibility of the participatory crowdsourcing system which indicates the ability to perform the functions required efficiently and reliably (Mallelieu, 2005). In the participatory crowdsourcing system, the ability of the system to record the public safety matter reported by the participant correctly would influence credibility.

In order to test this factor, four items were included in the questionnaire. These included "*Overall, were you satisfied that you could report your public safety matter?*"; "*I trust the system to reflect my public safety matter correctly"; "I feel confident about the system's ability to process my public safety matter*" and "*Will the information I provide increase the productivity of the Buffalo City Municipality?*"

The majority of the study participants (82.0%) were satisfied that they had been able to make use of the crowdsourcing system in order to report their public safety matters (Table 8.8). The mean for this item was 2 (agree) and the median 1.92.

Table 8.8: Item 1, Ability in the Trust Construct

	Frequency (n = 361)	**Percentage (%)**
1 (Agree strongly)	109	30.2
2 (Agree)	187	51.8
3 (Neutral)	43	11.9
4 (Disagree)	17	4.7
5 (Disagree strongly)	5	1.4
Total	**361**	**100.0**

The participants also indicated that they believed the system would correctly reflect the public safety matter which had been reported. The results showed that 84% believed this to be true while 1% only did not believe that the system would be able to reflect a true version of the public safety matter reported. The results for this item are summarised in Table 8.9. The mean for this item was 1.9 (Agree strongly) and the median 2.

Table 8.9: Item 2, Ability in the Trust Construct

	Frequency (n = 361)	**Percentage (%)**
1 (Agree strongly)	104	28.8
2 (Agree)	202	56.0
3 (Neutral)	51	14.1
4 (Disagree)	3	0.8
5 (Disagree strongly)	1	0.3
Total	**361**	**100.0**

The third item was "*I feel confident about the system's ability to process my public safety matter*". The participants were extremely positive (76.0%) about the service that the participatory crowdsourcing system would provide for reporting public safety matters. The mean for this item was 2 (Agree) and the median 2. The results for this item are depicted in Table 8.10.

Table 8.10: Item 3, Ability in the Trust Construct

	Frequency (n = 361)	**Percentage (%)**
1 (Agree strongly)	110	30.5
2 (Agree)	164	45.4
3 (Neutral)	69	19.1
4 (Disagree)	16	4.4
5 (Disagree strongly)	2	0.6
Total	**361**	**100.0**

The last item ascertained whether the participants believed that the information they had reported would help the BCMM to become more productive. The mean for this item was 1.94 (Agree strongly) and the median 2. The results for this item are reported in Table 8.11 as per the Likert scale rating.

Table 8.11: Item 4, Ability Factor in the Trust Construct

	Frequency (n = 361)	Percentage (%)
1 (Agree strongly)	129	35.7
2 (Agree)	144	40.0
3 (Neutral)	58	16.1
4 (Disagree)	19	5.2
5 (Disagree strongly)	11	3.0
Total	**361**	**100.0**

This concludes the findings for the ability catergory in the trust construct. The results in this section confirm that the study sample believed that the participatory crowdsourcing system had the ability to reflect their public safety matters correctly and to improve public safety in East London. The next section will discuss the second category found in the trust construct, namely, reliability.

8.5.3.2. Reliability

The second category, reliability, may be defined as the perception that the trustee prescribes to the principles that the trustor finds acceptable (Mayer et al., 1995). Two items were included to test this category. The first item read as follows: "*The information that is reported in a participatory crowdsourcing system must be complete, accurate and current in order to be useful*." The mean for this item was 1.75 (Agree strongly), while the median was 2. The majority of the participants agreed with this statement (88.6%), while 2.2% only did not agree with the item. The results for this item are presented in Table 8.12.

Table 8.12: Item 1, Reliability in Trust Construct

	Frequency (n = 361)	Percentage (%)
1 (Agree strongly)	139	38.5
2 (Agree)	181	50.1
3 (Neutral)	33	9.2
4 (Disagree)	5	1.4
5 (Disagree strongly)	3	0.8
Total	**361**	**100.0**

The second item deals with the integrity of the information once it has been provided. The item read: "*I do not worry that the information I provided will be modified in any way*". The mean for the item was 2.53 and the median 2. The results may be seen in Table 8.13.

Table 8.13: Item 2, Reliability in the Trust Construct

	Frequency (n = 361)	**Percentage (%)**
1 (Agree strongly)	64	17.7
2 (Agree)	150	41.6
3 (Neutral)	58	16.1
4 (Disagree)	68	18.8
5 (Disagree strongly)	21	5.8
Total	**361**	**100.0**

The reliability of the public safety, participatory crowdsourcing system was found to be of an acceptable level. However, it was a matter of concern to some of the study population that the public safety information reported to the crowdsourcing system would be modified. This concern is further investigated in the next section when the results for the benevolence of the participatory crowdsourcing system are reported.

8.5.3.3. Benevolence

Benevolence may be defined as the extent to which the trustee is believed to want to act in the trustor's best interest. It implies helpfulness and cooperation on the part of the trustee (Mayer et al., 1995; Mallelieu, 1995). In this study it is not possible for the participatory crowdsourcing system to act in the participants' best interests although the information that was recorded via the participatory crowdsourcing system by the participant (trustor) must be made available to an unknown party (trustee) if it is to be of any use. When the information is made available it is essential that the intent of the trustee not be malicious as certain public safety matters may be of a sensitive nature. Both the nature of the incident and the identity of the participant may be considered as information that could be detrimental to the individual reporting the information reporter if made public.

In order to test the perceptions of the participants regarding benevolence , two items were included in the questionnaire. The first item "*If the information I reported is improperly disclosed to a third party, the impact for me could be potentially devastating*", refers to the impact that information could have on the trustee if it were accessed by an unauthorised

person. Overall, the majority of the participants (62.0%) believed that, if the information that was reported via the participatory crowdsourcing system were disclosed to a third party, this may have negative consequences for the person reporting the information. The mean for this item was 2.4 (Agree) while the median 2. The results for the item are presented in Table 8.14.

Table 8.14: Item 1, Benevolence in the Trust Construct

	Frequency (n = 361)	**Percentage (%)**
1 (Agree strongly)	55	15.2
2 (Agree)	169	46.8
3 (Neutral)	68	18.8
4 (Disagree)	59	16.3
5 (Disagree strongly)	10	2.9
Total	361	100.0

The second item addressed whether the participants were concerned that information that had been reported could be used for something other than the intended purpose. The mean for this item was 2.62 (Agree) and the median 2. The item stated "*I do not worry if the information provided will be used for something other than the intended means*". The results for this item are depicted in Table 8.15.

Table 8.15: Item 2, Benevolence in the Trust Construct

	Frequency (n = 361)	**Percentage (%)**
1 (Agree strongly)	48	13.3
2 (Agree)	161	44.5
3 (Neutral)	53	14.7
4 (Disagree)	76	21.1
5 (Disagree strongly)	23	6.4
Total	**361**	**100.0**

The benevolence and reliability factors of the public safety, participatory crowdsourcing system are closely related. As reported, the study population were concerned that the public safety information that was reported via the crowdsourcing system could be modified, while an even larger percentage of the study sample were of the opinion that if the information were disclosed to or used by unauthorised third parties, the end result would be harmful to the individual who had reported the information. The next section

discusses the results for the three categories that contribute to the information security construct, namely, confidentiality, integrity and availability.

8.5.4. Information Security

Kainda et al. (2010) propose that the natural way in which a user interacts with any information system should be considered a secure way. However, the fact is that many information systems are not secure. It is, thus, essential that the crowdsourcing system make use of technology which is secure and which provides sufficient procedural information to ensure the confidentiality, reliability, availability and accountability of the system. If these controls are in place, the sensitive information provided by the user would be protected and the privacy of the user ensured (Karnouskos et al., 2004).

8.5.4.1. Confidentiality

Confidentiality of information refers to the prevention of the disclosure or exposure of information to unauthorised individuals or systems (Whitman & Mattord, 2005). In order to test the importance of the confidentiality of the information reported to the participatory crowdsourcing system, one item was included in the questionnaire. The results for this item will be discussed below.

The participants were asked to consider whether they would prefer to report information anonymously. The majority of participants (72.6%) indicate that they would prefer to report public safety information anonymously when making use of a participatory crowdsourcing system. The results for this item are presented in Table 8.16 and support the findings reported in the previous section, trust. In terms of these latter findings the study sample had indicated that, if the crowdsourcing system was neither reliable nor benevolent; the impact on the user of the system could be negative. The mean for this item was 2.1 (Agree) and the median 2.

Table 8.16: Item 1, Confidentiality in the Information Security Construct

	Frequency (n = 361)	**Percentage (%)**
1 (Agree strongly)	79	21.9
2 (Agree)	183	50.7
3 (Neutral)	79	21.9
4 (Disagree)	15	4.1
5 (Disagree strongly)	5	1.4
Total	**361**	**100.0**

8.5.4.2. Integrity

Integrity refers to the safeguarding of the accuracy and completeness of information and its processing methods (Whitman & Mattord, 2005). The item used in this section asked the participants to consider who had access to the information that had been reported. The results showed that 25% of the participants were concerned about who would have access to the public safety information reported via the crowdsourcing system. The mean for this item was 2.6 (Agree), and the median 2. The results for this item are presented in Table 8.17.

Table 8.17: Item 1, Integrity in the Information Security Construct

	Frequency (n = 361)	**Percentage (%)**
1 (Agree strongly)	56	15.5
2 (Agree)	151	41.8
3 (Neutral)	61	16.9
4 (Disagree)	75	20.8
5 (Disagree strongly)	18	5.0
Total	**361**	**100.0**

The last category for this construct, availability, will be discussed in the next section.

8.5.4.3. Availability

The crowdsourcing system is intended for emergency reporting and, thus, it is essential that information reported be reliable and available when needed. According to Carlsson, Henningson, Hratinski and Keller (2011), the availability of the information is concerned with ensuring that authorised users have access to both the information and the associated assets when required. The majority of the participants (86.6%) indicated that they believed that the information should be available 100% of the time in order to be useful. The mean for this item was 1.8 (Agree strongly) and the median 2. The results for this item are depicted in Table 8.18.

Table 8.18: Item 1, Availability in the Information Security Construct

	Frequency (n = 361)	Percentage (%)
1 (Agree strongly)	146	40.4
2 (Agree)	167	46.2
3 (Neutral)	36	10.0
4 (Disagree)	10	2.8
5 (Disagree strongly)	2	0.6
Total	**361**	**100.0**

This section presented the results for the information security construct with confidentiality, availability and integrity being discussed in the various sections. The majority of the study participants reported that they would prefer to report public safety matters to the participatory crowdsourcing system anonymously, while a quarter indicated that they were concerned about who would have access to the public safety information that had been reported. The vast majority of participants, however, felt that, if for the public safety, participatory crowdsourcing were to be of use, it would have to be available all the time. The next section will discuss the dependent variables in the study.

8.6. Dependent Variables in the Study

Two items were included in the questionnaire in order to test the overall impression of the participants as regards to the use of a participatory crowdsourcing system to report public safety matters.

The first item in this category tested the intention of the participants to make use of the participatory crowdsourcing system if they wished to report another public safety matter in the future. The majority (82.2%) of the participants indicated that they would use the system in future to report public safety matters, 5% indicated that they were undecided, while 11.9% indicated that they would not make use of the system in future. The results for this item are presented in Table 8.19 below.

Table 8.19: Future Intent of Participants

	Frequency (n = 361)	Percentage (%)
1 (Agree strongly)	109	30.2
2 (Agree)	188	52.1
3 (Neutral)	43	11.9
4 (Disagree)	18	5.0
5 (Disagree strongly)	3	0.8
Total	**361**	**100.0**

The second item in this category asked the participant to consider the mode which would be more convenient to use to report public safety matters. The choices provided included SMS or an IVR system. The median for this item was 3, thus indicating that participants were undecided as regards the two modes while the mean (2.96) indicated a slight preference for a SMS service. Figure 8.2 depicts the preferences of the participant for SMS (38.5%) or an IVR system (38%).

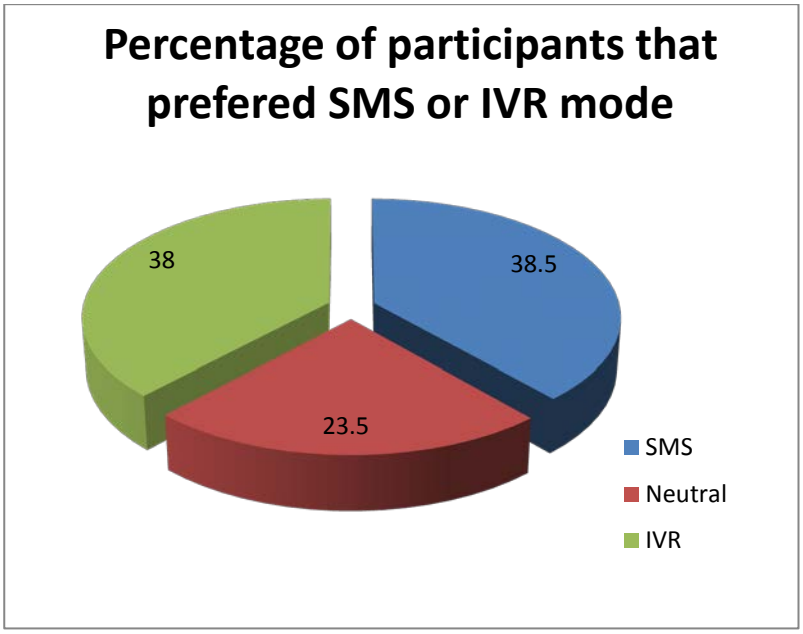


Figure 8.2: Percentages for Different Modes to Report a Public Safety Matter

The demographic data obtained from the questionnaire and the descriptive statistics for each item in the questionnaire were discussed in this section. The remainder of the chapter discusses the statistical analysis of the data collected using the questionnaire. The next section examines the validity of the questionnaire used in this study.

8.7. Validity of the Measuring Instrument

The validity of a scale refers to whether the items of the scale actually measure the constructs they are supposed to measure. The first step in the data analysis process involved assessing the discriminant validity of the research instrument, namely, the questionnaire. Factor analysis was used, specifically principal component analysis with an oblimin rotation method with Kaiser Normalisation.

No exploratory factor analysis was conducted in respect of the dependent variables ("*Would you make another call to report another public safety matter"* and *"If, given a choice, I would rather use a text based (SMS) system to report public safety*") as it was considered that this would be pointless in view of the diversity of measures making up this variable. As a consequence it was anticipated that no underlying dimensions of this measure would exist.

Common factor analysis was used to identify the various categories measured by the constructs. This was done by extracting the combinations of constructs which explained the greatest amount of variance. Based on the literature review discussed in Chapter 5, nine independent categories were identified and grouped into three different constructs, namely, trust, information security and user satisfaction. These constructs were then subjected to a factor analysis process in order to group them into meaningful clusters and verify their unidimensionality. As anticipated, the eigenvalues in combination with the scree test suggested that three constructs or factors would be appropriate.

These factors, trust, information security and user satisfaction, were identified through six iterations. The factors that did not load higher than 0.300 were deleted. This cut off point was based on the exploratory nature of the study. In view of the fact that the aim of this research project was to develop a public safety participatory crowdsourcing model, it was deemed prudent not to make the cut off point too high as possible factors may have been left out that may have affected the success of the model. Regression will be used to test the results (section 8.15) in order to establish the significance of the factors identified in this section. Accordingly, a cut of point of 0.300 was deemed satisfactory for the purposes of this study.

Table 8.20: Rotated Factor Loading

	Factors		
	1 User Satisfaction	2 Trust	3 Information Security
T4	.916		
U1	.656		
U4	.589		
S2	.584		
U6	.572		
U3	.337		
T6		.837	
T5		.734	
T3		.602	
T7			.794
S1			.680
S3			.325

Table 8.20 depicts the factor loadings in respect of the constructs that were tested. The table indicates that a total of 12 items were grouped into three factors. Each of the items in the questionnaire was assigned a unique number before the factor analysis. These numbers may be found in section 8.12.4, Table 8.25. After due consideration by the researcher, the three factors were termed user satisfaction, trust and information security according to the items that loaded in each of the factors. The next section discusses the reliability of the measuring instrument.

8.8. Reliability of the Measuring Instrument

The reliability of a scale refers to the consistency or the stability of a scale. The most popular test of reliability is that of internal consistency where the consistency of constructs in a summated scale is measured. The belief is that, as the variables are measuring the same scale, they should all be highly correlated (Parasuraman, 1991).

The study used the Cronbach's Alpha coefficient to determine the reliability of all the factors which had identified in the exploratory factor analysis. Cronbach's Alpha values of 0.70 and above are typically employed as a rule of thumb to denote a good level of

internal reliability; values between 0.50 and 0.69 denote an acceptable level of reliability while values below 0.50 denote poor and unacceptable levels of reliability (Bryman & Bell, 2007). All of the factors identified recorded a Cronbach's Alpha coefficient score in excess of 0.650 and were, therefore, considered to be at an acceptable level of reliability. These results are discussed below in conjunction with the relevant factors.

8.9. The Factors Identified by Means of Factor Analysis

As discussed previously, three factors were identified in respect of the variables that would determine the successful implementation of a public safety, participatory crowdsourcing smart city project in a developing country. These three factors will be discussed individually in the next section. The Cronbach's Alpha coefficient values, the eigenvalue, factor loading, item to total correlation and the Cronbach's Alpha value after deletion are indicated for each factor.

8.9.1. Factor 1: User Satisfaction

Three different aspects were identified for this construct in Chapter 5. These included system quality, interface quality and the usefulness of the system. The questionnaire used six items (U1, U2, U3, U4, U5 and U6) to measure the various aspects for user satisfaction. Four of these items (U1, U3, U4 and U6) loaded on a single factor as expected while factors U2 and U5 did not load on any factor and were deleted.

Items T4 and S2 also loaded on this factor. While item T4, '*Will the information I provide increase the productivity of the Buffalo City Municipality?*', was originally included in the trust factor in order to test the ability of the crowdsourcing system, T4 also related to the usefulness of the system. Thus, the information provided via of the crowdsourcing system should be analysed in order to provide useful information that may be used by the BCMM so as to ensure that better use is made of existing resources. The second item, which loaded on this factor, S2, *'I do not worry about who has access to the information that I reported',* was originally included in the information security factor to test the integrity of the crowdsourcing system. The access control to the information recorded by the crowdsourcing system will influence the confidence of the citizens of East London when they make use of the system. If the system is perceived to be trustworthy, the confidence of the citizens in the participatory crowdsourcing system would also increase. In order to

avoid confusion, item T4 was renumbered as U7 and item S2 was renumbered as U8 (see Table 8.21).

Table 8.21: Factor 1 - User Satisfaction

Cronbach's Alpha: 0.796					
Item number	New Item number	Item	Factor Loading	Item-Total correlation	Cronbach's Alpha after deletion
T4	U7	Will the information I provide increase the productivity of the Buffalo City Municipality	0.916	0.274	0.825
U1	U1	The overall length of the phone call is acceptable in terms of cost	0.656	0.586	0.735
U4	U4	Making use of the IVR system will save me time when reporting public safety matters	0.589	0.588	0.729
S2	U8	I do not worry about who has access to the information that I reported	0.584	0.527	0.746
U6	U6	The IVR system provided information/instructions that was clear	0.572	0.580	0.732
U3	U3	In general, it was easy to use the IVR system to report a public safety matter	0.337	0.715	0.699

It is apparent from Table 8.21 that this factor, user satisfaction, had a Cronbach's Alpha coefficient of 0.796 and, therefore, it may be considered to be a reliable measuring instrument for the factor. The next section will discuss the second factor, trust.

8.9.2. Factor 2: Trust

Based on the literature review that was discussed in Chapter 5, three categories were identified for this factor, namely, ability, reliability and benevolence. The original questionnaire used 8 items (T1, T2, T3, T4, T5, T6, T7 and T8) but three of the items only, T3, T5 and T6, loaded on this factor. Both items T5 and T6 represented the category reliability while item T3 represented the ability of the crowdsourcing system to perform according to expectation. Factors T1, T2 and T8 did not load on any factors and were deleted.

Table 8.22: Factor 2 - Trust

Cronbach's Alpha: 0.765				
Item number	Question	Factor Loading	Item-Total correlation	Cronbach's Alpha after deletion
T6	I do not worry that the information I provided will be modified in any way	0.837	0.666	0.605
T5	The information provided must be accurate, authorized and complete in order to be useful	0.734	0.608	0.673
T3	I feel confident about the system's ability to process my public safety matter	0.602	0.523	0.766

It is apparent from Table 8.22 that the trust factor had a Cronbach's Alpha coefficient of 0.765 and, therefore, it may be considered a reliable measuring instrument for the factor. The next section will discuss the third factor, information security.

8.9.3. Factor 3: Information Security

As discussed in Chapter 5, three categories were identified for this construct, namely, confidentiality, integrity and availability. The questionnaire used 3 items (S1, S2 and S3) to test the three categories. Item S2 had previously loaded on Factor 1 and was

renumbered to U8. For this factor, items S1, S3 and T7 loaded. Item T7, '*If the information I reported was improperly disclosed to a third party, the impact on me could be potentially devastating*', was originally included in the questionnaire to test the benevolence category in the trust factor. This item refers to the consequences for the user of the crowdsourcing system if information security measures or the integrity of the system is not in place in order to protect information.

Table 8.23: Factor 3 – Information Security

Cronbach's Alpha: 0.688					
Item number	New Item number	Question	Factor Loading	Item-Total correlation	Cronbach's Alpha after deletion
T7	S4	If the information I reported was improperly disclosed to a third party, the impact for me could be potentially devastating	0.794	0.531	0.532
S1	S1	I prefer to provide information anonymously	0.680	0.547	0.506
S3	S3	The information must be available 100% of the time in order to be useful	0.325	0.407	0.712

It is apparent from Table 8.23 that this factor had a Cronbach's Alpha coefficient of 0.688 and, therefore, it may be considered a reliable measuring instrument for the factor information security. The dependent variables will be discussed in the next section.

8.9.4. Dependent Variables

As mentioned previously, the dependent variables were not included in the factor analysis as it was not anticipated that they would load on a single factor. The two items, '*Would you make another call to report another public safety matter?*' and '*If, given a choice, I*

would rather use a text based (SMS) system to report public safety matters' were included in the questionnaire as dependent variables and will be discussed in Table 8.24 below.

Table 8.24: Dependent Variables

Cronbach's Alpha: 0.683				
Item	Question	Factor Loading	Item-Total correlation	Cronbach's Alpha after deletion
G1	Would you make another call to report another public safety matter?	N/A	0.518	0
G2	If, given a choice, I would rather use a text based (SMS) system to report public safety matters	N/A	0.518	0

It is apparent from Table 8.24 that this factor has a Cronbach's Alpha coefficient of 0.683 and it may, therefore be considered a reliable measuring instrument for the dependent variables. Table 8.25 represents the changes that were made after the factor analysis had been completed with the grey areas representing items that were deleted. Items that loaded on a different factor than the factor for which they were originally included are also indicated.

Table 8.25: New Factors and Categories Indicated after Factor Analysis (Grey Areas Indicate items and Categories that did not Load on for any Factor)

Old number	New number		General	User Satisfaction			Trust			Information security		
				System Quality	Usefulness of the system	Interface quality	Ability	Reliability	Benevolence	Confidentiality	Integrity	Availability
G1	G1	Would you use the system in the future to report public safety matters?	X									
G2	G2	If, given a choice, I would rather use a text based (SMS) system to report public safety matters	X									
U1	U1	The overall length of the phone call is acceptable in terms of cost		X								
U2		The voice prompts allowed me to navigate the IVR system efficiently		X								
U3	U3	The IVR system is an effective way to report a public safety matter		X								
U4	U4	The IVR system is an effective and efficient means of reporting a public safety matter			X							
U5		The IVR system provided sufficient information for me to report my public safety matter				X						
U6	U6	The IVR system provided information/instructions that was clear				X						
T4	U7	Will the information I provide increase the productivity of the Buffalo City Municipality			X ←		X					
S2	U8	I do not worry about who has access to the information that I reported		X ←							X	
T1		Overall, were you satisfied that you could report your public safety matter?					X					
T2		I trust the system to reflect my public safety matter correctly					X					
T3	T3	I feel confident about the system's ability to process my public safety matter					X					
T5	T5	The information provided must be accurate, authorized and complete in order to be useful						X				
T6	T6	I do not worry that the information I provided will be modified in any way						X				
T8		I do not worry if the information provided will be used for something other than the intended means							X			
S1	S1	I prefer to provide information anonymously								X		
S3	S3	The information must be available 100% of the time in order to be useful										X
T7	S4	If the information I reported was improperly disclosed to a third party, the impact for me could be potentially devastating							X →		X	

This section discussed the results of the factor analysis. The three factors identified, user satisfaction, trust and information security, were discussed in detail. The next section discusses the correlation analysis that was used.

8.10. Correlations

Correlations analysis is used to identify and evaluate the strength and direction of the relationships that exist between the variables and the multicollinearity of these relationships. The Pearson correlation was used to determine the relationship between the dependent variable, the successful implementation of a participatory crowdsourcing system, and the three factors, user satisfaction, trust and information security, which were identified in the previous section. Pearson correlation was used because all the variables were appropriately centred and normally distributed (Bryman, 2012). The relationships are evaluated using Cohen's criteria (Salkind, 2010):

- 0.1 – small correlations;
- 0.3 – moderate correlations;
- 0.5 – large correlations and
- 0.8 – extremely large correlations.

A Pearson correlation of +1 points to a perfect positive linear relationship or correlations between the variables, while a Pearson value of 0 indicates an uncorrelated relationship between the variables. This, in turn, means that the closer the coefficient is to 1, the stronger the correlations between the variables (Bryman, 2012). The correlation matrix is presented in Appendix F in order to show the relationships that existed between the variables measured.

The dependent variable was shown to have a strong correlation with the user satisfaction (0.534) and information security (0.559) factors and a small correlation with the trust factor (0.127). Similarly, the user satisfaction factor was found to have a large correlation with the information security factor (0.525) and a small correlation with trust (0.135). However, the factor information security had a bigger correlation with the trust factor (0.204) than with the user satisfaction (0.135) factor. In addition, the dependent variable tested statistically significant for all three factors with user satisfaction, trust and information security all recording p-values of less than 0.01.

The relationship between the different factors also tested statistically significant ($p < 0.01$). The next section will discuss the results of the multiple regression analysis.

8.11. Multiple Regression Analysis

Multiple regression analysis is used to explore the relationships between the dependent and the independent variables. The summary of the results of the multiple regression analysis and the variance analysis for the dependent variables are presented in Table 8.26.

Table 8.26: Regression Analysis Summary

Dependent variables	Independent variables	Coefficient	Beta	R2	F	Sig.
Successful implementation of crowdsourcing model	User Satisfaction	1.22	0.332	0.392	76.796	0.00
	Trust	0.002	0.003			0.936
	Information Security	0.235	0.384			0.00

The relationships between the dependent variable and the independent variables were tested using regression analysis. A significance level of $p < 0.01$ was chosen for this analysis and the criteria for multicollinearity were set at a tolerance value of more than 0.25 and the VIF value not exceeding 4 (Hair, 2010). An analysis was conducted to ascertain whether the data met the assumption of collinearity. However, the analysis indicated that multicollinearity was not a concern in this research project (see Appendix F).

It is evident from the results presented in Table 8.26 that user satisfaction and information security do have a significant impact on the implementation of a public safety participatory crowdsourcing model and that, together, these variables explain 39.2% ($R^2 = 0.392$) of the total variance of ouput control. Based on the beta weights, trust (Beta weight = 0.003; $p > 0.05$) was not shown not to impact significantly on the dependent variable. The predictive variable, trust, also showed the weakest relationship of the three predictive factors to the outcome variable.

The analysis of variance showed that the model is fit because the significance value is $p < 0.01$. Of the two variables, user satisfaction and information security, included in the model, information security is the most important variable predicting the successful implementation of a public safety participatory crowdsourcing model (Beta value = 0.384).

8.12. Summary of the Validation of the Questionnaire

The proposed model to implement a public safety, participatory crowdsourcing, smart city project in a developing country was introduced in Chapter 7 and is depicted in Figure 8.3. The main findings from the user review will be discussed next.

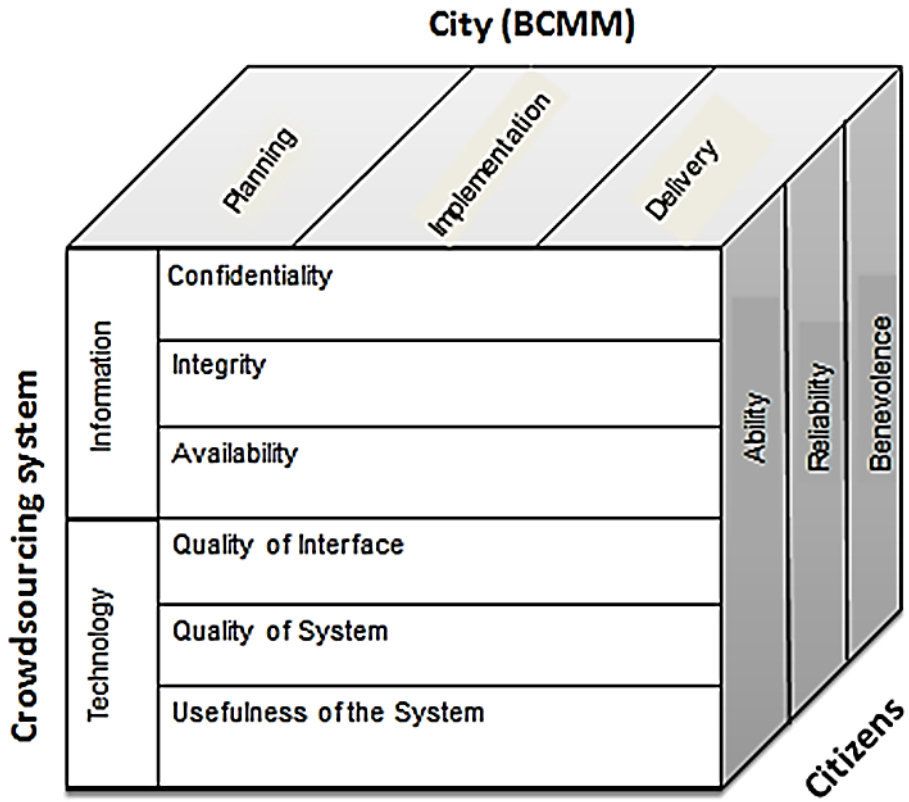


Figure 8.3: PSPC Smart City Model for a Developing Country

Crowdsourcing system – Information

This factor loaded for all three categories identified by the CIA triad discussed in Chapter 5, namely, confidentiality, integrity and availability.

- **Confidentiality**

Sixty-two percent of the participants indicated that, if the information reported was disclosed to a third party; this would have negative repercussions for the individual reporting the information. Subsequently, 72.6% of the study participants indicated that they preferred to make use of the crowdsourcing system anonymously.

- **Integrity**

It was found that 43% of the participants acknowledged that they were concerned about who had access to the public safety information that they had reported, while 62% believed that, if the integrity of the information were to be breached, this would have a negative impact on the individual reporting the information. The reason for these negative perceptions is that the individual reporting the information has no control over what happens to the information.

- **Availability**

The majority of the participants agreed that the system should be available for 100% of the time to be useful (86.6%) with the reason for this being that the crowdsourcing system would be used to report public safety matters which may require the emergency services to respond and, thus, the system should be available at all times. On the other hand, in order to provide a timely response, it is essential that the authorities such as the police and emergency services have access to the information that has been reported in a usable format and familiar language.

During the launch of the crowdsourcing system, technology problems were experienced. These problems meant that the system was not available 100% of the time. The technology problems included electricity outages and hardware failure. This, in turn, also meant that the project website was not always accessible and the participants were not able to register for the project during this time. However, these are typical problems that may be expected in a developing country and they must be considered and catered for when a public safety, participatory crowdsourcing smart city project is implemented. The next section will discuss the technology factor.

Crowdsourcing System – Technology

This factor loaded for all three of the categories identified for the usability of the public safety participatory crowdsourcing system in Chapter 5, namely, quality of the system, quality of the interface and the usefulness of the system.

- **Interface Quality**

The confidence of the citizens in the crowdsourcing system will be affected by their experience with the crowdsourcing system. In view of the fact that this technology has not been used in the public safety domain in East London before, and an asynchronous interface was used, the researchers anticipated some problems in this area.

The public safety participatory crowdsourcing system prototype was developed using of more than 20 iterations. The reason for this number of iterations was to anticipate and solve any problems that were experienced during the pilot phase of the development of the system. Some of the problems encountered included the following:

- The inability of the speech software to understand the answers provided by callers as a result of the large number of accents in South Africa. This problem was solved by providing a sample of as many accents as possible prior to the system going operational in order to train the speech software.
- The non-input time allowed for recording the public safety event was too short and, thus, users were cut off before they had started speaking. The non-input time was, therefore, extended from 3 seconds to 5 seconds.
- The time which was allowed to elapse between the recording of the message and the next voice prompt was too long. This, in turn, resulted in the caller becoming confused. The time period was shortened in order to allow the next voice prompt to start almost immediately.
- The '*yes/no*' prompts and '*press 1 for yes and no for 2*' prompts were played right after each other instead of waiting for a voice input before the numeric option was given.

The iterations were concluded before the system went operational. The benefit of the exercise was evident in the fact the majority of the study participants reported that they had found the crowdsourcing system to be understandable (92.4%) and provided sufficient information to enable them to report their public safety matters (94.4%)

- **System Quality**

Based on the conversational analysis, the high unemployment and poverty rates were identified as possible barriers to the successful implementation of a public safety, participatory crowdsourcing, smart city. In addition, the cost of mobile phone calls is expensive in South Africa and may have contributed to participants not participating in the smart city project. However, the majority of the study participants (82.8%) indicated that

the length of the phone call was acceptable in terms of cost, while 83.6% indicated that the voice prompts were an efficient way in which to navigate the participatory crowdsourcing system.

- **Usefulness of the System**

The participants indicated that they felt the participatory crowdsourcing system would contribute positively to increasing public safety in the city. Public safety was chosen as the context of this study as crime affects the quality of life of all citizens in East London. The response from the study participants was overwhelmingly positive with 75.0% indicating that the crowdsourcing system was an effective way in which to report public safety matters, while 75.6% indicated that the system had the potential to improve the productivity of the BCMM.

Citizens −Trust

The third factor, trust, did not test statistically significant as a control measure in a public safety, participatory crowdsourcing system but, after due consideration, was included in the smart city model in the citizen component. The reason for this decision was that trust is a complex and subjective issue that may be used in either individual or organisational relationships. The possibility exists that the study participants had not understood the concept of trust correctly as no definitons were provided prior to administering the questionnaire. Alternatively, the citizens may have considered the trustworthiness of the BCMM and not that of the crowdsourcing system.

In addition, no system is 100% secure and, thus, there will always be a level of risk assoicated with any system. One of the many reasons why the citizens of East London may not participated in the project may be that they did not trust the participatory crowdsourcing system to reflect their public safety matters correctly. Participation may, therefore, be regarded as a measure for the level of trust in the public safety, participatory crowdsourcing system and is, thus, included in the smart city model.

- **Ability**

The ability of the system was tested making use of the following item: '*I feel confident about the system's ability to process my public safety matter*'. As regards the usefulness of the crowdsourcing system, 76% percent of the study participants perceived the public safety, participatory crowdsourcing system to possess the capability to perform satisfactorily.

- **Reliability**

The second category, reliability, may be defined as a perception that the trustee prescribes to the principles that the trustor finds acceptable. The majority of the participants (88.6%) agreed that the system was reliable.

- **Benevolence**

In order to test the perception of the participants regarding this category, two items were included in the questionnaire. The first item, '*If the information I reported is improperly disclosed to a third party, the impact on me could be potentially devastating*', reports on the impact that the information which has been reported may have on the trustee if it were accessed by an unauthorised person. Overall, the majority of the participants (62.0%) believed that, if the information reported to the participatory crowdsourcing system were disclosed to a third party, this would have negative consequences for the individual who had reported the said information. The second item asked the participants about the possibility of this happening. It was found that 58% of the participants did not believe that the information which had been provided would be used for something other than the intended purpose.

8.13. Conclusion

The PSPC smart city model for developing countries was developed from the theoretical foundation of the secondary data – Chapters 2 to 5. As described in this chapter the model was then validated by making use of the results from the primary data analysis conducted in the research project. Thus, the chapter indicates the answers to the primary research item as well as the three sub-items as it provides a validation of the PSPC smart city model for developing countries. The discussion in the chapter also contributes to Guidelines 3 (Evaluation of research) and 5 (Research rigour) in the Design Science Research paradigm.

The chapter started with an explanation of the pilot study that was conducted in order to ensure the user friendliness of the questionnaire. The questionnaire was adjusted in accordance with the feedback that was received from the participants of the pilot study.

A response rate of 81% was recorded for the study. This was attributed to the competition that was held in order to promote participation in the research project. A general discussion about the demographics of the study participant then followed. The majority of

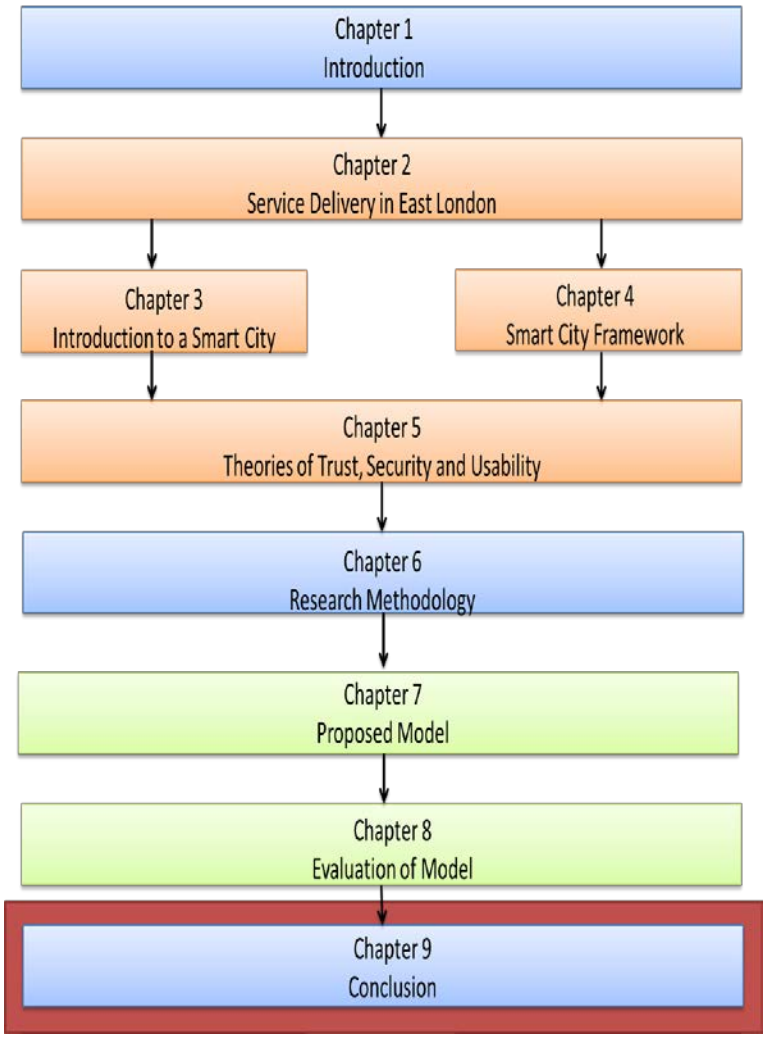
the participants were male (60%), younger than 30 years of age (48%) and had completed at least Grade 12.

The next section provided an overview of the descriptive statistics for each item pertaining to the various constructs that had been identified in Chapter 5. These three constructs were the user friendliness of the system, trust and information security. The participants indicated an overwhelmingly positive attitude towards the crowdsourcing system as regards reporting public safety matters.

The validity and reliability for the questionnaire were then discussed. This was followed by a description of the factor analysis that was used to identify the different factors that had been highlighted by the study participants as playing an important role in the implementation of a public safety, participatory crowdsourcing system in a developing country. The two factors that were identified were user satisfaction and information security. Trust was found not to be statistically significantly but, in view of the fact that trust is a complex issue that must be considered in the implementation of a public safety, participatory crowdsourcing, smart city model in a developing country it was included in the final model.

The results of the regression analysis show that two factors, user satisfaction and information security, have positive significant effects on the successful implementation of a participatory crowdsourcing model. In addition, the R square value of 0.392 indicated that 39.2% of the variation of the successful implementation of a participatory crowdsourcing model is explained by the model. The next chapter will contain the conclusion to the thesis.

Chapter 9
Conclusion



9.1 Introduction

9.2 Research Summary

9.3 Research Questions

9.4 Contribution of the Study

9.5 Theoretical Framework

9.6 Research Methodology

9.7 Limitations of the Study and Recommendations for Future Research

9.8 Concluding Remarks

9.1. Introduction

The previous chapter evaluated the PSPC smart city model for developing countries. The model presented in Chapter 7 was based on critical thought, the arguments presented in Chapters 2 to 5, data which was obtained from the conversational analysis and observations during the building of the crowdsourcing prototype. The model was then evaluated by means of an online questionnaire that was sent to the registered participants of the project.

This chapter provides a summative conclusion to the research project. Firstly, a summary of the research project is provided. The research question and sub-questions are then addressed. This is followed by a discussion of both the contribution made by this study and also the theoretical frameworks that were used in the research project. The limitations of the research project are then described and recommendations made for future research developments in order to provide a brief overview of the expected expansion of the model.

9.2. Research Summary

The literature review created an expectation regarding what the research project would entail. By introducing existing knowledge about the research topic, the researcher supplied a textual guide in terms of moving from the knowledge that is already known and has been reported in literature to the accommodation of new knowledge about a smart city. A detailed summary of the research is presented in Figure 9.1.

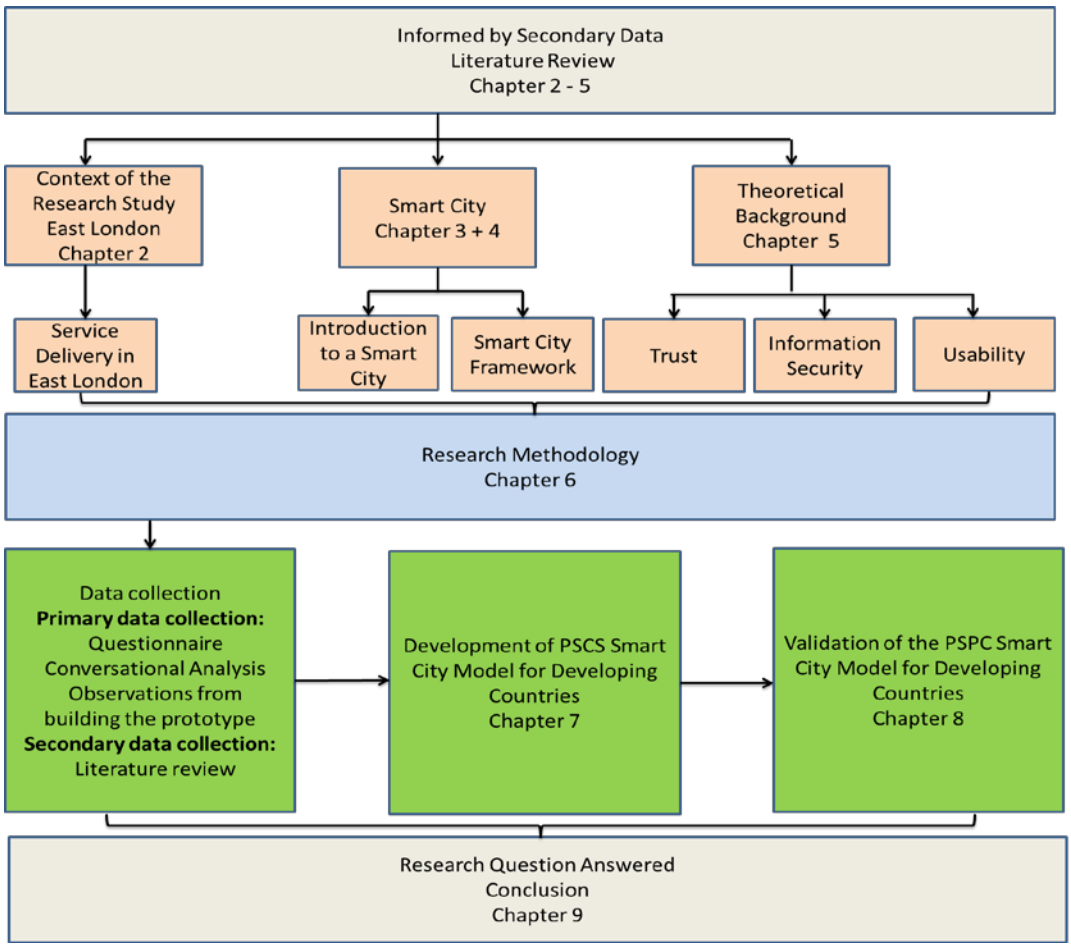


Figure 9.1: Research Project Review

Chapter 1 introduced the research project. The existing literature on smart cities was investigated and the researcher found that there is a lack of academic literature on the topic, probably because the field is still relatively new. In addition, the majority of smart city projects have been are implemented in developed countries. Based on the literature review the following research question for the study was formulated: **What factors need to be in place in order to implement a public safety, participatory crowdsourcing, smart city project in a developing country?**

Three sub-research questions were also formulated to assist the researcher to answer the main research question. These were listed in section 1.5. The PSPC smart city model for a developing country was then briefly introduced and was based on General Systems Theory.

Chapter 2, the first literature review chapter, provided a synopsis of the context in which the study was implemented – the city of East London. A brief overview and history (Section 2.3 - 2.5) of the city was provided in order to highlight some of the challenges facing the Buffalo City Municipality. In 2009 the city became a Metropolitan Municipality (Section 2.5). Unfortunately, the disadvantaged areas that were included in the metropolitan area had not received adequate services or infrastructure prior to 1994. The high degree of urbanisation, as well as the high rates of unemployment and poverty, means that the BCMM is struggling to provide services to the increasing population. An overview of these service delivery problems is contained in section 2.6. East London is classified as a developing city in South Africa and is, thus, characterised by the following typical problems:

- Low standards of living as a result of low income levels, socio-economic inequality, poor health care and inadequate education systems;
- Low levels of productivity as a result of poor education levels;
- Skills and capacity problems;
- High rates of population growth, and
- High and rising levels of unemployment.

The increasing population has also led to the deterioration in public safety, e.g. an increased crime rate. The BCMM does have a dedicated Directorate for Health and Public Safety. Nevertheless, the problems associated with public safety in East London include the lack of coordination between departments and the confusing responsibilities of the various departments (see section 2.7.3).

Chapter 3 introduced the smart city concept and provided insights into what makes a city smart. In view of the fact that this is a relatively new concept, a discussion about the definition of a smart city then followed. This definition was proposed by Caragliu et al. (2009, p. 6): "*The point of departure is the definition which states that a city may be called 'smart' when investments in human and social capital and traditional (transport) and modern ICT communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governmen*t." This was followed by an overview of the technologies that enable a city to become smarter (section 3.4). In section 3.6 the benefits of a city becoming smarter are discussed as it pertains to the various categories identified by Giffinger et al. (2007). The difference between crowdsensing and crowdsourcing is discussed in section 3.5 with the discussion providing an insight into the privacy issues associated specifically with crowdsensing. An overview of the steps that must be followed by a city for the city to become smarter is provided in section 3.8. These are used to develop the model that is discussed in Chapter 8. Some examples of smart city, public safety projects in both developing and developed countries are described in section 3.7.

Chapter 4 provided an overview of the literature, with particular focus on the models that have been introduced in the smart city domain. The models of Nam and Pardo (2011) (section 4.2) and, in particular, Chourabi et al. (2012) (section 4.3) are discussed in detail. The eight areas of the model as identified by Chourabi et al. (2012) include technology, people/community, policy, city, governance, built infrastructure, natural environment and the economy.

Chapter 5 introduced the various theories that were considered while developing the PSPC smart city model for a developing country. The literature suggests that trust and, subsequently, participation, in the system would increase only if the user were to make use of the crowdsourcing system and then received positive feedback from the system while the risk associated with the system were minimised. The trustworthiness of the crowdsourcing system was investigated in detail in order to establish the factors that would be necessary in order to generate trust in the system (section 5.2). The definitions (section 5.2.1), need for trust (section 5.2.2) and the benefits of trust (section 5.2.3) were then discussed. The Model of Trust as proposed by Mayer et al. (2005) was used to describe the various categories, namely, ability, reliability and benevolence that determine the trustworthiness of the crowdsourcing system.

The chapter then used Uncertainty Reduction Theory (section 5.2.6) to investigate the risk associated with the system. The usability and, specifically, user satisfaction with the

crowdsourcing system, was included in the questionnaire in order to measure the confidence of the participants in the crowdsourcing system. User satisfaction was found to encompass three aspect of the crowdsourcing system, namely, information quality, interface quality and the usefulness of the system (section 5.4). In order to minimise the risk associated with the crowdsourcing system, it was established that control measures could be used in the absence of trust in order to mitigate risk. If such control measures are instituted, the following categories would then be in place, namely, the confidentiality (Section 5.3.4.1), integrity (Section 5.3.4.2), and availability (Section 5.3.4.3) of the information.

The research methodology of the study was the focus of Chapter 6. The research methodology selected was directed by the research question. The research methodology process was conducted in two phases. Phase 1 comprised an extensive literature review on the basis of which a conceptual framework was devised. Part of phase 1 involved identifying the appropriate research paradigm (section 6.2.6) and research methodology (section 6.6) to be used in this research study. A Design Science Research paradigm was deemed to be the most appropriate for the purposes of this research project while the guidelines, as proposed by Hevner et al. (2004), were adopted for the study. Phase 2 involved the data collection, data analyses and the research findings and the conclusion as to whether the research questions had been answered.

The model was introduced in Chapter 7. The way in which the various parts of the model fit together is analysed using General Systems Theory in order to describe the '*whole*'. The emergent property, which is represented in the form of a model or artefact is a public safety, participatory crowdsourcing system.

Chapter 8 deals with the validation of the PSPC smart city model for a developing country. An online questionnaire was sent to the study participants and the findings from the questionnaires were analysed. A summary of the descriptive statistics is provided (section 7.6) for each category of the questionnaire as well as of the factor analysis that was conducted (section 7.8–7.13). The next section will discuss how the research question and sub-questions were answered.

9.3. Research Questions

Due to the increasing population in cities, local government is struggling to provide adequate services to the city. In order to improve poor service delivery, it is essential that

cities find a way to use information more intelligently in order to consume resources more effectively and efficiently. One solution is to make use of smart cities. Smart cities have been implemented in developed countries, but these countries have different characteristics and challenges than developing countries. Therefore, there is a need for a model to implement a public safety, participatory crowdsourcing, smart city project in a developing country. Accordingly, this study investigates the following research question: **What factors need to be in place in order to implement a public safety, participatory crowdsourcing, smart city project in a developing country?**

In order to answer the main research question, the following four sub-questions were identified.

- **How can a smart city improve public safety in a developing country?**

The first sub-question is addressed in Chapters 3 and 4 where the various benefits of a smart city in a developing country were discussed. Some examples of the public safety, smart city projects that have been implemented around the world were also discussed. Chapter 2 also provided the context of this research project – the city of East London. It was established that East London is a developing city. The various problems that contribute to the poor level of service delivery in the city were then identified. These two chapters established the grounds on which a possible model could be considered.

- **How does the trust factor effect the implementation of a public safety, participatory crowdsourcing, smart city in a developing country?**

This sub-question was addressed in Chapter 5, sections 5.2 to 5.2.6. This sub-question investigated the way in which the trustworthiness of the crowdsourcing system would influence the implementation of a public safety, participatory crowdsourcing, smart city project in a developing country. The Model of Trust, as proposed by Mayer et al. (1995), was used to identify the various categories that would determine the trustworthiness of the public safety, participatory crowdsourcing system. Thesec ategories included the ability, reliability and benevolence of the system. It emerged from the user analysis presented in Chapter 8 that the participants rated the public safety, participatory crowdsourcing system implemented in the project positively as regards to all three categories. While benevolence did not load during the factor analysis, it was included in the final model as it is considered important for the implementation of the PSPC smart city project for developing countries. Possible reasons for the inclusion of benevolence included the complexity of the concept of trust and the lack of understanding of the definition of benevolence on the part of the participants

- **How does the information security factor effect the implementation of a public safety, participatory crowdsourcing, smart city in a developing country?**

This sub-question was addressed in Chapter 5, sections 5.3 – 5.3.3.5. If the citizens are to trust the participatory crowdsourcing system, it is essential that the risk associated with reporting information to the system be minimised. The CIA triad, based on ISO/IEC 27002, was used to depict the information security that should be incorporated into the public safety, participatory crowdsourcing system. The three pillars of the triad, namely, confidentiality, integrity and availability, were confirmed during the validation of the model (Chapter 8) as factors that must be present in order to implement the PSPC smart city project for developing countries. These three categories are especially important in a public safety context where the information reported must be complete and accurate in order to ensure the correct response from the emergency services.

- **How does the usability factor effect the implementation of a public safety participatory crowdsourcing smart city in a developing country?**

The trustworthiness of the public safety participatory crowdsourcing system would increase if the citizens make use of the system and have a positive experience. This research sub-question was discussed in Chapter 5, sections 5.4 to 5.4.3.2. The confidence in the system was investigated using the usability factors of the crowdsourcing system. These three aspects of the crowdsourcing system included the quality of the system and interface as well as the usefulness of the crowdsourcing system. All three of the factors are present in the the PSPC smart city project for developing countries. It emerged from the user review that the users had viewed all three of the aspects positively.

Once the research questions had been answered, a model to implement a public safety, participatory crowdsourcing, smart city project in a developing country was developed. The model was introduced in Chapter 7.

9.4. Contribution of the Study

Golden-Biddle and Locke (2007, p. 10) state that "*an idea becomes a contribution when it is construed as important by the members of a scholarly community, relative to the accepted knowledge constituted by the field's written work*". Literature on how to implement a public safety, participatory crowdsourcing, smart city project in a developing

country is limited at present and, thus, this research project makes a valuable contribution to this field.

While resources such as health, water and electricity are finite, the population to which these services must be provided is increasing. This, in turn, means that new and innovative methods must be found to ensure that these finite resources are used more effectively and efficiently. Smart cities are still a relatively new field of study and, therefore, there is relatively little literature available on the subject. This is evident in the lack of a common definition of the term smart city.

While some projects have been launched to transform cities into smart cities, these have taken place primarily in the developed countries. However, as compared to the developed countries, the developing countries, where smart innovation is needed, face different challenges that must be considered when smart cities are implemented. These challenges include low literacy rates, high poverty and unemployment rates and the lack of technology infrastructure. Thus, the main purpose of this research project was to develop a model for the implementation of a public safety, participatory crowdsourcing, smart city project in a developing country. The PSPC smart city model is unique as it was developed specifically for developing countries, while taking into account the challenges facing these countries. It is essential that such a crowdsourcing system employ technology that is relevant and available in a developing country. This study showed that crowdsourcing is appropriate for the developing countries as it has low entry level costs and eliminates the privacy fears of citizens. In view of the fact that many developing countries have high illiteracy rates, an IVR system was found to be more suitable than a SMS based system for developing a smart city in a developing country. This, in turn, also eliminated the problems with text-based interfaces during predictive analytics. Cost is also a factor as regards participation in smart cities, especially in view of the fact that poverty is characteristic of developing countries. However, the PSPC smart city model for a developing country takes this into consideration with the system quality aspect.

Table 9.1 provides a summary of the critical areas, problems of a developing country and the specific factors of the model that were included in order to addresses the problems. The first column contains the three areas in the model of Chourabi et al. (2012), namely, city, technology and people/community that contributed to this research project. These areas were identified in Chapter 4.

The next column, critical areas, was also discussed in Chapter 4. As regards to technology, three elements were identified in section 4.4.2 as per the model of Chourabi et al., (2012). The critical elements in the people and community area are included in the

model which was proposed by Sharma (2010). These include vision and strategy, human capital, infrastructure, external environment as well as linkages and trust and were discussed in section 4.4.5. The governance model, proposed by Ferro et al. (2013) and discussed in section 4.4.3, was used for the third factor, city. The three pillars of the governance model, namely, enable, transform and inform, are used.

The characteristics of a developing country in the next column represent a combination of the characteristics mentioned by Kumar et al (2010) and the characteristics of the city of East London discussed in Chapter 2. Typical characterisitcs of a developing city include high poverty and unemployment rates, low literacy rates and the unavailability of technology (Kumar et al., 2010). The city of East London was discussed in Chapter 2 and was determined to be in a developing state. The problems identified that are responsible for the poor service delivery in the city included inadequate infrastructure in the peri-urban areas, internal problems such as political infighting, poor administrative and financial controls, under functioning ward committees and low human resource capacity.

In the last column, the various components of the model are mapped to the critical areas and characteristics of a developing city. Thus, Table 9.1 contains a concise summary of the line of argument that was used in this research project. Based on the preceding chapters, this argument line is presented in a clear, substantiating and convincing manner.

Table 9.1: Summary of the Contribution of the Research Project

	Critical areas	Characteristics of a developing city									Model
		Poor technology infrastructure	High poverty rate	High unemployment rate	Low literacy rates	Political infighting	Legislation not in place	Poor financial controls	Limited citizen participation	Poor skills capacity	
Technology	ICT infrastructure	X				X		X	X	X	**Crowdsourcing system** (Technology) **City** (Planning, Development, Delivery)
	Security and Privacy					X	X			X	**Crowdsourcing system** (Information) **Citizens** (Reliability, Benevolence)
	Operational cost	X				X		X		X	**City** (Planning, Development, Delivery)
People/community	Vision and strategy					X	X	X	X	X	**City** (Planning, Development, Delivery)
	Human capital		X	X	X				X	X	**Citizens** (Reliability, Ability, Benevolence)
	Infrastructure	X				X	X	X		X	**Crowdsourcing system** (Technology) **City** (Planning, Development, Delivery)
	External Environment	X					X		X	X	**City** (Planning, Development, Delivery)
	Linkages and Trust		X	X	X				X		**Citizens** (Reliability, Ability, Benevolence) **Crowdsourcing system** (Information)
City	Enable	X					X	X	X	X	**City** (Planning, Development, Delivery) **Citizens** (Ability) **Crowdsourcing system** (Technology)
	Transform	X	X	X	X	X	X	X	X	X	**City** (Planning, Development, Delivery) **Crowdsourcing system** (Information, Technology) **Citizens** (Reliability, Ability, Benevolence)
	Inform					X			X		**City** (Delivery)

9.5. Theoretical Framework

In order to develop the PSPC smart city model for a developing country, several models, standards and theories were used. These included General Systems Theory, the Model of Trust as proposed by Mayer et al. (1995), Uncertainty Redcution Theory of Berger and Calabrese (1975), the Information Security Standard (ISO 27002, 2005) and, for the defintion of usability, the ISO/IEC 9241-11, 1998 standard.

General Systems Theory is an interdisciplinary theory that may be used to study systems in nature, in society and in many scientific domains, and to investigate phenomena in a holistic way. In other words, it was possible to investigate the research problem of how to implement a public safety, participatory crowdsourcing, smart city system in a developing country by choosing specific components or topics related to the problem and which together represented a solution or the whole.

In their Model of Trust, Mayer et al. (1995) make a distinction between the trustor and trustee characteristics that foster a trusting relationship. In addition, the following three characteristics are proposed that form the foundation for the perception of trustworthiness, namely, ability, benevolence and integrity. Every individual's propensity to trust will differ and, thus, the trustor's propensity which is referred to in the model refers to a general willingness to trust others. The trustor's propensity is influenced by how much trust is instilled in another party before considering any of the trustee's characteristics.

The Theory of Uncertainty Reduction, as proposed by Berger and Calabrese (1975), provides for the reduction of uncertainty at the beginning of a relationship. There will always be a degree of uncertainty in our interactions with others. However, this uncertainty may be reduced by generating and confirming predictions about the behaviour of the other party by making use of an exchange of information about each party (Berger & Calabrese, 1975). Covey (2006) further proposes that trust will affect two outcomes, namely, speed and cost. Thus, as the trust decreases, the control measures put in place to increase the trust result in both a lower speed (less efficient system) and increased cost to various stakeholders.

The CIA triad is an Information Systems security term that relates to data protection. The primary goal of the CIA triad is to assure the confidentiality, integrity and availability of the sensitive and private information or data held by an organisation (ISO/IEC 27002, 2005).

End-user interaction is a prerequisite for designing and developing an appropriate interface and interaction with an information system. One of the most common ways in which to involve users in the software design process is through usability testing. If the crowdsourcing system is viewed as user-friendly by the user, this will increase the confidence of the user and, thus, decrease the risk that is associated with using the system. The definition adopted for the term usability in this research project included three characteristics, namely, effectiveness, efficiency and user satisfaction. These three characteristics were used to evaluate the three different aspects of the public safety participatory crowdsourcing system, namely, interface quality, system quality and usefulness of the system. In the next section the research methodology used in the research project will be summarised.

9.6. Research Methodology

The study was conducted within the Design Science paradigm. The study adopted a mixed method approach. Accordingly, the study made use of both qualitative and quantitative data collection methods. The research project also made use of inductive reasoning.

Having considered the various options for approaching Design Science Research, the study adopted the seven guidelines of Hevner et al. (2004). This is the most widely cited set of guideliens for Design Science Research and was, thus, deemed relevant for the purposes of the study. The seven steps adopted in the research project are briefly discussed below:

- **Guideline 1: Design as an Artefact**

The study produced a model which represents the principles learnt from the protootype in order to implement PSPC smart city model for a developing country.

- **Guideline 2: Problem Relevance**

Public safety projects have been implemented elsewhere in the world, but these have typically been in developed countries. Developing countries face specific problems that would influence the implementation of a PSPC smart city model for a developing country. These include low literacy rates and income levels, high unemployment and the cost and unavailability of technology. In addition, the literature on smart city projects is limited. This, in turn, means that those who wish to make use of smart cities are forced to “re-invent the wheel” with each new project.

- **Guideline 3: Design Evaluation**

In this study the most appropriate method with which to evaluate and validate the artefact was found to be a user review. The results of the user review are discussed in Chapter 8.

- **Guideline 4: Research Contribution**

The contribution of this research project is the improving of lives of people in cities as they participate in the running of their city by providing public safety reports.

- **Guideline 5: Research Rigour**

In terms of rigour, the research project employed valid data gathering and analysis techniques. These were described in Chapter 6. The model was evaluated by means of a user review. The participants were asked to complete a questionnaire about the public safety, participatory crowdsourcing system that had been implemented as part of the research project in East London. The results of the validation were discussed in Chapter 8.

- **Guideline 6: Design as a Search Problem**

This guideline was satisfied by the extensive literature review which had been conducted. In addition, the iterative nature of the research process was achieved through the use of a user review and the building of the public safety, participatory crowdsourcing system prototype.

- **Guideline 7: Communication of Research**

This guideline was satisfied by the publishing of the academic papers included in Appendix B. The publication of the completed thesis will provide an additional avenue in terms of which to communicate the research findings. Feedback will also be provided to the BCMM. The next section will discuss the limitation of this study.

9.6.1. Limitations of the Study and Recommendations for Future Research

The first limitation of the study was the lack of predictive analytics on the information that had been reported via the public safety, participatory crowdsourcing system that was implemented in East London. While it was clearly stated in section 1.10 that this activity was outside of the scope of this research project, it could add valuable insights into the benefits of a smart city project in a developing country.

The second limitation that must be mentioned is the fact that more data would be needed in order to perform the predictive analytics. Thus, more calls would have to be made to the public safety, participatory crowdsourcing system in order to secure enough data that could be used. At present, the cost of telecommunications in South Africa and the high poverty rate in the city of East London may be seen as inhibitors to the collection of more data.

Future research would involve incorporating a motivational model as discussed in section 4.4.5. This motivational model would have to investigate how to attract more callers to make use of the public safety, participatory crowdsourcing system in order to perform the predictive analytics. As discussed in section 4.4.5, it was felt that instant gratification, such as receiving airtime after reporting a public safety matter to the crowdsourcing system, should be investigated as a motivational tool to increase the participation rate.

Another avenue of research could involve the feedback loop that was presented in Figure 1.3 and discussed in section 4.4.5. The feedback loop would be used by the city of East London to provide information about the outcomes of the public safety data that had been reported to the crowdsourcing system. This research would also contribute to the motivational model that was discussed in the previous paragraph.

9.7. Concluding Remarks

This thesis presented a study of the factors that must be present in order to implement a a PSPC smart city model for a developing country. The value of the study may be determined by the impact it has on the implementation of future smart city projects. Overall, the model may be regarded as crucial for the implementation of smart cities in developing countries as these cities have specific requirements that must be taken into consideration if they are to become smarter. If the model proposed in Chapter 7 were used, these requirements would be met and local governments would be able to use the existing resources of their cities more effectively and efficiently.

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APPENDIX MASTER LIST

Appendix A	List of Abbreviations and Definitions
Appendix B	Article presented at World Wide Web Conference, Cape Town, 2013
	Article presented at INEER Conference, Cape Town, 2013
	Article submitted to Journal, December 2013
Appendix C	Project Website
Appendix D	Flyer used as Promotional Material in Project
Appendix E	Online Questionnaire
Appendix F	Correlation Matrix and Collinearity Table

Appendix A

List of Abbreviations and Definitions

List of abbreviations

ASR	- Automatic speech recognition
BCM	- Buffalo City Municipality
BCMM	- Buffalo City Metropolitan Municipality
BLUE CRUSH	- Blue Criminal Reduction Utilising Statistical History
CCTV	- Closed-circuit television
CSI	- Crowdsourcing Safety Initiative
GNI	- Gross National Income
GPS	- Global Positioning System
HCI	- Human Computer Interaction
ICT	- Information and Communication Technologies
IoT	- Internet of Things
IT	- Information Technology
IVR	- Interactive Voice Response
MPD	- Memphis Police Department
PEIR	- Personalised Environmental Impact Reports
SMS	- Short Message Service
SPSS	- Statistical Package for Social Sciences
TMF	- Touch tone dialling

List of definitions

Ability

The skills, competencies and characteristics that ensure the trustee has influence in the relationship with the trustor (Mayer, Davis & Schoorman, 1995).

Availability

The availability of information enables authorised users to access information without interference or obstruction, and to receive it in the required format (Whitman & Mattord, 2005).

Benevolence

Defined as the extent to which the trustee is believed to want to act in the trustor's best interests in the relationship (Mallalieu, 2005).

Confidentiality

Confidentiality of information refers to the prevention of disclosure or exposure of information to unauthorised individuals or systems (Whitman & Mattord, 2005).

Conversational analysis

Technique used to obtain information from voice technology experts in the telecommunication industry. Makes use of teleconferences, e-mails and telephone calls.

Crowdsensing

Collection of data making use of various sensors. These sensors may either be part of the existing infrastructure, such as water or electricity networks, or else citizens with mobile devices may volunteer to attach the sensors to their phones (Demirbas, Bayir, Akcora & Yilmaz, 2011).

Crowdsourcing

Refers to a group of individuals who collect data, or report on certain events of a similar nature, and then pool all the data collected (Mehta, 2011).

Effectiveness

The accuracy and completeness with which users achieve specified goals (Wallace, Reid, Clinciu & Kang, 2013).

Efficiency

The resources expended in relation to the accuracy and completeness with which users achieve goals (Wallace, Reid, Clinciu & Kang, 2013).

Integrity

Information has integrity when it is whole, complete, and uncorrupted (Whitman & Mattord, 2005).

Mxit

Mxit *(pronounced "mix it")* is a free instant messaging application developed by Mxit (Pty) Ltd. in South Africa that runs on on over 8000 devices, including feature phones, Android, BlackBerry, iPhone, iPad, Windows Phone and tablets.

Public safety

Involves the prevention of and protection from events that could endanger the safety of the general public and, thus, expose the general public tosignificant danger, injury/harm, or damage, for example, rime or disasters (natural or man-made) (PSECGC, 2008).

Reliability

Refers to the belief that the person or institution will act in an honest, reliable, and credible manner (Mayer, Davis & Schoorman, 1995).

Satisfaction

The comfort and acceptability of use (Wallace, Reid, Clinciu & Kang, 2013).

Smart City

A smart city makes use of Information and Communication Technologies (ICT) in order to integrate the operation of urban infrastructure and services (Harrison & Donnelly, 2011).

Smart Computing

A new generation of integrated hardware, software, and network technologies that provide Information and Communication Technology (ICT) systems with real-time awareness of the world and advanced analytics to help people make more intelligent decisions about alternatives and actions that will optimize business processes and business balance sheet results (Washburn & Sindhu, 2010).

Trust

Willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party (Mayer et al., 1995).

Appendix B

Article presented at World Wide Web Conference, Cape Town, 2013

Cilliers, L., Flowerday, S. (2013). Trust in a crowd-sourcing system in order to improve public safety. 15th Annual Conference on World Wide Applications, Cape Town, South Africa, 10–13 September.

Article presented at INEER Conference, Cape Town, 2013

Cilliers, L., Flowerday, S., Satt, A. (2013). Can Information Security Produce Trust in a Public Safety Smart City Project? INEER Cape Town, South Africa, 9–11 December 2013.

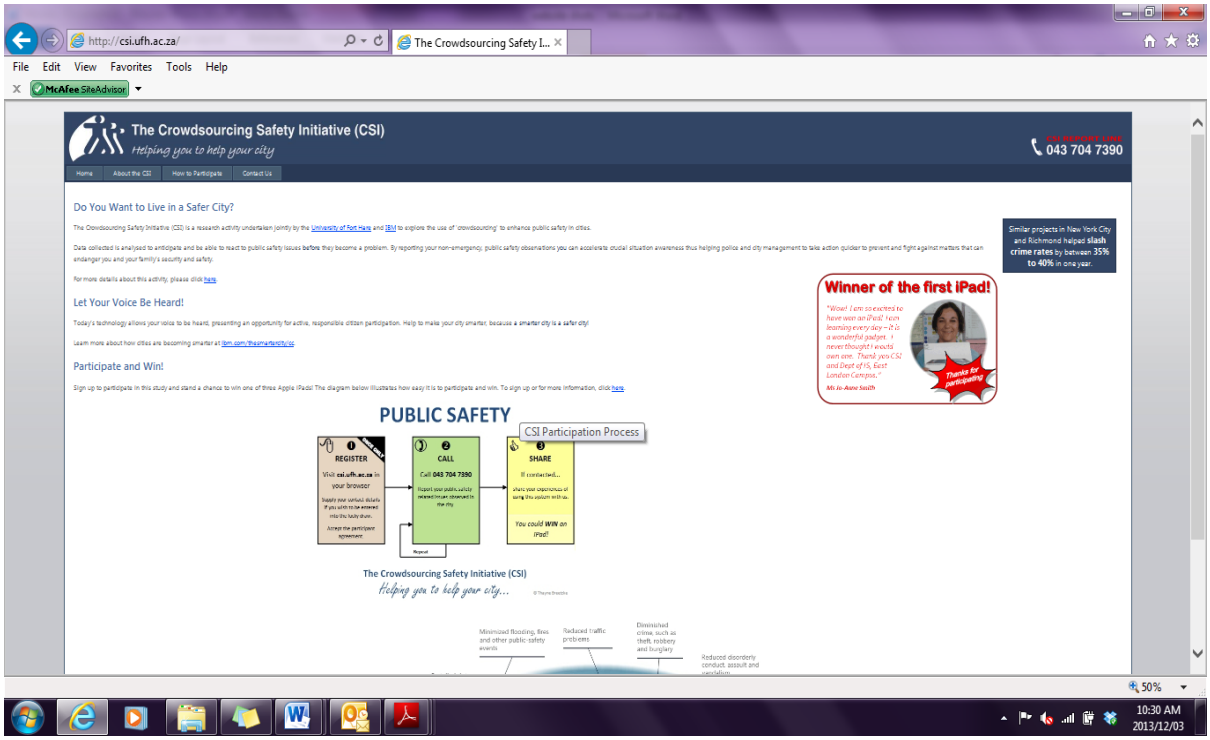
Article under review in journal, December 2013

Cilliers, L., Flowerday, S., Satt, A. (2013). PSPC Smart City model for developing countries. European Journal of Information Systems, under review

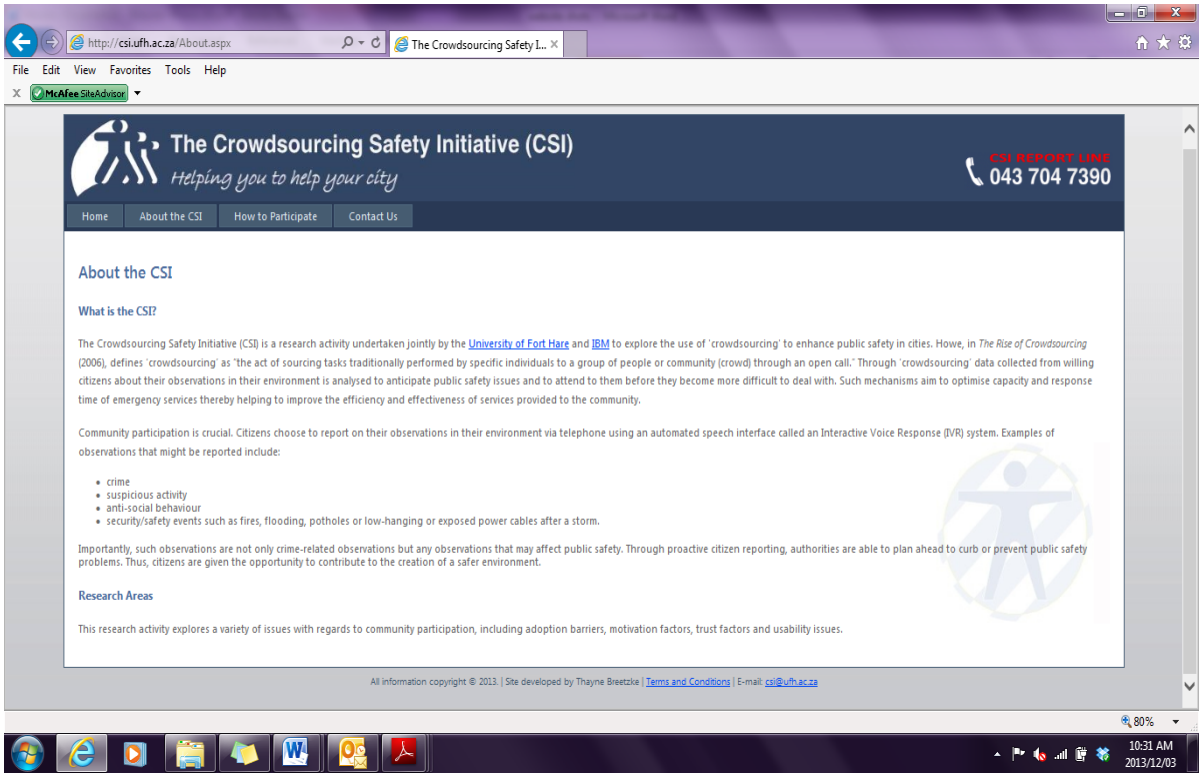
Appendix C

Project Website

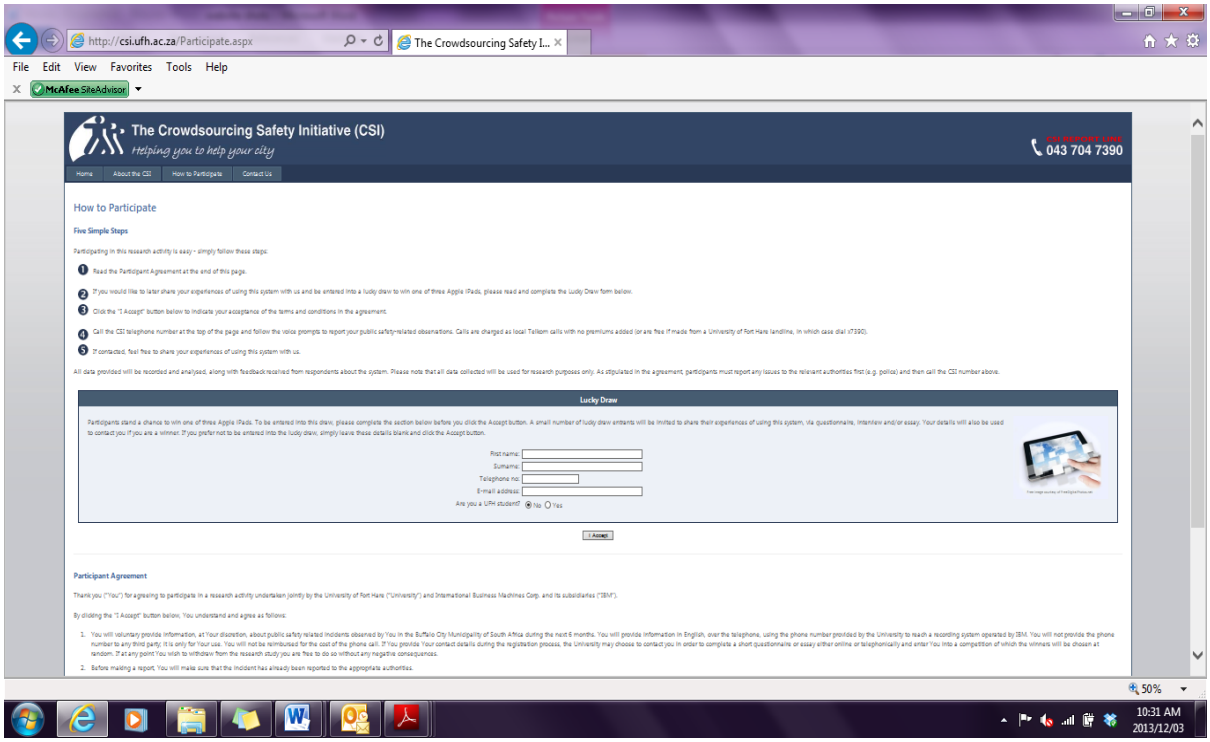
Home page



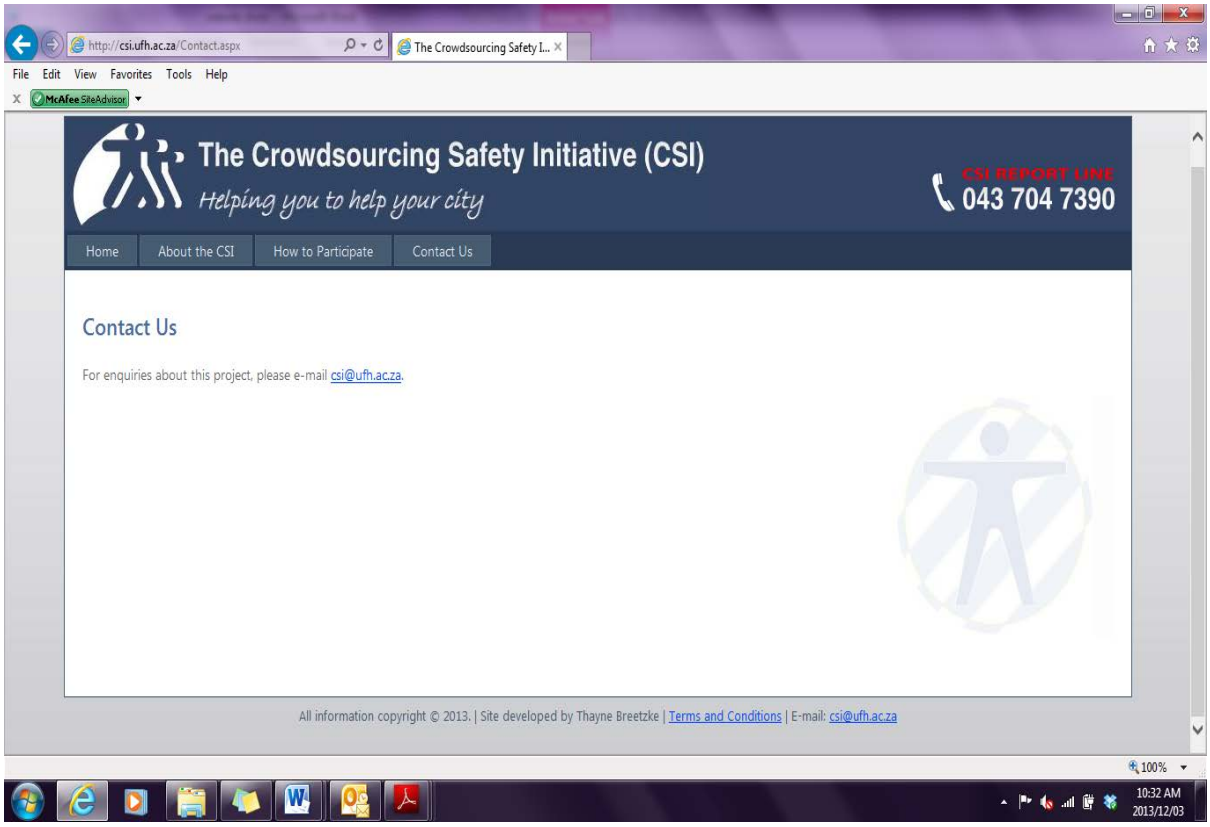
About Us Page



How to participate page



Contact us page



Appendix D

Flyer used as Promotional Material in Project

Appendix E

Online Questionnaire

PAGE 1

What is your age?
What is your gender?
What is your highest qualification?

PAGE 2

	Agree Strongly	Agree	Neutral	Disagree	Disagree Strongly
Would you use the system in the future to report public safety matters?					
If, given a choice, I would rather use a text based (SMS) system to report public safety matters					
The overall length of the phone call is acceptable in terms of cost					
The voice prompts allowed me to navigate the IVR system efficiently					
The IVR system is an effective way to report a public safety matter					
The IVR system is an effective and efficient means of reporting a public safety matter					
The IVR system provided sufficient information for me to report my public safety matter					

PAGE 3

	Agree Strongly	Agree	Neutral	Disagree	Disagree Strongly
The IVR system provided information/instructions that was clear					
Will the information I provide increase the productivity of the Buffalo City Municipality					
I do not worry about who has access to the information that I reported					
Overall, were you satisfied that you could report your public safety matter?					
I trust the system to reflect my public safety matter correctly					
I feel confident about the system's ability to process my public safety matter					
The information provided must be accurate, authorized and complete in order to be useful					
I do not worry that the information I provided will be modified in any way					
I do not worry if the information provided will be used for something other than the intended means					
I prefer to provide information anonymously					
The information must be available 100% of the time in order to be useful					
If the information I reported was improperly disclosed to a third party, the impact for me could be potentially devastating					

Appendix F

Correlations Table

		DependentVariable	TotalUsability	TotalTrust	TotalSecurity
Pearson Correlation	*DependentVariable*	*1.000*	*.534*	*.127*	*.559*
	TotalUsability	.534	1.000	.135	.525
	TotalTrust	.127	.135	1.000	.204
	TotalSecurity	.559	.525	.204	1.000
Sig. (1-tailed)	DependentVariable	.	.000	.008	.000
	TotalUsability	.000	.	.005	.000
	TotalTrust	.008	.005	.	.000
	TotalSecurity	.000	.000	.000	.
N	DependentVariable	361	361	361	361
	TotalUsability	361	361	361	361
	TotalTrust	361	361	361	361
	TotalSecurity	361	361	361	361

Collinearity Diagnostics

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions			
				(Constant)	TotalUsability	TotalTrust	TotalSecurity
1	1	3.812	1.000	.00	.00	.01	.01
	2	.102	6.122	.00	.08	.72	.16
	3	.052	8.537	.30	.16	.12	.73
	4	.034	10.575	.70	.76	.15	.10