A resilience-oriented guiding framework for managing post-disaster reconstruction projects

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A thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy in Civil Engineering, The University of Auckland, New Zealand

2021

Abstract

This research explores the problem of limited success measurement indicators for post-disaster reconstruction project assessment, primarily because of the miniscule inclusion of end-users' perspectives and involvement in project planning and execution, and limited contribution with project objective(s) setting. Consequently, the success of reconstruction projects has traditionally been judged on the metrics of time, cost and quality; however, new resilience-oriented metrics such as satisfaction, sustainability and maintainability have added new success dimensions. The purpose of this research is to develop best practice guidelines for embedding or mainstreaming resilience into project management practice for post-disaster reconstruction projects.

This research thesis focuses on the context of the Caribbean region and the perspectives of Caribbean project end-users (beneficiaries). By using a mixed-methods approach, comprising desktop reviews and a questionnaire survey in four islands (Antigua, Dominica, Grenada and St. Vincent), this research gathered data from 268 people. Factor analysis, multiple regression and structural equation modelling were used for data analysis. Quantitative analysis identfied 26 reconstruction project success factors and 24 resilience factors, among which governance was considered as the most critical and cross-functional factor required for successfully embedding resilience into reconstruction practice.

A resilience-oriented guiding framework for managing post-disaster reconstruction projects is developed with a set of best practice guidelines. The framework is hoped to assist construction industry practitioners and professionals in decision making and planning before a reconstruction project commences.

This research contributes to the body of knowledge in project management by way of evidence-based findings from project end-users' perspective. The guidelines developed from this research can also add value to the Project Management Institute's guidance document for post-disaster reconstruction projects. As the post-disaster reconstruction period is critical for incorporating resilience into communities that are vulnerable to future disaster events, how to monitor and improve resilience performance in reconstruction projects, in coordination with project management knowledge areas, deserves attention for future research.

Dedication

To the three women in my life

My Mom, who taught me that poverty is not an end game, and love for our Almighty God, love for family, and love for self will be a constant combined source of strength for perseverance and survival.

My wife, who supported my quest to achieve this goal and tolerated years of my absence. A testament of your unlimited love. Much appreciated and cherished.

My daughter, who strengthens my resolve to succeed, knowing that amidst life's challenges and adversities, there are positives to explore and be thankful for.

To myself

Motto

Educate to eradicate.

Motivations

Before I formed thee in the belly, I knew thee. **Jeremiah 1:5**

I can do all things through Christ which strengtheneth me. **Philippians 4:13**

Acknowledgements

Greatest thanks to the Almighty Father, my God, my Provider, and my Friend. You have steered the course, helped me navigate this emotional rollercoaster, and help me to be proud of myself.

Special thanks to my supervisors. Most grateful appreciation to Dr Alice Chang-Richards, thank you for believing that I can achieve this goal and, most importantly, your patience throughout the journey. You have been with me through the entire process, from application to completion and without your unwavering support, I did not think any of this would be possible. My deepest gratitude to my second supervisor, A/Prof. Tak Wing Yui; I am also grateful for your mentorship during this journey. Your guidance in my academic development is appreciated, and I want to acknowledge your patience with me. To both of you, your guidance, encouragement, constructive criticism, and source of academic strength will forever be entrenched in my mind and heart.

An extra special thank you to the government and people of New Zealand. Your financial support through the MFAT New Zealand Aid scholarship programme has provided Grenada, through me, the opportunity to help our world with this research output. It is my intention to use the knowledge gained to assist New Zealand and Grenada, as we both suffer the financial, emotional and psychosocial wrath of disasters.

Special thanks to Dr. Suzanne Wilkinson who encouraged me to pursue this journey, long before I was even thinking it was possible. Thank you for believing in me. To Dr. Garry Miller for his encouragement and constant admonishments to dream high and reach for it. To Dr. Andreas Neef, Sir, I tried my best to live up to your expectations. You have levelled a breath of confidence in me and I am eternally grateful for your support. It means so much. I thank you, wholeheartedly.

To all those in the Caribbean islands who assisted my research data capture. While the list is quite long, there are those who require special mention and have contributed significantly by way of accommodation, transportation, contact initiation, and social and emotional support.

Antigua (Mr. Sean Peters, people of Antigua and staff members of Antigua Public Utilities Authority)

Dominica (Mr. Victor John (dec.) and family, Mr. John Fontaine, Joana Guiste and the people of Belle Vue Chopin, Mr. Ronaldson Piper and the people of Cochrane)

St. Vincent (Mrs. Jacquline Ollivere, Mr. Cornelieus Richards, Mrs. Yolande James, Mr. Elias Francis, Ms. Carlene Jones)

Grenada (the residents of Soubise, Mt. Gay and La Colombe housing settlements, staff of the National Water and Sewerage Authority, staff of the Maurice Bishop International Airport, staff of the Grenada Electricity Service Ltd.)

Thanks to International Student Affairs Office at the University of Auckland, especially Mr. Arthur Johnson. Your warm support went beyond your duty and our friendship will forever remain. To my new circle of friends: Olabode and family, Tony and family, Nipuni, Gerald, Amara, Ed, and son. Thank you for all the love and support shown and given. A massive thank you to all.

By no means least, to my entire family for emotional support. To my mom, my wife, my siblings and all my nieces and nephews. I love you all. To my daughter, daddy was away for more than three years, I promise to make it up to you. Daddy loves you unconditionally. To everyone who reached out on different communication platforms, especially to ensure that I am doing fine during the Covid-19 pandemic, I feel special and appreciated. Thanks.

Sincere thank you to everyone who believed in me, especially to the following people who contributed significantly to my academic pursuits:

Godfather Mr. Denneth Modeste	Ambassador for the OAS in Grenada
Motivator Mr. Carlyle John (dec.)	Advisor to the Prime Minister (Grenada)
Teacher Mrs. Sylvia Forsyth-Modeste	St. Mark’s RC School (Grenada)
Teacher Mr. Wilbert Simon	Bonaire Government School (Grenada)
Teacher Mrs. Earldine Alexander	Bonaire Government School (Grenada)
Principal Mrs. Maudlyn Ferguson	St. Mark’s Secondary School (Grenada)
Teacher Ms. Irva Alexander	St. Mark’s Secondary School (Grenada)
Teacher Mr. Bartholomew Grant	St. Mark’s Secondary School (Grenada)
Principal and Motivator Dr. De Vere Pitt (dec.)	Grenada National College (TAMCC - Grenada)
Motivator Mr. William Samuel	Grenada National College (TAMCC - Grenada)
Assoc. Prof. Dr. Rolf DeBy	Universitet Twente (ITC, Netherlands)
Mr. Emmerson Howard	Universitet Twente (ITC, Netherlands)
Mr. Sjef Van Der Stein	Universitet Twente (ITC, Netherlands)
Assoc. Dean Dr. Garry Miller	University of Auckland (New Zealand)
Eng. Karl Pivotte	National Water and Severage Authority (Grenada)
Eng. Christopher Husbands	National Water and Severage Authority (Grenada)
Eng. Alphonsus Daniel	National Water and Severage Authority (Grenada)

God bless you all.

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Glossary

ANOVA	Analysis of Variance
ASCE	American Society of Civil Engineers
AUSAID	Australian Agency for International Development
BIM	Building Information Modelling
CARICOM	Caribbean Community
CAS	Complex Adaptive System
CDEMA	Caribbean Disaster Management Agency
CDM	Comprehensive Disaster Management
CFA	Confirmatory Factor Analysis
CII	Critical Infrastructure Indexing
CRED	Centre for Epidemiological Study of Disasters
CSF	Critical Success Factor
DFID	Department of International Development (UK)
DRR	Disaster Risk Resilience
DV	Dependent Variable (Outcome Variable)
EFA	Explanatory Factor Analysis
EM-DAT	Emergency Events Database
GDP	Gross Domestic Product
GFDRR	Global Facility for Disaster Reduction and Recovery
HTMT	Heterotrait–Monotrait
ICT	Information, Communication and Technology
IV	Independent Variable (Predictor Variable)
KPI	Key Performance Index
KRA	Key Results Area
MANOVA	Multivariate Analysis of Variance

NZAID	New Zealand Agency for International Development
PCA	Principal Component Analysis
PIS	Personal Information Sheet
PPP	Public–Private Partnership
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analysis
SCSF	Sub-Critical Success Factors
SDG	Sustainable Development Goal
SEM	Structural Equation Modelling
SFA	Sendai Framework for Action
SPSS	Statistical Package for Social Sciences
UAHPEC	University of Auckland Human Participant Ethics Committee
UN	United Nations
UNDP	United Nations Development Programme
UNISDRR	United Nations International Strategy for Disaster Risk Reduction
USAID	United States Agency for International Development

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Chapter 2 "A systematic review of success factors for managing post-disaster reconstruction" was extracted from this co-authored work:

Charles, S. H., Chang-Richards, A., & Yiu, T. W. (2021). New success factors for construction projects: A systematic review of post-2004 literature. Construction Innovation: Information, Process, Management (CIIPM). (Under review)

Nature of contribution by PhD candidate	Desktop exploration of the literature and paper writing
Extent of contribution by PhD candidate (%)	90 %

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Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work.

Chapter 3 "A systematic review of resilience factors affecting post disaster reconstruction" was extracted from this co-authored work:

Charles, S. H., Chang-Richards, A., & Yiu, T. W. (2021). A systematic review of factors affecting post-disaster reconstruction projects resilience. International Journal of Disaster Resilience in the Built Environment (IJDRBE). (Accepted for Publication)

Nature of contribution by PhD candidate	Desktop exploration of the literature and paper writing
Extent of contribution by PhD candidate (%)	90 %

CO-AUTHORS

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Chapter 5 "Critical success factors for post-disaster recovery projects in the Caribbean" was extracted from this co-authored work:

Charles, S. H., Chang-Richards, A., & Yiu, T. W. (2021). From expectation to reality: Critical success factors for post-disaster reconstruction projects in the Caribbean. Engineering, Construction and Architectural Management (ECAAM). (Under review)

Nature of contribution by PhD candidate	Data collection using survey questonnaire, data analysis and paper writing
Extent of contribution by PhD candidate (%)	90 %

CO-AUTHORS

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Chapter 6 "Factors affecting resilient disaster-reconstruction in small island developing states" was extracted from this co-authored work:

Charles, S. H., Chang-Richards, A., & Yiu, T. W. (2021). Factors shaping resilient disaster-reconstruction building and infrastructure in small island Caribbean states. International Journal of Disaster Resilience in the Built Environment (IJDRBE). (Under review)

Nature of contribution by PhD candidate	Data collection using survey questionnaire, data analysis and paper writing
Extent of contribution by PhD candidate (%)	90 %

CO-AUTHORS

Name	Nature of Contribution
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Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work.

Chapter 7 "Post-disaster reconstruction project success indicators: End-user's perspectives" was extracted from this co-authored work:

Charles, S. H., Chang-Richards, A., & Yiu, T. W. (2021). What do post-disaster reconstruction project success indicators look like? End-user's perspectives. International Journal of Disaster Resilience in the Built Environment (IJDRBE). https://doi.org/10.1108/IJDRBE-11-2020-0112

Nature of contribution by PhD candidate	Data collection using survey questonnaire, data analysis and paper writing
Extent of contribution by PhD candidate (%)	90 %

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Chapter 8 "Discussion" was extracted from this co-authored work:

Pages 139- 145 extracted from: Charles, S. H., Chang-Richards, A., & Yiu, T. W. (2021). From expectation to reality: Critical success factors for post-disaster reconstruction projects in the Caribbean. Engineering, Construction and Architectural Management (ECAAM). (Submitted for review)

Pages 146-151 extracted from: Charles, S. H., Chang-Richards, A., & Yiu, T. W. (2021). Factors shaping resilient disaster-reconstruction building and infrastructure in small island Caribbean states. International Journal of Disaster Resilience in the Built Environment (IJDRBE). (Under review)

Pages 152-153 extracted from: Charles, S. H., Chang-Richards, A., & Yiu, T. W. (2021). What do post-disaster reconstruction project success indicators look like? End-user's perspectives. International Journal of Disaster Resilience in the Built Environment (IJDRBE). https://doi.org/10.1108/IJDRBE-11-2020-0112

Nature of contribution by PhD candidate	Interpretation of analysis results, developing solutions for research questions and paper writing
Extent of contribution by PhD candidate (%)	90 %

CO-AUTHORS

Name	Nature of Contribution
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Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work.

Journal Article: "A systematic review of indicators for measuring post-disaster reconstruction resilience"

Charles, S. H., Chang-Richards, A., & Yiu, T. W. (2021). A systematic review of indicators for measuring post-disaster reconstruction resilience. International Journal of Disaster Risk Reduction (IJDRR). (Under review)

Nature of contribution by PhD candidate	Desktop exploration of the literature and paper writing
Extent of contribution by PhD candidate (%)	90 %

CO-AUTHORS

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Chapter 1: Introduction

1.1 Background

After a large disaster strikes, the post-disaster recovery period is often plagued with confusion and uncertainties (Hayles, 2010), though it offers opportunities for improvements to community resilience (Aitsi-Selmi et al., 2015; Dilanthi Amaratunga & Haigh, 2011). Over the past several decades, the frequency and magnitude of natural hazards have increased significantly since the 2004 Indian Ocean tsunami. How to rebuild the damanged infrastructure and restore normalcy of life for people, or even build back in a better way, remains a big challenge for government agencies and recovery organisations in those affected countries.

Le Masurier et al. (2006) investigated the differences between construction at normal times and in the post-disaster reconstruction period and concluded that the lack of applicable legislation, poor stakeholder coordination and resource scarcity are common factors exacerbating the chaos in the aftermath of a disaster. Davidson et al. (2007) also explained the post-disaster situation as a far more chaotic environment because of resource scarcity when skilled labour is limited. In many developing countries, pressures also come from donor agencies who desire speedy recovery progress without considering the local circumstances.

In examining the post-tusnami reconstruction process in Banda Aceh, Indonesia following the 2004 Indian Ocean tsunami, Y. Chang et al. (2011) highlighted the problems faced in tsunami reconstruction projects, including such as the inadequacy of material and human resources, degradation in quality workmanship due to the urgency in restoration, and the importation of materials from unassessed sources with usually long lead times. Several other researchers, such as Hidayat and Egbu (2010); Yi and Yang (2014) and Pathranarakul and Moe (2006), have explored past, present and future trends in the recovery process and supported these factors as being crucial to achiving successful reconstruction outcomes:

- Supportive laws and regulations with supporting information management systems.
- Competent project managers and team members.
- Effective institutional arrangement with clearly defined stakeholder responsibilities.
- Effective coordination and collaboration among stakeholders at the international, national, regional, organizational, and project level.

- Optimal mobilization and disbursement of resources (people, equipment, and material), with effective risk management.
- Effective consultation with key stakeholders and target beneficiaries.
- Effective communication mechanisms for boosting trust and cohesion among stakeholders.
- Clearly defined objectives and commitments by key stakeholders to aid logistic management.

When comparing reconstruction projects in developed and developing countries, the issues of financing (Freeman, 2004), time constraints (Quarantelli, 1995), project quality (Chang et al., 2011), and availability and suitability of resources (Y. Chang et al., 2010) are determinant factors for project success. Other topical issues include involvement of key stakeholders in a collaborative manner (Mayunga, 2007), effective project communication at all stages (Hidayat & Egbu, 2010), the management of risks and preparations for future events (Jigyasu, 2004), and the overall competency of project managers. It is also observed that the nature of traditional systematic project management is time-consuming and does not harmonise well with a post-disaster setting that is characterised as being inflexible, rapid response, having multi-stakeholder activities and high uncertainty levels (Hidayat & Egbu, 2010; Ismail et al., 2014).

Researchers have suggested various initiatives to improve the process of post-disaster reconstruction, including such as more resilient organisations (Wilkinson et al., 2016), inclusive community involvement (Mayunga, 2007), community collaboration on large mitigation projects (Winchester, 2000), sensitivity to the culture and traditions by recognising building preferences (Boen & Jigyasu, 2005), preserving gender equality for post-disaster opportunities (Delaney & Shrader, 2000), pre-impact recovery plans (Hayles, 2010) and resettlement plans (Dikmen, 2006; Oliver-Smith, 1991). While the combination of these initiatives and measures has been utilised, the literature suggests that there is a need for mainstreaming resilience in the post-disaster reconstruction process (Dilanthi Amaratunga & Haigh, 2011).

1.2 Disasters in the Caribbean and post-disaster reconstruction

Evidence of the Caribbean region experiencing damage to buildings and infrastructure from natural hazards has been recorded as far back as 1722, however, in more recent years and within the last 100 years, several natural hazards, including the three worst kinds (hurricanes, volcanic eruptions and earthquakes) have been the dominant natural forces (Collymore, 2007). As shown in Figure 1.1, within the last three decades, there has been an observable increase in frequency, thus revealing the Caribbean's susceptibility.

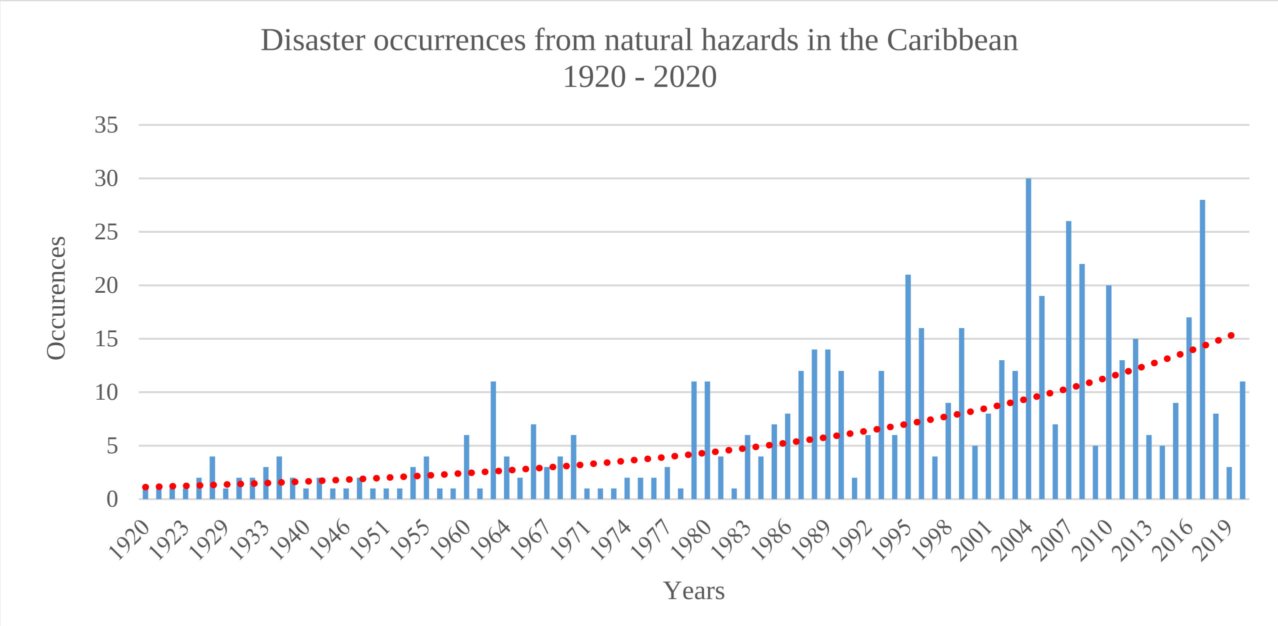


Figure 1.1 Caribbean climate-related disaster trend from 1920 to 2020 (source: EM-DAT)

This research focuses on the Caribbean region for the case study analysis, as it has been identified as the second most disaster-prone region in the world (Clerveaux et al., 2010) with several disasters types affecting the region's built environment. Using the EM-DAT 'climate-related' generalisation term for climatological, hydrological, meteorological and geophysical hazards (Wallemacq & McLean, 2018), the region suffers annually from these, though dominantly meteorological (hurricanes) disasters. Wallemacq and McLean (2018) identified the Caribbean region in six of the top 10 climate-related world disasters for absolute economic losses in the last two decades (1998-2017), amounting to almost US$294B in recovery and reconstruction costs. Despite the extensive body of literature on disaster management, there is scant resource coverage of the Caribbean region. Several attempts to remedy this issue have included a pursuit towards a regional consensus for a standard building code; however, these remain futile. The initial attempt to establish the Caribbean Uniform Building Code (CUBiC) in 1979 prompted a 10-year debate, which concluded on an inadequate 'code of practice' for earthquake-resistant designs (Chin & Pantazopoulou, 1993). Subsequent improved revisions to CUBiC included minimum standards for designs against hurricanes and earthquake hazards, which were influenced by several international code standards documents, including the New Zealand building code. The debate among engineers, at the time, could not agree on what exactly to include in an official CUBiC code, as they were split along the code's simplicity or its detailed technical content. Amidst the debacle, several member states developed country-specific building codes from extracts of the draft CUBiC document, which mostly referenced building construction principles, and very little, if any, on infrastructural works. More recently, in an effort to supplement the deficiencies of these national codes, unofficial references to the I-Codes of the International Code Council started as early as 1999, and funded projects by the Pan American Health Organisation (PAHO) were approved upon design compliance with the ASCE 7-05 codes. The lack of regional standards and asset data repositories continues to significantly hamper any coordinated and structured built environment development and accurate pre- or post-disaster assessments.

1.3 Statement of problem

Previous studies have suggested that there is scant research work on how end-users, particularly community members who have been affected by disasters, perceive the success of post-disaster reconstruction projects, such as residential homes, schools, hospitals, roads and bridges. To fill this gap that describes their miniscule input, this research aims to develop a framework of best practice guidelines for post-disaster reconstruction projects by identifying the critical factors for disaster reconstruction projects to be both successful and resilient from the perspectives of end-users. In order to provide a pathway to mainstream resilience in project management practice, the research will elicit the views of the 'relatively silent' end-user group in case studies of four Caribbean islands. In setting the context for this thesis, guidance is provided by some preliminary statements:

a. Though project end-users are the beneficiaries of project outputs, their engagement is not fully integrated into the planning and execution stages because of their distant access to project operations (Maly, 2018; Walton et al., 2017).
b. Project participants (project managers, practitioners, clients, engineers: the stakeholders directly involved in the operations and management processes) have assessed project success on the metrics of time, cost, quality, and scope management, with minimal considerations to metrics aligned to end-users' expectation and satisfaction (Korde et al., 2005; Lim & Mohamed, 1999).

c. Project end-users tend to assess project success on matters related to satisfaction, longevity, fitness-of-use and a project's ability to improve socio-economic conditions (Bustani et al., 2012; Oke et al., 2017; Tshiki, 2015).

d. There is a need to contextualise the expectations of project end-users because of the varying conditions that determine satisfaction (Lima et al., 2009; Othman, 2007).

e. Though the concept of resilience is evolving in the construction industry, there appears to be a link between resilient reconstruction projects and satisfaction (Bilau et al., 2017; Maly, 2018; Venable et al., 2018).

f. There is a vague representation as to what resilience means to end-users for rebuild projects, primarily because of its contextualisation on psychosocial, economic, and disaster vulnerabilities (Di Gregorio & Soares, 2017; X. J. Shi, 2010).

g. The built environment (buildings and infrastructure) remains an essential pillar in supporting a community's social, natural and economic resilience (Le Masurier et al., 2006).

1.4 Research aim, objectives and questions

The overall research aim is to develop a best practice framework for incorporating resilience into the practice of managing post-disaster reconstruction projects. Table 1.1 lists four research questions that encompass the research aim and which are guided by seven research objectives.

Table 1.1 Research question and objectives

Research Questions	Research Objectives
• What project success factors contribute to achieving positive outcomes in disaster recovery projects?	1. To investigate the factors that contribute to successful outcomes for normal construction projects and draw on applications to post-disaster recovery projects. 2. Understand project end-users' perceptions of successful projects.
• What resilience factors have been deployed within the industry and how have they affected outcomes in disaster reconstruction projects?	3. To investigate how prevelant resiliency has been central to reconstruction projects and its contribution to stakeholders' satisfaction. 4. Understand end-users' perceptions regarding what a resilient project means to them.

• What are the critical success factors and resilience factors, and their relationships for successful resilient reconstruction projects, in line with end-users' success expectation indicators?	5. To understand what the measurement indicators are for end-users' expectations of project success. 6. Determine the interrelations and the major contributors among the factors to assess and achieve the end-users' success expectations.
• How can the concept of resilience become mainstream as a project management practice in post-disaster recovery construction projects?	7. To develop a guiding framework to serve as a pathway to mainstreaming resilience into project management practice for disaster reconstruction.

For this research, some key definitions will guide this process. The literature provides several interpretations of the terms such as project success, project resilience, project management, case study, and the mixed-method approach (see Appendix 1). The implications of these definitions assist in framing discussion or questionnaire development for gaining active understanding and participation. Further explanations of these terms are provided in subsequent chapters.

1.5 Scope of the research

The geographic scope of this research is within the Caribbean region, seeking an improved understanding of what constitutes a successful and resilience reconstruction project in local contexts. The geographic scope of this research also factors global perspectives, to include: 1) an understanding of international stakeholders' influences that continuously reshape the construction industry, such as the International Labour Organization recommendations on construction health and safety resilience (Lopez-Valcarzel, 2001), 2) the Sendai Framework on construction practice and personal well-being resilience (Aitsi-Selmi et al., 2015), and 3) the United Nations Sustainable Development Goals (SDGs) on environmental and sustainability resilience (Sachs, 2012).

As mentioned earlier, the data supporting this research originates from both the literature and end-users' questionnaire survey in the Caribbean region. The survey participants were from random communities in the Caribbean islands of Antigua, Dominica, Grenada and St. Vincent. The targeted participants were residents of these communities who had undergone disaster-related home damage or losses, and/or infrastructural facilities inconvenience. The development of a resilience guiding framework and any associated practical and policy guidelines should subsequently have an international appeal. Therefore, the benefits of this research, regarding beneficiary scope, are likely to garner worldwide interest.

1.6 Research methodology

The research process is organised and shown in Figure 1.2 below. First, a preliminary investigation in the literature was undertaken to identify the research gap and formulate the research problems. Second, the research process was developed to address the gap. Third, findings with respect to critical factors that drive successful outcomes of post-disaster reconstruction projects were analysed. Finally, the research findings, in particular the framework developed, were verified with those people who are directly affected by the disaster and who had participated in the survey. This process was achieved using a variety of research methods in each of the stages, corresponding to the chapters presented. Consequently, while the research methodology and the 'strategies of inquiry' will generally guide the research's epistemology and query design, respectively, the methods or analysis applications differ in each stage.

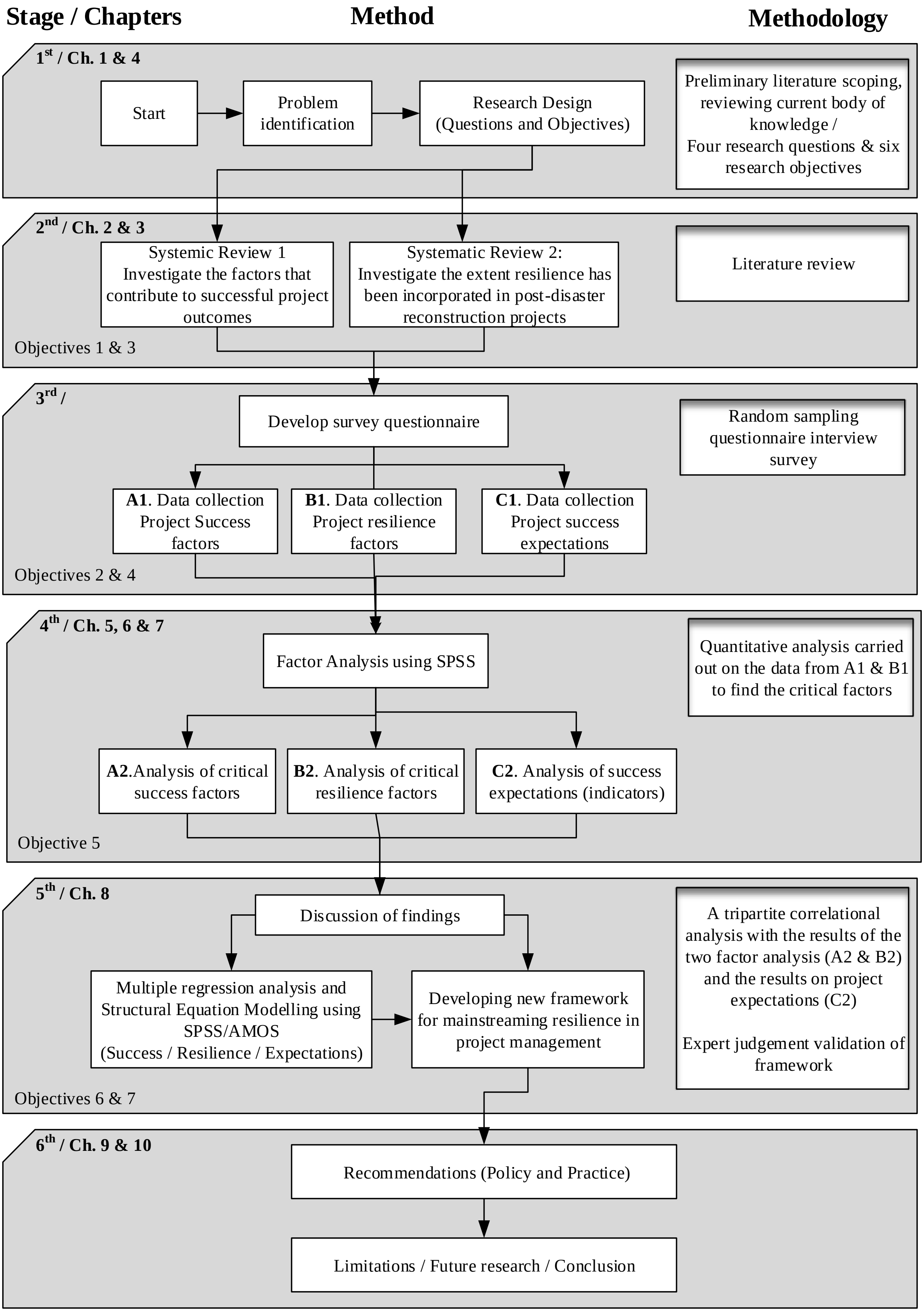


Figure 1.2 Research process (phases, methods and query strategy)

1.7 Thesis structure

This thesis comprises 10 chapters, which follow the sequence of the research process presented in Figure 1. The chapters are organised in the following structure:

Chapter 1: introduces the research process, which includes the background to the research, a problem statement, the research questions, aims and objectives, and highlights relevant key definitions, and the proposed contribution to the body of knowledge.

Chapter 2: a comprehensive systematic review of the literature on project success factors for post-disaster reconstruction projects. Relevant success factors emanating from the included articles in the review process are discussed in regard to the characteristics of successful projects.

Chapter 3: a comprehensive systematic review of the literature on project resilience factors for post-disaster reconstruction projects. The strategies deployed to improve the structural robustness of the 'built environment' for supporting a community's social, and economical structures are identified, and the findings on the characteristics of what constitutes a resilient project are discussed.

Chapter 4: presents the research methodology, comprising the philosophical considerations, the query strategies and the research methods to achieve the objectives of this research.

Chapter 5: focuses on the analysis of the end-users' survey responses on the success factors' findings from the literature review presented in Chapter 2 (see Table 2.3). This includes the use of appropriate statistical methods, namely multivariate analysis of variance and factor analysis on the independent variables (success factors). Multivariate analysis of variance will be used to verify homogeneity in perspectives among the islands, and factor analysis to reduce the 26 factors into a manageable summary, representing the critical success factors. Multiple regression analysis will be used to further understand the relationships between the project success factors and success expectations.

These factors will be used in the development of a hypothesised model on factors influencing project success.

Chapter 6: focuses on the analysis of the quantitative survey responses that solicit end-users' perspectives on the 24 resilience factors obtained from the systematic literature review presented in Chapter 3. The analysis includes the use of appropriate statistical methods, namely multivariate analysis of variance and factor analysis on the independent variables (resilience factors). Multivariate analysis of variance will be used to verify homogeneity in perspectives among the islands, and factor analysis used to reduce the 24 factors into a manageable summary, representing the critical resilience factors. Multiple regression analysis will be used to further understand the relationships between the resilience factors and success expectations, and resilience factors and success factors.

Chapter 7: focuses on the preliminary analysis of the quantitative survey data collected that summarised the end-users' success expectations findings from the literature reviews in Chapters 2 and 3. This analysis includes the use of appropriate statistical methods, namely multivariate analysis of variance and factor analysis on the dependent variables (success indicators), and structural equation modelling. Factor analysis will be used to investigate any correlations among the eight indicator variables and SEM will be used for understanding possible measurement constructs. Resulting composite indicator variables will be used in the development of a hypothesised model to structurally model the effects of both success factors and resilience factors on success expectations.

Chapter 8: presents a relationship verification using structural equation modelling of the correlations established in Chapters 5, 6 and 7. The structural equation model approach was used to understand the relationship possibilities among the three latent variables (project success factors, project resilience factors and project success expectations), but more specifically, the influence or loading strength of resilience factors on both the success factors and the expectations as a contributor to the overall success of disaster reconstruction projects. Discussions on the findings will follow with an aim to develop and suggest avenues for formalising strategies for synergistic possibilities with project management practices. Chapter 8 also discusses the findings of all analyses conducted in this research project and subsequently presents a new framework for mainstreaming resilience. Present project management practice will be discussed with the view of finding practical solutions for incorporating resiliency.

Chapter 9: outlines a series of policy and practical recommendations.

Finally, **Chapter 10** summarises the research project, its contribution to the theory, and practical implications to the construction industry and disaster agencies. Research limitations and future research directions are also presented.

1.8 Contribution to the body of knowledge

In this research, a clearer understanding of the relationships among reconstruction project success factors, resilience factors and success expectations will be established, from the perspectives of the project end-users. It is well established that a global consensus on what constitutes a successful project is still debatable (S. W. Hughes et al., 2004). It is also well established that the disaster-risk reduction approach used to guide policies and construction practices, aiming to reduce the effect of damage to the built environment, has not generated the intended outcomes and a disaster-resilience approach uptake may yield more significant results (Aitsi-Selmi et al., 2015). This research contributes to knowledge by establishing the end-users' resilience assessment criteria for judging a project's success. However, the prime contribution of this research is the empirical illumination on the combined applications of success and resilience strategies to significantly influence greater probabilities for successful projects.

The research contribution to knowledge will assist the disaster recovery period by reducing the chaos that normally exists by quickly forming linkages between the reconstruction scope and end-users' expectations. It is anticipated that these linkages will lead to more informed project management practices and improved project planning and execution. As this area of study (end-users' contributions and expectations for project outcomes) is relatively under-researched, there is an encouraging scope for which this research can be a foundational resource. The traditional use of objective metrics (time, cost, quality) to assess project success suggests that project success assessment was limited to project participants. However, this research output serves to widen the success assessment criteria to include subjective factors and consequently expand the stakeholder assessment base.

This contribution can be summarised as an intrusive framework that introduces resilience as an additional project management principle, intended to garner greater success in disaster recovery projects. It is intended that the findings of this research will inform theoretical, practical and policy considerations to mainstreaming resilience in post-disaster project management.

Practical considerations of the framework can include:

a. Assist project management practitioners to better align success strategies to maximising stakeholder satisfaction.
b. Promote greater levels of end-user confidence with improvements to the built environment, which is essential to both social and organisational resilience.
c. Provide confidence assurances to donor agencies in maximising the resources provided to disadvantaged communities and minority groups.

Chapter 2: A systematic review of success factors for managing post-disaster reconstruction

2.1 Introduction of this chapter

As the construction industry benefits from continuous advances in technology uptake and safety standards, the set of critical factors that drive project success needs to be revisited. More importantly, the foundation to this research analysis requires a deep understanding on the industry's cross-sectional viewpoint on what constitutes a successful project. To investigate the list of possible success factors, a systematic literature review was deemed appropriate. This chapter will investigate the literature using a systematic literature review that will follow the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol for systematic reviews, after which, the articles obtained will be open-coded in search for strategies used by industry professionals. This chapter presents the justifications, methodology and findings of this systematic review process, with an understanding of the factors that leads to positive project outcomes.

2.2 Introduction

The volatile and dynamic nature of the construction industry requires an improved understanding of the factors that lead to positive outcomes for managing construction projects. There have been many studies on project success factors over the past several decades (e.g. (Belassi & Tukel, 1996; Chua et al., 1999; Lim & Mohamed, 1999; Schultz et al., 1987; Thi & Swierczek, 2010; Toor & Ogunlana, 2009); however, global consensus has not yet been achieved. The demand for residential and infrastructural projects to satisfy the need of growing populations warrants more affordable housing, accessible utilities, and improved economic and social infrastructure. The performance of the construction industry in executing these projects continues to be an indicator of a country's physical development (Hussain et al., 2018) and its socioeconomic profile (Idrus et al., 2011), which continually pose escalating challenges and complexities as the industry searches for ways to transform.

Characterised by Larsson et al. (2015), projects are defined as 'complex sequences of activities, both planned and unplanned, performed to meet objectives that are often [but not always] strictly defined' (p. 1). Extensive research has been conducted to identify the factors that affect project outcomes using the ‘iron triangle’ of cost, time and quality metrics (K. N. Jha & Iyer, 2007). Most studies in the literature based their findings on the empirical experience of those involved in projects. However, few studies have investigated success factors from the perspective of wider stakeholders, such as clients and end-users (Lim & Mohamed, 1999, p. 247).

During ancient times, construction was a community-based activity using locally available materials and people who were connected culturally, ideologically and often tribally, thus making communication and conflict resolution almost seamless (Ngowi et al., 2005). Researchers have argued that over centuries, colonialism, invasions and globalisation have induced many vagaries that propagated eccentric construction practices into new territories, thus changing perceptions and actualisations of projects. For example, the introduction of new building methods, types and materials, which were synchronic with the revolutionization of architectural designs, have been involuntary imposed on minority cultures (Ngowi et al., 2005). In more recent times, industrial revolutions have generated a pressing need for meeting the changing requirements because of increased population growth and mobility. The developments in the transportation sector, for instance, to build more railways, bridges and wider roads, and catering to the growing connections in urban settings, have imposed demands on new construction techniques and designs to build smarter and more cost-effective solutions.

Over the past several decades, growing concerns on environmental conservation enforced a paradigm shift in construction to meet Millennium Development Goals (WHO, 2008), and their transition into Sustainable Development Goals (Sachs, 2012). This requires, for instance, ‘access to safe and sustainable water and sanitation, adequate nutrition, primary health services, and basic infrastructure, including electricity, roads, and connectivity to the global information network’ (Sachs, 2012, pg.3). Therefore, the factors that lead to successful outcomes of a construction project would resonate with the changing demands and needs of the end-users in a wider context. The inclusion of end-users’ perspectives regarding their cultural, societal and economic dimensions, and even their aspirations of how a completed building can be used, are crucial when planning for a building project (Adinyira et al., 2014; Youneszadeh et al., 2017). The complexity of the construction industry includes diverse expectations, unknown risks and segmented sectoral structural issues, all of which compels a need to systematically revisit the factors that lead to optimum project performance. In addition, with the ongoing influence of Industry 4.0 (the term given to the trending application of modern smart technology to automate traditional manufacturing and industrial practices), and the increased need for efficiency and productivity gains, the construction industry is desperate for transformation. Building on previous project success literature, this systematic review seeks a comprehensive introspection of factors that lead to successful outcomes of construction projects. The results of this review will highlight the success factors that guide managers, planners and practitioners for managing both construction and reconstruction projects, and also, those used to frame the success factors frameworks used over the years.

2.3 A systematic review methodology

This study adopted the systematic review method. According to Green and Higgins (2005), a systematic review is an exploratory and unbiased approach that includes searching multiple large bibliographic databases to identify, evaluate and integrate the analogous and sometimes divergent views of researchers. White and Schmidt (2005) also note a systematic review's ability to 'retrieve, appraise and summarise all the available evidence on a specific question and then attempts to reconcile and interpret it' (p. 1), thus becoming a rigorous method of exploring myriad high-quality empirical findings. Given the purpose of this study, which is to synthesise construction project stakeholders' views on project success factors, it is beneficial to employ a systematic review approach as opposed to a traditional literature review. A systematic review can also further leverage our ability to identify implications for renewed practice and policy development in the project management space and help identify future research directions.

Step 1: Identification of articles

The systematic review was conducted following the PRISMA 2015 guidelines (Moher et al., 2015). Eight databases were searched and included Scopus, ScienceDirect, ProQuest, Web of Science, ASCE Library, SpringerLink, Engineering Village and Google Scholar. References to other relevant studies, which were indexed by the eight databases, were found through a snowballing method during the full-text review process. The article identification process is shown in Figure 2.1.

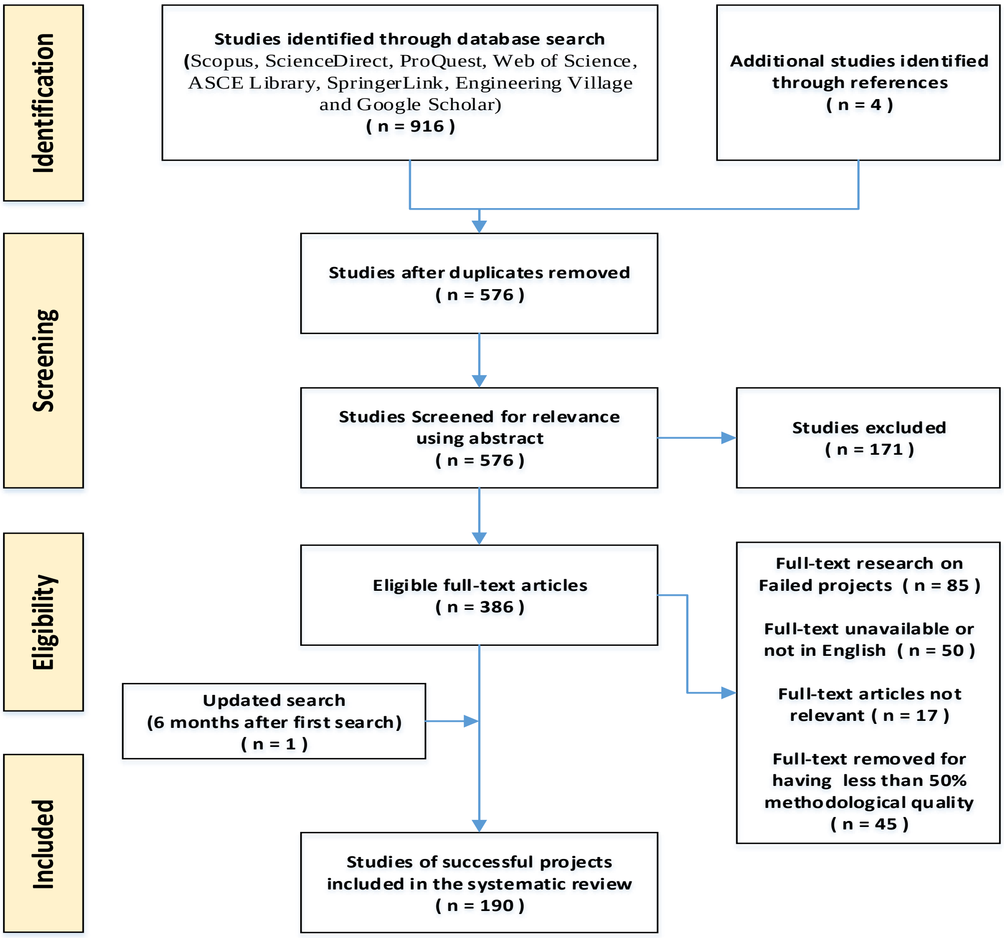


Figure 2.1 PRISMA flow-chart summary of search strategy and results

The search terms used were (“construction project*” OR “building project*”) AND (“success*” OR “progress*” OR “achieve*” OR “fail*” OR “pitfall*”) AND (“factor*” or “determinant*” or “contrib*”) AND (“infrastructure or resident*” or “hous*”). The search was extended to include search terms that were synonyms for the words ‘success’ and ‘failure’. Citations were managed using Endnote 8® and duplicates were excluded. A total of 916 articles matched the search criteria. However, four articles were further included when a cross-check method was applied.

Step 2: Screening

In terms of assessing what specifically the outcomes of a construction project are, there are two levels used in the search: 1) a project’s outcomes are determined against the established traditional time, cost and quality metric (Mahamid, 2017; Shenhar et al., 2001; Sidawi, 2012) and 2) any pre-determined stakeholder personal project desire or fit-for-use objective (Adetola et al., 2013; Bustani et al., 2012; Toor & Ogunlana, 2009). The inclusion and exclusion criteria are described below:

Inclusion criteria

a. Only English language articles that focused on residential buildings and infrastructure projects were considered because of their impact on the populace over industrial and commercial projects, with regards to addressing their socioeconomic interest of end-users, especially in post-disaster situations.
b. Articles on worldwide projects were considered to garner the widest measure of stakeholders' perspectives on success strategies, and captured the similarities and diversity of social, cultural and economic constraints.

Exclusion criteria

a. Trade journals and other types of publications that are often characterised as containing bias, and those that did not provide a clear project outcome.
b. Articles that did not conform to an established methodological quality protocol.

The database search and article cross-referencing returned 920 articles with a total of 363 duplicates, leaving 557 articles for further screening. The first screening process was an abstract overview of each article for relevance according to the research topic and the corresponding rubric listed in Appendix 3. A total of 171 articles were considered irrelevant and therefore omitted. The remaining 386 articles documented various strategies advancing positive outcomes.

Step 3: Eligibility

As shown in Figure 2.1, the remaining 386 articles were individually appraised using the HTA Initiative #13: standard quality assessment criteria for evaluating primary qualitative, quantitative and mixed methods research papers (Joseph-Williams et al., 2014; Kmet et al., 2004). A full quality assessment of each article was conducted.

In the quality assessment phase, all 386 articles were rated according to the qualitative assessment criteria (Kmet et al., 2004). These criteria were utilised in this review process primarily to assess the studies for research protocol astuteness. A summary score between 0 and 1 for each study indicated the study's methodological quality, where a value of 1 is the highest. The exploratory nature of this systematic review, in investigating the strategies to a project's outcome, makes it prudent to include all strategies found because of their independent characteristics. While several strategies were observed, some had associations to the same success themed factor. For example, warranty contracting (Cui et al., 2010) and 2) alliance contracting (Mistry & Davis, 2009) and 3) relational contracting (A. Chan et al., 2015) can be themed into the success factor of 'ensuring clarity of contractor and subcontractor responsibilities'. While the quality assessment primarily assessed the studies to ensure they satisfied the parameters of good to excellent research, they did not quantify the degree of influence of the strategy observed. The frequency of a specific strategy observed is not an indicator of the strategy's severity or significance and not in the scope of this research; therefore, this review sought to include all success factors identified as a single item.

With duplicates removed and abstracts screened for relevance according to the rubric in Appendix 3, 386 articles were made available for full-text quality assessment. The 85 articles that recorded a failed outcome were excluded. Fifty articles written in a language other than English or with their full text not able to be retrieved in full were also excluded. A further 17 articles were removed upon being deemed irrelevant after full-text assessment. The articles with a methodological quality score under 0.5 (50%), were observed to reiterate factors already documented in articles of higher quality. These articles, totalling 45, were also excluded. This band of studies, comprising 189 articles, was assessed as appropriate for the review process. Discrepancies in assessment value were resolved through discussion with supervisors, the authors, and re-checking the studies in question.

Step 4: Inclusion for review

Upon full-text assessment, 189 articles were identified as documenting a successful outcome according to established project determined objectives, in harmony with the inclusion criteria and methodological quality assessment. Approximately six months later, the same search strategy was performed to identify any newly published relevant articles. One additional article was found, which brought the number of articles to 190. Data extracted from the 190 articles were publication type, publisher, year, outcome strategy, location, construction type, construction sector, data sources of included studies, research data instruments, procurement type and publication output beneficiary. The quality distribution of the studies included is shown in Figure 2.2.

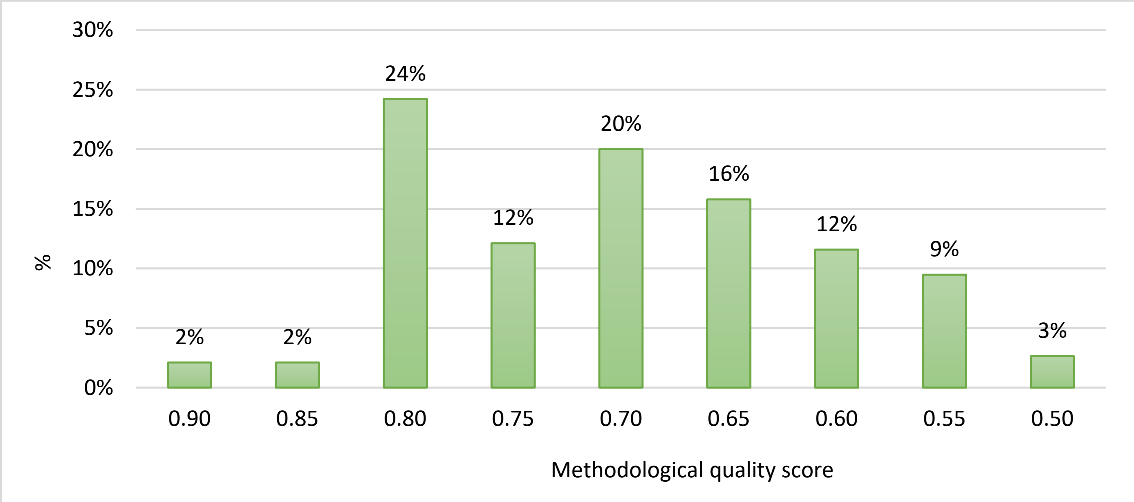


Figure 2. 2 *Distribution of included studies according to methodological strength (n = 190).*

2.4 Systematic literature review results

2.4.1 Descriptive analysis

Information about the included articles

To identify the list of success factors from the corresponding success strategies, content analysis using the open-coding method was conducted on the included articles (Bauer, 2000; Cavanagh, 1997). Bauer (2000) describes content analysis as mapping the knowledge presented in text into logical inferences, with the validity of 'the analysis deliver[ing] interesting results and withstand[ing] scrutiny' (p. 29). Data extraction of success strategies was performed. They were then grouped based on similar themes, subjects and meanings. Although researchers' terminologies can differ when referring to success strategies and factors, there were obvious contextual similarities that could be denoted with generic themes. This method provided greater clarity in the application, synthesising and simplicity of the results. Related construction themes in this review were stakeholders, project type, project sector, project region, stakeholders, research instrument, publication year, publication type and success strategy. A themed summary of the included studies is provided in Table 2.1.

Table 2.1 A summary of included studies for the systematic review (n = 190)

Category	Description	n	%	Category	Description	n	%
Construction project type	Building	55	29%	Research instrument	Case study	51	27%
	Infrastructure	71	37%		Database	1	1%
	General construction	64	34%		Focus group discussion	3	2%
	Water	2	1%		Interview	44	23%

Construction project sector	Transportation	23	12%
	Residential	28	14%
	Recreational	2	1%
	Health	2	1%
	The industry	128	67%
	Flood mitigation	1	1%
	Entrepreneur	1	1%
	Energy	1	1%
	Education	1	1%
	Coastal	1	1%
	End-user	6	3%
	Practitioner	69	31%
	Project manager	24	11%
	Researcher	57	25%
Region where the research project was undertaken	Africa	37	13%
	Asia	107	45%
	Europe	38	18%
	Middle East	28	10%
	North America	14	4%
	South America	2	1%
	South Pacific	18	6%
	Worldwide	31	10%
Stakeholder participation in research work	Client	27	12%
	Consultant	13	6%
	Contractor	28	13%
	End-user	6	3%
	Practitioner	69	31%
	Project manager	24	11%
	Researcher	59	35%

	Literature review	1	1%
	Observation	2	1%
	Questionnaire	101	53%
	Report	1	1%
Date of publication	1980–1989	1	1%
	1990–1999	3	2%
	2000–2009	49	26%
	2010–2018	137	72%
Publication type	Journal article	141	74.2%
	Conference paper	25	13.2%
	Feature	10	5.3%
	Dissertation/Thesis	11	5.8%
	Article in press	1	0.5%
	Review paper	2	1.1%
Strategies distribution by success factors and success criteria	**Success criteria**	**Factors (n / %)**	**Strategies (n / %)**
	Satisfaction related	6 / 12%	11 / 5%
	Compliance related	1 / 2%	13 / 6%
	Sustainability related	2 / 4%	7 / 3%
	Operations related	7 / 13%	36 / 17%
	Engineering related	3 / 6%	6 / 3%
	Technology related	5 / 10%	26 / 12%
	Procurement related	2 / 4%	24 / 11%
	Competency related	5 / 10%	24 / 11%
	Resource related	9 / 17%	34 / 16%
	Stakeholder related	9 / 17%	24 / 11%
	Change related	3 / 6%	6 / 3%
Total	**11**	**52**	**211**

Analysis of articles by construction type

The number of articles specifically focusing on either residential or infrastructure construction projects was almost evenly split at approximately one-third each, while the remaining 64 articles representing 34% viewed the construction industry as an entity and were categorised as ‘general construction’. The studies in the general construction category reported the strategies without specifically referring to a construction type. Thus, we conclude that the generic nature of these strategies affect all project types. Figure 2.3 shows the distribution of included articles by construction type.

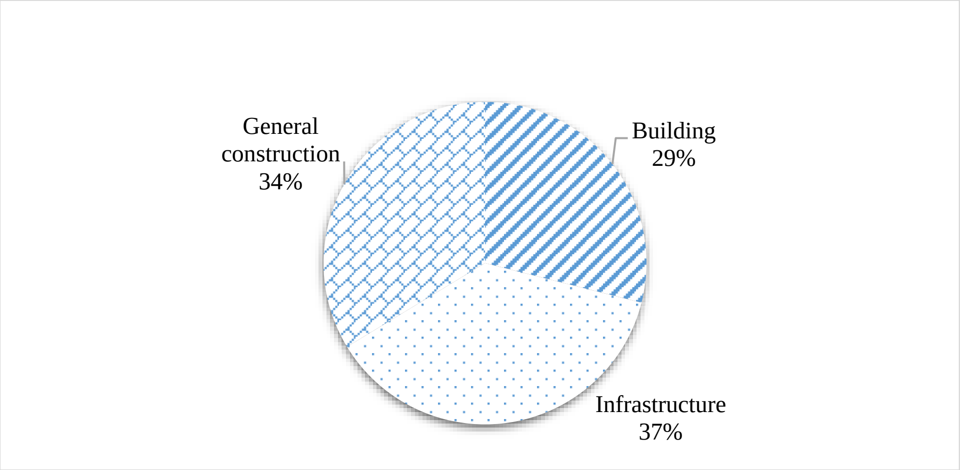


Figure 2.3 Distribution of included studies by construction type

Analysis of articles by construction sector

A breakdown of the distribution of included studies by construction type and sector is presented in Figure 4. Among the three construction types, 67% of the studies were generic and did not conform to any particular construction sector, while 14% focused on residential buildings and the remaining 19% were infrastructural projects in the water, transport, recreational, health, flood mitigation, business, energy, education and coastal management sectors. Dominating the articles for the infrastructural category were transportation-related projects, accounting for one-third of the total infrastructure studies and mostly focusing on road projects. Only the health sector consisted of both building and infrastructural projects, which qualifies the notion that a single project can be categorically different depending on the considered use of the finished project. It can be concluded that a successful project is predicated on a clear understanding of the project's objectives, selecting the right success factors and associated strategies to achieve them, and thus further emphasising the challenges in determining a universal set of critical success factors.

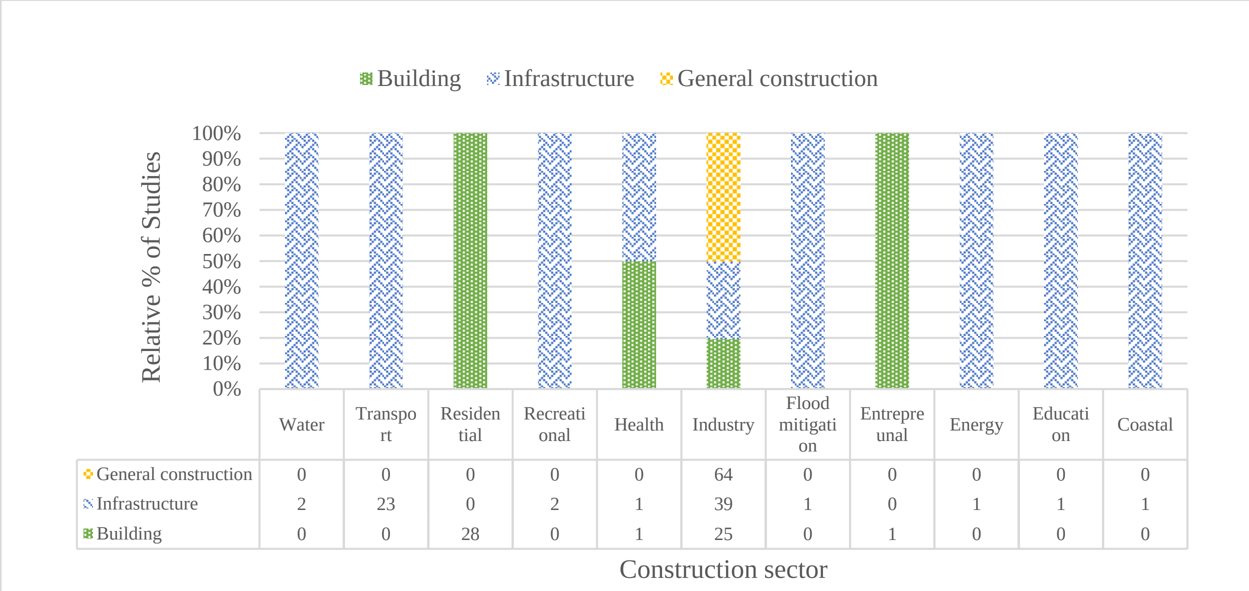


Figure 2.4 Frequency and comparison of included studies by construction type and sector

Distribution of articles by world region

Figure 2.5 displays the distribution of the studies according to an eight-region grouping. The summarised grouping was utilised for two reasons: 1) 163 study publications spanned 46 countries, and the remaining 27 were without reference to any specific country of origin; and 2) only three countries contributed 10 or more output studies with the remaining countries contributing an average of two. Regional representation was chosen because it was deemed easier to represent the studies' distribution as regional clusters for reasons of proximity, social homogeneity and culture commonality in construction projects (Ankrah et al., 2009). Of note are the percentages of studies produced by individual countries, with the greatest contributions coming from Malaysia (8%), China (7%), India, Nigeria and the UK (5% each), and Thailand, Australia, Ghana and Hong Kong (4% each). Studies from the Asian region represented 39% of all articles, and dominated this topic accounting for almost 1.5 times the contribution from Europe and double the amount from the African and Middle East region countries separately. As can be seen, only two studies originated from the South America region, which can be attributed to the inclusion criteria of English-only articles. As shown in Table 1 and illustrated in Figure 5, almost 50% of the articles focused on projects implemented in the Asian region, with the second largest contributing region being Europe with 18%.

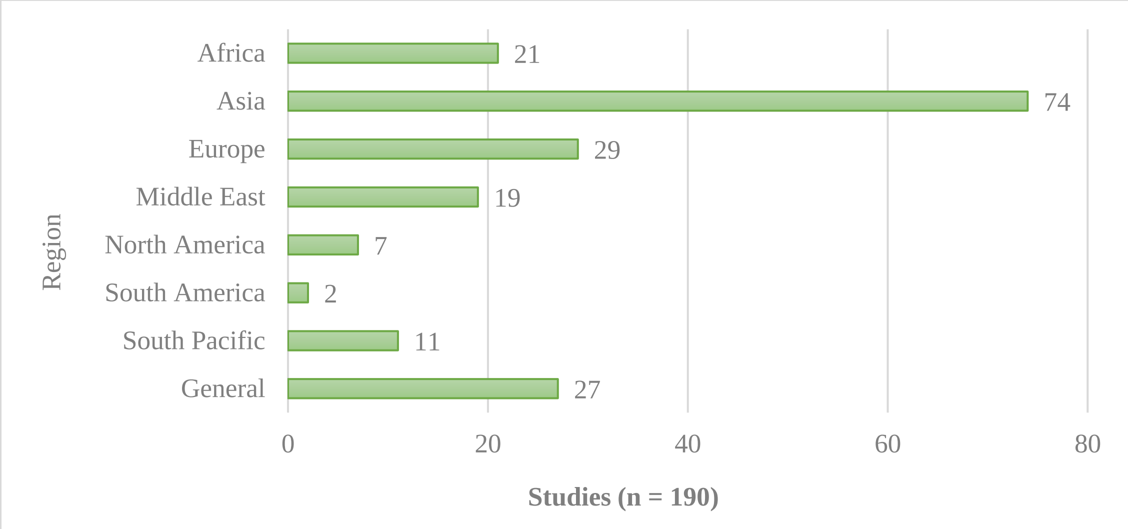


Figure 2. 5 Frequency distribution of included studies by regions (country associations)

Note: 'General' captured the perspective of industry stakeholders without any specific reference to a region.

Participants assisted with the research in the included articles

The literature identified 91 different job titles though some have similar roles and responsibilities within the construction industry; this is a clear demonstration of global variations. Job titles were categorised into seven groups: clients, consultants, contractors, project managers, practitioners, end-users and researchers (refer to Appendix 2) according to their project salience dynamics, which is the weighted combined factor of a stakeholder's power, legitimacy and urgency of project influencing function (Aapaoja & Haapasalo, 2014). Researchers are not usually entrenched as mainstream construction industry stakeholders; however, for this thesis, a researcher was defined as a stakeholder performing investigative work in the construction industry from an academic perspective.

This thesis identifies two classes of stakeholders: contributors and beneficiaries. Contributors were active stakeholders in the research process, while beneficiaries were the intended users of the research output. Table 2.2 shows the comparative frequency and distribution of research contributors and beneficiaries in the included articles. It is apparent from Figure 2.6 that the greatest contributing group was the practitioner group. Possible explanations for this finding are 1) that the diversity and quantity of challenges this group faces within the industry gained greater focus when compared to other groups, and 2) the ease of access to this group. The second highest contributor is the researchers group with 25% input, while the end-users consisted of a mere 2%. Consultants and end-users were not major contributors, and their views may not have been captured thoroughly during the period. The findings also revealed that the research output largely focused on benefiting the practitioners, clients and project managers, with 34%, 25% and 23% of outputs, respectively. A minimal number of studies engaged the contributions of consultants, end-users and researchers, reflecting a cumulative 5% of the included studies. Table 2.2 provides further clarity on the frequency distribution of participants.

Table 2.2 Frequency distribution of research contributors and beneficiaries

Stakeholder type	Contributors		Beneficiaries	
	Studies having stakeholder participation	%	Studies specifying benefiting stakeholder	%
Client	27	12%	46	25%
Consultant	13	6%	1	1%
Contractor	28	12%	22	12%
End-user	6	3%	6	3%
Practitioner	69	31%	64	34%
Project manager	24	11%	43	23%
Researcher	57	25%	4	2%

Note: The frequency represents the number of studies by stakeholder involvement. Several stakeholder types may collaborate on a single research project.

The group comprising consultants, clients and end-users were termed 'wider stakeholders' for this research. With under 25% participation and corresponding influence in the research output, the wider stakeholders' views were inadequately represented.

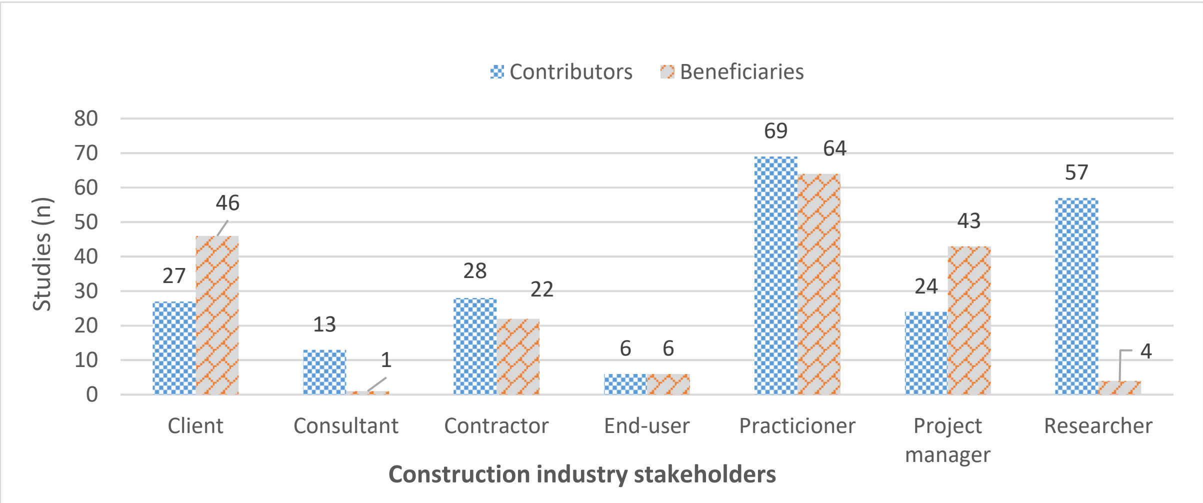


Figure 2.6 Research participants group and frequency comparisons

Success factors' categorisation by project objective

The construction projects within the 190 articles employed a variety of factors for achieving successful outcomes. Figure 2.7 provides a closer look at the success strategies deployed. Two hundred and eleven strategies were identified among the articles and were utilised in all phases of the project cycle within residential and infrastructural projects. Throughout the literature, project outcomes were tested against predefined objectives or metrics. For example, Kinawy and El-Diraby (2010) identified the 'e-society' strategy to achieve client and end-user satisfaction as a community involvement success criterion. With such an open-coding construct, it was necessary to group these strategies and their emerging success factors into similar themes to demonstrate their relationship to the broad categories of project success criteria. The categorisation of the 211 project strategies is also consistent with the literature's definitions of criteria (Atkinson, 1999; Belassi & Tukel, 1996), factors (Zakaria et al., 2017) and strategies (Stoy & Schalcher, 2007).

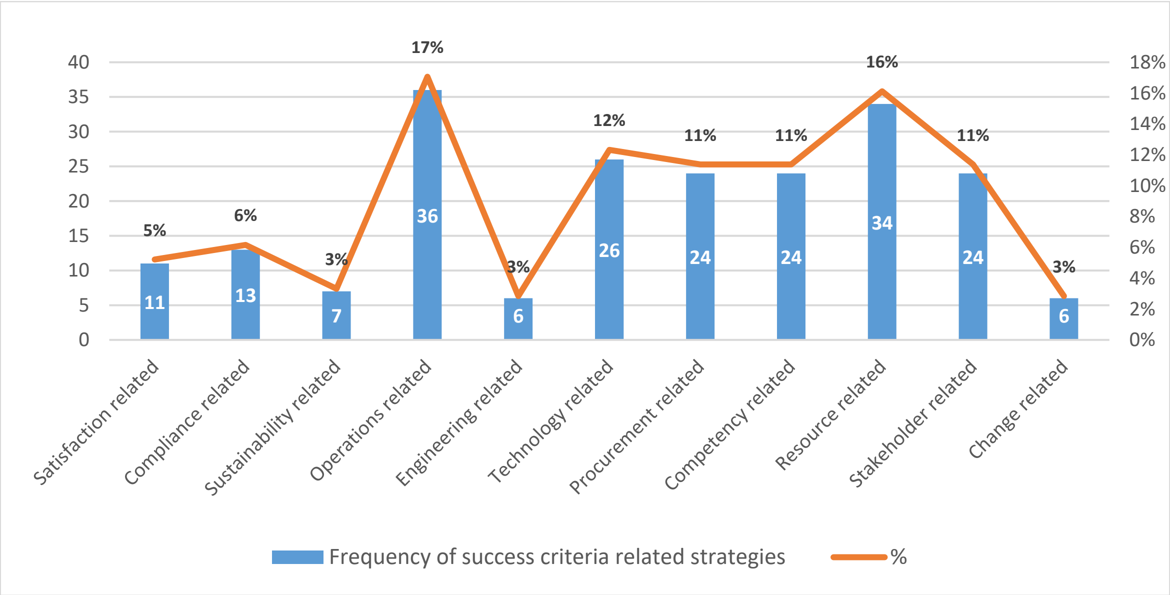


Figure 2.7. Frequency of success factors according to criteria classification (n = 211)

Dominating the variations of successful strategies are those aimed to optimise the operational aspects of the project planning and execution, representing 17% and the corresponding subtotal of 36 strategies. These included strategies such as key process indicators, risk management, communication, cost containment, work process re-engineering, and avoiding the cost of poor quality. Almost equal attention was given to resource management strategies, totalling 34 strategies, the second highest.

While most of the remaining success criteria groups attempted a comparable significant number of strategies, sustainability, engineering and change-related research strategies were observed to be largely unexplored. For this thesis, the terms are understood as follows: ‘sustainability’ refers to the environment and ecosystem stewardship (Y. Yang et al., 2018), ‘engineering’ refers to the proper deployment of technology and engineering practice (Ahuja et al., 2010), and ‘change’ refers to timely mitigation and adaption to operational variations and the industry’s developmental trends (Senaratne & Sexton, 2009).

2.4.2 Analysis of project success factors

From the extracted strategies, we identified 52 success factors aligned to 11 themed success criteria, namely: satisfaction-related, compliance-related, sustainability-related, operations-related, engineering-related, technology-related, procurement-related, competency-related, resource-related, stakeholder-related and change-related, listed and described in Table 2.3. According to Yu et al. (2006), success factor classifications are contextual; the authors argued that factors that attend to ‘clients and user experience’ are categorised as human-related, encompassing satisfaction, compliance, procurement, resource, stakeholder and change related. Human-related factors represented 67% of the success factors identified (see Table 1). Project-related factors that were operations- and engineering-related accounted for 19%, while technology and sustainability accounted for 14% of the process-related/project-management-related factors. The success criteria list demonstrates a bias toward factors that affect all stakeholders (input related) over the factors addressing product quality (output related) (Yu et al., 2006).

Previous research work categorised success factors into relatable criteria themes including competency, collaboration, communications, coherence, quality, safety and investment returns (as evident in frameworks such as those by (Belassi & Tukel, 1996; Chua et al., 1999; Lim & Mohamed, 1999; Schultz et al., 1987; Terwel & Vambersky, 2013; Toor & Ogunlana, 2009)) being operationally aligned to the tripartite ‘iron triangle’. However, this thesis extends these frameworks by identifying additional criteria that are congruent with clients and end-users (wider stakeholder) expectations and the looming industry changes influenced by Industry 4.0. These new project success dimensions include sustainability, compliance, innovation and adaption to technological advancement, and change management. These new criteria align success to both the project component phase objectives and ensure all stakeholders’ expressed or implied input is validated throughout the project’s lifecycle.

Adherence to climate change concerns by constructing energy-efficient homes with eco-friendly materials imposes paradigm shifts within the industry that embrace the need for innovation with new designs and construction techniques. Complying with local and global environmental regulations and safety standards, while ensuring operability and longevity concerning maximising project objectives, requires the ability to cultivate a versatile attitude that seamlessly adapts to the meandering diversity of stakeholder expectations and demands. These paradigm shifts need to be technology oriented; factoring newly (semi-) automated equipment and measurement techniques and in some cases, real-time monitoring provided for timely decision making in line with stakeholders' expectations. It is therefore incumbent on project participants to appraise themselves to continually affirm their competence with these challenges, even beyond the operational project matters.

Of critical importance towards engaging wider stakeholder views is the need for an increased understanding into the qualitative aspects of successful outcomes. Used extensively among the included studies is the questionnaire method that is oriented to quantitative analysis (postal, online and structured interviews) and the case study method, which is characterised as yielding deep but narrow results (Fellows & Liu, 2015; Jefferies, 2006). Group discussion and observational data capture methods were used in only 3% of the included studies, thus limiting relevant stakeholder views for a complete success factor analysis. Table 2.3 provides the list of the success factors elicited from the systematic review of the included articles.

Table 2.3 A list of success factors for construction project management

Success criteria	Success factors	Description and expected outcome	Source
Satisfaction	Client and end-user engagement at all stages	An approach that enhances opportunities for the client and end-users to be part of the integrated team over the project's life cycle; building on pre-existing relationships and advancing trust and teamwork.	(Doloi, 2012), (Da Rocha et al., 2013), (Li et al., 2013); , (Mei-yung et al., 2014); (Moon et al., 2017); (Kinawy & El-Diraby, 2010)
	Consideration for end-user expectations	The desired value that reflects the customer/client expectations regarding the usability and practicality of a project, on which perceived value and satisfaction judgments are made.	(Othman, 2007), (Lima et al., 2009)
Compliance	Project operations guided by project management principles	Adherence to industry standards, regulations, and the practices and procedures that align to the established principles and practices of project management.	(S. Z. S. Tabish & K. N. Jha, 2011a)
Sustainability	Environmentally friendly construction	The concept surrounding innovations and actions adopted to reduce negative project impacts on the earth's resources, necessary for maximising social and ecological advantages.	(Oke et al., 2017)
	Unbiased care for the ecosystem	Technological-centric or human-centric construction strategies where the built environment and the natural environment co-exist, promoting a flourishing relationship for mutual and hyper-efficient sustainability.	(Ozer, 2014)
Operations management	Waste management (e.g. materials, time)	A production management-based project delivery technique that emphasises reliability and speedy delivery, maximising value, minimising waste, and pursuing perfection.	(Al-Aomar, 2012)
	Management of project risks	A typical efficiency-oriented practice that provides effective communication and focuses on contract compliance, schedule monitoring, budget management, and document control.	(Miller & Ortega, 2006)
	Cost management at all stages	The dynamic assessment of project cost against project scope and time, aimed at avoiding cost overruns.	(Cheng et al., 2010)

	Optimisation of project success factors	A clear understanding of the factors influencing labour productivity, team management to effectively allocate their limited resources, provide workers with better support, increase workers' motivation, and enhance workers' commitment to productivity.	(Nasirzadeh & Nojedehi, 2013)
	Assessment of work processes and output	A planning and design knowledge feature within project development and execution process aimed at investigating possible negative issues and ensuring feasibility of project tasks and outcomes.	(Goodrum et al., 2003)
Engineering	Engineering designs with technical specifications	The absence of unacceptable danger that predisposes buildings and infrastructures to failures.	(Terwel & Vambersky, 2013)
	Assessment of project feasibility and practicality	The concept of the creative mix of construction knowledge, innovation and experience utilised in all project stages for achieving its objectives.	(Bustani et al., 2012)
Innovation	Use of new technology and tools	The collaborative infrastructure of multiple electronic devices for collecting, analysing archived or real-time information for visualisation, processing, monitoring, tracking and communicating data or information in the construction industry.	(H. Liu et al., 2014)
	Exploration and deployment of safety improvement measures	The use of a management technique, such as off-site manufacturing, adopted to assist in addressing traditional on-site project inefficiencies of time and cost overrun, and safety concerns.	(Bustani et al., 2012; Elnaas et al., 2014)
Procurement	Adoption of best procurement method	Relates to the frameworks adopted and activities within which construction particulars or essentials are acquired.	(CIB, 1991 as cited in (Rameezdeen et al., 2005)).
	Clarity of contractors and subcontractors' responsibilities	Performance-based contracting that reduces pitfalls in warranty contracting, alliance contracting, and relational contracting that guarantee the integrity of the project, based on accountability.	(Cui et al., 2010); (Mistry & Davis, 2009); (Mills et al., 2011);
Competency	Competent leadership of project managers	A leadership style that harnesses the skills, talents and attitude of team members and ensures that the project's objectives remain sufficiently in focus.	(Larsson et al., 2015)
	Project-related knowledge at all levels	The leveraging of experiences and tacit knowledge at a personal or organisational level.	(Ly et al., 2005), (Teerajetgul et al., 2009), (Rasli & Mohd, 2008); (Lin & Lin, 2006); (Loh et al., 2000)

Resource management	Use of specialist skillset	The strategic deployment of human resources for maximising the time and quality of work output.	(Nitithamyong & Tan, 2007)
	Project staff incentives	The technique of optimising incentives that motivate the employer or client to improve the project and personal performance.	(Graboviy, 2016)
	Efficient use of project resources	Supplying and supporting the project with resources to achieve the established time objectives and contain costs in line with budgetary guidelines.	(Memon et al., 2011)
Stakeholder management	Decentralisation of project tasks	An open-ended or specific off-site term relationship between two or more parties to achieve the objectives of a project.	(Black et al., 2000); (S. Z. S. Tabish & K. N. Jha, 2011a)
	Staff motivation that fosters openness	A technique that includes pre-project team-building, a joint project charter, periodic assessment, shared goal review, process improvement, and risk-sharing strategies for a dispute-free environment.	(Jacobson & Ok Choi, 2008), (M. Jarkas et al., 2014)
	Knowledge sharing amongst team members	A network of tender information that thrives on the methodology of parallel data sharing.	(Cheung et al., 2006)
Change management	Change management plan	A risk management technique that makes allowances for any adverse effects from internal or external influences.	(Senaratne & Sexton, 2009)
	Communication plan	Having a defined structure to address all types of project issues, including modification to the initial project designed specifications, or additions, deletions or revisions to the original objectives.	(Lebcir & Choudrie, 2011)

2.5 A review of empirical success factors in construction projects

Globally, the drive to find solutions for positive construction projects outcomes continues to be an unsurmountable task, especially as more diverse stakeholders are involved in all project stages (B. Liu et al., 2015; Bingsheng Liu et al., 2018), and project risks (internal and external) increases (Ramanathan & Rathinakumar, 2017; Yucelgazi et al., 2019). The difficulty in gaining consensus on a project success definition remains a recurring theme. Two decades ago, A. Liu and Walker (1998) emphasized the necessity of stakeholders to reaching an agreement on the definition of success, and warned that if an agreement is not forthcoming, the outcomes of projects will be difficult to be predicted or monitored. In a conscious effort to clarify types of success, Baccarini (1999) suggested two separate yet related success concepts: 1) project success with the implementation of time, cost and quality objectives, and 2) product success that focuses on goals and purposes to meet stakeholders' satisfaction. To date, the literature still does not provide a consistent standardized definition nor an accepted methodology for measuring it, as several researchers continue to underscore the difficulty (Gupta et al., 2013; Kahwajian et al., 2014; Nasirzadeh & Nojedehi, 2013; Ramlee et al., 2017).

There has been a wealth of studies within the past two decades attempting to identify the critical success factors for construction and building projects of various kinds. A list of 26 critical success factors derived from literature can be categorised into 11 groups, which include: stakeholder satisfaction, compliance to industry standards and regulations, sustainable projects promoting environmental and ecosystem stewardship, efficient operations and work processes, effective use of technology and engineering practice, adopting new techniques and measures for work process improvement (H. Liu et al., 2014), strategic procurement methods, competent team members in all project stages, optimal use of project resources, effective engagement of project stakeholders, and an effective change management plan. These success factors and their categorisation were presented in section 2 (Table 2.3).

2.5.1 Satisfaction-related factors

Traditionally, project success has been judged at the hand-over or close-out phase, using the two stakeholder-type driven measures suggested by Baccarini (1999). The measures differ with one alluding to the project participants judging success on cost, time and quality operational criteria (Ada Chan et al., 2005; Idrus et al., 2011; Takim & Akintoye, 2002), and the other features end-user, clients and owners judging on usability, sustainability and value-creation (Bustani et al., 2012; Fahri et al., 2015; Tshiki, 2015). Satisfaction as a success factor stems from an ongoing relationship among stakeholders that is built on a level of trust, generated because of public engagements (Da Rocha et al., 2013; Li et al., 2013). Lima et al. (2009) advised on perceived value creation and satisfaction in anticipation of the finished project. Othman (2007) alluded to the tangible and intangible objectives on the project's usability and maintainability. Maintaining and improving social stability are also major assessment indicators, by ensuring risks associated with diminishing the community's social comfort are to be managed or eliminated (Q. Shi et al., 2015). These measures are all outside the bounds of project operations, and though receiving minimal coverage in the literature as a success factor, it has gained greater resonance among the project's beneficiaries.

2.5.2 Compliance-related factors

Miller and Ortega (2006) summarised compliance as an efficiency-oriented practice that focuses on contract adherence, budget management, schedule monitoring, and document control. A compliance-oriented framework developed by S. Tabish and K. N. Jha (2011) aims to guide practitioners on alleviating industry irregularities through transparency, professional standards, contract monitoring and regulations, fairness, and procedures for corruption-free performance in public projects. The extensive work set out in management standards such as the Project Management Institute Book (PMI, 2017) also assists in guiding project managers to established procedures, including adherence to international protocols like the Sustainable Development Goals (SDG) for achieving environmentally sustainable projects (Opoku et al., 2019).

2.5.3 Sustainability-related factors

Sustainability takes on two dimensions in the literature regarding construction projects. First, the development of projects that reduce negative environmental effects for which the industry has been repeatedly accused (Wen-der et al., 2018), and second, refining project management practices to include innovations in materials and methods, and aid the management of risks associated with ex-post life-cycle transaction cost towards sustainability (Ali et al., 2018; Xue et al., 2018). New phenomena and concerns with worldwide attention, such as climate change and the increased effects of natural hazards, obliges the industry to reconsider practices that use sustainable materials, adopt techniques to promote energy efficiency, and reduce carbon emission (Oke et al., 2017). Equally important, Ozer (2014) advances the development of strategies that seek levels of efficiency between the built and natural environment to advance a flourishing relationship.

2.5.4 Operations-related factors

Construction is known for its operational processes. Consequently, factors for successful operational management centres on reducing waste and adopting innovative monitoring approaches to boost overall efficiency, geared towards cost containment and time management (Al-Aomar, 2012; Obi et al., 2017). Miller and Ortega (2006) have also emphasized the need to manage project risks to better control expenditure through all project phases and to avoid bankruptcy. Project financing has also been flagged as critical to project success (Hassim et al., 2003). More so, the identification and prudent resource management of all work processes, utilizing strategies such as Cheng et al. (2010) 'estimate of completion' technique, which factors performance and risks in final costing, and Goodrum et al. (2003) advice on investigating possible issues to ensure feasibility of project tasks as a default planning and design feature.

2.5.5 Engineering practice-related factors

Engineering factors concentrate on 1) structural integrity and robustness of projects to avoiding collapse failure or if unavoidable, design to facilitate a progressive collapse (Adam et al., 2018), 2) clear technical specifications oversight in planning and designs (H. S. Lee & Lim, 2017), and 3) ensuring a project's feasibility and practicality (L.-y. Shen et al., 2010). Bustani et al. (2012) and Huh et al. (2012) advanced the need for conceptualising a creative mix of direct and tacit knowledge required for a clear feasibility pathway to achieving objectives. Additionally, a critical engineering component is design management, which is an essential pre-contract process that aims to minimise design changes in subsequent project phases (Pukite et al., 2017). It should be noted that engineering factors appeal to construction practices by ensuring the design plans reflect the project's objectives and the project conforms to established standards.

2.5.6 Innovation-related factors

Innovation-related factors revolve around adopting new devices, equipment or techniques that alter existing practices or adopt new ones for process improvement and output, by synthesizing and integrating technological, human resource, societal, economic and managerial factors (H. Liu et al., 2014). Innovation contributes significantly to various sectors of the industry, for example, off-site manufacturing to replace several on-site safety, time and cost-overrun inefficiencies (Ahmad, 2000; Elnaas et al., 2014), leveraging digitally enabled communication devices for real-time on-site information collection and transfer (Ahuja et al., 2009; Foroozanfar et al., 2017). A significant game changer in the industry is the ability of technical staff to produce graphical digital representation using 'virtual prototypes' to facilitate meaningful conversations among the wider stakeholder groups, and simulations to assess functional specifications under various operating conditions (Benjaoran & Dawood, 2006; Kong, 2010). Factors in this category seek to leverage ideas among industry professionals through strategic corporation and explore avenues with decentralisation of project tasks, primarily for improving efficiency and mitigating safety risks to decrease document errors, rework and design time (Ahuja et al., 2010; Cao et al., 2015)

2.5.7 Procurement-related factors

Procurement is characterised as the framework within which construction products and services are brought about, acquired and obtained through an organised relationship structure (Rameezdeen et al., 2005). Factors in this category include procuring the most appropriate resources for optimising project success, primarily based on performance-based contracting and reliable supply chain networks (Cui et al., 2010; Mills et al., 2011; Moon et al., 2017). Additional factors include effective relationship management that ensures contractors are held responsible for their scope of works and demonstrate an appreciated sense of accountability (A. Chan et al., 2015). Several researchers have concluded that selecting an unsuitable procurement method leads to project failure (Nicał & Wodyński, 2015; Thanh Luu et al., 2003). Strategizing the selection process is still vague, however, S. Thomas Ng and Li (2006) underscore the vicious nature of the bidding processes and proposed a more guided process that alleviate project failure instigators regarding the client's tendencies to accept the lowest bid cost without proper correlation to the project's scope (Cindrela & Ananthanarayanan, 2017) or the contractor under-bidding to achieve a competitive edge (Olaniran, 2015).

2.5.8 Competence-related factors

The essence of having competent project leaders and team members were expounded upon, when Larsson et al. (2015) explained that effective leadership ensures that team members are satisfied or have the potential to be satisfied with a leader that harnesses their skills and attitude to be sufficiently aligned for achieving the project's objectives. Competency factors span all project phases – from the time of making the crucial and binding decisions about the project's feasibility and execution (Faniran et al., 2000; Wondimu et al., 2016), through to project delivery, while leveraging leadership and technical skills, and experience and tacit knowledge at the individual and organisational levels (Ly et al., 2005; Müller & Rodney Turner, 2010; Rasli & Mohd, 2008). Removing uncertainty and unpredictability in project execution and promoting an atmosphere that fosters knowledge sharing have been hailed as the basis for productivity and competency development in the industry (Afolabi et al., 2018).

2.5.9 Resource management-related factors

Optimising financial, technical and material usage is a key factor during the post-disaster reconstruction period (Memon et al., 2011). Ensuring that the right skillsets are procured from either internal or external sources will serve to maximise production schedules while reducing project contingency allocations (Nitithamyong & Tan, 2007). Resource allocation extends to having a motivated workforce (Graboviy, 2016; Ohueri Chukwuka et al., 2018): in this situation, an attitude that promotes widespread understanding of the project's objectives and a level of consciousness that significantly minimises project resources wastage is needed (Mahpour & Mortaheb, 2018; Moon et al., 2017). Staff motivation can also lead to minimal communication problems, improved collaborations through positive personal behaviours, and improved labour output, by engaging the correct skills in line with the specific tasks and prudent work safety ethics (Nasirzadeh & Nojedehi, 2013; Nitithamyong & Tan, 2007). Deep et al. (2019) reviewed findings on collaborations in construction projects. The authors discovered trust, commitment and reliability to be the prime enablers that inform the timely acquisition of key resources, especially in PPP projects, which can significantly improve time management and reduce down times.

2.5.10 Stakeholder management-related factors

A clear understanding of who the key stakeholders are, their expectations and their level of involvement is a critical element in the project planning stages and augers well for project success. Sharing project risks across project stages to prevent conflicts, improve clarity of roles and objectives, and having a transparent appeal procedure, can be achieved through stakeholder effective consultation (Osei-Kyei et al., 2019). Again, the need to maintain a motivated workforce, including partnerships, enforces a culture of openness at all levels, which boosts confidence for open communications (Jacobson & Ok Choi, 2008; M. Jarkas et al., 2014). It also reduces or eliminates any emotional and physical stress (Liang et al., 2018), and displays sensitivity to the interests of all who may be affected by the project (Bahadorestani et al., 2020; Ramonu et al., 2018). Factors related to stakeholder management also enter the territory of project tasks' decentralisation (Black et al., 2000). While off-site manufacturing poses its own challenges, S. Z. S. Tabish and K. N. Jha (2011b) efficiency claims support a construction environment that fosters innovations among construction organisations.

2.5.11 Change management-related factors

Change management success factors encompass 1) a visible change management plan (Senaratne & Sexton, 2009), and 2) a clearly mapped communications plan (Lebcir & Choudrie, 2011). A change management plan visible to stakeholders, especially the project end-users, provides an avenue to voice project concerns with an assurance that their criticisms will be acknowledged. In collaboration with an effective communication plan, provisions to sharing tacit knowledge among multi-stakeholder groups can be a reality towards avoiding conflicts and legal proceedings (Mahfouz et al., 2018). Additionally, proper communication plans assign responsibilities to the particular teams members that can reduce miscommunication challenges among the stakeholder groups and clearly communicate the project's objectives.

2.6 Summary

By using a systematic review approach, this chapter has provided a summary of the most recent literature on success factors for managing residential building and infrastructural reconstruction projects. The 26 project success factors were further categorised into 11 project success categories with the open-coding method. The review points to new dimensions of project success, suggesting that traditional operational success factors have been mainstreamed and new factors have evolved. It was found that in addition to the triangle ‘cost, time and quality’ targets in conventional project management, the pursuits of sustainability, maintainability and ‘fit-for-purpose’ have become increasingly important for end-users. This review highlighted additional success factors such as unbiased ecosystem care (Ozer, 2014), social life enhancement (Q. Shi et al., 2015) and continuous engagement through all project stages (Doloi, 2012; Lebcir & Choudrie, 2011), which reflect new types of stakeholder expectations.

There is a growing involvement of the wider stakeholders groups, often accompanied by their conflicting interests and expectations. These include concerns related to project safety, practicality, and sustainability. Avenues to achieving commonality on objectives are the adoption of technology through innovations for aiding visualisation of the project before contract awards and roll-out, whilst addressing project satisfaction concerns during its execution and beyond hand-over.

Existing project success frameworks centred on the operational aspects of project management (Belassi & Tukel, 1996; Lim & Mohamed, 1999). The review revealed new success criteria, namely client and end-user satisfaction, project sustainability, technological adaptation, and change management, which sharply impose the need for recognising the additional success dimensions. As the expectations of industry stakeholders grow, especially with clients and end-users, the demand for successful projects has also grown proportionally. It is hoped that the state-of-the-art review presented in this chapter provides insights for project stakeholders and researchers about how the practice of project management should evolve to address the increased complexities for large and mega projects. The factors elicited will form the basis for further analysis in the development of this thesis resilience framework.

Chapter 3: A systematic review of resilience factors affecting post-disaster reconstruction

3.1 Introduction of this Chapter

Similar to Chapter 2, another fundamental to this research process is a profound understanding of resilience as an applied disaster management technique in reconstruction, and the technique's prevalence within the construction industry. The literature confirms the importance of a resilient built environment as a community's component and partner for advancing sustainability, and an impetus to the other pillars' regeneration (social, economic, and environmental) after a disaster. Following the PRISMA protocol and content analysis, this chapter's systematic review into the literature will assist with eliciting the resilience-oriented factors that are used by industry practioners to achieve resilient reconstruction projects, as assessed by improved robustness against future disasters and rebuilds in harmony with the satisfaction of the intended users of the finished project, called 'end-users'. This chapter provide the justifications, methodology and findings of this review process.

3.2 Introduction

Resilience in reconstruction projects has become a critical component subject in a) assisting in the need for more robust built systems against perturbation (Adam et al., 2018), b) advancing the sustainability dialogue in the increased use of environmentally friendly building materials (Hiwase, Hajare, et al., 2018) and c) maximising a construction project's social life cycle (S. Liu & Qian, 2019). Though gaining prominence over the last decade as a measurement tool, the resilience of the built environment remains a contentious issue (M. Mojtahedi et al., 2017), and its application to post-disaster reconstruction projects is still not precise. Without a guiding resilience factors framework, 'trial and error' are commonplace, as the efficacy of a community's ex-ante and ex-post functionalities for continuously providing social, natural and economic services bears enormous reliance on its buildings and infrastructures' ability to maintain robustness.

Both typical construction and post-disaster construction exhibit varying execution challenges; however, Le Masurier et al. (2006) investigation into their differences has attributed the general lack of applicable legislation, stakeholder coordination and resource scarcity as factors exacerbating these challenges in the aftermath of a disaster. Davidson et al. (2007) also agreed that the post-disaster climate is a far more chaotic environment because of resources and skilled labour scarcity, normally attributed to simultaneous projects accessing the limited workforce pool, and an unavoidable atmosphere that pressures speedy recovery reporting from donor agencies, especially in developing countries. Adding to the dilemma is the prevalence of new and innovative construction techniques and materials for promoting sustainability, vulnerability reduction and satisfying stakeholders' concerns on practicality, socio-economic value improvement and longevity (Hiwase, Hajare, et al., 2018; Saidu & Yeom, 2020).

The challenges in restoring a community to its pre-disaster functional state have been widely researched, and several disaster management frameworks spanning diverse scenarios have been advanced, e.g. (Faulkner, 2001; Houston et al., 2015; O'Sullivan et al., 2013). Declarations of these frameworks as being optimally successful have been relatively slow (Djalante et al., 2012), and are somewhat attributed to their short life from frequent revisions, due to the dynamism of existing and emerging disasters types. Additional stipulations originate from stakeholder expectations congruent with environmental changes, existing and emerging disaster management protocols, and international resilience frameworks requiring political and financial compliance. Consequently, paradigm shifts into resilience techniques are becoming mainstream as a more adaptive and inclusive strategy (Norris et al., 2008).

Resilience strategies for improving the stability and robustness of construction projects have attracted the interest of industry professionals, including those in academia. The resilience concept has adopted various dimensions over the past five decades, and it has mainly been construed as an entity's functional attribute that can only be modified and improved to maintain robustness. Resilience concepts over the period include: Holling (1973) formalising the concept as 'the need for persistence' (p. 21), and Hoiling et al. (1997) asserting a measurable dimension as ‘the magnitude of disturbance that can be absorbed before a system changes its structure’ (p. 50). More recently, Bruneau et al. (2003a) have characterised resilience as the ability to ‘reduce failure probabilities, reduced consequences from failures, and reduced time to recovery’ (p. 744). Resilience definitions and applications have been explored by several researchers (Adam et al., 2018; Bocchini et al., 2014; Johannessen et al., 2014; Mannakkara et al., 2018; Mycoo, 2014) and across several disciplines (such as ecology, social science, engineering, disaster management and personal development). The proliferation of definitions has somewhat created ‘resilience silos’ within these disciplines, which often limits its conversation with their fundamental domain-related science, for example, Mayunga (2007) on disaster resilience, Adger (2000) on socio-ecological resilience, and Mancini et al. (2012) on socio-economic resilience.

Martin-Breen and Anderies (2011) expounded on resilience epistemological orientations, applications, and justifications for its application and measurement insights. Zhou et al. (2010) previously compiled a comprehensive list of definitions that dated back to 1973, in which the constant among the definitions narrowed to two dimensions being a) the ability to be robust to perturbation and b) the ability to recover from adverse effects quickly. In later years, further insights extend into a third dimension that centres on the ability of affected systems to adapt to the changing external environment by remedial modifications to its internal structures termed complex system adaptation (Dalziell & McManus, 2004; Fiksel, 2003). Aggregating these three dimensions into a single resilience concept definition, across all disciplines, has proven to be very difficult, primarily due to an inability to converge on common indicators and measurement metrics (Quinlan et al., 2016).

With partial convergence on these three dimensions, built environment resilience has gained prominence in disaster recovery, and more specific, disaster reconstruction. Its applications to post-disaster rebuild (buildings and infrastructure reconstruction) construes two salient schemes that focus on addressing 1) the built environment’s long-term resilience development plans and 2) its effectiveness through safety and innovation techniques as an enabler to adopting new approaches in built system designs, operation and governance (Hassler & Kohler, 2014). Typically, conventional projects are designed and constructed according to standard industry-accepted risk-mitigation principles surrounding structural and safety risks. However, resilient-oriented construction extends into addressing the traditional flaws and failures by instituting corrective measures during reconstruction, also factoring the issues affecting the typical project end-users with comfortability, practicality, social sustainability and socio-economic gains (Hosseini et al., 2018; Razzaq et al., 2018). Notably, resilience has gained prominence as a proactive approach over traditional reactive reduction approaches for its support to long-term development plans.

The literature is quite exhaustive on interpreting, expanding and advancing the resilience concept. Recent attempts to transform the concept of resilience from theory to practice (applying measurement indicators) are quite promising. Incorporating resilience in industries such as construction, reconstruction and disaster management with applications to disaster preparedness, recovery and rehabilitation, including vulnerability and sustainability assessments, can assist in its operationalisation (Martin-Breen & Anderies, 2011). Several authors have postulated on its operationalisation by strategically linking the management of known and emerging risks associated with stand-alone or interdependent built systems, and the fundamentals of resilience with the need to increase robustness by assessing deficiencies and making adaptive adjustments to improve the system's vulnerability and sustainability characteristics (Bakkensen et al., 2017; Lizarralde et al., 2015; Milman & Short, 2008; Moles et al., 2014; Olsson et al., 2014). Dalziell and McManus (2004) have also argued for resilience as a fundamental attribute to the built environment developmental agenda. They postulate that reducing system vulnerabilities and advancing sustainability thrives on resilience strategies that focus on an 'efficiency of function' and a 'maintenance of function' attribute of perturbed systems (Dalziell & McManus, 2004).

Though the resilience message has been mostly positive and encouraging, Nicol and Knoepfel (2014) averred the need for the support of institutional programmes to mainstreaming resilience, because, by itself, there is no direct pathway to inserting its principles into the built environment. Leveraging institutional support prompts the identification of key actors across all applicable sectors, using strategic policy directives and a resource-based approach as propelling vehicles (Nicol & Knoepfel, 2014). With resilience as an enabler to improving the build environment's vulnerability and sustainability, post-disaster reconstruction stands to benefit from an institutional framework that synergises the facets of governance, integration, adaptation and stakeholder engagements for a holistic embracing of the concept.

Built environment resilience remains a contentious issue, though gaining prominence as a measuring tool, over the last decade (M. Mojtahedi et al., 2017). Referencing the typical disaster management cycle (Coetzee & Van Niekerk, 2012), several researchers have alluded to the adoption of resilience development techniques in disaster preperation and response situations (Aitsi-Selmi et al., 2015; Dilanthi Amaratunga & Haigh, 2011; Bocchini et al., 2014); however, there is yet a resilience framework to guide resilience factors' selection to reconstruction projects. Without a strategically defined framework, factor misappropriations arising from 'trial and error' are commonplace, giving rise to an urgent need for an investigation into the literature, specifically to understand how resilience factors have been applied. This chapter aims to highlight the findings of a thorough systematic investigation into the literature, specifically to elicit factors and strategies intended to improve the built environment's resilience. To achieve this chapter's objective, the following research questions will guide this review:

1) To what extent are resilience factors considered in reconstruction projects?
2) Are there pathways to mainstreaming resilience in post-disaster reconstruction projects?

3.3 A systematic review methodology

This thesis uses a systematic review approach into the literature, guided by the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) protocol. The protocol provides for an exploratory and unbiased investigation into multiple bibliographic databases (Green & Higgins, 2005), rendering it more systematic than traditional approaches, especially with its unique ability to summarise all available empirical findings on a specific question with analytical clarity (Moher et al., 2015; White & Schmidt, 2005). The review extracted relevant articles in four distinct, yet connected steps: 1) a systematic search through the literature in digital bibliographic databases 2) a screening stage that includes a brief relevancy confirmation of the articles found 3) an eligibility assessment stage that investigates the remaining studies' full text against established inclusion and exclusion criteria for further relevance to the research question and 4) the final stage accepts the remaining sample studies as representative of the population of relevant studies on reconstruction project resilience and is now ready for data extraction, coding and systematic review.

Step 1: Identification of articles

In March 2019, English language titles in four databases, which included SCOPUS, Web of Science, ScienceDirect and Google Scholar, were searched based on specific keyword search terms. These databases have wide acclaim to an enormous quantity of scientific outputs on resilience in diverse disciplines (Falagas et al., 2008).

Since resilience has only recently been adopted into the construction industry as a measurement tool for system robustness (M. Mojtahedi et al., 2017), only articles published within the last decade (2009-2019) were considered. The base search keywords were resilience, disaster, recovery, reconstruction, rehabilitation, and project management. The search term arising from the keywords was ((resilien* AND ("disaster reco" OR "disaster rehabilitation") AND "*project")). The initial search returned 117 studies, and their citations were managed using Endnote 8® software. The article retrieval process is shown in Figure 3.1.

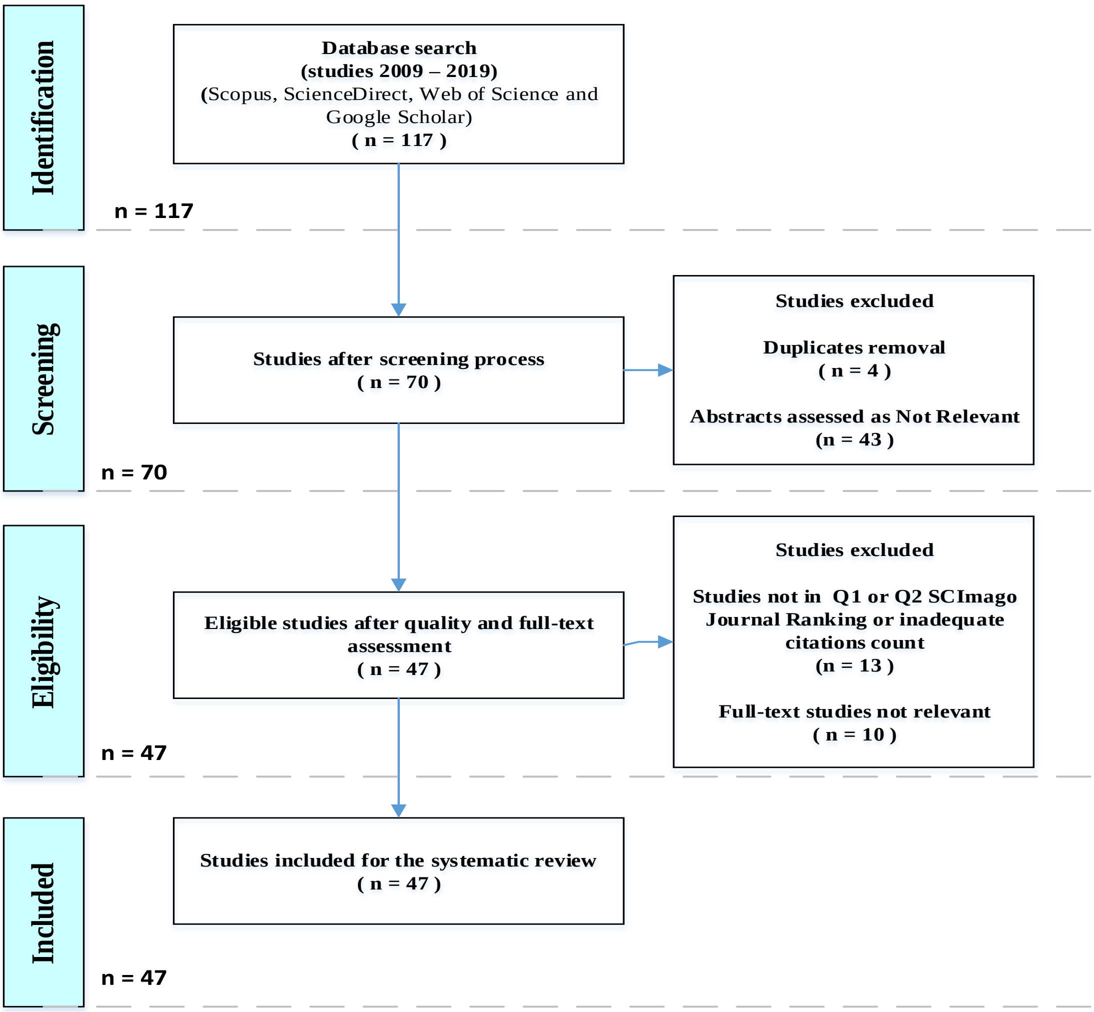


Figure 3.1 The PRISMA flow-chart summary of the search strategy

Step 2: Screening

The screening process continued to a two-stage exercise that comprised a) the removal of duplicate titles arising from the multiple database searches and b) an abstract overview that checks for relevance to the research question. Additionally, inclusion and exclusion criteria limit articles within the last decade from industry journals and high-quality conference papers that report on a resilience strategy applied to a reconstruction project. The initial search returned 117 articles with four duplicates. These duplicates were removed, and the remaining 113 studies were abstract assessed for relevance. Forty-three studies were considered irrelevant to answering the research questions and were also removed, thus leaving 70 studies qualified as somewhat relevant to the research question.

Step 3: Eligibility

The selection of eligible articles followed a combined two-step 2x2 taxonomy based on two quality assurance assessment factors (refer to Figure 3.2): publication (article in recognised industry journal) and citations (citations over the life of the article). First, articles were assessed for published empirical studies and conference papers in scientific journals having Q1 and Q2 quartile ranking (W. Liu et al., 2016), following the SCImago peer-reviewed Journal Ranking Metric (SJR) and used by previous authors (Ayodele et al., 2020). Second, the articles were also assessed on the number of citations over a three-year window. The Google Scholar citation index was used based on Kousha and Thelwall (2007) exploratory assessment that concluded the online bibliographic database as credible to reporting citations count. With allowance for one self-citation and an exception for studies less than three years old, studies with three or more citations were considered sufficiently adequate and determined as relevant. Only articles satisfying quadrants A, B and C were eligible for this review following Seglen (1992) conclusion that the non-uniformity in author citations is largely skewed and being published in a top-quality journal does not necessarily translate as having high productivity recognition. Therefore, this review favours research output having top methodological acclaim and a sufficient number of citations. This assessment identified 13 articles as not meeting the quality eligibility criteria.

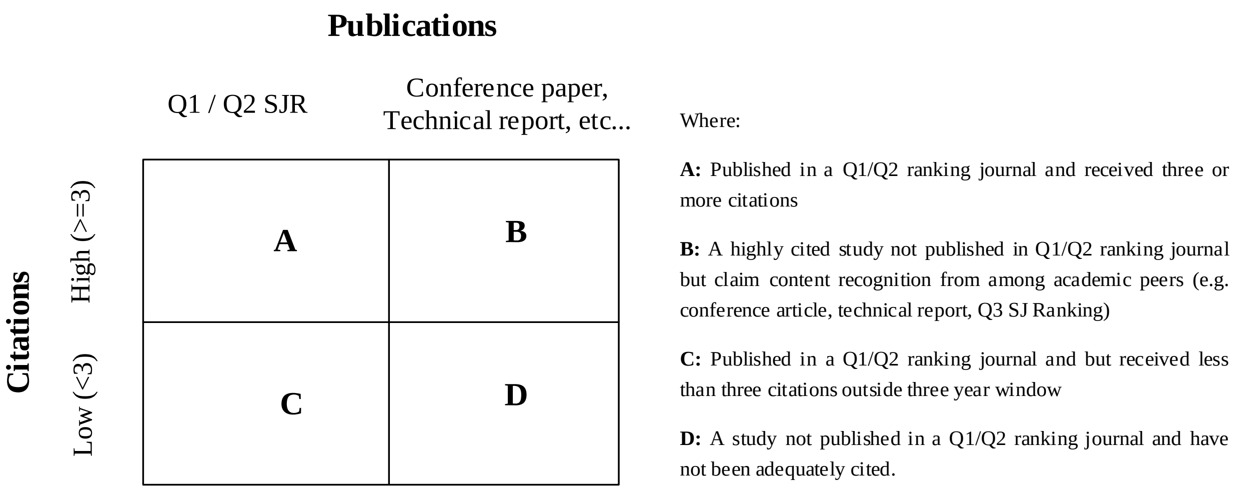


Figure 3.2 A 2x2 taxonomy on scientific journal publications and citations

Further full-text screening for relevance identified 10 articles as not applicable to the research topic and was therefore eliminated according to the following rating scale. Articles' relevance to this research was guided by the rating scale of '1' on low relevance for having a narrow view of the research topic with time-constraint conclusions, '2' on medium relevance for either providing useful material for supporting or contradicting an argument related to the research topic with dated concepts and terminologies, and '3' for high relevance where relevant literature is cited throughout with modern concepts and terminologies and the conclusion can establish a basis for future research. Only articles with a ranking of 3 on the scale were considered. The result of the eligibility process realised 47 studies as a representative sample of the article population on the subject matter.

Step 4: Inclusion for review

Forty-seven articles were identified as suitable for meta-analysis and covered diverse perspectives of resiliency. They were included for this review to elicit the resilience techniques undertaken in post-disaster reconstruction, in line with the research questions. Using the open-coding method, a content analysis mapping technique (Cavanagh, 1997), resilience factors were grouped into themes. The extracted data were managed and analysed using Microsoft Excel version 2016, and a summary of the findings is described in Table 1 and discussed in the remaining sections.

3.4 Systematic literature review results

3.4.1 Descriptive analysis of selected articles

Relevant articles within the last decade (2009-2019) were retrieved, totalling 47; the earliest relevant article was published in 2011. As shown in Figure 3.3, journal articles contributed 90% of the articles with an annual increased interest in resiliency research. Investigations into resilient building and infrastructure type projects received almost equal attention, however, within the two construction types, the housing (60%) and transportation (25%) sectors received the most attention, respectively. Other construction sectors, where resilience development factors were applied, include water, energy, ICT, tourism and education.

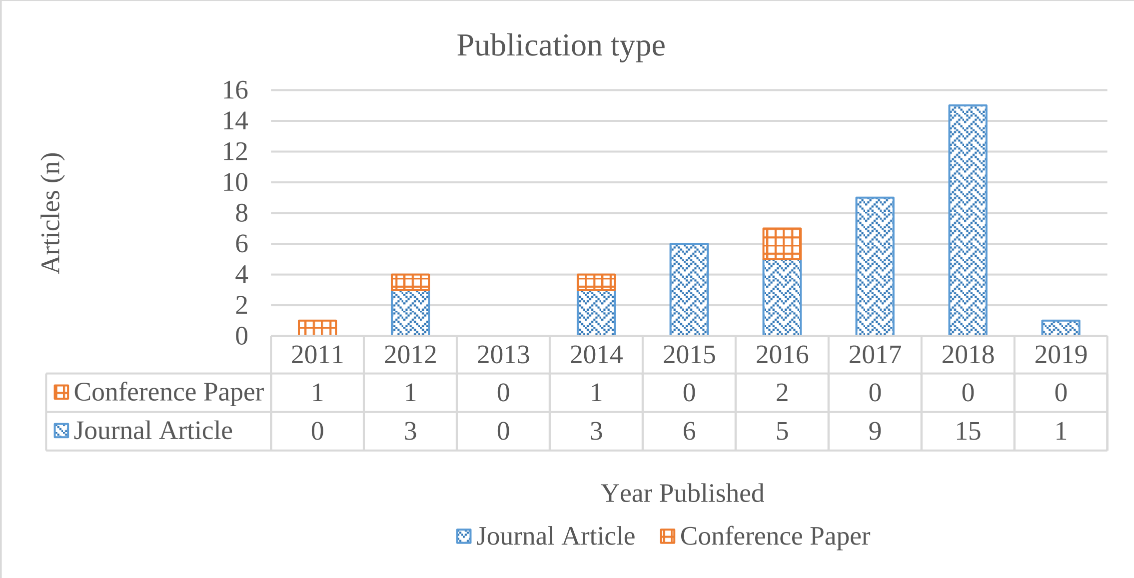


Figure 3.3 Distribution of included articles published from 2009-2019

Referencing the designation of world regions by the UN Statistics Division (UN/SD, 1970), the American, Asian and European regions have each contributed a 29% average of the included studies. The Oceanic region (Australia and New Zealand) contributed 13%, while Africa contributed 2%. Various instruments were used in the research data gathering. Approximately 30% of the studies utilised two or more research instruments, mainly literature reviews in combination with interviews or case studies. Overall, the literature review method was used in 38% of the studies, while case studies, interviews and questionnaires were performed in 20%, 18% and 14 % of the studies, respectively. Other instruments included observations (6%), internet surveys (2%) and reports (3%).

The 47 included articles documented resilience measures in response to particular disasters. Almost 20% of the studies identified earthquakes as triggers to the development of resilience strategies. They were well distributed over the Asian, Americas and Oceanic regions. Flooding followed, by contributing almost 17% of the studies, with 50% of these from the Asian region. Overall, most hazards that can induce structural damages were represented among the articles (earthquakes, floods, tsunami, hurricanes or typhoons, volcanic eruptions, terrorism, cyclones and climate change); however, only one article dealt explicitly with the collapse of built systems from structural defects.

3.4.2 Resilience factors applied to disaster reconstruction projects

As highlighted earlier, Holling (1973, p. 21) formalised the resilience concept as 'the need for persistence'. It has since been applied in various disciplines, though with minuscule variations. Its recent adoption by the construction industry has somewhat centred on the ability of a system to mitigate, resist, absorb and recover from the perturbation by maintaining its functions and structure (Fatiguso et al., 2017; Lizarralde et al., 2015). The contextual application of resilience factors, as identified in the literature, suggests that the factors can be categorised into five criteria categories, using the open-coding technique (Khandkar, 2009), namely: governance, innovation, reconstruction approaches, resource management and stakeholder expectations. Table 3.1 provides a comprehensive listing of resilience factors elicited from this systematic review.

Table 3.1 Synthesis of resilience development factors from the articles reviewed

Resilience criteria	Resilience factors	Description and expected outcome	Sources
Governance	Policies and legislature	▪ Strict national laws and policies	(Mannakkara et al., 2018)
	Development objectives	▪ Transparent government short-term and long-term objectives for the construction sector	(Lizarralde et al., 2015)
	Institutional strengthening	▪ Supportive public and private sector institutions (e.g. donor agencies, banks, NGOs)	(Bilau et al., 2015)
	Urban governance	▪ Defined land-use and development plans	(Mycoo, 2014)
	Communication	▪ Understanding of the local culture and design accordingly	(Yilmaz, 2014)
Innovations	Critical infrastructure indexing	▪ Some infrastructure considered more critical and should be treated accordingly	(Andrić & Lu, 2017; Hromada & Lukas, 2012; Kaminsky & Faust, 2018; Oh et al., 2012; Pitilakis et al., 2016; Serre & Heinzlef, 2018)
	Structural robustness and retrofitting	▪ Continuous design improvements and modifications	(Adam et al., 2018; L. Chang et al., 2012; Psyrras & Sextos, 2018)
	Progressive or disproportionate collapse	▪ Avoiding or delaying structure collapse	(Adam et al., 2018)
	Preventative maintenance	▪ Active assessment of structures to repair and improve	(Andrić & Lu, 2016; Hariri-Ardebili, 2018; Khan et al., 2017)
	Redundancy	▪ Availability of alternative systems or structure	(Brotherton & Dietz, 2014)
Reconstruction Approach	Knowledge-based approach	▪ Reliance on past experiences during reconstruction	(Arain, 2015)
	Absorptive capacity approach	▪ Reconstruction is highly influenced by future demographic or development changes	(Inzulza Contardo et al., 2018)
	Pre-emptive approach	▪ Reconstruction design based on possible future hazards	(M. Mojtahedi et al., 2017; W. Zhang & Wang, 2016)
	Build-back-better approach	▪ An equal focus on the structural and non-structural components during recovery	(Maly, 2018; Ong et al., 2016)
	Climate resilience approach	▪ Establishing construction policies and actions that mitigate the effects of climate change	(Umoh & Lugga, 2019)
	Sustainability approach	▪ Reconstruction with equal focus on environmental, social and economic improvement	(Bocchini et al., 2014)
	Participatory approach	▪ The need to understand the beneficiaries' wishes in reconstruction or relocation	(Santiago et al., 2018)
Resource Management	Funding and labour allocations	▪ Ensure funds or resources are readily available for reconstruction	(Kumar et al., 2015; Macaskill & Guthrie, 2018)
	Competency	▪ Strategic development and deployment of construction skills	(Abe et al., 2018; Roosli & Collins, 2016; Roosli et al., 2018)

	Material re-use	▪ Salvage materials that can be re-used during recovery	(Arnott, 2017)
	Public–private partnership	▪ Public and private stakeholder collaboration	(Johannessen et al., 2014)
Stakeholder expectations	Community participation	▪ Community engagement at all times during reconstruction	(Bilau et al., 2017; Di Gregorio & Soares, 2017; Gimenez et al., 2017; Maly, 2018; Sadiqi et al., 2017; Walton et al., 2017)
	Multi-sector collaboration	▪ Collaboration among all sectors during the rebuilding process	(Y. Lu & Xu, 2015; Y. Yang et al., 2018)
	Anti-neoliberalism	▪ Ensure unbiased interest from either the public or private sector	(Tierney, 2015)

3.5 A review of empirical resilience factors in reconstruction projects

3.5.1 Factors related to governance

Governance resilience factors were applied in several contexts, including 1) the political will to ensure applicable laws support long-term planning and development policies for sustainable reconstruction projects (Lizarralde et al., 2015; Mannakkara et al., 2018), and 2) the availability and ease of access to disaster risks mitigation funding for both public and private projects (Bilau et al., 2015). Other key components of governance are effective national communication with all stakeholders (Yilmaz, 2014) and land-use development plans and administration (Mycoo, 2014) while paying close attention to cultural inclinations and emerging anthropogenic activities that can affect vulnerabilities.

3.5.2 Factors related to innovation

Innovation factors encompass the tactical use of technology for efficiently designing and developing highly effective and robust structures (Adam et al., 2018), including informed preventative maintenance plans, especially using modern and adaptive materials and techniques (Andrić & Lu, 2016; Hariri-Ardebili, 2018). Prioritising and indexing some infrastructure as critical (Oh et al., 2012; Serre & Heinzlef, 2018) have designated their lifeline attributes, social, and economic importance over others, thus advancing clear budgetary considerations for implementation, maintenance and redundancy planning (Hotchkiss et al., 2013).

3.5.3 Factors related to the reconstruction approach

The literature points to seven approaches to reconstruction projects (Arain, 2015; Bocchini et al., 2014; Inzulza Contardo et al., 2018; Maly, 2018; Mohammad Mojtahedi & Oo, 2017; Santiago et al., 2018; Umoh & Lugga, 2019). While no clear arguments on optimisations have been forwarded for any of the approaches identified, they bear semblance to mainstream mitigatory objectives against prevailing hazards, mostly congruent to minimising the direct and indirect losses to future disasters.

3.5.4 Factors related to resource management

Resiliency involves engaging appropriate skillsets and methods (Abe et al., 2018; Kumar et al., 2015) to minimise any rework tendencies while exploiting modern techniques to mitigate or alleviate the effects of new construction industry risks, such as congestions from urbanisation, retrofitting and climate change. Ensuring accessible funding sources are readily available (Macaskill & Guthrie, 2018), effective procurement collaborations (Johannessen et al., 2014), and the management of resources that also embraces waste management in all forms (Moon et al., 2017) act as financial conservator methods.

3.5.5 Factors related to stakeholder expectations

Maintaining system functionality, adherence to progressive policies through compliance and the acceptance of innovative building and infrastructure designs to acceptable and appreciable standards depend on effective communication and understanding stakeholders' expectations. Including community members' participation at all project stages (Bilau et al., 2017) and ongoing dialogue among utility sectors (R. J. Yang et al., 2018) for coordinated reconstruction activities are also considered essential. Key to reconstruction resilience, with cross-cutting benefits to all stakeholders, is the presence of a neo-liberal climate that seeks to eliminate biased to specific stakeholder groups or individuals (Tierney, 2015).

3.6 Contextual application of resilience factors

This literature review article explored resilience factors in disaster reconstruction within the realms of the vagueness surrounding a single definition. Though resilience context-specific explanations have emerged over the past four decades within various disciplines (Hassler & Kohler, 2014; McAslan, 2011), the multifaceted and chaotic disaster recovery period amplifies the difficulty in applying the concept. Modern resilience applications within disaster management seek to undertake recovery activities strategically and undergo relevant changes to reduce future disturbances while maintaining function and structure (Bhamra et al., 2011; Bruneau et al., 2003b). The strategic applications of resilience factors have received little attention and can be attributed to an ongoing transition from the disaster risk reduction approach to the risk resilience approach.

Built resiliency in this discourse connotes the ability of the built environment to maintain functional fitness and also to provide a supportive role to the other components of community existence (social, economic and natural) (Bosher, 2014). Such relevance to community support ascribes pivotal roles of governance, innovations, reconstruction approaches, resource management and stakeholder management to managing these complex environments into an integrated resilient system, through an underlying complex adaptive perspective (Aritua et al., 2009), in all facets of reconstruction and recovery.

3.7 A conceptual framework for factors influencing reconstruction projects resilience

The factors highlighted within the five resilience categories demonstrate distinct characteristics; however, there is an interrelated phenomenon where a factor in one category can influence a factor in another, citing synergistic opportunities. For example, the designation of an entity as critical infrastructure would have garnered influence from state and governance responsibilities to ensure citizens' health and safety according to stakeholder expectations. Consequently, it will drive innovations and reconstruction techniques based on available resources, including maintenance priorities. Assimilating the impact of resilience strategies in the built environment, a novel conceptual framework for factors affecting resilience in post-disaster construction is presented in Figure 3.4.

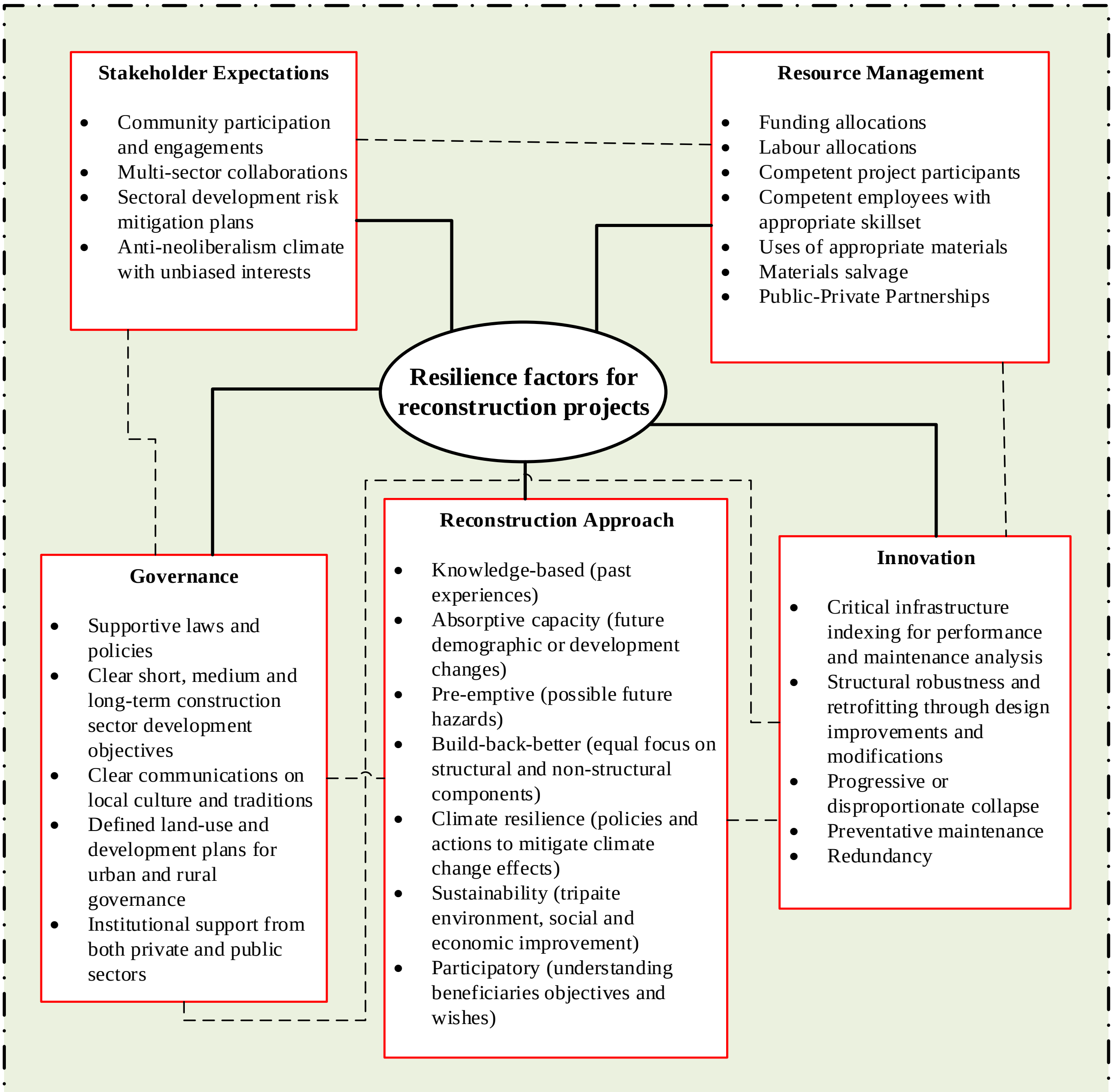


Figure 3.4 Conceptual framework for factors influencing reconstruction project resilience

Illustrated in Figure 3.4, post-disaster reconstruction resilience has been conceptualised into practice with avenues for developing measurable goals for more resilient built systems, which transcend the natural, social and economic components for ensuring a community's minimal disturbance. It is hypothesised that these factors, once utilised effectively with management competence, will improve confidence in reconstruction projects as being reliable, robust, sustainable, and stakeholder-expectation centric. More importantly, this framework can assist in identifying gaps for gaining an improved understanding of, and the strategic applications of, resilience factors, for successful reconstruction project outcomes.

Moreso, the framework has clear potential to advancing the objectives of the Sendai Framework of Action (SFA). Interestingly, Aitsi-Selmi et al. (2015) noted the conclusions of several research on the progress in disaster risk reduction and summarized that "it is often not the hazard that determines a disaster, but the vulnerability, exposure, and ability of the population to anticipate, respond to, and recover from its effects"(p. 164). This assertion points to the need for a resilience approach, with inclusivity and leveraging local solutions with community involvement. The factors elicited supports the process-driven SFA that replaced the product-driven Hyogo Framework for Action (HFA) in 2015 and continues to be the United Nations endorsed disaster management framework for aiding disaster reduction programmes.

3.8 Summary

Resilience as an operational technique in disaster management has become increasingly popular with post-disaster reconstruction, mainly because of its potential to assisting the built environment in maintaining stability during perturbation; however, its concepts transforming into practice remain mostly vague (Fekete et al., 2014). Following recent deviation from disaster risk reduction approaches to the more inclusive disaster resilience approaches (Aitsi-Selmi et al., 2015), this review gained an in-depth understanding of the resilience factors assimilated within the last decade, as documented in four well-established academic bibliographic databases. With the earliest published article on the research topic in 2011, 47 journal and conference articles recited reconstruction-related resilience initiatives between 2011 and 2019, which formed the basis of the included articles. Twenty-four factors in five resilience categories answered the research questions regarding an understanding of the built environment's role in creating both community resilience and resilience for post-disaster recovery.

This review also answered the second question of this review; the results can guide project managers, developers, planners and practitioners of reconstruction projects with improving the built environment's functional robustness characteristics by applying these factors to project management practices. The resilience factors identified during this review process will be foundations to the required analysis in the development of this thesis resilience framework.

Chapter 4: Research methodology

4.1 Introduction to this Chapter

Achieving the objectives of this research for answering the research questions (refer to section 1.4), it is critical to select the most appropriate philosophical approach, the optimal inquiring strategy, and the tools necessary to collect and analyze the data for interpretation of the findings. As with most research work, the process normally starts with one or more literature reviews to assist with understanding the current conversations surrounding topics being researched. The reviews acts as the research's foundation and assist with formulating the research's theoretical framework.

After a thorough overview into the requirements for this research work, pragmatism was identified as the most appropriate epistemological paradigm for its exploratory characteristics. Consequently, the mixed-method approach, comprising both qualitative and quantitative data types, was used to collect the relevant data for analysis. Qualitative data was used to inform the survey questionnaire which was used to elicit the caribbean end-users perceptions on project success factors, project resilience factors and project success expectations, and quantitative data from the survey's Likert scale scores were used for statistical analysis. The research paradigm influenced the choice of case study data collection technique and informed the statistical tools that includes factor analysis, regression analysis and structural equation modelling to be used in interpretating the data and the discussion of the research findings. A discussion of the research's methodology, including the rationale for the philosophical orientation, the strategies of inquiry and tools for eliciting and analysing the data is presented in this chapter.

4.2 Research design

This research focuses on the development of a pathway to mainstreaming resilience in project management practice; consequently, the research design follows a logical sequencing of research methods, guided by a research philosophy and data inquiry techniques for answering each research question (refer to Table. 1.1). The nature of this research sought data from various sources; therefore, appropriate research methods were also adopted for addressing each of the objectives. As such, this chapter will explain the research design and methodology for this project.

The choice of research design should be assessed as the most appropriate for reasonably interrogating and explaining the specific issues with clarity, to which the research questions pertains. Denscombe (2014) affirmed that ignoring appropriateness can lead to poor and substandard research output findings, and may subject such findings to scrutinity, criticism and doubt. Yin (2017) work provides guidance in adopting the most appropriate research design. As explained in Table 4.1, three conditions guiding the selection are: 1) the form of research question, 2) the control a researcher has over actual behavioral events, and 3) the degree of focus on contemporary or historical events.

Table 4.1 Relevant situations for different research methods

Strategy	Form of research question	Requires control over the behavioral events?	Focuses on contemporary events?
Experiment	how, why?	Yes	Yes
Survey	who, what, where, how many, how much?	No	Yes
Archival Analysis	who, what, where, how many, how much?	No	Yes / No
History	how, why?	No	No
Case Study	how, why?	No	Yes

Source: Yin (2017)

Another critical component to research design development is the research purpose determination. Depending on the purpose of a research, it can be categorised as either exploratory, descriptive or explanatory (Neuman, 2014). Other less utilised purposes include interpretive case studies, where the researcher interprets the data by developing conceptual deductions, supporting or challenging the assumptions made regarding the initial phenomenon, and with evaluative case studies, the researcher digs further into the data by adding their judgement to the phenomena found (McDonough & McDonough, 1997; Neuman, 2014). While a research project can simultaneously satisfy multiple purposes, one purpose, in principle, dominates any research design. With further explanation in Table 4.2, the mostly used purposes can be sumarised as either exploring a new topic, describing an existing phenomenon, or explaining why something occurs or occured.

Table 4.2 Purposes of research types

Purpose	Particulars	Practicality
Exploratory	• Become familiar with the basic facts, setting, and concerns • Create a general mental picture of conditions • Formulate and focus questions for future research • Generate new ideas, conjectures, or hypotheses • Determine the feasibility of conducting research • Develop techniques for measuring and locating future data	Use when the topic is novel, very new, know little or nothing about it, and no one has yet explored it. Research used to develop preliminary ideas about the topic, then used to develop research questions.
Descriptive	• Provide a detailed, highly accurate picture • Locate new data that contradict past data • Create a set of categories or classify types • Clarify a sequence of steps or stages • Document a causal process or mechanism • Report on the background or context of a situation	It presents a picture of the specific details of a situation, social setting, or relationship, and starts with a well-defined issue or question and tries to describe it accurately.
Explanatory	• Test a theory's predictions or principles • Elaborate and enrich a theory's explanation • Extend a theory to new issues or topics • Support or refute an explanation or prediction • Link issues or topics to a general principle • Determine which of several explanations is best	Use to explain why events occur and to build, elaborate, extend, or test theory. Building on the strengths or exploratory and descriptive research, it attempts to identify the reason something occurs.

Adopted and modified from Neuman (2014)

Upon analysis of the choice of research methods (refer to Table 4.1) and research types (refer to Table 4.2) for this research design, the case study design emerged as most appropriate. The case study research design stands out as the strategy that does not permit predetermined conclusions, but enables reporting data from a real-life context in an unbiased manner (Amerson, 2011). Its method of inquiry proposes a logical sequence to collecting and analysing empirical evidence as part of a novel theory. Consequently, it proposes an exploratory purpose approach.

Guided by the research process in Figure 1.1, this research starts with an investigative approach into the literature of what a successful resilient project mean. Emanating from a theory that suggests the incorporation of resilience into project management practice will significantly improve reconstruction project success, the process continues to elicit the opinions of reconstruction project beneficiaries. The theory then demands an understanding of their opinions on what a resilient project means to them, using particular statistical analysis software. The outcome will be a generalised perception of end-users' perception on resilient disaster reconstruction projects. Consequently, this research design will employ the case study research approach to guide the collection, analysis and interpretation of the data obtained, to formulate a generalised result on the perceptions of end-users towards project success.

It is worthwhile to emphasise that the appropriateness of the research design is a key determinant to the validity of the research process and output. While each design carries its own advantages, disadvantages, and challenges, the case study design approach was deemed appropriate above the others for the following reasons:

a. Approaches a phenomenon with a holistic view that is accompanied by several factors with an aim to investigate the details and intricacies of the complex phenomenon.
b. Deemed suitable for small-scale research, both in a geographical and problem-size context.
c. Has the ability to facilitate multiple research methods and multiple sources of data depending on the prevailing data capture situation.
d. Since case studies mostly investigate naturally occurring settings, the case study approach is particularly suitable in circumstances where it is not possible to manipulate research participants assisting the investigation.
e. Quite applicable to theory-building and theory-testing research (Denscombe, 2014).

4.2.1 Framework to support the research design and methodology

Consistent with Rajasekar et al. (2006) definition of methodology as 'the procedures by which researchers go about their work of describing, explaining and predicting phenomena' (p. 5), in this study, the combined applications of the philosophy and the techniques deployed in the research process are referred to as the methodology. The common definitions of research methodology suggest that the overall approach is linked to an epistemological framework while the methods embrace the systematic modes, procedures or tools used for the collection and analysis of data. The development of the methodology for this research follows the framework provided by Creswell (2009), with additional supportive pertinent materials from other relevant sources. The framework, illustrated in Figure 4.1, exemplifies a tripartite relationship among epistemological philosophy, data inquiry strategies and research methods. This framework will assist in the development of the plan for this research project.

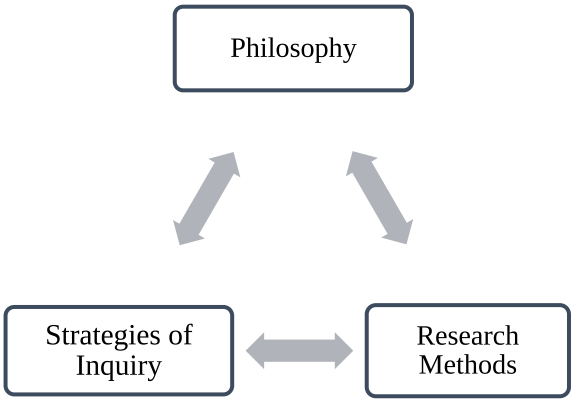


Figure 4.1. Research design framework (Creswell, 2009)

This research methodology forms a subset of the research's broader framework's and is developed with a strategic plan of action that is depicted by tenets of the framework. In summary, the tenets of the framework should provide the foundation for adopting or developing aspects of the design process that will inform the choice of approaches, strategies and methods for completing the research project. The framework tenets should provide the gateway to answering the following questions:

a. What questions provide direct focus to investigating the phenomenon,
b. What data are relevant to the investigation,
c. What data to collect and how to ethically collect, and
d. How to analyse the results and prepare to inform others.

An overview of the typical framework's components is provided in Table 4.3.

Table 4.3 Overview of the research design framework components and functions

Component	Domain	Constructs / Tools	Overview
Research Philosophy	Epistemology or paradigm	• Postpositivism • Constructivist • Advocacy • Pragmatism	A basic set of beliefs that guide action. It includes the consideration of either cross-sectional or longitudinal observations.
Strategies of Inquiry	Query design	• Quantitative • Qualitative • Mixed methods	Models that provide specific direction for procedures.
Research method	Practical applications	• Questions / surveys • Data collection / analysis • Interpretation • Validations	Selection of the data collection instrument. Instruments are influenced by the type of procedure.

Source: Modified from (Creswell, 2009)

4.2.2 Research philosophy

DePoy and Gitlin (1994) define research as 'multiple, systematic strategies to generate knowledge about human behaviour, human experience, and human environments in which the thinking and action processes of the researcher are clearly specified so that they are logical, understandable, confirmable, and useful' (p. 3). Research is ubiquitous (formal or informal) whereby data are collected and processed with an aim to 'understand, describe, predict or control an educational or psychological phenomenon or to empower individuals in such contexts' (Mertens, 2014, p. 2). Forming a cohesive and logical array of tasks to obtain a useful outcome requires an appropriate philosophy that is well positioned to facilitate the selected statistical techniques or other tools during the analysis and interpretation.

The framework alludes to four epistemological or paradigm constructs, namely: postpositivism, realism (constructivism), interpretivism (advocacy) and pragmatism. The constructs are approaches of the 'branch of philosophy that addresses the nature of knowledge and how one comes to know' (DePoy & Gitlin, 1994, p. 375). The postpositivist approach to research begins with a theory that aims to support or refute that theory through reductionism (Phillips & Burbules, 2000). The realist (constructivisionist) sets out with an open-ended approach to understanding the subjective nature of behaviours (Crotty, 1998). The interpretivism (advocacy) approach advances a participatory constructivism by including any external influences on behaviours that help shape an individual's thinking with a focus on improving the marginalised or disenfranchised (Kemmis &

Wilkinson, 1998). The pragmatic approach arises out of the need to rectify a known problem, drawing from both qualitative and quantitative inferences in a pluralistic manner (DePoy & Gitlin, 1994). A summary of the philosophical views is provided in Table 4.4.

Table 4.4 Comparison of philosophical views in management research

	Positivism	**Realism**	**Interpretivism**	**Pragmatism**
Ontology: The researcher's view of the nature of reality or being	External, objective and independent of social actors	Is objective. Exists independently of human thoughts and beliefs or knowledge of their existence (realist), but is interpreted through social conditioning (critical realist)	Socially constructed, subjective, may change, multiple	External, multiple views chosen to best enable answering of research question
Epistemology: The researcher's view regarding what constitutes acceptable knowledge	Only observable phenomena can provide credible data, facts. Focus on causality and law like generalisations, reducing phenomena to simplest lements	Observabl phenomena provide credible data, facts. Insufficient data means inaccuracies in sensations (direct realism). Alternatively, phenomena create sensations that are open to misinterpretation (critical realism). Focus on explaining within a context or contexts	Subjective meanings and social phenomena. Focus upon the details of situation, a reality behind these details, subjective meanings motivating actions	Either or both observable phenomena and subjective meanings can provide acceptable knowledge dependent upon the research question. Focus on practical applied research, integrating different perspectives to help interpret the data
Axiology: The researcher's view of the role of values in research	Research is undertaken in a value-free way, the researcher is independent of the data and maintains an objective stance	Research is value laden; the researcher is biased by world views, cultural experiences and upbringing. These will impact on the research	Research is value bound, the researcher is part of what is being researched, cannot be separated and so will be subjective	Values play a large role in interpreting results, the researcher adopting both objective and subjective points of view
Data collection techniques most often used	Highly structured, large samples, measurement, quantitative, but can use qualitative	Methods chosen must fit the subject matter, quantitative or qualitative	Small samples, in-depth investigations, qualitative	Mixed or multiple method designs, quantitative and qualitative

Adopted from Saunders et al. (2009)

An overarching objective of this research is to understand the relationship of three abstract constructs (project success, project resilience, and project expectations) to achieve the research objectives. Characterised by its pluralistic attribute and research problem-solving focus, the pragmatic approach stands out as the most appropriate. This approach also draws on the strength of other epistemologies as it places the research question 'central' to understanding the problem, the data collection strategy and analysis methods (Creswell, 2009). Pragmatism is also heralded as the most appropriate philosophical foundation fit for case study design and mixed methods approaches (Tashakkori et al., 1998). Acceeding to Tashakkori et al. (1998) views, the pragmatic perspective provides a philosophical basis for research.

4.2.3 Strategy of inquiry

Creswell (2009) describes research approach as 'types of qualitative, quantitative, and mixed methods designs or models that provide specific direction for procedures in a research design' (p. 11). Quantitative and qualitative approaches have had two discourses in the literature, one that is representative of the research philosophy and explains how the research's nature of knowledge influences the research, and the other describing the research method that guides the collection and analysis of the data (Mackenzie & Knipe, 2006). The fundamentals of these traditional paradigms can be summarised as: the quantitative purist believes that an observer, being separate from the entities, should maintain an objective inquiry and treat the social observations as entities, while the qualitative purist contends that multiple-constructed realities abound and it is impossible to differentiate causes and effects fully, due to the context-free generalised logic flows that bear on the subjectivity of the source (Johnson & Onwuegbuzie, 2004).

This research seeks the perspectives of the project end-user or beneficiary stakeholders related to disaster reconstruction projects, and draws on both qualitative and quantitative strategies to explore the answers to the proposed theory reflected in the research questions. Though both purists argue on the superiority of their model, Johnson and Onwuegbuzie (2004) argued that the strengths of both quantitative and qualitative research models merited combinations, and recommended an integrated mixed method strategy (p. 14). The ability to accommodate this third-dimensional paradigm has been attributed to the capabilities of computer technology to manipulate large datasets and to analyse complex models (Creswell & Creswell, 2017). Both qualitative and quantitative data will be harnessed in preparation for analysis. Therefore, this research will adopt a mixed methods approach.

Mixed methods are defined as ‘studies that are products of the pragmatist paradigm that combine the qualitative and quantitative approaches within different phases of the research process’ (Tashakkori & Teddlie, 2008, p. 22). Terrell (2012) later expounded on multi-method variety approaches and the factors influencing these approaches within the mixed methods strategy. An overview of the factors in the mixed methods approach is provided in Table 4.5.

Table 4.5 Factors in the mixed methods paradigm

Factor	Particulars	Applicable to this research
Theoretical perspective	• Explicit – based firmly on a theory • Implicit – based indirectly on a theory	Explicit
Priority of strategy	• Equal • Qualitative • Quantitative	Equal
Sequence of data collection	• Qualitative first • Quantitative first • No sequence (concurrent)	Qualitative first
Point of data integration	• At data collection • At data analysis • At data interpretation • With some combination	At data analysis

Source: Terrell (2012)

Mixed methods allow the collection of evidence that is integral and particularly specific to the research topic, to facilitate in-depth exploration of the research phenomena being investigated, satisfy the research objectives, and answer the research questions (Yin, 2017). The mixed methods strategies of inquiry pride themselves on collecting varied and confirmatory types of data that can provide the researcher a better comprehension of the research problem (Creswell & Creswell, 2017). There are four common mixed methods strategies based on whether the data collection and analysis occur sequentially or concurrent. The six mixed methods research strategies are:

- Sequential explanatory
- Sequential exploratory
- Sequential transformative
- Concurrent triangulation

- Concurrent nested, and
- Concurrent transformative

The data collection method and role of the qualitative and quantitative data in each mixed methods design are summarised in Table 4.6. Based on the overview provided above and in Table 4.6, the research philosophy of this thesis adopts a mixed methods sequential exploratory research design.

Table 4.6 Six designs of mixed methods research

Design	Data collection	Role of qualitative or quantitative data
Sequential explanatory	Quantitative data are collected and analysed, followed by qualitative data. Priority is usually unequal and given to quantitative data.	Qualitative data are used to explain unexpected outcomes of quantitative research. Qualitative part is used to augment quantitative data.
Sequential exploratory	Qualitative data are collected and analysed first, followed by quantitative data. Priority is usually unequal and given to the qualitative data.	The qualitative part is used to develop theory and explore relationships between phenomena.
Sequential transformative	Either quantitative and qualitative data can be collected first. The data is used to support a particular perspective (vision, advocacy, ideology or conceptual framework).	Data are integrated during interpretation. The perspective is more important in guiding the research than the two types of data collected.
Concurrent triangulation	Quantitative and qualitative data collected and analysed at the same time. Priority is usually equal and given to both forms of data	The qualitative part is used to confirm and cross-validate the findings of the quantitative part.
Concurrent nested	Either quantitative or qualitative data can be collected first. The other one is embeded with less priority is used to support a particular perspective.	For gaining a broader perspective than could be gained from using only the predominant data collection method. Data are mixed during the analysis phase.
Concurrent transformative	Quantitative and qualitative data collected and analysed at the same time. Priority is usually equal and given to both forms of data	Data are integrated during analysis or possibly during interpretation phase. It allows the researcher to employ methods that will best serve their theoretical perspectives.

Adopted from Terrell (2012)

The research aims to provide clarity to the issues regarding the existence of post-disaster reconstruction resiliency, its prevalence or lack thereof, in the reconstruction of post-disaster projects for sucessful outcomes, from the perspective of end-users. This idea fits an explicit theoretical perspective, which encompasses both traditional inquiry strategies (qualitative and quantative) with equal importance. The sequence of mixed methods data collection in this thesis follow a qualitative investigation into the literature for prevailing success and resilience factors, then proceed into quantitative surveys and data analysis. The data integration will follow a progressive process that allows for the data output in one stage to be the input for the next (refer to Figure 1.1 for the outline of research stages).

4.2.4 Research theoretical approach

Guiding this research is the theory that resilience as a de facto principle in project management may yield more resilient built projects. According to DePoy and Gitlin (1994), 'the purpose of research is to construct theory and/or to test theory' (p. 19). Researchers have been consistent in defining a theory as an interrelated set of constructs (or variables) formed into propositions, or hypotheses that specify the relationship among the variables (magnitude or direction) (Creswell, 2009; DePoy & Gitlin, 1994). Further, a theory may appear as an argument, a discussion, or a rationale, intended to help explain or predict phenomena. As such, the theory purported for this research has been a rationale within the construction sector to assist in the continuous functionioning of residential buildings and infrastructure projects after a disaster. Other researchers supporting the theory are highlighted in Table 4.7.

Table 4.7 Theoretical basis for the research

Supporting Researchers	Resilience perspective	Resilience perspective summary
(Victoria, 2003); (McAslan, 2011)	Socio-economic resilience	Disaster resilience development programmes with strong community influence will be more effective than repetitive recovery interventions.
(Nowell & Steelman, 2013)	Psycho-social resilience	Without frameworks tailored to specific populations, levels of analysis, the phase of disasters, and even the unique disaster context, our ability to advance the science of disaster response toward more resilient communities is limited.
(Wilkinson et al., 2016, p. 183)	Physical systems robustness	'The construction sector, as a key recovery stakeholder, is one which requires more active engagement. Loss of functionality of the construction sector leads to slow, uncoordinated recoveries. There is a need to promote the resilience of the construction sector and provide advice, education, training and support to enhance construction sector resilience.'

Further support of the theory is captured in Figure 4.2, explaining the causal relationship among the key variables. The theory advances the idea that incorporating strategic resilience factors and techniques (R_1) to applicable project success factors and techniques (Y_1) influences rigorous project management characteristics and practices, in combination with established success indicator metrics (S_1) can produce more successful project outcomes (Z_1). The success of these projects is determined by their ability to maintain the built environment in the contexts of system, economic, organisational and community resilience in the affected environment, following a disaster (Comfort, 1994; A. V. Lee et al., 2013; Norris et al., 2008; Rose & Krausmann, 2013).

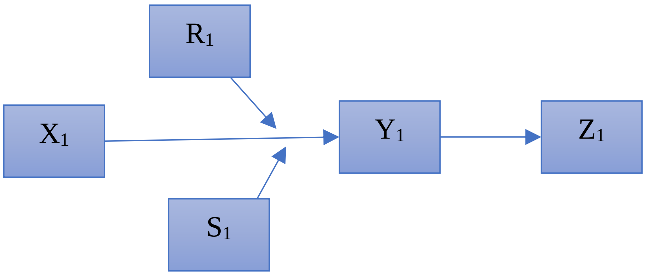


Figure 4.2 The basic causal relationship among variables of this research

Where: X_1 : Project success factors

R_1 : Project resilience factors

S_1 : Stakeholder expectations (end-users)

Y_1 : Project management practice

Z_1 : Successful projects

4.3 Case study

To analyse the perspectives of project end-users, the case study method was used to achieve this objective of the research. Denscombe (2014) describes case studies as aiming 'to illuminate the general by looking at the particular' (p. 54). In principle, the purpose of the case study is to provide the researcher an avenue to analyse whether the assertions of a theory can actually be found in practice in real-world settings. The result of a case study culminates in one of two outcomes: 1) reinforce the suppositions of that theory by demonstrating how it works in reality; or 2) test whether the particular theory might be applicable under the specific conditions to be found in the case setting (Denscombe, 2014).

4.3.1 Case study approach

Mode of inquiry

The case study approach mostly focuses on a single phenomenon that may be occurring in multiple locations. The approach is principally geared to investigate and understand in great depth the intrinsic details on the cause of an event, or the perspective of an individual or group in determining a particular behaviour (Denscombe, 2014). While a theory represents a generalised view of the phenomenon, the case study approach allows for a more micro-analysis of the processes or thinking that will significantly aid formulating the theory's outlook. Characterised as being opposite to mass study, the case study mode of inquiry posits an in-depth investigation. This mode of inquiry is quite applicable to this research, in that the need to understand the thought process that formulates the expectations of project end-users for resilient post-disaster projects is crucial to accepting or rejecting the theory proposed. With utilising the case study approach, the findings in the literature of the processes adopted for both resilient and successful projects can explain 'why' certain decisive actions were taken to achieve various reconstruction project objectives. Neuman (2014) explains it as the clarification of our thinking and 'allows us to link abstract ideas in specific ways with the concrete specifics of cases we observe in detail, [and] also enable us to calibrate or adjust the measures of our abstract concepts [resilience] to actual lived experiences and widely accepted standards of evidence' (p. 42).

According to Yin (2017), the case study research strategy assists with answering how and why questions mostly significant in situations when the researcher has minimal control over the events, and requires a focus on phenomena that occur in a real-life context (refer to Table 4.1 and Table 4.2). The matrix in Table 4.8 summarizes how this research project's mode of inquiry confirms the approach's approriateness using the three considerations in choosing the case study design to answer the research questions.

Table 4.8 Matrix of research inquiry mode and considerations for selecting case study design

Particulars of this research project		**Does the mode of inquiry align to case study design?**
Consideration No. 1: Research Questions	**Form of question**	
1. What project success factors contribute to achieving positive outcomes in disaster recovery projects?	What?	**Yes**
2. What resilience factors have been deployed within the industry and how have they affected outcomes in disaster reconstruction projects?	What?	
3. What are the critical success factors and resilience factors, and their relationships, for successful resilient reconstruction projects, in line with end-users' success expectation indicators?	What?	
4. How can the concept of resilience be mainstreamed as a project management practice in post-disaster recovery construction projects?	How?	
Consideration No. 2: Researcher's control	**Requires control?**	**Yes**
• Interviews of the persons involved in the investigation • Questionnaire survey that solicits their opinions on the theory's suppositions • Integration of multiple views from multiple locations	No defining rule for formal engagement, but an informal exercise requiring voluntary participation	
Consideration No. 3: Focus event	**Contemporary events?**	**Yes**
• Post-disater reconstruction perceptions in ○ Antigua and Barbuda ○ Doninica ○ Grenada ○ St. Vincent and the Grenadines	Recurring multiple climatological-related disaster over a significant period	

Generalising multiple perspectives from multiple locations may not rely on a single post-disaster event for formulating or justifying a theory. While multiple disaster events preempt the perceptions of end-users, the research does not accentuate a longitudinal analyis of the phenomenon. The end-users' perceptions required for this research rely on a cross-sectional analytical generalisation that originates from repeated disaster losses and inconvenience, over time. The contemporary events aiding the research design decision process pertain to the natural setting of the survey participants being directly involved, and certainly not artificial or fabricated scenarios.

On that basis, it will be misleading to suggest generalisation using one event, as it will be difficult to draw accurate perception inferences regarding the end-user's desires for reconstruction project satisfaction. Alluding to the tenets of the research design framework (refer to Figure 4.1), the four guiding questions (***what questions prompt the research, what data is relevant, what to collect, and how to analyze***) will dictate the methods of inquiry. Proper selection of the methods will certainly assist with bridging the gap between the research design and the data collected, for the best generalisation towards supporting the research theory.

Methods of inquiry

Identified by several researchers, a common misconception with utilising the case study approach is the notion that the research strategies applied should be arranged hierarchically. Such an idea restricts the investigative process as being primarily exploratory in nature. However, the diverse purposes of case studies do not restrict investigations to a purely sequential manner, but in a logical process. Utilising multiple research methods can be ordered as both sequential and concurrent. The approach allows the researcher to use a variety of data types (qualitative and/or quantitative) and a combination of research methods (surveys, observation, interviews, documents, questionnaires) as part of the investigative process. Such variety promotes a holistic generalised output.

Multiple cases

The strength of a generalised end-user's perception is harnessed from the collective opinions of the proposed Caribbean region's participants in the case. Bromley (1990) characterised the benefit of case study design as a systematic inquiry into an event or a set of related events, which aims to describe and explain the phenomenon of interest. As such, case study researchers can employ a variety of case study designs. Common designs include single-case and multiple-case design. Single-case design is used where events or phenonmena are limited to a single occurrence. However, the main drawback of this design is its inability to provide a generalised conclusion, especially when the events are rare. Multiple-case design is utilised with real-life events when numerous sources of evidence are replicated, thus rendering greater confidence, and being regarded as more robust and often more compelling (Yin, 2017).

Though data collection in four countries in the region, and each representing a unique case, the collective case study type was adopted. As a result, the case study design comprises multiple embeded cases, and an integration of the data to form an overall regional perception result. The unique case studies seek the initial collective opinions of a specific country on project success expectations, factors affecting project success, and factors affecting project resilience. The data integration prepares the data collected in all four countries to be combined and treated as one unit for analysis.

Unit of inquiry (cases)

The case to be investigated in a case study is, in principle, the event(s), individual or phenomena. The selection implores a certain measure of precision in choosing from among the several possibilities that can potentially assist with answering the research question. Table 4.9 provides further guidance with the criteria requiring consideration to strategically choosing the case(s) that can be characterised as most suitable for the research. According to Denscombe (2014), a suitable case is one that has either practical or theoretical relevance to the issue the researcher intends to investigate, and a further determination whether a single event of that occurrence is sufficient to generate a generalised conclusion. More so, is the occurrence merely an infrequent or unique matter that increases the difficulty with understanding its features, or is it frequent enough to generate an adequate amount of data for more informed comparisons? Then, a more compelling consideration is a determination of the generalisation aimed at advancing a developing theory or confirming the views of an existing theory.

Table 4.9 Criteria considerations in choosing a case

Criteria	Considerations	Justifications
Relevance to the topic	• Practical problem • Theoretical issue	Comparative analysis with other events, individual or phenomena, indicating the peculiarity of the case(s) chosen to accurately inform the output generalisation: • single vs multiple
Type of case	• Typical instance • Extreme instance • Test-site for theory • Least likely instance	Using the case characteristics to decide whether it is: • normal vs unique • theory-testing vs theory-building
Practical considerations	• A matter of convenience • Intrinsically interesting	Case chosen on thorough appropriateness to the research topic: • convenient vs inexpedient • likeability vs merited
No real choice	• The study is part of commissioned research • There are unique opportunities	Occurs when the researcher receives pre-determined case from an existing research design. • stipulated vs optional • extremely rare vs predictable

Source: Denscombe (2014)

The choice of case should not be predicated on ease of access to the subjects who will assist with the investigation nor on possible cost implications. While these are important considerations in determining the convenience of the case, care must be taken to ensure that they are not the foremost priorities. Additionally, sensationalism should not be a major feature in choosing a case. The researcher's preference towards a topic should also be far removed from the decision, though in a positive sense that should serve as a stimulant in conducting the investigation. Instead, Denscombe (2014) advises on choosing a case on the merits of its features in providing clear and unambiguous information to answering the research questions. Last, but by no means least, the choice of case may have been pre-determined as part of a larger research project. When this happens, the time sensitivity of the case may arise as a challenge, in that a new situation analysis may very well determine that the suggested case is no longer relevant. It is in the interest of all case studies that the chosen case be relevant to the phenomenon.

Summary of case study approach

The case study approach embarked upon in this research centres on choosing a case(s) that clearly adheres to the appropriate mode of enquiry and utilises methods of enquiry that serve to maximise the relevant data and the collection strategy. Table 4.10 provides a summary of the selected cases and their suitability according to the criteria identified above for the case study research approach.

Table 4.10 Summary of criteria in this research case selection

Case study approach	**Relevant particulars and selection preferences**	**Applicability to case selected**			
		Case #1	**Case #2**	**Case #3**	**Case #4**
Purpose of the research	Exploratory	Yes	Yes	Yes	Yes
Mode of inquiry					
Relevant research questions		Yes	Yes	Yes	Yes
Researcher's control	Not required (voluntary and not pre-determined)	No	No	No	No
Focus event	Contemporary (inconveniences from disaster-related damage to building and infrastructre)	Yes	Yes	Yes	Yes
Methods of inquiry					
Order of investigation	Logical	Yes	Yes	Yes	Yes
Data types required	Mixed (quantitative and qualitative)	Yes	Yes	Yes	Yes
Relevant methods	Interviews and questionnaires	Yes	Yes	Yes	Yes
Quantity of cases	Multiple (combined single cases)	Single	Single	Single	Single

Unit of inquiry					
Case relevance to topic	Theoretical issue	Yes	Yes	Yes	Yes
Type of case	Normal	Yes	Yes	Yes	Yes
Contribution to theory	Theory-testing	Yes	Yes	Yes	Yes
Case constraints	Inexpedient	Yes	Yes	Yes	Yes
Case consideration	Merited	Yes	Yes	Yes	Yes
Case choice	Optional	Yes	Yes	Yes	Yes
Case pre-arranged	Predictable	No	No	No	No

Case locations: *#1-Antigua and Barbuda, #2-Dominica, #3-Grenada, and #4-St. Vincent*

4.3.2 Case selection

Selecting four islands as case studies

The economic impact of disaster in the case locations' region (the Caribbean)

For some disasters in Caribbean island states, damage exceeds the size of their economy (GDP) by more than 200%. Figure 4.4 illustrates a comparative analysis of the Caribbean with other countries from other parts of the world. Clearly indicated, the Caribbean has suffered from an increase in disaster frequency and damage. Actual realisation is evident with the effects of the category 5 Hurricane Maria that hit Dominica in September 2017. Maria was one of over 300 climatological disasters that have significantly affected the region since 1950, killed approximately 250,000 persons and affected over 24 million through injury, death, loss of homes and livelihoods.

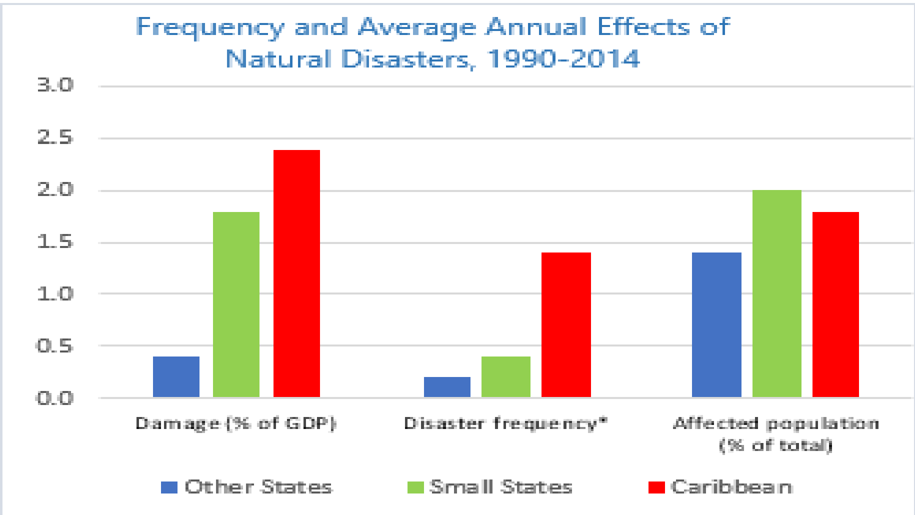


Figure 4.3 The Caribbean high exposure to disasters from natural hazards

Source: IMF (2016)

The case study method enables the researcher to diligently examine the data collected within a specific context. Quite common is for the case study method to focus on a small geographical area or a limited number of research participants as the subjects of study (Zainal, 2007). This is manifested in the case selection. More importantly, the region appears to have a neglectful and non-proactive approach towards disaster risk management as demonstrated above in the region's reluctance to develop a unified approach to establish policies, codes and procedures for improving the preparedness and recovery of potential buildings and infrastructure projects. The region, including the four case locations, continues to depend upon costly reconstruction and post-disaster international assistance. This reactive attitude is largely unsustainable as worldwide international assistance dwindles, due to donor countries own myriad disasters. This operational phenomenon, and the vagueness regarding the unclear boundaries and context between successful projects and resilient projects, means these specific multiple sources of evidence were deemed appropriate to understand the perspectives of 1) an individual's desire for successful resilient projects and 2) the region's desire for the formulation of standards and procedures that inform reconstruction resiliency policy development in the wider Caribbean.

The case locations' hazardscape

These islands were chosen according to diversity in construction methods and techniques, and geographical locations in the Caribbean archipelago. First, the Caribbean map shown in Figure 4.5 illustrates the locations of the four islands that span the spatial context of this data capture. Second, Caribbean buildings are built with a diversity of design influences from the Dutch, Spanish, French and Portuguese European colonial settlers (Pérez Escolano, 2005). However, over the last century, the American influence has introduced significant variations into northern islands' architecture, materials and construction practices, while the southern Caribbean maintained varied mid-century European modernism designs and concept (Raymond, 2013). These diversities in project planning, designs and construction methods induce varying resilience considerations.

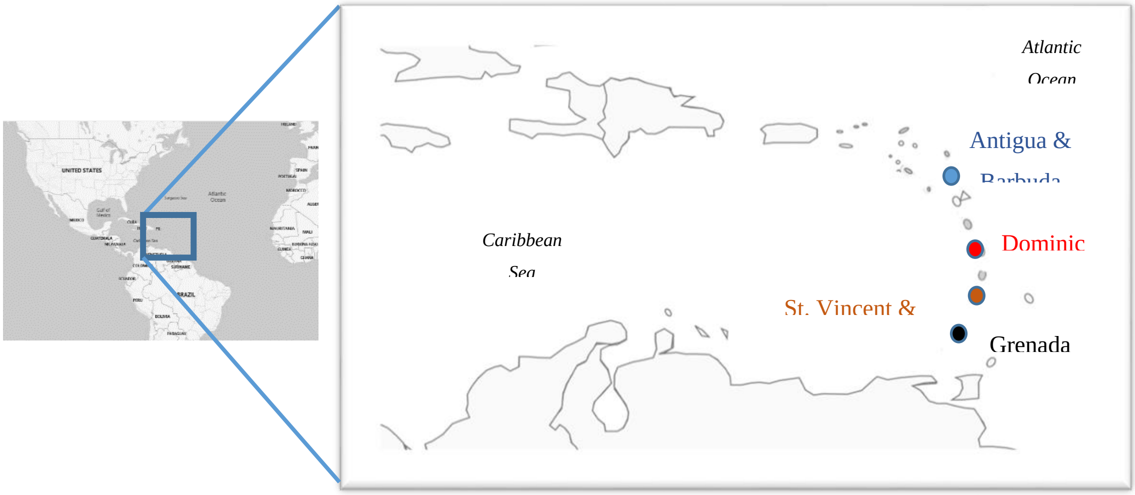


Figure 4.4 Caribbean map showing Antigua, Dominica, Grenada and St. Vincent

The Caribbean islands, like other world regions with commonalities such as the Pacific Islands, comprise small island states that respond annually to climatological, metrological, geophysical or hydrological disaster-related damage, with recovery costs that often exceed their gross domestic product (GDP). Their limited resources almost certainly prompt a reliance on external technical and financial assistance in their recovery process. Ironically, the region's status quo disaster management strategies have somewhat focused on coping capacities, with little interest on identifying the underlying risk factors that accentuate these disaster effects (Bisek et al., 2001; Collymore, 2011).

Additional reasons for selecting these four islands include: 1) their combined characteristics represent the Caribbean region in terms of diversity in socio-economic conditions and geographical locations, thus supporting the need for multiple cases, and 2) they have experienced devastating climate-related disasters in the past decades, which have caused severe disaster damage to buildings and infrastructure. For example, Antigua and Barbuda suffered insurmountable damage from Hurricanes Irma and Maria in September 2017. The total cost of damage to physical assets in the tourism and building sectors were US$136M, bearing 44% and 37% allocated to reconstruction projects, respectively (GFDDR, 2018). Tropical storm Erika devastated Dominica's infrastructure and the economy in August 2015 equivalent to 90% of its US$483M GDP. Major damage impacted the transport sector (60%), the housing sector (11%) and the agriculture sector (10%) (UNDP, 2019). Grenada suffered damage amounting to approximately 90% of building stock (residential and other large public facilities) from Hurricane Ivan in September 2004 and Hurricane Emily in July 2005. Cumulative damage has accounted for 200% of the GDP (UNDP, 2007). St. Vincent and the Grenadines share in the region's devastation, as evident in the damage incurred from Hurricane Tomas in November 2010. Two government buildings, five schools and 1200 residential buildings were severely affected, including the water supply and electricity distribution network being adversely impacted (CDEMA, 2010).

The four case locations share several similarities regarding landmass size, population, economic conditions, climatological hazards exposure and susceptability, and disaster management structure. All island states in the region are governed by the paliamentary democracy system with Queen Elizabeth II as the Head of State and her local representative as the Governor General. The Head of Government is the Prime Minister. In all case locations, the national disaster management office has direct oversight by the Prime Minister. While there are generalised legislations on disaster management in the island states, they are limited on specifics in regard to construction and reconstruction guidelines for more resilient buildings and infrastructure. Table 4.11 provides a summary of basic information on case locations.

Table 4.11 Basic profile of these island case locations

Case Location	**Size**	**Population**	**Avg. annual population growth**	**Gross domestic product ($ EC)**	**Major buildings and infrastructure damaging hazards**
Antigua and Barbadua 17°7′N, 61°51′W	441 sq.km	96,286 (est. 2018)	0.9 %	$1.717 billion (2019 estimate)	Hurricanes Floods
Dominica 15°18′N, 61°23′W	745.5 sq.km	71,625 (est. 2018)	0.3 %	$485 million (2018 estimate)	Hurricanes, Floods, Landslides, earthquakes
Grenada 12°03′N, 61°45′W	384.5 sq.km	111,454 (est. 2018)	0.5 %	$1.1249 billion (2019 estimate)	Hurricanes,Landslides Ground movements Sea surges
St. Vincent 13°10′N, 61°14′W	389 sq.km	110,211 (est. 2018)	0.3 %	$864 million (2019 estimate)	Hurricanes Landslides

Source: 1) www.indexmundi.com, 2) World Bank online documents

Case location: Antigua and Barbuda

Antigua and Barbuda is principally a service-based economy, relying predominantly on tourism as the main revenue earner, with support from the construction sector. The country relies on desalinated potable water to meet the national demand that approximates eight million imperial gallons per day.

With high costs for energy, infrastructure, transportation, and communication, including a fragile natural environment with high vulnerability to natural hazards, the two-island state faces mounting challenges. In addition, decades of unsustainable fiscal practices and weak institutional structures has led to an extreme and unsustainable debt burden (O'Marde, 2017), making it difficult to effectively and efficiently address building and infrastructure developments, especially with post-disaster reconstruction (GFDDR, 2018). A strategic de-urbanisation of the population continues with significant growth in locations on the outskirts of the capital city, which increases the need for housing, public utilities and sanitation services. The topography is mostly flat, with an uninhabited hilly part occupying approximately 15% of the main island.

The economy lacks diversity and therefore resilience (O'Marde, 2017). The islands are exposed to a wide range of natural and anthropogenic hazards. Hydro-meteorological hazard impacts, predominantly hurricanes and floods, dominate the disaster landscape. To a lesser extent, seismological events such as earthquakes and landslides are experienced from time to time. More than 80% of the GDP is at risk from hydro-metrological disasters.

The National Office of Disaster Services (NODS) is the government's state-run authority for disaster management. With responsibility to reduce vulnerabilities to natural and technological hazards in the twin-island state, the office advocates multi-sector and integrated hazard risk reduction management. NODS assists in the planning and regular execution of comprehensive stakeholder disaster management exercises at the national level, aiming to improve preparation. Table 4.12 provides a listing of disasters that have significantly affected buildings and infrastructure over the last 50 years.

Table 4.12 Hydro-metrological disasters in Antigua and Barbuda since 1950

Year	Disaster Group	Disaster type	Event Name	No. Homeless	Total Affected	Reconstruction Costs ('000 US$)	Total Damages ('000 US$)
1950	Meteorological	Tropical cyclone	Dog				1000
1960	Meteorological	Tropical cyclone	Donna				
1966	Meteorological	Tropical cyclone	Inez				
1989	Meteorological	Tropical cyclone	Hugo	530	8030		80000
1990	Meteorological	Tropical cyclone	Gustav				
1995	Meteorological	Tropical cyclone	Luis	3537	3702		350000
1998	Meteorological	Tropical cyclone	Georges	2000	2025		100000
1999	Meteorological	Tropical cyclone	Jose	516	2534		

1999	Meteorological	Tropical cyclone	Lenny	923	3423		
2008	Meteorological	Hurricane	Omar		25800		
2010	Meteorological	Hurricane	Earl		5000		12600
2017	Meteorological	Hurricane	Irma		1800	200000	250000

Source: EM-DAT (Blanks indicate information not available)

Case location: Dominica

With an estimated population of 71,625 (etc. 2018 census) and a gross domestic product per capita of US$7,144 Dominica, like the other case locations, is considered an upper-middle-income small island state. Dominica produces a small range of goods and services for export. These are primarily agricultural products and educational services through an international medical school. Dominica's main agricultural exports include bananas, cereal, tropical fruits, citrus, cassava, beer, spices, and vegetables. Although the economy is predominantly agricultural, in more recent years, tourism has become more significant to the country's development. The 2020 United Nations Development Program Human Development Index ranked Dominica as 94 of 187 countries, while poverty remains a persistent development challenge (UNDP, 2020).

Dominica continues to improve the social conditions of its citizens through infrastructural investments, economic diversification and employment generation, yet its population and economy remains highly exposed to natural hazards, primarily hurricanes, landslides and soil movement. Disasters from these natural hazards such as high wind from hurricanes, and flash floods and landslides have destroyed several critical infrastructure, and derailed advanced development gains. The recurring disaster recovery and reconstruction efforts have largely been a feature in the annual budgets, thus imposing substantial costs on the country's economy.

Responsibilities for disaster management in Dominica are shared between the Office of Disaster Management (ODM), operating within the Ministry of National Security and Home Affairs, and the National Emergency Planning Organisation (NEPO), which is under direct oversight of the Prime Minister. While there may be overlaps in disaster management operations, the ODM is focused on instituting proactive and timely measures to prevent or reduce the impact of disasters, while NEPO's responsibilities are central to the planning and organization of the counter-disaster measures. Table 4.13 provides a summary of recent disasters impacting the island of Dominica.

Table 4.13 Hydro-metrological disasters in Dominica 1950

Year	**Disaster group**	**Disaster type**	**Event name**	**No. homeless**	**Total affected**	**Reconstruction costs ('000 US$)**	**Total damage ('000 US$)**
1963	Meteorological	Tropical cyclone	Edith				2600
1970	Meteorological	Tropical cyclone					
1979	Meteorological	Tropical cyclone	David & Federick		72100		44650
1980	Meteorological	Tropical cyclone	Allen				
1984	Meteorological	Tropical cyclone	Klaus		10000		2000
1989	Meteorological	Tropical cyclone	Hugo		710		20000
1995	Meteorological	Tropical cyclone	Marilyn				175000
1995	Meteorological	Tropical cyclone	Luis	5000	5001	65000	20000
1999	Meteorological	Tropical cyclone	Lenny	315	715		
2004	Geophysical	Ground movement			100		
2007	Meteorological	Tropical cyclone	Dean		7530		20000
2011	Meteorological	Storm	Ophelia	96	240		
2015	Meteorological	Hurricane	Erika	574	28594		482810
2017	Meteorological	Hurricane	Maria		71393		1456000

Source: EM-DAT (Blanks indicate information not available)

Case location: Grenada

Grenada is second to last in the Caribbean archipelago and the most southern of the case locations. The country comprises three islands, the largest of which is Grenada, then Carriacou, and the smallest is Petite Martinique. Though Grenada was historically considered relatively safe from hurricanes owing to its southernmost location in the region's 'hurricane belt,' recent disasters have caused severe damage to the island's buildings and infrastructure. The most recent event, and still fresh in the minds of people, was the devastation of Hurricane Ivan in 2004. The impacts brought an estimated US$800 million in total losses, which included damage to infrastructure and agricultural losses estimated at US$450,000, twice Grenada's GDP. The country remains heavily reliant on tourism and agriculture.

Much of the island's construction occurs on slopes often exceeding 45 degrees. There is little protection from direct hurricane-force winds and prolonged rainfall the triggers severe slope destabilization. Informal construction is at greatest risk as it does not benefit from adequate engineering (GFDRR, 2010). With several miles of the road network and all commercial centres located on the coast, the risk of sea surges remains a concern, especially after experiencing the island's west coast ravages by Hurricane Lenny in 1999 that brought with it severe wave action.

Disaster management operations are executed by the National Disaster Management Agency (NaDMA). Disaster management in Grenada is still a committee-driven program, with no specific enabling legislation. Emergency operations are conducted through the government statutory authorities with coordination through NaDMA. Table 4.14 provides a list of notable devastating disasters that have caused significant damage to building and infrastructure in recent years.

Table 4.14 Hydro-metrological disasters in Grenada since 1950

Year	**Disaster group**	**Disaster type**	**Event name**	**No. homeless**	**Total affected**	**Reconstruction costs ('000 US$)**	**Total damage ('000 US$)**
1963	Meteorological	Tropical cyclone	Flora				
1975	Hydrological	Flood					4700
1980	Meteorological	Tropical cyclone	Allen				5300
1990	Meteorological	Tropical cyclone	Arthur		1000		
1999	Meteorological	Tropical cyclone	Lenny		210		5500
2004	Meteorological	Tropical cyclone	Ivan		60000		889000

Source: EM-DAT (Blanks indicate information not available)

Case location: St. Vincent and the Grenadines

St. Vincent and the Grenadines comprises several island of which eight are inhabited. St. Vincent is the main island, and the seven smaller inhabited ones are: Bequia, Mustique, Union, Canouan, Mayreau, Palm Island, and Petit St. Vincent. Disasters from hurricanes remain the dominant hazard, while occasional flooding has destroyed several forms of infrastructure over the years. An active volcano always has people on alert in anticipation of an eruption. Like the other case locations, St. Vincent and the Grenadines rank among the world's most vulnerable countries, yet disaster management is not a central theme in its legislative plans (GDFRR, 2014). A comprehensive disaster management strategy is lacking; however, the constitution makes provision for issuance of a state of emergency in response to threats or disaster outcomes of natural or anthropogenic hazards. This provision is sensitive to disaster response and does not speak to preparedness or risk mitigation, underscoring these to be central themes in disaster management.

The National Emergency Management Office (NEMO) was established to be the administrative as well as operational arm of the National Emergency Council (NEC). NEC is overseen by the Prime Ministry in the Ministry of National Security, Air & Sea Port Development. NEMO's responsibilities primarily centres on classification and cataloguing of resources, training, practice drills, and evaluation of experiences related to disaster preparedness, mitigation, response and recovery. Table 4.15 provides a list of notable disasters that have caused significant damage to building and infrastructure in recent years.

Table 4.15 Hydro-metrological disasters in St. Vincent since 1950

Year	Disaster group	Disaster type	Event name	No. home less	Total affected	Reconstruction costs ('000 US$)	Total damage ('000 US$)
1955	Meteorological	Tropical cyclone	Janet				
1967	Meteorological	Tropical cyclone	Beulah				4500
1971	Geophysical	Ash fall	Mount Soufrière		2000		
1977	Hydrological	Flood					
1979	Geophysical	Ash fall	Mount Soufrière		20000		
1980	Meteorological	Tropical cyclone		500	20500		16300
1986	Hydrological	Flood			152		
1987	Meteorological	Tropical cyclone	Emily	200	208		5300
1987	Hydrological	Flood			1000		5000
1992	Hydrological	Coastal flood			200		
1999	Meteorological	Tropical cyclone	Lenny		100		
2002	Meteorological	Tropical cyclone	Lili				11000
2004	Meteorological	Tropical cyclone	Ivan		1004		5000
2005	Meteorological	Tropical cyclone	Emily		530		
2010	Meteorological	Hurricane	Tomas	100	6100		25000
2011	Hydrological	Riverine flood			275		
2013	Hydrological	Riverine flood		500	17422		108000
2016	Hydrological	Flood			25000		6500
2016	Meteorological	Hurricane	Matthew				

Source: EM-DAT (Blanks indicate information not available)

4.4 Research methods

The recognition of case study as a research approach is central to the notion that researchers are concerned about the limitations of quantitative methods in providing the desired holistic and in-depth explanations of the social and behavioural problems captured in research questions. This approach enables the researcher to probe beyond the quantitative statistical results and understand the behavioural conditions through the participants' perspective (Zainal, 2007). The case study approach is a strategic decision that is directly aligned to the scale and scope of the intended investigation, which in principle does not dictate which method(s) of data capture and analysis to be used. Instead, the strength of the approach provided a platform for using a variety of methods depending on the prevailing circumstances, and the specificity of the data and the phenomenom (Denscombe, 2014).

The methodology for this research will be a mixed methods approach, primarily due to the method's ability to address both qualitative and quantitative data analysis. Typical methods used include: literature review, in-person questionnaire survey, and statistical analysis with appropriate software. The questionnaire survey instrument, comprising a combined qualitative and quantitative oriented data request structure, invited end-users from the selected communities in the Caribbean islands of Antigua, Dominica, Grenada and St. Vincent, who suffered inconveniences resulting from damage to their homes including the infrastructure within their community, following recent disasters. No one under the age of 18 was recruited for this research. The researcher is Grenadian and has been previously employed only within the utility sector. Therefore, the researcher had no prior engagements with any of the organisations assisting in this research nor any of the potential participants. A concerted effort was undertaken to prevent involvement of family members or relatives in this research project.

4.4.1 Data collection methods

A critical component of the research proces is the selection of the most appropriate data collection method, and particular to the case study research approach is the ability to develop a generalisation based on multiple data sources of evidence. According to Yin (2017), six categories of data collection techniques are considered mainstream, which are guided by four relevant principles of data collection. It must be noted that data collection techniques are not limited to six categories, and several others may be applicable to other research processes. An extensive list of additional techiques, though mostly qualitative research oriented, can be found in Marshall and Rossman (2014, pp. 276-385) work, which includes: films, videotapes and photographs, projective techniques and psychological tests, proxemics, kinesics, ethnography, and life histories.

This research focuses on the applicability of the six primary techniques, which are: documentation, archival records, interviews, questionnaire surveys, direct observations, participant-observation, and physical artifacts, and the principles of their data collection are: a) multiple, not just single, sources of evidence, b) creating a case study database, c) maintaining a chain of evidence, and (d) exercising care in using data from electronic sources of evidence, such as social media (Yin, 2017). Table 4.16 lists the six sources of evidence with comments on their strengths and weaknesses. This research mainly employed a mixed methods approach of document analysis and questionnaire survey.

Table 4.16 Seven sources of evidence: Strengths and weaknesses

Source of evidence	Strengths	Weaknesses
Documentation	• stable – can be reviewed repeatedly • unobtrusive – not created as a result of the case study • specific – contains exact names, references, and details of an event • broad coverage – long span of time, many events, and many settings	• retrievability – can be low • biased selectivity, if collection is incomplete • reporting bias – reflects (unknown) bias of author • access – may be deliberately blocked
Archival records	• [same as above for documentation] • precise and quantitative	• [same as above for documentation] • accessibility for privacy reasons
Interviews	• targeted – focuses directly on case study topics • insightful – provides perceived causal inferences (e.g. presonal views, perceptions and meanings)	• bias due to poorly constructed questions • response bias • inaccuracies due to poor recall • reflexivity – interviewee gives what interviewer wants to hear
Questionnaire survey	• Anonymity of responses • Avoiding sensitive or controversial issues • More generalized findings	• Bias due to respondents' misinterpretation of questions • Potential of a low response rate • Sample size and representativeness
Direct observation	• reality – covers events in real time • contextual – can cover case's context	• time-consuming • selectivity – broad coverage difficult without several observers • reflexivity – event may proceed differently because subjects know they are being observed • cost – hours needed by human observers
Participant observation	• [same as above for direct observations] • insightful into interpersonal behaviour and motives	• [same as above for documentation] • bias due to observer's manipulation of events
Physical artefacts	• insightful into cultural features • insightful into technical operations	• selectivity • availability

As observed earlier, the researcher visited the case study locations to collect the relevant data. Also mentioned above, the data harnessed from the literature reviews informed the design of the survey questionnaire. Several documents were reviewed on reconstruction project success expectations, project success and project resilience, and using the content analysis technique, the data obtained from the literature documents were packaged to aid in eliciting the end-users' views. Table 4.17 provides an overview of data collection methods employed in achieving research objectives #1 through #5.

Table 4.17 Research instruments and analysis types in this research

Research objective	**Source of evidence**	**Instrument**	**Method**	**Analysis / operation**	**Expected output**
No. 1 No. 3	Documents	Bibliographic databases	Systematic literature review (Qualitative)	Content analysis	Understand the status of success factors and resilience exploration as documented in the body of knowledge.
No. 2	Questionnaire survey / Interview	SPSS and Microsoft Excel	Semi-structured and closed-ended (Quantitative)	Factor analysis	Identify any underlying dimensions among the project success factors and variables.
No. 4	Questionnaire Survey / Interview	SPSS and Microsoft Excel	Semi-structured and closed-ended (Quantitative)	Factor analysis	Identify any underlying dimensions among the project resilience factors and variables.
No. 5	Questionnaire survey / Interview	SPSS and Microsoft Excel	Semi-structured and closed-ended (Quantitative)	Factor analysis / SEM	Identify the underlying dimensions among the project end-users' success indicators.
No. 6	N/A	SPSS (AMOS)	Raw data / Factor analysis scores from No. 2, No. 4 and No. 5 (Quantitative)	Multiple regression analysis / SEM (path analysis)	Understand the direct and indirect contributors, the relationships and covariances among all the latent variables (project success, project resilience and project expectations) and observed variables in the model.
No. 7	N/A	-	Results from all previous analyses	Data synthesis by understanding the established correlations	Deduce the salient relationships inferred from the analysed data and formulate reasonable conclusions for leveraging the correlations for more informed project management practices.

Systematic literature review

A systematic literature review differs from traditional literature reviews as being more robust by following a well-defined approach to reviewing the documented literature in a specific subject area (Moher et al., 2015). Typically, most research starts with a literature review and systematic reviews appraise and summarise all the available and relevant evidence on a specific research topic. Guided by a protocol, such as the 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses' (PRISMA), systematic literature reviews are designed to reduce the effect of the reviewer's own bias with identifying, evaluating and interpreting relevant data. Its guidance includes framing the research question, identifying previous relevant research output, extracting data on outcomes and quality, summarising the evidence found, and interpreting the relevant evidence to continue the conversation on the research topic (Panic et al., 2013).

In addition to the theory governing this research, the systematic literature review presented in Chapters Two and Three forms the foundation for the research project. The output from Chapters Two and Three enlightened the researcher's insights on the body of knowledge's account on reconstruction projects and assisted in formulating the knowledge gap with regards to achieving sucessful resilient reconstruction projects. The gap is illustrated with Figure 4.6. as the synergestic possibilities with finding the correlations among three independent knowledge bases, namely: end-user expectations, project success and project resilience. While the two reviews were conducted to extract and synthesise the techniques related to project success and project resilience in the various documented construction and reconstruction projects in the studies, the third knowledge base was derived from a broader investigation on the success metrics and benchmark used to assess success.

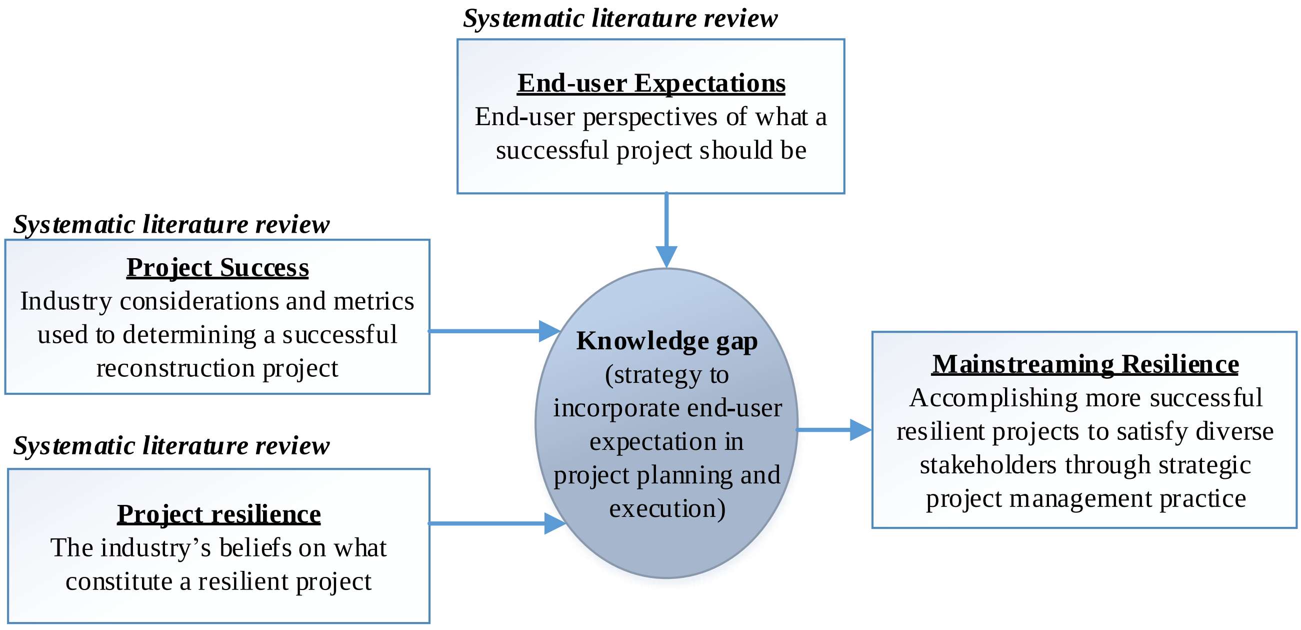


Figure 4.5 The influence of systematic literature reviews in this research project

The two systematic reviews (Chapters Two and Three) followed the PRISMA structured protocol. The four phase protocol was chosen as the standard among authors for the reporting of secondary data from systematic reviews and meta-analyses, guided by Mohler et al.'s (2015) 27-item checklist. While the PRISMA protocol guides the unbiased and transparent systematic review process, which is based on pre-defined eligibility criteria and follows a pre-defined methodological approach, the protocol is not a quality assessment instrument to measure the quality of a systematic review. Figure 4.7 illustrates the systematic review process used in this research project. Having adopted the documented literature as a source of evidence and followed the protocol describes above, it can be concluded that the systematic reviews conducted are a fundamental knowledge base for achieving the research objectives.

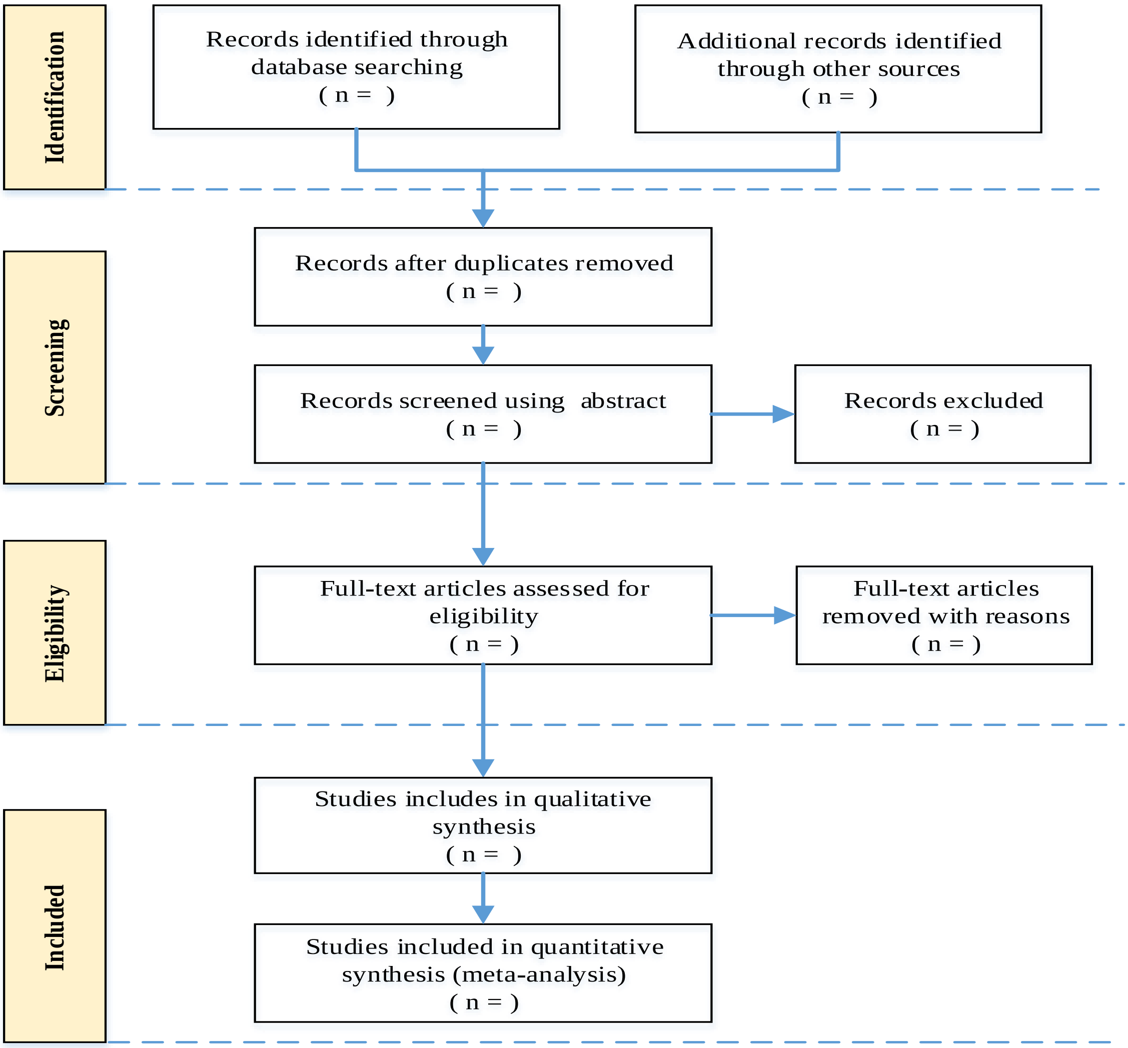


Figure 4.6 PRISMA flowchart (Moher et al., 2015)

Questionnaire survey and interviews within case studies

According to Yin (2017), a hybrid of face-to-face contact and the use of a questionnaire is deemed a survey interview, where the survey will most likely be designed as part of an embedded case study to produce quantitative data as part of the case study evidence. The 'interview' component of the data collection process comprised a detailed explanation on the purpose of the research and the contents of the questionnaire, with a brief question and answer period focusing on the participants' rights and ethics governing this research. The researcher's presence were merely to provide explanation on items in the questionnaire that required clarity. The typical participant information sheet (PIS) and consent form (CF) were also explained (sample PIS and CF shown in Appendices 5, 6 and 7). The semi-structured questionnaire, also shown in Appendix 5, was the primary instrument requiring survey participants to individually complete it.

The initial contact with the survey participants was made with the assistance of the local disaster management institutions and radio stations in the respective islands. The participating institutions were provided with an organisation-focused participant information sheet (PIS), which upon familiarisation with the research project, meant they may decide to opt to assist by expressing consent to participate via email. Media companies were also provided with details of the research project, soliciting their assistance with advertising the 'request for volunteer participation' in the interview questionnaire survey. Appendix 9 provides a sample of the request for volunteers.

The interview questionnaire survey was the source of primary data and the most applicable tool for soliciting and compiling data within the case studies. In line with Kasper (1999) and Keats (1999) advice on achieving exploratory research goals requiring open, inclusive, and few predetermined modes of inquiry, the interview technique proved critical. The major techniques include: face-to-face interview, telephone interview, or focus group interview. A face-to-face interview technique was used in this research at the case locations. Figure 4.8 shows how the interview method was applied as part of the data capture, supporting the questionnaire survey in this research. With the questionnaire method documenting the perspectives of the participants, the interview was necessary to make initial contact and provide clarity on any concerns with items in the questionnaire.

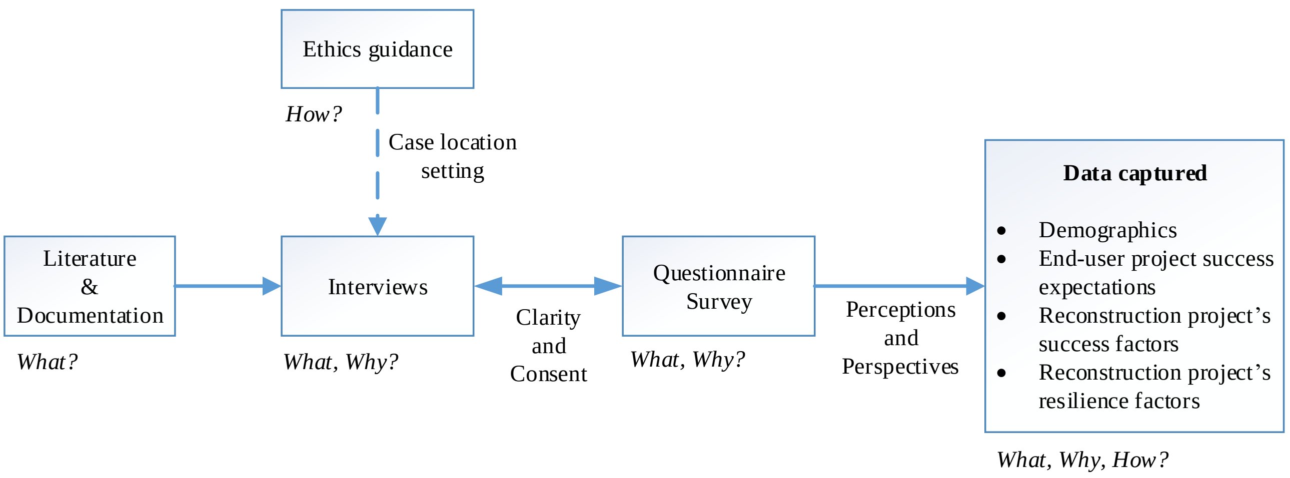


Figure 4.7 Logical flow with the questionnaire survey in the data capture process

Sampling approach

The sampling approach used for survey participants was the non-probability purposive technique. According to G. Sharma (2017), sampling is a technique used by a researcher to systematically select a relatively smaller number of representative items or individuals (a subset) from a pre-defined population to serve as subjects (data source) for observation or experimentation as per objectives of a research project. On the premise that a researcher has neither time nor the resources to collect data from an entire population in a case, there is a need to select a sample. Applied research chooses from 10 possible techniques, divided equally into probability (the probability of choosing each subject is the same) and non-probability (subject selection is totally based on judgement) sampling types. Table 4.18 provides a summary of the strengths and weakness of sampling techniques used in applied research.

Table 4.18 Strengths and weaknesses of sampling techniques

Type	Technique	Particulars	Strengths	Weaknesses
Probability (random)	Simple random	Each subject has an equal chance of being selected independently of the other subjects in the population	Easy to assemble, unbiased with equal selection opportunity, quite representative, and produces more accurate generalization	Requires a complete and up-to-date list of all possible subjects
	Systematic	Selection based on the first and subsequent ‘nth’ subject in a random start	Spreads the sample over the population, and easier to conduct than a simple random sample	Chance of an undisclosed or hidden periodic trait
	Stratified	The population with a great deal of variation is divided into strata (or subgroups) and a random sample is taken from each subgroup	Reduce the potential for human bias, and highly representative and effective with statistical inferential generalization	Not useful if subgroups are not exclusive, overlaps may skew generalizations
	Cluster	The population is divided into naturally occuring clusters or groups, then a random sample is taken from these clusters.	Cost effective by reducing travelling expenditure, and has a feasibility advantage when dealing with large population size	Biased inferences highly possible on the population’s character, and results are prone to higher errors than other probabilistic techniques
	Multi-stage	A process of moving from a broad to a narrow sample, using a step by step process.	Cost and time effective, and convenient as concentration is in smaller geographic regions	Complex form of cluster sampling and less accurate than random sampling

Non-probability (Non-random)	Quota	Subjects are chosen on the basis of predetermined characteristics	Best and quickest non-random probability sample	impossible to determine the possible sampling error and make generalizations
	Snowball	Also called chain sampling, it uses a few subjects to help encourage other subjects to take part	Useful in hidden populations not easily accessible or no available public list, also, it can estimate rare characteristics	impossible to determine the possible sampling error and make generalizations
	Convenience	Subjects are selected because they are often readily and easily available	Least expensive, least time-consuming, most convenient	Selection bias, sample not representative, not recommended by descriptive or casual research
	Self-selection	Subjects volunteer to take part in the research rather than being approached by the researcher	Reduce subjects search time, and they are likely to be committed with willingness to provide deeper insights	Possible self-selection bias if incentives are offered, and a risk of being unrepresentative
	Purposive or judgmental	Subjects are selected deliberately to provide important information specific to the research	Justified ability to make theoretical, analytic and logical generalizations from the sample	Sample is created on researchers judgement, therfore it can be highly prone to bias.

Extracted from: Denscombe (2014), Taherdoost (2016) and G. Sharma (2017)

Non-probability sampling is often associated with case study research design, and case studies tend to focus on small samples. As explained earlier, case studies aim to examine a real life phenomenon, not to make statistical inferences in relation to the wider population, but to form a generalized concept that either tests a theory or builds one (Denscombe, 2014). Due to the exploratory nature of this research and the need for subjects (interview survey participants) related to the cases, the careful selection of purposive sample subjects was required for the best representation of the population. Noting that each of the cases (refer to section 4.2) carries their own uniqueness with respect to disaster experiences, way of life, building standards and socio-economic conditions, the technique also satisfies the need to incorporate multiple cases. The sample selection strategy adopted sought to engage the subjects in their capacity as private citizens within their particular affected and disaster-striken community. The relevant data for this research were from persons in the disaster-affected communities who were directly affected and inconvenienced by damage to their homes and related infrastructure, preferably over an extended period, and are beneficiaries of the reconstructed structures with a desire for greater resilient projects. While the snowball technique was not part of the primary sampling approach, however, aspects of the technique was useful in the referral and recruitment of subjects during the field visits to the various communities.

The survey participants were randomly chosen following advice provided by Silverman (2013) on purposive sampling methods and Creswell (2009) admonishments on the willingness of participants to add value to the research topic. With the assistance of the local disaster management offices in the four islands, communities where there are major building and reconstructed infrastructure projects were identified. While these areas were primarily ideal for satisfying the research objective, the potential survey participants were randomly selected from these specific communities.

Sample size

Neuman (2014) distinguishes between three approaches to the calculation of the sample size, namely: statistical, pragmatic and cumulative. Though being heralded as the proper approach, the statistical approach that is best applied to large-scale surveys and probability sampling techniques is not always practical for reasons that include cost constraints and population size. The pragmatic approach, which is practically opposite to the statistical approach, gravitates to smaller-scale surveys where there may not be clear boundaries and statistical paramaters to aid the selection of subjects. The approach is prided on using available resources to determine selection criteria relevant to the research topic and it is often significantly less costly. The cumulative approach is also associated with small-scale qualitative research. The approach, as the name suggests, increases the sample size until it is satisfactorily quantified to benefit the research objective(s) through continuously adding subjects as they become available.

The ideal participants for the questionnaire survey identified for the case studies have been described as citizens in the case locations who have suffered inconveniences from disaster-damaged buildings and infrastructure, who desire more resilient rebuilds in anticipation of future disasters. While the total citizenship population of the islands is known, the population pertinent to the research remains vague. A great deal of uncertainty in determining the true population of the affected citizens relates to factors including an unknown number of affected communities, the extent of the damages, and the varying considerations of what constitutes an inconvenience. As such, statistically calculating an anticipated sample size can be challenging, especially for lack of comprehensive disaster-related data in the case locations. Therefore, the pragmatic approach was deemed appropriate in this research project.

Representativeness is a pivotal consideration of the sample size composition. Upon affirming the pragmatic approach, the best representative sample of affected citizens, which consists of the disenfranchised project end-users, remains central to this research. These subjects are most appropriate from which inferences or generalisations can be harnessed (Neuman, 2014). Consequently, as an initial step and on the premise that the data collected will undergo statistical analysis, the researcher adopted a rule of thumb suggested by several researchers, which included having 15 sample observations (subjects) per measured variables or 10 observations per independent variable, with a minimum critical ratio of 5:1 (Hair Jr et al., 2016; Kline, 2015). In treating the case study as comprising four unique case locations, Kline (2015) suggestion of a sample size less than 100 as small; between 100 and 200 as medium, and greater than 200 as large can be applied to each location.

In addition to online searches regarding disaster-affected communities, the local disaster management authorities in the respective islands were contacted to both request assistance with the research effort, but more so, to obtain information on the affected communities and damage requiring reconstruction. The fieldwork was scheduled for three months (mid-May to mid-August, 2019) in the four islands. An attempt was made to have all islands equally represented in terms of participation and background diversity. The sample size in this research consisted of 268 unique questionnaire responses. Table 4.19 provides a cross tabulation of the representative sample across the four islands and by the amount of years known to be inconvenienced or have end-user experience with disaster reconstruction projects.

Table 4.19 Respondents' island location * Years-of-experience cross-tabulation

			Years of experience with reconstruction projects						
			0-5	6-10	11-15	16-20	21-25	25+	**Total**
Respondents' Island	**Antigua**	Count	1	3	0	2	1	7	**14**
		%	0.4%	1.1%	0.0%	0.7%	0.4%	2.6%	**5.2%**
	Dominica	Count	52	7	8	4	3	11	**85**
		%	19.4%	2.6%	3.0%	1.5%	1.1%	4.1%	**31.7%**
	Grenada	Count	18	7	51	14	15	3	**108**
		%	6.7%	2.6%	19.0%	5.2%	5.6%	1.1%	**40.3%**
	St. Vincent	Count	26	13	9	2	1	10	**61**
		%	9.7%	4.9%	3.4%	0.7%	0.4%	3.7%	**22.8%**
Total		Count	97	30	68	22	20	31	**268**
		%	36.2%	11.2%	25.4%	8.2%	7.5%	11.6%	**100.0%**

4.4.2 Data collection procedure

Only persons over 18 years residing in the sample region and who had been adversely affected were invited to participate upon contact. Upon demonstration of a willingness to participate, their rights governing the survey interview were made known through an ethics approved personal information sheet, then a four-part questionnaire was administered. The first part asked some general demographic and work-related questions; the second part focused on project success expectations; part three asked their perceptions on the 26 success factors; and part four focused on resilience for reconstruction projects.

The data was manually collected using printed questionnaires. The interview period went over the scheduled three months, which ended in August 2019. As a Caribbean community (CARICOM) citizen with a clear understanding of the people and their culture, there were no unforeseen hindrances or special requirements for the researcher in meeting the interviewees.

The procedure for survey participant recruitment was as follows:

1. A radio advertisement informing of the research project and requesting volunteers within the specified communities, at least two weeks before commencement and a reminder at the start of the data collection week.
2. The researcher met random persons within the communities, with face-to-face contact. The researcher politely asked of their awareness on the voluntary request for participation from the radio anouncements. If interested in participating, formal engagement began.
3. The engaged participants were provided additional information through an explanation of the PIS provided and the consent form.
4. The researcher and survey participants proceeded with a single participant responding to a single questionnaire sheet. No focus group exercise was conducted.
5. Upon completion, the survey participant assisted with identifying other person in the community that may be available to assist with the questionnaire survey.
6. Subsequently, upon returning to Auckland from the Caribbean, the SPSS® analysis software was used to digitise the interview questionnaire survey data.

4.4.3 Data analysis methods

This research follows the mixed methods approach to data analysis, in similar fashion to the mixed methods approach to data collection. Combining both qualitative and quantitative research methods may still appear somewhat bizarre to some researchers, however, a great number are interested in fusing the two approaches in order to harness their respective strength (Bryman, 2003). The combination possibilities are mostly along the lines of mutual technical contribution and not in the realm of epistemological orientations, and is the recommended strategy for the philosophical outlook of pragmatism, and as such, was adopted for this project. Just as the justifications for its adoption and application to data collection have been summarized in sections 4.1.2 and 4.1.3, acceeding to Denscombe (2014) advice for data analysis, the combinaion does not distinguish between the data types, but proceed to; 1) describing the data, 2) explaining how the data works and 3) interpreting what it means.

Bryman (2003) admonishes that the distinct characteristics and purpose of the two types of data are significantly important to not loose focus on their value. The merging of both data sets is made possible with the technique of integration. Integration is the point in the research procedures wherein qualitative research interfaces with quantitative research (Creswell & Clark, 2017). Triangulation also play a critical role, however, it refers to the concept of data mining from multiple data sources and the use of different data collection techniques within one study to augment and confirm the message from one or more data sources (Saunders et al., 2009). There are several analysis techniques to describe, explain and interpret data. However, the practically opposing data types, analysis structure, and analysis techniques have naturally assigned them according to the approach type; either quantitative (numbers) or qualitative (words and images). Bryman continued to solidify the combination with the assertion that 'qualitative research may act as a source of hunches or hypotheses to be tested by quantitative research… and may also facilitate the construction of scales and indices for quantitative research' (p. 133). While the reverse does occur, where the quantitative research facilitates qualitative research, it is far less numerous.

Having established the combination as a longstanding viable analysis option, the analysis process in this research adopted Creswell and Clark (2017) five-stage data analysis plan. A summary of the plan was obtained from Denscombe (2014) and represented in Table 4.20. Included in Table 4.20 is an identification of activities in the research process where specific data analysis technique was used.

Table 4. 20 Five stages of data analysis

	Quantitative data		Qualitative data	
Stage 1 Data preparation	• Coding (which normally takes place before data collection) • Categorizing the data • Checking the numbers	N/A	• Cataloguing the text or visual data • Transcribing the text • Preparation of data and loading to software (if applicable)	Content Analysis Ch. 2 Ch. 3
Stage 2 Initial exploration of the data	• Looking for obvious trends or correlations	Ch. 2 Ch. 3	• Looking for obvious recurrent themes or issues • Adding notes to the data. Writing memos to capture ideas	Ch. 2 Ch. 3
Stage 3 Analysis of the data	• Use of statistical tests (e.g. descriptive statistics, factor analysis, cluster analysis) • Linking to research questions or hypotheses	Ch. 5 Ch. 6 Ch. 7 Ch.8	• Coding the data • Grouping the codes into categories or themes • Comparison of categories and themes • Looking for concepts (or fewer, more abstract categories) that encapsulate the categories	Ch. 2 Ch. 3
Stage 4 Presentation and display of the data	• Tables • Figures • Written interpretation of the statistical findings	Ch. 8 Ch. 9	• Written interpretation of the findings • Illustration of points by quotes and pictures • Use of visual models, figures and tables	N/A
Stage 5 Validation of the data	• External benchmarks • Internal consistency • Comparison with alternative explanations	Ch. 8 Ch. 9	• Data and method triangulation • Member validation • Comparison with alternative explanations	N/A

Source: Adopted from: Denscombe (2014)

Analysing qualitative data

Preliminary data analysis of secondary data from documents and relevant literature assists with shaping the direction and development of the remaining data collection process. Among a range of qualitative data analysis techniques, which includes content analysis, discourse analysis and thematic analysis, this research adopted content analysis. Content analysis, as explained below, assists in logically mapping knowledge obtained from text or images into themes (Bauer, 2000; Cavanagh, 1997).

The qualitative data used in this research is displayed in the form of tables (refer to Table 2.3 and Table 3.1), generated from documents analysed in the systematic literature reviews. Particularly, the documents used were related to project success and project resilience and were thematically searched through online bibliographic databases. Details of the search criteria and terms are provided in both Chapters Two and Three. The qualitative data analysis was aided by the Microsoft Excel computer software, which facilitated managing the vast amount of data from almost 300 studies on the two themes. A major benefit to using this software is the ability to maintain the thematic compositions of the data that help generate patterns and perspectives without undermining categorial and comparative richness of the data. The thematic nature of the results from the qualitative data analysis will eventually be translated as variables on import into the quantative data analysis relm. The identification of themes on project success and project resilience factors from the literature followed the research process sequence leading to the development of survey questionnaires. The content analysis technique with the systematic literature review assisted in meeting objectives #1 and #3.

Content Analysis

Bauer (2000) describes content analysis as mapping the knowledge presented in a text into logical inferences with the validity of 'the analysis deliver[ing] interesting results and withstand[ing] scrutiny'(p. 12). It is claimed that content analysis combines statistical formalism and the qualitative analysis of the materials found in literature. The underlying proceedures in content analysis are syntactical (how something is said or written) and semantic (what is being said or written). In this research, the open-coding technique, based on content analysis, was utilised to group traditional and emerging success and resilience strategies into similar themes, to demonstrate their relationship to the broad categories of project success, project resilience and project expectation criteria.

Analysing quantitative data

The data collected from the survey was digitized from the questionnaire paper and entered into the SPSS® software application in preparation for analysis. The data entered was checked twice to ensure accuracy, and coded according to the themes generated from the qualitative review. This research work utilised the statistical techniques of factor analysis, multiple regression, path analysis and structural equation modelling, with correlation analysis and variance analysis as underlying analysis constructs.

After using the secondary data from the content analysis to develop the survey questionnaire, initial results from factor analysis provided oversight to the relationship among the project success variables, project resilience variables and project expectation variables. Variables are either observed (measured or indepenent) values or unobserved (latent or dependent) values. Multiple-regression expresses the relationship of one dependent variable to many independent variables while path analysis demonstrates strengths among complex causal relationships among the variables in a model. Correlation analysis is the principal measurement of the strength and direction of the relationship between two variables, statistically termed the linearity. Variance measurements tell a bit more information than correlational values by reducing the assumption that linearity (fully positive or negative) in full range across both variables, meaning that the degrees of positive or negative inferences on each other, may not be proportional. Full rationale for the choices of analytic techniques are provided below.

Factor analysis

Factor analysis is a collection of methods for explaining the correlations among variables into more fundamental entities called factors (Tinsley & Brown, 2000). It statistically analyses the relationship between multiple variables and produces a pattern among all the variables. A key feature of factor analysis is the ability to reduce the number of variables, if required, owing to its multi-dimensional analysis technique. Two types of factor analysis are either exploratory or confirmatory. Confirmatory factor analysis (CFA) differs from exploratory factor analysis (EFA) for the simple reason that it starts with a theory about the relationship among the variables that requires verification. Since the intention in this section of the research process is to understand perceptions, an exploratory approach was applicable. EFA is the factor analysis method applied to a group of variables that searches for relationships between them, to reduce the broad set of interrelated variables into smaller composites (Hair Jr et al., 2016). To identify any correlations among the project success factor obtained from the systematic literature reviews, and a similar exploration exercise with the project resilience factors, the result was a reduction of 26 success factors to four, and 24 resilience factors to three. The EFA output helped determine the number of fundamental influences underlying a domain of variables.

Further, it established the extent to which each variable is associated with the factors. This method was used to satisfy objectives #2 and #4.

Multiple regression and correlations

Also a causal analysis, multiple regression predicts the relationship among a dependent variable and several independent variables. It is superior to correlation as it facilitates a one-to-many relationship outputting regression coefficients or multiple correlation coefficients, while correlation analyses often relates to a one-to-one relationship. The regression coefficients partials out the effect of other variables that is lacking in the correlation analysis. For this reason, part 'A' of objective #6 was generated with the multiple regression method. Part 'B' of objective #6 was the verification of the correlations found from the regression analysis using the structural equation method. The regression method provided the results of strength among all the project resilience success regressing on both project success factors and the success expectation factors. Also, the results of the regression analysis of project success factors on success expectation factors were generated. Ultimately, several regression equations depicting the relationships were formulated.

In this research, multiple regressions assisted with understanding the quality of relationships among success factors and resilience factors (independent variables – IV) and the project success expectations (dependent variable – DV). The two sets of independent variables are represented as four success factors as shown in the Table 8.1, and three resilience factors shown in Table 8.2. The dependent variables are the eight observed end-user indicator variables (end-user project expectations), listed in Table 8.3. Multiple regression models will explain the quantitative impacts of the IV and the DV and represented by the measurements in the following equation:

$$Y_i = \beta_0 + \beta_1\alpha_{1i} + \beta_2\alpha_{2i} + \ldots + \beta_n\alpha_{ni} + \varepsilon_i$$

Where: Y = *value of DVs;*

β_0 = *constant;*

β_1 *to* β_n = *regression coefficients;*

α_1 *to* α_n = *values of IVs,*

ε_i = *random error.*

Structural Equation Modeling (SEM)

The structural equation modelling (SEM) method was used to achieve research objectives #5 and part ‘B’ of #6. Regarding objective #5, in attempt to understand project success from an end-user perspective, this method was used to elicit any measurement construct to which end-users assess project success. It was established earlier that end-users are remote to the construction project operations, therefore, the traditional measurement metrics are not available to them. Consequently, abstract concepts such as satisfaction, sustainability and practicality have evolved in end-user measurement schemes. The eight success criteria derived from the systematic literature review in objective #1 and #3 were used to asked their opinions. One of SEM’s strengths is measuring latent or abstract constructs in a model. Therefore, SEM was used to analyse the eight success expectations towards an investigation into any new end-user oriented measurement construct.

Similar to part ‘A’, part ‘B’ of objective #6 sought to futher analyse this research’s theory that hypothesises a relationship among three latent variables, namely project success, project resilience and project success expectations. The structural equation approach was used to understand the relationship possibilities among them, but more specifically, the relationship between resilience as a contributor and the overall success of disaster recovery projects. For testing hypothetical models among latent variables and complex relationships, the SEM approach is considered an effective method for representing the structural relationships (S. Thomas Ng et al., 2010). The SEM is an amalgamated multivariate technique, used to simultaneously estimate a series of interrelated relationships among variables, incorporating various statistical methods that include confirmatory factor analysis, multiple linear regression, path analysis, analysis of variance and covariance (S. Thomas Ng et al., 2010). The SEM is deemed superior to the multiple regression method because of its ability to reduce reliability biases normally associated with regression analysis, as measurement errors are virtually purged due to the inclusion of observed variables measurements in the model’s framework (Molenaar et al., 2000). Figure 4.10 demonstrates the fusions of analysis techniques in SEM. Further explanations of the components are provided below.

Figure 4.8 Analysis techniques composition in a SEM

Proposed as the premier analytical tool in this research project, the SEM was developed in these steps: 1. establish the structural (latent) and measurement (measured) components of the model; 2. analyse the goodness of fit among the variables with the proposed theoretical (hypothetical) model; 3. determine the strength of the relationship between each pair of variables; 4: respecify the theoretical model to improve its fit to the real-world data, if necessary; and 5: verify the model and interpret the findings (Bollen, 2005). These steps are expounded upon in Chapter 8.

Underlying data analysis constructs

Variance and correlation

Advancing the work of correlation analysis, variance analysis also provides more relevant information than correlations by not only recognising a relationship between two variables but indicating the strength of influence on each other, especially group comparisons. For example, another subtheory is that end-users perceive success and resilience differently based on experience and locations. For each of the success factors assigned in the model, an analysis of variance can be conducted to ascertain the differences between their mean scores and standard deviations. The result will indicate and assist in understanding the 'variances' among the perceptions, if any.

Path analysis

Acknowledged as a causal analysis technique, the path analysis vividly represent the often complex relationships in SEM. Measured by path coefficients, the strength of these relationships is compared to systematically determine the predictive power of each independent variable within the measurement or structural model with the effect of the other variables being partialled out. The strength of path analysis contributes to SEM by its ability to simultaneously accommodate a variable as both a predictor and a criterion.

In summary, Table 4.21 provides a list of the methods and a description of their association with the research objectives, including the positives and challenges in applying them.

Table 4. 21 Summary of research analytic strategies to answer the research questions

Question #1	What project success factors contribute to achieving positive outcomes in disaster recovery projects?
Objective #1	**To investigate the factors that contribute to successful outcomes for normal construction projects and draw on applications to post-disaster recovery projects.**
Query	Qualitative research
Method	Systematic literature review, content analysis
Corresponding Chapter	Ch. 2
Pros and Cons	**Pros:** limited bias and improved reliability and accuracy of the literature account on a specific topic **Cons:** sometimes arduous and time consuming, a traditional review is usually quicker and less costly
Question #1	What project success factors contribute to achieving positive outcomes in disaster recovery projects?
Objective #2	**Understand the perceptions of successful projects from project end-users.**
Query	Qualitative and quantitative research
Method	Questionnaire survey, factor analysis
Corresponding Chapter	Ch. 5
Pros and Cons	**Pros:** used to identify the hidden dimensions in both objective and subjective attributes that may or may not be apparent from direct analysis in groups of inter-related variables **Cons:** renaming new factor constructs can be difficult and multiple attributes can be output as highly correlated with no apparent justifiable reason
Question #2	What resilience factors and measures have been deployed within the industry and how have they affected outcomes in disaster reconstruction projects?
Objective #3	**To investigate how prevelant resiliency has been central to reconstruction projects and its contribution to stakeholders' satisfaction**
Query	Qualitative research
Method	Systematic literature review, content analysis
Corresponding Chapter	Ch. 3
Pros and Cons	**Pros**: limited bias and improved reliability and accuracy of the literature account on a specific topic **Cons**: sometimes arduous and time consuming, a traditional review is usually quicker and less costly

Question #2	What resilience factors have been deployed within the industry and how have they affected outcomes in disaster reconstruction projects?
Objective #4	**Understand end-users' perceptions regarding what a resilient project means to them.**
Query	Qualitative and quantitative research
Method	Questionnaire survey, factor analysis
Corresponding Chapter	Ch. 6
Pros and Cons	**Pros:** used to identify the hidden dimensions in both objective and subjective attributes that may or may not be apparent from direct analysis in groups of inter-related variables **Cons:** renaming new factor constructs can be difficult and multiple attributes can be output as highly correlated with no apparent justifiable reason
Question #3	What are the critical success factors and resilience factors, and their relationships for successful reslilent reconstruction projects, in line with end-users' success expectation indicators?
Objective #5	**To understand what measurement indicators of end-user's expectations of project success are.**
Query	Quantiative research
Method	Factor analysis, structural equation modeling
Corresponding Chapter	Ch. 7
Pros and Cons	**Pros:** used to identify the hidden dimensions in both objective and subjective attributes that may or may not be apparent from direct analysis in groups of inter-related variables **Cons:** renaming new factor constructs can be difficult and multiple attributes can be output as highly correlated with no apparent justifiable reason
Question #3	What are the critical success factors and resilience factors, and their relationships for successful reslilent reconstruction projects, in line with end-users' success expectation indicators?
Objective #6	**Determine the interrelations and the major contributors among the factors to achieve an end-user's success expectations**.
Query	Quantitative research
Method	Multiple regression, path analysis, structural equation modeling (SEM)
Corresponding Chapter	Ch. 8
Pros and Cons	**Pros:** a methodology designed primarily to test unobservable variables and observed variables of a substantive theory from empirical data **Cons:** with SEM being a unifier of several 'second-generation' methodologies (path analysis, multiple regression, etc..), its 'first-generation' results rely on the 'second-generation' epistemologies so as to realize its true potential in achieving a 'well-fitting' model

Question #4	How can the resilience concept become mainstream as a project management practice in post-disaster recovery construction projects?
Objective #7	**To develop a guiding framework to serve as a pathway to mainstreaming resilience into project management practice for disaster reconstruction.**
Query	N/A
Method	Data synthesis (correlation analysis and deductions)
Corresponding Chapter	Ch. 8
Pros and Cons	**Pros:** correlation analysis assist in determining the strength and direction of a relationship between variables, and where possible, determine causation for relationship effects **Cons:** correlational analysis primarily uncovers a relationship, but does not normally provide a conclusive reason for the relationship and its quality

4.5 Reliability, validity and limitations

This research project has adopted a philosophy, applied particular strategies of inquiry and used a variety of methods towards achieving the research objectives. Two concerns that would naturally emerge during the research process are: 1) the reliability and validity of the research, and 2) limitations with using case study inquiry methods. While validations occurred at various process outputs during the research, validation is addressed in this section from a holistic perspective on the reseach process. To aid in characterising this research as robust, the following strategies were applied to address these two concerns.

4.5.1 Data validation methods and reliability of survey response data

Accurate data collection

The survey and data collection were conducted between May and August 2019, in the four Caribbean islands. The researcher was present with the survey participants only to solicit responses and to provide clarity on any questionnaire item; however, each questionnaire was filled by the individual, and not in a group setting. The participants were asked to provide accurate demographic information in section A of the questionnaire and their opinions on the remaining three sections (refer to Appendix 8). Every effort was made to have an equal distribution of participants across the island in terms of quantity. The distribution of the participants by island locations and years of experience with disaster inconveniences from reconstruction projects is shown in Table 4.22.

The data collection, represented as step three in Figure 4.9, follows a two-step process, comprising: 1) a systematic literature review, and 2) semi-structured questionnaire development. The literature review was conducted according to the Preferred Reporting Items for Systemic Reviews (PRISMA) guidelines, which identified 26 project success factors from 190 relevant articles and 24 resilience factors from 60 relevant research articles (refer to Table 2.3 and Table 3.1, respectively). The PRISMA guidelines (Moher et al., 2015) offer a superior exploratory and unbiased investigation into the literature over traditional literature reviews (Green & Higgins, 2005). The questionnaire was developed to solicit the impact level of project end-users' perception on what constitutes a resilient project on a seven-point Likert scale. The measurement scale depicted 7 as strongly agree, 6 agree, 5 slightly agree, 4 neutral, 3 slightly disagree, 2 disagree, and 1 strongly disagree. Project success expectations was measured on a 'priority' five-point Likert scale with 5 as essential priority, 4 high priority, 3 neutral, 2 low priority, and 1 indicating not a priority. This scales were chosen following Finstad (2010) recommendation on the Likert scale's ability to better reflect respondents' proper subjective evaluation over other scales. The data were subsequently analysed using the Statistical Package for the Social Sciences (SPSS) software. The data was synthesized and the results and interpretations are presented in subsequent sections.

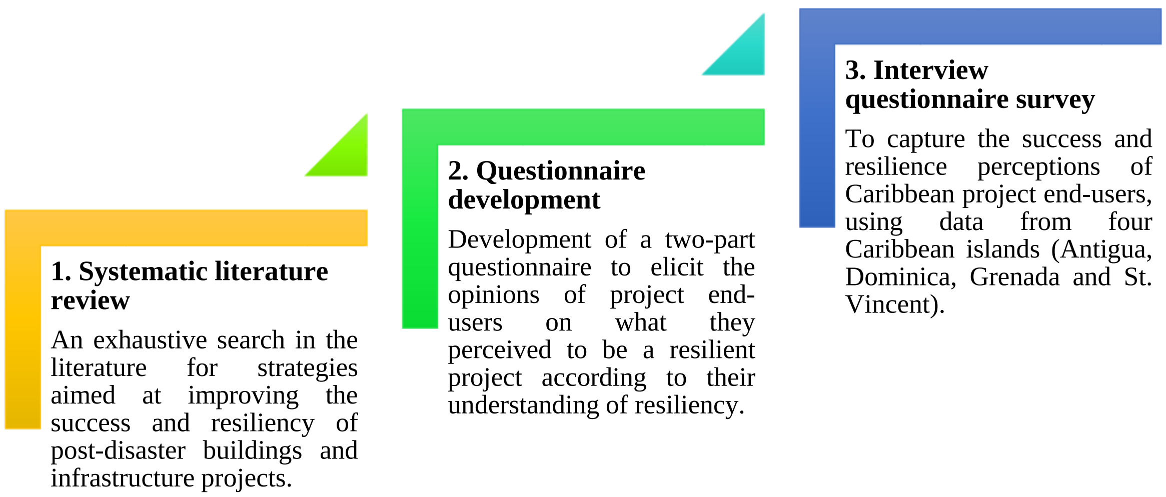


Figure 4.9 Research data collection procedure

Data validation: Project success factors survey data

Distribution of respondents by island country and years of experience

Table 4.22 provides a cross-tabulation frequency distribution of the survey respondents affected by disaster-damaged buildings or infrastructure, across the islands and their categorisations according to years-of-experience. The distribution shows approximately 20% of the responses captured end-user experiences well over the past two decades, with the remaining 80% having up to a maximum of 20 years. Within this 80% group, almost half (44%) were the youngest set of end-users (0-5 years of experience) when compared to the other five categories. This distribution captures a representative sample with wide-ranging perspectives that augers well to elicit diverse opinions and concerns. Grenada saw the largest participation (40%), while Antigua's participation was the lowest (5%). With haste to clarify the disparity, available survey time constraint was the only reason.

Table 4. 22 Respondents' island location and years-of-experience cross-tabulation

		Years of experience with reconstruction projects						Total
		0-5	6-10	11-15	16-20	21-25	25+	
Respondents' island	Antigua	1	3	0	2	1	7	**14**
	Dominica	52	7	8	4	3	11	**85**
	Grenada	18	7	51	14	15	3	**108**
	St. Vincent	26	13	9	2	1	10	**61**
Total		**97**	**30**	**68**	**22**	**20**	**31**	**268**

Distribution of respondents by construction sector and years of experience

Table 4.23 shows the distribution of the respondents aligned to the reconstruction project types that actively affected them for an extensive period (years of experience). One may observe that the number of project type associations exceed the number of respondents by a ratio of almost 2:1, indicating that most responders have been affected by at least two different types of building or infrastructure damage. Residential building projects, which approximate 42%, dominated the number of projects, which include personal home rebuild or relocation to a new housing development. The remaining 58% are primarily national post-disaster redevelopment and modernisation projects (such as roads and bridges, schools, hospitals and government buildings) and major commercial projects (such as telecommunications, water and wastewater and electricity networks).

Table 4. 23 Respondents' project type associations and years-of-experience cross-tabulation

		Years of experience with reconstruction projects						No. of respondents
		0-5	6-10	11-15	16-20	21-25	25+	
Building and infrastructure construction type	Residential	59	20	51	18	15	22	**185**
	Water and Wastewater	23	4	15	4	3	11	**60**
	Transportation	19	4	14	6	6	8	**57**
	Energy	11	5	22	5	4	6	**53**
	Health / Education	15	3	7	2	6	7	**40**
	Climate change	8	3	7	1	3	3	**25**
	ICT	5	2	2	0	1	1	**11**

Data validation: Project resilience factors survey data

The survey participants were project end-users who have endured inconvenience related to the demise of a building or a form of infrastructure and who were concerned about the possibility of repeated damage from successive failures and who desired keen assurances that the reconstruction and the associated rebuild processes are characterised to output more resilient rebuilds. The Caribbean region, like other world regions with commonalities such as the Pacific region, comprises small island states that respond annually to climatological, metrological, geophysical or hydrological disaster-related damage, with recovery costs that often exceed their gross domestic product (GDP). Their limited resources almost certainly prompt a reliance on external technical and financial assistance in their recovery process. Ironically, the region's status quo disaster management strategies have somewhat focused on coping capacities, with little interest on identifying the underlying risk factors that accentuate these disaster effects (Bisek et al., 2001; Collymore, 2011)

To ascertain any commonalities in resilience-related perceptions, and to garner a regional perspective, 268 random individuals responded to the survey questionnaire that solicited their reflections on reconstruction projects. Participant selection was random, according to purposive sampling techniques suggested by Creswell (2009) and Silverman (2013). The sample of participants comprised the energy sector, transport sector, water and wastewater sector, agriculture workers, recipients of housing development homes, government agencies and the general public across the islands.

A sample of the questionnaire can be found in Appendix 8. The distribution of survey participants affected by post-disaster reconstruction projects is shown in Table 4.24. In total, across the Caribbean islands of Antigua, Dominica, Grenada and St. Vincent, 268 individual participated in the questionnaire survey.

Table 4.24 Distribution of the survey participants

	Public/ community members	Energy	Transport	Water & Wastewater	Agriculture	Housing development	Gov't agencies
Antigua	√	√					√
Dominica	√	√	√	√		√	√
Grenada	√	√	√	√		√	√
St. Vincent	√	√	√	√	√	√	√

Data reliability: Project success factors analysis using survey data

The relative importance of the data extracted from 26 factors in the questionnaire is explored by the means of a seven-point Likert scale survey instrument (Ahire et al., 1996). The Cronbach's coefficient alpha was 0.953, indicating strong internal consistency among the 26 factors and the data is reliable for further analysis (Pallant, 2013).

Bearing in mind that the dataset originates from four different jurisdictions, to verify that the complete dataset can be treated as a whole, MANOVAs were performed to test the null hypothesis claims that the respondents' perceptions are similar across the islands and across years of experience regarding reconstruction project success factors in the Caribbean region. Results show that as a group, there was no significant difference (at the 98.4% confidence level) across the group based on 'years of experience' (i.e. 0-5, 6-10, 11-15, 16-20, 20-25 and 25+), and only two success factors showed significant difference (at 97.5% confidence level) when grouping was based on 'island state' (i.e., Antigua, Dominica, Grenada, St. Vincent). Since only the two factors showed significant difference ($p < 0.0125$) between only two islands, in comparison to the whole set of factors analysed (qty. = 26), it can be concluded that there is general agreement about the region's perception about success factors for reconstruction projects irrespective of their experience with reconstruction projects.

Data reliability: Project resilience factor analysis using survey data

A relative importance test of the 24 empirical factors used in the survey questionnaire was undertaken. The results of an analysis of the effectiveness of the data captured by the seven-point Likert scale (Ahire et al.,

1996) returned a Cronbach's coefficient alpha of 0.945. A coefficient greater than 0.7 indicates that there is sufficient consistency among the variables to be reliable for further analysis (Pallant, 2013).

Multivariate analysis of variance (MANOVA) was performed to test the hypotheses claims that a) the respondents' resilience perceptions are similar regardless of years of experience and b) resilience perceptions are similar in all islands regarding reconstruction projects for the Caribbean region. Results point to a statistical significance in one resilience factor (Factor #2, refer to Table 6.3), 'An equal focus on structural and non-structural components during recovery' ($p < 0.008$) (at the 98.4% confidence level) across the 'years-of-experience' group (i.e. 0-5, 6-10, 11-15, 16-20, 20-25, 25+) (refer to Table 6.3). Since the difference is only between two groups on the single factor, we fail to reject the null hypothesis, and we can generally accept that the opinions of the respondents are similar. Regarding resilience perceptions across the islands, one success factor showed significant difference (at a 97.5% confidence level) when grouping was based on 'island states' (i.e., Antigua, Dominica, Grenada, St. Vincent). This factor showing significant difference ($p < 0.0125$) is (Factor #23, refer to Table 6.3) 'Establishing construction policies and actions that mitigate the effects of climate change' (refer to Table 6.3). For similar reason, though having statistical significance, its practical significance is negligible, we fail to reject the second hypothesis and conclude that resilience perceptions are similar in the islands included in the research. Therefore, the results from both hypotheses with insignificant practical differences across all 24 empirical strategies, we conclude that the collective sample can be treated as representative of the Caribbean region and be used for further statistical analysis.

4.5.2 Research reliability and validity

Primarily to boost the confidence with accepting the research findings, several researchers underscored ensuring the validity and reliability of the research design and measurements (Fellows & Liu, 2015; Neuman, 2014). Reliability and validity are ideas that assist with establishing credibility and believability of findings. Reliability and validity concerns are significant because the constructs to be measured are usually abstract and not directly observable. Both terms also have multiple meanings, especially when applied to either qualitative or quantitative measurement. Reliability relates to the accuracy of the actual measuring instrument or procedure, where the degree of consistency in interpretations with which similar instances are assigned to the same category by different observers or by the same observer on different occasions (Bryman, 2003). Validity is concerned with the success of measuring what the researcher's purpose is in terms of measuring to determine whether or not the inferences that the researcher makes are supported by the data (Peräkylä, 2011).

As identified by several researchers, four main aspects of the reliability and validity issues are considered relevant to establishing the quality of this research, which are: construct (measurement) validity, internal validity, external validity and reliability (McDonough & McDonough, 1997; Neuman, 2014; Silverman, 2013; Yin, 2017). Table 4.24 summarises the strategies taken for addressing the trust concerns in this case study's research design (adopted from Yin (2017, p. 87)).

These concern were considered in designing this research project and a set of tactics have been adopted to address them:

- **Construct (measurement) validity:** establishing correct operational measures for the concepts being studied. Referencing to the three actions recommended by Yin (2017), this research ensured construct validity, first, by using triangulation of evidence from multiple sources (document analysis and interview surveys) to converge lines of inquiry by having multiple measures of the same phenomenon. Second, by establishing a chain of evidence that confirms the logical sequencing from previously unknown information to generalization, and third, making the research reports available to key experienced or expert informants for review.
- **Internal validity:** recognising the conditions that are shown to lead to other conditions by confirming 1) the rigor to which the research was conducted, and 2) the extent to which alternative solutions were explored, especially when a causal relationship is established. Internal validity is strengthened using the more desirable strategy of pattern-matching logic, which enables a comparison between the empirically-based findings and predicted patterns gained from a literature review. If the qualitative data analysis shows the empirical findings coincide with the predicted patterns, then the internal validity of the results can be strengthened.
- **External validity:** establishing the domain to which a case study's findings can be generalized. This was achieved in this research with the application of a multiple-case approach. The underlying replication logic with multi-case designs reduces the subjectivity in the generalization of the results.
- **Reliability:** demonstrating that the operation of a study, such as the data collection procedures, can be repeated, with the same results. This research tackled the concern of reliability with two repeatable systematic literature reviews, structured interviews and a questionnaire survey with both ethical and operational protocols, and data analysis proceedures that comply with mimimum statistical principles. Reliability is ensured according to protocols on documenting and archiving the responses to the

questionnaire survey. These responses are protected by the University of Auckland for a period up to six years following the completion of the research project. Additionally, validations of generalizations, new frameworks or recommendations with subject matter experts helped to enhance the validity and reliability of this research.

Table 4.25 Tactics for the four concerns in this research

Tests	Case study tactic	Research in which the tactic is addressed
Construct validity	Use multiple sources of evidence	• Ch. 2 and Ch. 3: Foundation data for survey questionnaire development from multiple documents • Ch 4: Data from four case locations using survey questionnaire • Multiple sources summarized in Tables 5.1, 6.1, 7.1 and 8.2
	Establish chain of evidence	Sequence of evidence gathering guided by the research questions, objectives and collection methods and summarized in Figure 1.2
	Have key informants review draft case study report	Individual case study report reviewed by key informants and prepared for publishing in industry journals
Internal validity	Pattern matching	Convergence on perspectives that were summarised with MANOVA tests (sections 4.3.3.4 and 4.3.3.5) and two frameworks shown in Figure 8.2 and Table 8.1
	Explanation building	Combining perspectives from questionnaire surveys, interviews and literature documents to support the research theory, as summarized in Table 4.24 and Figure 4.6
	Addressing rival explanations	Involvement of key informants in justifying or criticizing the research findings (e.g. in peer review publishing)
	Use logic models	Application of the complex adaptive systems logical approach to monitor and update the relationship between project success and project resilience integration, as summarised in Figure 8.7
External validity	Use theory in single-case studies	The theory guiding the research has been described at various stages in the research process, however, a summary can be found Ch. 1 and Ch. 4
	Use replication logic in multiple-case studies	Replicated design for the four (multiple) cases, as explained in Section 4.2.1.2 and summarized in Figure 4.8
Reliability	Use case study protocol	Protocols of data collection explained in Section 4.3.1 and summarized in Figure 4.7
	Develop case study database	• Compiled quantitative questionnaire results • Endnote library for literature

Adopted: Yin (2017)

4.5.3 Expert judgement

The goal of applying structured expert judgement techniques is to enhance rational consensus, by generating an estimate of possible project management outcomes. Expert judgement has always played a large role in science and engineering (R. T. Hughes, 1996; Mumpower & Stewart, 1996; Winter et al., 2014). Increasingly, expert judgement is recognised as just another type of scientific data, and methods are continuously developed for treating it as such. The technique is deemed reliable when relevant information on the specific topic is non-existent or scant, and it very instrumental with project management activities.

Reliability of this research's novel output framework requires validation of the hypothesized positive effects with its proposed implementation and application. Thus, it may be necessary to garner information from industry experts who have project expertise and knowledge in post-disaster reconstruction projects. Though the technique is characterized as subjective to cognitive limitations from individual biases, this research adopts the vague definition of expert judgement as an estimate based on the experience of one or more professionals who are familiar with the area of research (Winter et al., 2014). To reduce potential bias with applying this technique, the researcher prepared a structured questionnaire (refer to Appendix 13), based on the proposed framework for resilience development (refer to Figure 8.3). Several reconstruction project professionals at the management, engineering and operational levels were targeted through a snowballing recruitment process in the Caribbean.

4.5.4 Limitations acknowledged in this research

Through a pragmatic philosophical approach, this research project uses a combination of data sources and research mehtods to achieve the objectives of the research. The strength of the apparatus was leveraged throughout the research process as: pragmatism produced a realisation of the best qualitative and quantitative paradigms, and case study offers the unique ability to simultaneously deal with a variety of evidence sources (documents, reviews, questionnaires and surveys). The advantages of the approach and methods were identified, however, this section provides some reflections on the limitations of using the approach and methods undertaken.

Research philosophy

This research adopted the pragmatic philosophy as the most appropriate to legitimizing the combined applications of the qualitative and quantitative paradigms of data collection and manipulation. Though pragmatism provides a coherent and integrated paradigm support, several researchers have critized its philosophical aptitude, especially with addressing the assumptions of the qualitative and quantitative paradigms (Maarouf, 2019). Notwithstanding the benefits of the approach's contribution to the philosophy of pragmatism, there are concerns and controversies with its use and acceptance. The controversies, which can be translated as the limitations of the approach, centre on the approach being neither a paradigm nor a method, and the combined technique lacks direction (Amolo et al., 2018).

The first and most obvious limitation is the absence of a clear paradigm of inquiry. The approaches of qualitative (designed to collect words) and quantitative (designed to collect numbers) are fundamentally at opposite ends, hence, the research results beg the question of the dominant paradigm. Greene et al. (1989) challenge the confirmation of a true paradigm as the difficulty that exists with assigning the results of mixed research as either a generalization (point of view) or an inference. A second limitation is the approach's ability to produce results that cannot be achieved by other paradigms. Bearing in mind that mixed methods is the combined approach for the purpose of deep understanding and substantiation (Maarouf, 2019), it is not soley focused on data collection, but mostly on paradigms and designs. Therefore, having been promoted as the solution to the pragmatic multi-source evidence philosophy, Vogt (2008) considered this as a categorical mistake.

Third, the balance between objectivity and subjectivity increases the controversy of mixed methods. In some research projects, the risk of emphasising the objective findings causes the subjective to be marginalised. Pragmatism promotes equal attention, especially when the qualitative characteristics of the research finding are critical to inferential conclusions, and do not rely mostly on statistics (Amolo et al., 2018). Other researchers noted that in mixed research, the qualitative side of the research expressed as gender, race, ethnic grouping, linguistic, and other demographics are missed unless given the necessary attention (Lincoln & Cannella, 2004). Although all the above controversies have merit and keep the ongoing conversations and revisions of pragmatism as a philosophy, Amolo et al. (2018) argue that as long as the qualitative and quantitative designs in the research process are 'respectfully treated', the pragmatic philosophy as an epistomological supporter of the mixed methods approach should be accepted.

Strategy of inquiry

Limitations with the strategies of inquiry are central to the case study approach and the multiple sources of evidence. Accessing multiple data sources and their combuinations provide for the intermingling of qualitative and quantitative data in preparation for analysis. A notable positive of the case study approach is the ability to facilitate this combination in research; however, there are some limitations with the approach, which requires attention and some reflections.

The major demerit of case studies is the authenticity of the researcher's generalized findings. This concern is the approach's point of greatest vulneralility to criticism (Denscombe, 2014). Also, this limitation has been described as an 'unscientific feel to the research' (Saunders et al., 2009). The need for the researcher to alleviate any suspicions of bias is a critical component of the ethical responsibility in the process. This can be considered a summary of the several limitations with the case study approach.

Other limitations include an accusation of lacking research rigor. The result of a case study is tantamount to an assertion, and Stake (1995, p. 86) describes assertions in case studies as a propositional generalization. He explains that the researcher's interpretation summaries and claims consist of added personal experiences called natural generalizations. This possibility in the researcher's development of themes, patterns, theories or generalizations suggests mixed end points in the results. Lack of systematic handling of data is another demerit. Both Burton (2000) and Zainal (2007) have cited Yin's assessment on the seemingly lack of structure, as documented in his first publication, in that too many times, the case study investigator has been sloppy, and has allowed equivocal evidence or biased views to influence the direction of the findings and conclusions. Denscombe (2014) attributes this issue, almost solely, to the problems of defining the boundaries of the case, which can prove difficult in an absolute and unambiguous fashion. Further complications arise in deciding which sources of data are relevant to the case study and which to exclude.

Another demerit is that case studies are too long, difficult to conduct, and result in massive, unreadable documents (Yin, 2017). Devoted care is required in the management of case study data, especially in longitudinal studies or with multiple cases. The limitations summarized above are not applicable to every case study. Their pervasiveness is dependent on several factors that include: the research focus and topic, the researcher, sampling technique, type of method(s), the data source(s), and the coordination of the research's logic and sequence. In acknowledging these limitations, the procedures for multiple-case data integration, survey participants selection srategy, and research instruments can eliminate the possible concerns and enhance the research reliability and validity. Therefore, the limitations of using the case study methods can be effectively minimized.

Research methods

This research project mainly employed two research instruments as methods for investigating and gathering evidence for analysis, namely: systematic literature review and survey questionnaire.

Systematic literature reviews

Chapter 2: Despite the salient benefit of providing a rigorous and unbiased 'state of knowledge' overview of the research literature on a topic, Denscombe (2014) points out three limitations with this method of evidence gathering. The first criticism pertains to the reliance on an existing body of knowledge. The findings of the review are based on work already published and publicly available. This type of review draws on a body of existing research findings; however, it works best in disciplines or topics that have already attracted a lot of attention. Therefore, for research topics where there is only very limited research outputs, it is not really possible to conduct a systematic review. Second, since systematic literature reviews are based on publicly available published findings, those that aren't published, for whatever reason, are practically unavailable. Consequently, there may not be many opportunities for the direct comparison and evaluation of the data and findings from different research work on particular topics (Denscombe, 2014). Third, systematic reviews are almost exclusively applicable to qualitative research. Having its origins in research that requires 'objective' conclusions, especially when there is a need for comparative analysis from experiments and randomized controlled trials (Tranfield et al., 2003), there are concerns with the application of the process of systematic review in 'subjective' qualitative research.

Questionnaire surveys with interview component

Face-to-face interview-administered questionnaire surveys have undoubtly compelling advantages over telephone, mail-in and internet surveys. Such advantages include the ability to observe the surroundings and to use nonverbal communication and visual aids, especially when extensive probing is essential (Neuman, 2014). Despite these pertainent benefits, there are limitations with its use. Questionnaire surveys are usually a high-cost exercise when the process entails meeting each potential survey participant. The cost and time for training, travel, possible supervision, and personnel effects are directly proportional to the sample size and geographical extent of the case locations. While the researcher serves to motivate completion and to clarify any queries with items in the questionnaire, the tendency to introduce researcher bias is the greatest in face-to-face interviews. Appearance, tone of voice, and question wording may positively or negatively affect the participant's interest or lack thereoff in the responses.

Pre-coded questions can be both frustrating and imposing. A sense of frustration may arise when the participant finds the exercise less demanding due to merely assigning a rating number or a 'tick a box' as the response can be seen as restrictive. The participant can lose interest. The imposition occurs due to the inability to provide their preferred response to the issue being investigated, which can be construed as a bias by the researcher. According to Denscombe (2014), questionnaires, by their very nature, impose a structure on the answers and tend to shape the nature of the responses such that it reflects the researcher's thinking rather than the respondent's. There is the tendency to focus on the data required for analysis rather than the theory that is driving the research. Focusing on the data, in terms of sufficiency, description and generalizability, may skew the reliability with meeting research objectives (Neuman, 2014).

The ratio of depth to breadth is controlled by the survey size. This limitation forms the greatest disparity in large and small surveys. Deciding to conduct a large or small survey can significantly compromise a true appreciation for the issue being investigated, while a small survey may be inadequate for an informed generalization. The best solution may be to conduct a small survey with a sample that is equipped with the evidence required; however, participant selection continues to be a challenge in the recruitment process. Establishing contact with 'hard-to-reach' populations can be a drawback. Unlike other surveys, usually having some pre-existing listing or directory of possible participants, the time-consuming face-to-face method requires a continuous scouting, especially with random selection. Such realities force the resercher to develop innovative means to reach them, in which the solutions are bounded to the confines of the ethical considerations guiding the research. This research has summarized the sampling approach, sample size, advertising technique and recruitment process. Once these are executed as planned, the chances of these limitations gaining any traction can be kept at a minimum.

4.6 Summary

This chapter has presented the research process, the rationale for the selected research methodology and the appropriate research methods used to investigate and generate the research results for achieving the seven research objectives. The following have been discussed in detail: the preferred research philosphy, choice and application for mixed methods research design and the sequential exploratatory approach to searching the literature, engaging the sources of evidence using appropriate data collection instruments, and finally the data analysis method each stage of the reseach process (refer to Figure 1.1).

Throughout this thesis, the rationale for selecting the pragmatic philosophy, strategies of inquiry, including multiple cases studies, and the research methods, when compared to other options, were explained. The research design justified the choice of select Caribbean islands as case locations for the collection of evidence. The research methods described include: systematic literature review, case studies, and face-to-face (interview) questionnaire survey design. A clear strategy to achieving the research's objective and ultimately answering the research questions were elucidated. To fulfill the research objectives, qualitative evidence on the factors affecting reconstruction project success and resilience was obtained from the literature. This data formed the foundation for the remainder of the research process. The qualitative data was synthesised and generated a number of factors to both success and resilience. Project success expectations were also an output of the synthesis. These three sets of factors were central to the questionnaire survey, in which project end-users (beneficiaries) provided their perspectives.

The research process has combined qualitative and quantitative data, where the data output from the literature reviews became the data input for subsequent statistical analysis. Statistical analytical techniques were employed to understand the cross-sectional questionnaire's responses with the SPSS software. Recommended reliability and validation procedures were used to ensure the internal and external validity of the research methods and findings. In summary, this project is guided by a theoretical perspective, with a pragmatic investigative approach to understanding both direct and indirect correlations between project success and project resilience, aiming towards successful reconstruction project outcomes. It is postulated that the analytical framework presented will aid conformance to project management characteristics and determination of critical success and resilience factors in the execution of disaster recovery projects. Table 4.7 provides a summary of the methodological considerations in this research.

Table 4. 26 Summary of the research's analytical framework

Layer	Selected approach(es)
Research philosophy	Pragmatism
Strategies of inquiry	A mixed methods approach with a theoretical research basis, encompassing both qualitative and quantitative techniques
Research methods	Cross-sectional data collection comprising an in-person questionnaire survey, data analysis and data synthesis
Research analytics	Statistical computing using appropriate software for both qualitative and quantitative data analysis to include structural equation modelling, multiple regression, path analysis, variance analysis and correlation factor analysis

Chapter 5: Critical factors for successful resilient Caribbean reconstruction projects

5.1 Introduction to the chapter

This chapter presents findings on critical success factors for post-disaster reconstruction projects in the Caribbean (Antigua, Dominica, Grenada, St. Vincent). First using qualitative data from the systematic reviews (refer to Ch. 2 and Ch. 3) to generate the survey questionnaire, then analysing the survey data using quantitative methods. The data obtained from the random purposive sampling survey will aid the factor analysis for developing a new list of contextual critical success factors (CFS).

5.2 Critical success factors for post-disaster recovery projects in the Caribbean

5.2.1 Critical 'success' factors role in assessing project tasks

Within the last three decades, the term 'critical success factors' (CSF) gained prominence to assist industry stakeholders in focusing on key success requirements. In the business sector, achieving and maintaining business sustainability requires careful work process alignment to the strategic outlook, where success factors are adopted for guidance (Caralli et al., 2004). Studies in the construction sector have adopted comparative approaches and have demonstrated that success factors can be extensive; however, there will be a limited few that will be key to positive outcomes (Banihashemi et al., 2017; Caralli et al., 2004; Gudienė et al., 2013; Nethathe et al., 2011). Studies have demonstrated that success factors can be extensive; however, there will be a limited few that will be key to overall success. These CSFs define key areas of performance that are essential for the organisation [project] to accomplish its mission (Caralli et al., 2004).

Bullen and Rockart (1981) defined, "CSFs are the limited number of areas [factors] in which satisfactory results will ensure successful competitive performance for the individual, department or organization"(p. 7). Establishing CSFs for the project is an unspoken task for any manager, and the careful consideration of these critical factors are pivotal in setting goals and directing operational activities. However, effectiveness of these critical areas of performance depends heavily on communicating them to all stakeholders, The benefit of this approach ensures that any project task is of consistent high performance in line with the critical factors; otherwise, the project may not be able to achieve its goals and mission and consequently may fail (Caralli et al., 2004).

5.2.2 Misconceptions of CSF in projects

Simply put, a critical success factor (CSF) is that which a person or an organization must do exceedingly well to succeed or what must be done to accomplish the strategic objective. It must not be confused with key results areas (KRA) or key performance indicators (KPI), neither should it be seen as the core task of the project manager to ensure project success. They are, for practical reasons, measurable outcomes. Critical success factors are the strategic actions for ultimate success, and not the measurable objectives (Asgari et al., 2018; Bullen & Rockart, 1981; Sibiya et al., 2015). A typical CSF can appear vague at times, and this underscores the point that it can be cumbersome on its own. To ensure that the strategic project objectives are in focus, there needs to be measurable outcomes at periodic intervals to ascertain the objectivity of the CSFs. That is the purpose of KPIs. For example, a construction project may adopt an 'Sensitive to the natural environment' CSF, which is good; however, at when and what stage or stages can it be determined that the goal is being adhered to? Hence, a KPI such as 'Materials used in formwork should not be less than 60% recycled materials'. This measure can be a very good way of testing the CSF. CSFs have a project lifecycle connotation to their existence, while the KPIs are more multiple short-term assessment measures. Gilkey (2012) summarizes that the easiest way to understand CSF and KPI singly and in contrast is to understanding that CSFs are the cause of success, whereas KPIs are the effects of actions.

5.3 Analysis of reconstruction project success factors

5.3.1 Success factors' ranking

Factor ranking was conducted to understand the participants' perception as to the most and least important of the 26 success factors for reconstruction projects. In cases where multiple factors had the same mean value, a lower value deviation was assigned a higher ranking (Q. Shen & Liu, 2003). As shown in Table 5.1, all the factors received very high consideration as demonstrated by the value of their mean in relation to the average value of all means (5.67), suggesting that the importance of all factors are deemed relatively critical across the islands.

Table 5.1 Ranking of success factors for reconstruction project: End-user perspective

Success Factors	***N***	***Mean***	***Std. Dev.***	***Rank***	***Years of Experience*** *(p<0.008)*++		***Island states*** *(p< 0.0125)* ++	
					f	sig	f	sig
Exploration and deployment of safety measures	260	6.02	1.25	F1	.503	.774	1.853	0.14
Competent leadership of project managers	262	5.97	1.26	F2	.459	.806	0.618	0.604
Management of project risks	256	5.95	1.08	F3	.958	.445	0.243	0.866
Engineering designs with technical specifications	258	5.93	1.24	F4	1.153	.334	0.944	0.421
Efficient use of project resources	253	5.89	1.13	F5	.259	.935	0.267	0.849
Clarity of contractors and sub-contractors' responsibilities	256	5.86	1.13	F6	.510	.768	1.14	0.335
Assessment of project feasibility and practicality	258	5.86	1.21	F7	.382	.860	4.29	0.006*
Project-related knowledge at all levels	252	5.85	1.12	F8	.385	.859	0.961	0.412
Environmentally-friendly construction	257	5.84	1.18	F9	2.261	.051	0.846	0.47
Communication plan	254	5.83	1.22	F10	.473	.796	2.283	0.081
Waste management (e.g. materials, time)	258	5.82	1.33	F11	.495	.779	1.5	0.216
Project operations guided by project management principles	256	5.79	1.17	F12	2.617	.026	0.219	0.883
Cost management at all stages	256	5.74	1.22	F13	.546	.741	0.16	0.923
Unbiased care for the ecosystem	252	5.72	1.31	F14	1.478	.200	1.646	0.181
Knowledge sharing amongst team members	255	5.70	1.22	F15	1.090	.368	1.133	0.337
Assessment of work processes and output	252	5.70	1.25	F16	.695	.628	1.549	0.204
Consideration for end-user expectations	257	5.68	1.18	F17	.120	.988	0.108	0.955
Optimisation of project success factors	255	5.67	1.13	F18	.901	.482	0.724	0.539
Use of specialist skillset	249	5.63	1.30	F19	.829	.531	0.549	0.649
Adoption of best procurement method	251	5.58	1.34	F20	.812	.542	0.285	0.836
Staff motivation that fosters openness	250	5.45	1.37	F21	.292	.917	2.088	0.104
Client and end-user engagement at all stages	257	5.38	1.44	F22	.464	.802	0.218	0.884

Use of new technology and tools	255	5.32	1.42	F23	.444	.817	4.452	0.005*
Decentralisation of project tasks	245	5.31	1.24	F24	.992	.424	0.643	0.588
Change management plan	252	5.08	1.41	F25	.818	.538	2.134	0.098
Project staff incentives	252	5.05	1.39	F26	.794	.555	0.421	0.738

* Significant difference at 97.5% confidence level

++ Bonferroni adjusted alpha to reduce Type 1 error possibilities

5.3.2 Factor analysis

Reducing the 26 empirical success factors to more manageable success factor variables for further analysis was conducted using the exploratory factor analysis method. This method reduces a broad set of variables into smaller sets or components by investigating the multivariate relationship that exists among and between them (Pallant, 2013). The result is clusters of related factors that can be meaningfully interpreted.

All 26 success factors were subjected to factor analysis using the principal components analysis (PCA) method and the oblimin rotation. The PCA was used mainly due to its simplicity in producing an empirical summary of the data. The oblimin rotation was assessed as suitable for its ability in facilitating uneven group distributions. Prior to performing PCA, the suitability of the data for factor analysis was assessed. The Kaiser–Meyer–Olkin value was 0.926, exceeding the recommended value of 0.6 (Kaiser, 1974) and the Bartlett's test of sphericity (Bartlett, 1954) reached statistical significance, supporting the factorability of the correlation matrix. Additionally, for a factor to be considered ideal for factor analysis, the correlation loading should be equal to or greater than 0.3 (Pallant, 2013). The PCA produced four composite factors with eigenvalues greater than 0.3 (refer to Table 5.2).

Table 5.2 shows a strong structure in the outcome from the PCA. Factors loading under the correlation 0.3 threshold, representing weak correlations, were eliminated. Further analysis of the components and their Cronbach's alpha reliability index are as follows: component 1 is Knowledge Management and use with α = 0.920, component 2 is Ecosystem Care with α = 0.843, component 3 is Stakeholder Engagement with α = 0.827 and component 4 is Resource Management with α = 0.877. Henceforth, these composite will be regarded as the 'new success factors'.

Table 5.2 Oblimin rotated component matrix (where c = component)

Rank	Success Factors	C1	C2	C3	C4
	Cronbach's alpha	.920	.843	.827	.877
F2	Competent leadership of project managers	.779			
F7	Assessment of project feasibility and practicality	.750			
F8	Project-related knowledge at all levels	.724			
F6	Clarity of contractors and sub-contractors' responsibilities	.705			
F19	Use of specialist skillset	.653			
F4	Engineering designs with technical specifications	.645			
F5	Efficient use of project resources	.630			
F23	Use of new technology and tools	.456			
F16	Assessment of work processes and output	.418			
F1	Exploration and deployment of safety measures	.376			
F14	Unbiased care for the ecosystem		.848		
F9	Environmentally-friendly construction		.807		
F11	Waste management (e.g. materials, time)		.788		
F3	Management of project risks		.404		
F22	Client and end-user engagement at all stages			.753	
F17	Consideration for end-user expectations			.581	
F18	Optimisation of project success factors			.492	
F12	Project operations guided by project management principles			.404	
F13	Cost management at all stages			.355	
F26	Project staff incentives				.730
F24	Decentralisation of project tasks				.690
F15	Knowledge sharing amongst team members				.674
F25	Change management plan				.584
F21	Staff motivation that fosters openness				.558
F10	Communication plan				.412
F20	Adoption of best procurement method				.321

5.3.3 Reconstruction projects' success variables

Reiterating the results of the principal component analysis (PCA), a strong structure is revealed. The factors' components and their Cronbach's alpha reliability index showed factor 1 is strong on Knowledge Management with a α = 0.920, factor 2 is Ecosystem Care with α = 0.843, factor 3 is Stakeholder Engagement with α = 0.827 and factor 4 is Resource Management with α = 0.877. Henceforth, the factors, listed in Table 5.3, will be regarded as the aggregated critical project success factors.

Table 5.3 Reconstruction project success factors

Code	Success Factors	Cronbach's Alpha
KM	Knowledge Management	0.920
EC	Ecosystem Care	0.843
SE	Stakeholder Engagement	0.827
RM	Resource Management	0.877

5.3.4 Project success factors as predictors of project success

With reference to Figure 1.1, the research seeks to analyse the correlation and any impact of the project success factors on the project success indicators, according to end-users' expectations. The results show that all the project success factors contributed positively to the indicators; however, stakeholder engagement had the most significant impact on project outcomes with loadings on six of the eight indicators (see Table 5.4 below).

Table 5.4 Stepwise regression analysis of success factors on success indicators

Success Factors (IV) \ Project Indicators (DV)			Change	Cost	Quality	Safety	Satisfaction	Scope	Sustainability	Time
Constant (*β*)			2.499	3.906	3.239	1.535	3.193	2.776	2.420	1.016
Knowledge Management	*(KM)*	β_0				.523				
		Sig.				.000				
Ecosystem Care	*(EC)*	β_0							.317	
		Sig.							.001	
Stakeholder Engagement	*(SE)*	β_0		.222	.437	.247		.393	.286	.340
		Sig.		.049	.000	.036		.000	.004	.006
Resource Management	*(RM)*	β_0	.440				.417			.427
		Sig.	.000				.000			.000

Typical Regression equation: Safety = 1.535 + 0.523(KM) + 0.247(SE)

As stated, stakeholder engagement (SE) has the greatest influence on positive project outcomes. Notably, SE positively contributes to cost management ((β_0=.222, ρ_0=.049), project quality output (β_0=.437, ρ_0=.000), project safety concerns (β_0=.247, ρ_0=.036), scope (β_0=.393, ρ_0=.000), sustainability (β_0=.286, ρ_0=.000) and project time management (β_0=.243, ρ_0=.006). Knowledge Management (KM) and Stakeholder Engagement (SE) contribute positively to project safety (β_0=.523, ρ_0=.000; β_0=.247, ρ_0=.036). This finding coincides with Toor and Ogunlana (2009) investigation in the perceived safety concerns within the Thai construction industry to be related to adequate communication, the mutual understanding of project goals among stakeholders, the sufficiency of resources, and the procurement of services from competent designers and contractors. Ecosystem Care (EC) positively contributes to project sustainability (β_0=.317, ρ_0=.001). This correlation can assist in correcting the stigma of the industry's influence on the ecosystem with the adoption of sustainable practices and materials towards environmental protection (Hiwase, Raman, et al., 2018; W. Wang et al., 2018; Wen-der et al., 2018).

The benefits of stakeholder engagement were exemplified in several research outputs, including Mei-yung et al. (2014) investigation into the critical factors for formulating a project's logical decision-making process and understanding team behaviour, summarising engagement's true purpose. Strategic resource management (RM) is shown to contribute positively to 1) managing dynamic or systematic project changes from either internal or external sources (β_0=.440, ρ_0=.000), 2) fulfilling the community's satisfaction expectations as mandated by a project's practicality and fitness-for-use objectives (β_0=.417, ρ_0=.000), and 3) the optimal use of project time allotment amidst scheduling constraints (β_0=.427, ρ_0=.000). The analysis also concurred with several research outputs that attributed effective resource management to be enabled by prudent waste management, labour productivity, adequate planning, and project participants' competency in anticipating and addressing project's dynamics (Ajayi & Oyedele, 2018; Asgari et al., 2018; Ghodrati et al., 2018).

Table 5.5 presents the single regression results from the modelling investigation between project success factors and individual project success indicators. The regression output of the combined success factors regressed on the individual indicators suggesting that safety, time, and sustainability are the most important to end-users, corresponding to 19.8%, 17.7% and 17.2%, respectively. The least important was project cost, which corresponds to 1.6% of their variance in cost perceptions on project success.

Table 5.5 Simple model regression: Project success factors (IV) on success (DV)

Success Indicators	**R^2**	**Adj. R^2**	**SSE**	**F-value**	**Sig.**
Change	.073	.069	1.185	18.626	.000
Cost	.016	.012	1.294	3.921	.049
Quality	.075	.071	1.149	19.313	.000
Safety	.198	.192	1.035	29.308	.000
Satisfaction	.059	.055	1.257	14.828	.000
Scope	.061	.057	1.154	15.483	.000
Sustainability	.172	.165	.911	24.535	.000
Time	.177	.170	1.118	25.470	.000

5.4 Critical success factors' independent variables

Project success has always been contextually defined and has been described differently in varying world project settings, as evident in Sanvido et al. (1992)'s summary of project success conflicting definitions, and as detailed in Chapter 2. Besides, success definitions also vary across stakeholder groups. Amidst the conflicting views, success has been predominantly judged by time and cost (Belassi & Tukel, 1996; Iyer & Jha, 2006), primarily due to their simplicity in measurement. However, evidence of that limitation has manifested in the disparity among stakeholders regarding what constitutes a successful outcome. Upon completion of a building project, for instance, the project manager may deem it a success since the time or cost objective was met at the project delivery stage. However, the end-users may consider it a failure due to its practicality, discomfort or high post-delivery maintenance cost.

Within the industry, success factors are controlled hypotheses that assist in predicting the outcomes of projects (Almarri & Boussabaine, 2017). Among the list of potential success factors, a subjective percentage is defined as critical to success (Chua et al., 1999). Studies in the construction sector have adopted comparative approaches and have demonstrated that success factors can be extensive; however, there will be a limited few that will be key to positive outcomes and sustainability, termed Critical Success Factors (CSF) (Banihashemi et al., 2017; Caralli et al., 2004; Gudienė et al., 2013; Nethathe et al., 2011). The streamlining of success factors has been encouraged in all project management approaches, with intense focus on those factors that are critical to the success of the project. Bullen and Rockart (1981) defined 'CSFs [Critical Success Factors] as the limited number of areas [factors] in which satisfactory results will ensure successful competitive performance for the individual, department or organization [or project],' and further explained that 'CSFs are the few key areas where "things must go right" for the business [or project] to flourish' (p. 7). H. Liu et al. (2014) maintained that the use of critical success factors is an important feature in guiding the construction and reconstruction process. Thus, this research uses critical success factors as independent variables to optimise the success of projects relative to the success indicators highlighted earlier.

5.5 Summary

This chapter has presented the results of the success factor ranking and a factor analysis of the survey data on end-user perceptions for successful outcomes in post-disaster reconstruction projects. An investigation into 26 empirical factors (refer to Table 2.3) having the potential to affect building and infrastructure reconstruction project outcomes was performed through a study of interrelationships, using the factor analysis technique. These empirical factors were initially ranked according to the perceived importance to the end-users, using the mean score across the factors on all 268 respondents. All factors were deemed important, by virtue of their mean values ranging from 5.05 to 6.02 on the seven-point Likert scale. Eighteen factors were observed to be highly important by having a mean value above the grand mean (5.67).

Following the factor raking, factor analysis produced four composites of correlated factors that emerged as the critically new success factors (CSF) from the perspective of the end-user. Statistical and factor analysis have shown that the 26 empirical project success factors can be re-grouped into four critical factors, namely, 1) effective management of project knowledge, 2) environment and ecosystem stewardship, 3) stakeholder engagements at multiple levels, and 4) efficient management of financial, social and human resources. These four new CFSs represents the critical factors requiring considerations in assessing Caribbean reconstruction project's success.

Chapter 6: Factors affecting resilient disaster reconstruction in the Caribbean states

6.1 Introduction to the chapter

This chapter presents critical factors affecting resilient disaster reconstruction in the Caribbean. Further analysis from the findings of the systematic review revealed the top five resilience factors have been identified as: 1) reconstruction designs mindful of future hazards, 2) policies and actions that mitigate the effects of climate change, 3) active assessment of key structures, 4) ensuring funds or funding sources are readily available for reconstruction, and 5) ensuring unbiased interest from either public or private sector stakeholders. Factor analysis further revealed that the 24 factors are correlated and were clustered into three composites, namely, 1) collaborations with inclusive training and multi-stakeholder engagements, 2) critical infrastructure indexing, and 3) effective governance. This chapter aims to deduce the critical resilience factors (CRFs) that the Caribbean stakehholders, in particular, the Caribbean end-users deem applicable in realising resilient reconstruction projects.

6.2 Analysis of reconstruction project resilience factors

6.2.1 Resilience factor ranking

A ranking of factors was performed, primarily to understanding the highest and lowest relative significance among the 24 empirical reconstruction resilience factors. Where multiple factors obtained the same mean score, a lower value standard deviation was assigned a higher ranking (Q. Shen & Liu, 2003). Table 6.1 presents the results ranking of the resilience factors and a Bonferroni adjusted factor analysis of the 24 empirical factors.

Table 6.1 Ranking of building and infrastructure projects' resilience factors

Resilience factors	Mean	Std. dev.	Factor rank	Years of experience (p<0.008)++		Island states (p<0.0125)++	
				f	Sig	f	Sig
Reconstruction design based on possible future hazards	6.41	0.922	F1	.924	.466	2.523	.059
Establishing construction policies and actions that mitigate the effects of climate change	6.20	0.989	F2	2.516	.031	4.046	.008*
Active assessment of structures with intent to repair and improve	6.19	1.018	F3	.703	.622	1.624	.185
Ensure funds or funding sources are readily available for reconstruction	6.19	1.075	F4	1.148	.337	1.420	.238
Ensure unbiased interest from either the public or private sector	6.17	1.022	F5	.549	.739	2.107	.101
Strict national laws and policies to promote compliance	6.16	1.114	F6	1.272	.278	1.761	.156
Collaboration among all sectors during the rebuilding process	6.14	1.094	F7	1.533	.181	2.859	.038
Strategic development and deployment of construction skills	6.12	1.008	F8	.050	.998	.216	.886
Established and defined land-use and development plans	6.11	1.156	F9	.918	.470	.210	.889
Reconstruction with equal focus on environmental, social and economic improvement	6.08	1.077	F10	2.176	.058	3.095	.028
Avoiding or delaying structure collapse	6.05	1.298	F11	.878	.497	.534	.660
Supportive public and private sector institutions (e.g. banks, NGOs)	6.04	1.081	F12	1.779	.119	.301	.825
Reconstruction is highly influenced by future demographic or anticipated development changes	6.03	1.071	F13	2.347	.043	1.554	.202
Public and private stakeholder collaboration	6.00	1.120	F14	.714	.613	.271	.846
Clear government short-term and long-term objectives for the construction sector	5.97	1.086	F15	1.452	.207	2.778	.042
Understanding of the local culture for coordinated designs	5.95	1.171	F16	1.072	.377	.475	.700
Reliance on past experiences during reconstruction	5.92	1.234	F17	1.177	.322	.274	.844
Community engagement at all times during reconstruction	5.90	1.237	F18	1.837	.107	1.365	.255
The need to understand the beneficiaries' wishes in reconstruction or relocation	5.83	1.161	F19	.409	.842	1.076	.360
Salvage materials that can be reused during recovery	5.83	1.182	F20	.556	.734	.593	.620
Continuous design improvements and modifications	5.83	1.190	F21	.690	.631	1.907	.130
Availability of alternative systems or structure (redundancy)	5.76	1.150	F22	.869	.503	1.456	.228
An equal focus on the structural and non-structural components during recovery	5.66	1.310	F23	3.746	.003*	1.468	.224
Some infrastructure is more important and should be treated accordingly	5.46	1.702	F24	1.339	.249	2.723	.045

* Significant difference at 97.5% confidence level

++ Bonferroni adjusted alpha to reduce Type 1 error possibilities

Noticeable from the mean scores in Table 6.1, all the factors rank relatively high in terms of the responders' perceptions on their importance to reconstruction projects. Their mean scores (ranging from 5.46 to 6.41), when referenced to the seven-point Likert scale, suggest that the responders consider all the factors to be highly crucial in promoting resiliency for both building and infrastructural reconstruction projects in all the islands and across all years-of-experience age groups. Though all factors are deemed highly significant, 14 factors with mean values equal or above the grand mean (6.00) are determined as critical factors influencing resiliency in reconstruction projects.

6.2.2 Factor analysis

Factor analysis is a statistical function that correlates dependent variables having measurement characteristics, then produces clusters of factors that are associated with an underlying dimension (Pallant, 2013). The 24 resilience factors were subjected to an empirical summary reduction of the data collected, using the principal component analysis (PCA) method, and the oblimin rotation technique because of the uneven group size distribution of the correlated independent variables (Pallant, 2013), which resulted in three clusters, as presented in Table 6.2. Parameters of the analysis show the Kaiser–Meyer–Olkin measure of sampling adequacy is 0.942 (Kaiser, 1974), the Bartlett test of sphericity is 2847.383 (Bartlett, 1954), and the significance level is 0.000, which suggests a correlation matrix that is not an identity matrix and therefore considered suitable for analysis (Pallant, 2013). Factors assigned to a cluster would have calculated a correlation loading coefficients higher than 0.35. Lower values were removed. The total cumulative variance explained in the three clusters account for 57.689%, with eigenvalues greater than 1, from the PCA extraction method. Table 6.2 presents the results of the factor analysis of the 24 empirical factors into three new composite factors, representing the aggregated view of the Caribbean's project end-user's views on resilience factors.

Table 6.2 Oblimin rotated cluster loading coefficient and Cronbach's alpha

Factors	Cluster 1 α = **0.897**	Cluster 2 α = **0.832**	Cluster 3 α = **0.892**
F7	0.913		
F18	0.873		
F20	0.764		
F5	0.722		
F14	0.642		
F8	0.504		
F13	0.443		
F4	0.405		
F17	0.402		
F24		0.841	
F23		0.735	
F22		0.487	
F2		0.451	
F21		0.406	
F1		0.403	
F10		0.376	
F15			0.901
F6			0.837
F12			0.748
F9			0.703
F16			0.651
F19			0.424
F3			0.402
F11			0.396

6.2.3 Reconstruction project resilience variables

Table 6.3 demonstrates a strong cluster structure with satisfactory loading coefficients. To confirm the clusters' reliability and their underlying dimensions, the Cronbach's coefficient alpha was assessed and then their dimension identified. Cluster 1 centres on collaborations among stakeholders with α = 0.897, cluster 2 were identified with critical infrastructure indexing and redundancy with α = 0.832, and cluster 3 centres on governance including preventative maintenance with α = 0.892. These three clusters will be regarded as representative of the new resilience factors aligned to Caribbean end-users' resilience perspectives for reconstruction projects. These three factors, listed in Table 6.3, are regarded as representative of end-users' resilience perspectives.

Table 6.3 Reconstruction project resilience factors

Code	Resilience factors	Cronbach's alpha
CO	Collaborations	0.897
IX	Infrastructure indexing	0.832
GO	Governance	0.892

Collaborations as a resilience factors encapsulates the activities of consultations, inclusiveness of all stakeholders in the decision making process and the integration of institutional and policy making entities with the short-, mid-, and long-term developmental planning. Critical infrastructure and redundancy sensitizes on the need to identify built entities that either supports multiple services or so critical that its demise can further exercerbates the chaos and delay with the speedy return to normalcy. Identifying some infrastructure as more critical invites an attitde that can significantly encourage strategic preventative maintenance programmes, including strategic budgetary funding for alternative systems for minimising downtime. Governance relates to the guiding policies and procedures to ensure that operations are executed within the established boundries of intended objective at the highest quality, with transparency, integrity and standard engineering practice.

6.2.4 Project resilience factors as predictors of project success

The second hypothesis (H_2) framed the investigation into the impact of project resilience factors on the project success indicators from the perspective of the project end-users. Overall, governance (GO) as a resilience factor was observed to be most significant as a strategic technique in the development of resiliency for successful post-disaster reconstruction projects. Shown in Table 8.6, GO marginally correlates with all success indicators, except 'time', which suggests that end-users may be interested in the proper and thorough application of resilience strategies and resent short-cuts or rushed project deliveries within the time objective. Surprisingly, the analysis returns time as showing to explain the largest percentage variance of perceptions on resilience, at 11.5% (refer to Table 6.4). The most plausible explanation for this phenomenon is that end-users seemingly expect time management to be a default feature in a post-disaster scenario and believe it should not be competing or compromised with other strategies in the reconstruction process. In fact, issues regarding time have primarily been the 'ways and means' to reduce project planning, execution and delivery time for any project (Økland et al., 2018; Y. Wang et al., 2020).

Table 6.4 Stepwise regression analysis of resilience factors on success indicators

Resilience factors (IV) \ **Project indicators (DV)**			**Change**	**Cost**	**Quality**	**Time**	**Scope**	**Safety**	**Sustainability**	**Satisfaction**
Constant		*β*	3.188	3.665	3.395	1.329	2.101	3.029	3.096	2.831
Collaborations	*CO*	*β₀*				.661				
		Sig.				.000				
Governance	*GO*	*β₀*	.288	.249	.387		.482	.497	.471	.441
		Sig.	.013	.043	.001		.000	.000	.000	.000

Typical regression equation: Safety = 3.029 + 0.497* GO

Caribbean project end-users believe effective governance in the planning and execution of reconstruction projects can yield successful resilient projects. The model shows the positive effect of GO on addressing the often dynamic characteristics of project operational or objectives changes (β_0=.288, ρ_0=.013). Effective governance in managing change management for more resilient projects includes a focus on competency in project planning to minimise design or revision surprises (Senaratne & Sexton, 2009), eliminating stakeholder conflicts (Jaffar et al., 2011), and swift responses to impacts from external sources (Lebcir & Choudrie, 2011). Governance also positively affects project cost management (β_0=.249, ρ_0=.043). Resiliency improvement through cost management is two-fold, and emphasises 1) minimising cost during the construction period with programmes such as waste management, smart financing and strategic procurement methods (Hassim et al., 2003; Obi et al., 2017), and 2) significantly reducing maintenance cost in a project's post-handover life (Islam et al., 2019). Effective governance also contributed positively to project quality, scope and safety with model values of (β_0=.387, ρ_0=.001), (β_0=.482, ρ_0=.000), and (β_0=.497, ρ_0=.000), respectively. Evidence of GO playing any significant role in regard to these indicators is captured in Trinh and Feng (2020) assertion for a more resilient safety culture to address unforeseen safety risks with developmental projects, consequently impacting project scope and output quality.

Both sustainability (β_0=.471, ρ_0=.000) and satisfaction (β_0=.441, ρ_0=.000) are also positively impacted by strategic governance. To a certain extent, from the end-user's perspective, there appears to be a subtle correlation between the two indicators. For example, a home owner's social draw to 'green' buildings, as substitutes for traditional buildings and which promote environmental protection and resource conservation, can address both constructs related to resiliency (W. Wang et al., 2018). This phenomenon appears prevalent among Caribbean end-users, including the management of ex-post transition costs (Ali et al., 2018) and the adherence to cultural inclinations for reducing uncomfortable and unsustainable socio-economic interventions (Samaraweera et al., 2018).

Infrastructure indexing (IX) as a resilience factor has no significant effect on project success, suggesting that end-users think that lifeline and infrastructure projects should be equally prioritised in the reconstruction process and none is more important than the other. Consequently, no model was suggested with contribution from IX, and is therefore absent in Table 8.8. Strategic procurement, sharing of explicit and tacit project knowledge, and document management as requisites to effective collaborations (CO) contribute positively to timely project completion as an act of resiliency. Reiterating the assertions made earlier, end-users envisage time management as a collective responsibility and should be treated with such attitude. The regression model for time-related resiliency success is expressed by the following equation: Time = 1.329 + 0.661* (Collaboration). In conclusion to this model, while there are positive inclinations to resilience directly impacting project success, there is still not enough supporting data to suggest that resilience factors can significantly influence project success indicators. Table 6.5 presents the single regression results from the modelling investigation between resilience factors and individual project success indicators.

Table 6.5 Model regression results: Resilience factors (IV) on success (DV)

Success indicators	R^2	Adj. R^2	SSE	F-value	Sig.
Change	.025	.022	1.214	6.310	.013
Cost	.017	.013	1.293	4.154	.043
Quality	.049	.045	1.166	12.259	.001
Safety	.087	.083	1.102	22.623	.000
Satisfaction	.054	.050	1.259	13.653	.000
Scope	.077	.073	1.144	19.880	.000
Sustainability	.105	.100	.944	27.862	.000
Time	.115	.111	1.157	30.884	.000

6.2.5 Project resilience factors as predictors on project success factors

The model confirms the combined resilience factors (IV) of collaborations, infrastructure indexing and governance have contributed positively to the project success factors (DV). Significantly, the three resilience factors have all contributed to both project success stakeholder engagement factor (β_0=.207, ρ_0=.016, β_0=.213,

ρ_0=.008, β_0=.302, ρ_0=.000) and project success resource management factor (β_0=.287, ρ_0=.001, β_0=.183, ρ_0=.006, β_0=.227, ρ_0=.008). These results are in line with previous assertions in the literature, which includes Kumar et al. (2015) advice on end-users' critical engagement on labour resourcing for reconstruction projects. Community participation with psychosocial and social recovery as key considerations (Di Gregorio & Soares, 2017), multi-sectoral collaborations for unanimity on key lifelines and infrastructure (R. J. Yang et al., 2018), and the maximising of available resources through strategic public–private partnerships, capacity development and funding allocations (Johannessen et al., 2014; Macaskill & Guthrie, 2018) also exemplify this model's findings. Table 6.6 presents the stepwise regression results for resilience factors effect on success factors.

Table 6.6 Stepwise regression analysis of resilience factors on success factors

Success factors (DV) / **(IV) Resilience factors**		**Knowledge management**	**Ecosystem care**	**Stakeholder engagement**	**Resource management**
% Variance Explained		31.856	34.108	39.525	35.985
Constant		2.173	2.125	1.377	1.335
Collaborations (CO)	*β*	.290	.279	.207	.287
	Sig.	.000	.002	.016	.001
Infrastructure indexing (IX)	*β*			.213	.183
	Sig.			.008	.026
Governance (GO)	*β*	.326	.356	.302	.227
	Sig.	.000	.000	.000	.008

Typical Regression equation:

Stakeholder Engagement = 1.377 + 0.207*CO + 0.213*IX + 0.302*GO

The results demonstrate that collaborations and governance resilience strategies explain 31.52% of the variance that positively contribute to knowledge management p (β_0=.290, ρ_0=.000, β_0=.326, ρ_0=.000). Knowledge management from an end-user perspective connotes the use of community members' knowledge gained from experience with previous disasters, competency with new building and infrastructure designs, and leadership that will adopt resilience measures that support the community's long-term development plans. Collaborations and governance also positively contribute 34.10% of the explained variance to ecosystem care (β_0=.279, ρ_0=.002, β_0=.356, ρ_0=.000). Referencing the research work in the Cook Islands, a similar world setting to the Caribbean, Mannakkara et al. (2018) emphasise the essence of a thriving ecosystem to a sustainable tourism sector as an income generator. This is supported by applicable legislative frameworks, disaster and climate change policies, and construction standards that are necessary for improving the socio-economic quality of residential livelihoods for low-income households without depleting the ecosystem or compromising the needs of future generations.

Table 6.7 presents the single regression results from the modelling investigation between project resilience factors and success factors. The regression outputs suggest that the combined effects of the resilience factors account for an average 26% of the explained variances in the application of success factors.

Table 6.7 Model regression results: Resilience factors (IV) on success factors (DV)

Success factors	**R^2**	**Adj. R^2**	**SSE**	**F-value**	**Sig.**
Knowledge management	.262	.256	.616	42.042	.000
Ecosystem care	.232	.226	.689	35.838	.000
Stakeholder expectations	.296	.287	.631	33.057	.000
Resource management	.266	.257	.648	28.570	.000

6.3 Critical resilience predictor variables

Specific to the built environment, resilience strategies have been deployed in various aspects of project design, planning, execution and maintenance, as shown widely in Chapter 3. Governments have attempted to address resilience with the legislation of policies and procedures to guide the construction industry (Kiel et al., 2016; Lizarralde et al., 2015; Mannakkara et al., 2018). Sensitivity to the culture of the affected community in developmental programmes has been researched (Aliakbarlou et al., 2018; Sameen, 2018; Yilmaz, 2014). Innovations pervade resilience efforts with advances such as modelling structural robustness to facilitate a progressive collapse in extreme situations if a structure collapse is unavoidable, and also assist with ideas for retrofitting and material improvements (Adam et al., 2018; Fatiguso et al., 2017). Serre and Heinzlef (2018) advocate for mapping and critical infrastructure indexing as development and maintenance prioritizing strategies, while Hromada and Lukas (2012) support a critical infrastructure protection scheme. Pitilakis et al. (2016) stressed strategic maintenance and Hotchkiss et al. (2013) emphasize the need for redundant systems as part of the resilience pre-emptive solutions. Other scholars have investigated resource management and optimization as crucial resilience strategies with regards to project staff competency (Roosli & Collins, 2016), materials salvaging for possible re-use (Arnott, 2017) and the leveraging of public–private partnerships in the recovery and rebuilding schemes for both cost and knowledge sharing (Abe et al., 2018; Johannessen et al., 2014)

Resilience strategies for improving the stability and robustness of construction projects have attracted the interest of several industry professionals, including those in academia. However, no research has given attention to the project end-users' perspectives into what constitutes a resilient project.

With convergences on these three dimensions, built environment resilience has gained prominence in disaster recovery, and more specifically, disaster reconstruction. Its application to post-disaster rebuilding (building and infrastructure reconstruction) construes two salient schemes that focus on addressing the long-term development of the built environment and its effectiveness as a driver to investigating new approaches to system designs, operation and governance through safety and innovation techniques (Hassler & Kohler, 2014). Typically, conventional construction projects are designed and constructed according to industry-accepted risk-mitigation principles; however, resilience seeks to address empirically evidenced flaws and failures by instituting corrective measures during reconstruction. Notably, the application of resilience factors has gained prominence as a proactive attitude over traditional reactive approaches for its support to long-term reconstruction development plans. Thus, for this research, resilience factors are used as predictor variables to determine the influence on maximising the potential of project success factors for positive outcomes.

6.4 Summary

This study identified end-users' critical resilience factors and generated new factors to aid in developing a resilience measurement framework for disaster reconstruction projects. In this research, Caribbean end-users' perspectives on resilience in post-disaster reconstruction of building and infrastructure projects confirm their interests with the impact on their social, economic and psychological survival. The end-users' perceptions were captured using an interview questionnaire that solicited responses on 24 empirical factors. Reliability tests on the data showed strong internal consistency among the factors, then a factor ranking had 14 factors scoring over the grand mean (6.00), based on a seven-point Likert scale, indicating the strength of end-users' concerns among these factors. With the data from the 268 survey responses, factor analysis realised three new composite factors as critical to measuring resilience, from the perspective of the Caribbean end-user. The new critical resilience factors are collaborations among stakeholders, infrastructure indexing, and effective governance. These three CRFs ares now identified and branded as the crital reselience considerations for reconstruction project's planning and development.

Chapter 7: Post-disaster reconstruction project success indicators: An end-user's perspective

7.1 Introduction of the chapter

Data were gathered from end-users in four Caribbean islands using a questionnaire survey on eight empirical success indicators obtained from the extensive literature review (refer to Chapter 2). To elicit a ranking and any correlations with the end-users' perspectives on the indicators, factor analysis and structural equation modelling techniques (SEM) were conducted. The analysis found 'safety' to be the most important success indicator, while 'change' ranked the least important. Correlations of end-users' perspectives identified two composite success indicators, 1) 'competence' with delivering timely and quality environmentally friendly and sustainable projects, and 2) 'adaptability' by ensuring project objectives reflect beneficiaries' expectations amidst internal and external influences, to be the critical indicators that describe their overall assessment mechanism. Measurement and structural models validated 'safety' and 'satisfaction' to be the critical loading indicators of the two composites, respectively.

Up to the time of writing (January 2021), there has not been an identifiable item of research explicitly focusing on the project end-users' measurement criteria for reconstruction projects. A systematic review of the literature points to several success indicator types used to assess outcomes. Aggregating these indicators, the list of success indicator types adds change management, work safety, scope management, sustainability and satisfaction to the traditional project success measurements of cost, time and quality criteria. Thus, this review uses these indicator types to evaluate end-users' perceptions of what a successful post-disaster reconstruction project resembles. To investigate the end-users' preferred success measures, the following two questions guide this chapter:

a. Which indicator types are mostly applied by project end-users for assessing post-disaster reconstruction projects?
b. What are the critical indicators for evaluating post-disaster reconstruction projects from the perspectives of end-users?

7.2 Measuring project success

Construction and reconstruction projects worldwide have one of two outcomes – either success or failure. Outcomes have been construed differently by stakeholders based on perspectives, objectives and expectations. Recognising the volatility and dynamism within the industry, several researchers have investigated both the factors and indicators characterising either outcome. With challenges that span technical issues, contextual issues and interpersonal issues (Duy Nguyen et al., 2004), researchers have explored different models (De Wit, 1988; Odusami et al., 2003; Pinto & Slevin, 1989) in an attempt to assist in the measurement of project performance at various stages in the project's cycle. Models developed comprise combinations of key metrics, which include time, cost, scope, quality and safety (Korde et al., 2005). However, Korde et al. (2005) concluded, from a probe into the effectiveness of existing models, when assessed at the project, process and collaboration levels, "*there is no definitive model for predicting or explaining project performance*" (p. 8). Though acknowledging the models and frameworks developed as exemplary, Korde et al. (2005) underscored the need to be assertive of the project's success indicators and encouraged the continuous efforts of researchers to investigate additional metrics that can realise a more comprehensive measurement model.

Project success is normally judged at the hand-over or close-out (Ada Chan et al., 2005; Idrus et al., 2011; Takim & Akintoye, 2002). However, some researchers have characterised these traditional indicator types, or their combinations, as limited and do not represent an accurate measure of project success (Belassi & Tukel, 1996). More recently, measurement insights involving constructability (Kifokeris & Xenidis, 2017), sustainable project delivery (Hosseini et al., 2018), social and ecological sustainability (Oke et al., 2017), societal involvement (Kinawy & El-Diraby, 2010), organisational and client satisfaction (Bustani et al., 2012), maintainability and reliability (Tshiki, 2015), the absence of legal claims or proceedings from unsafe health and safety practices (Sanvido et al., 1992), and the timely addressing of critical project changes (Jaffar et al., 2011; Lebcir & Choudrie, 2011) have emerged as new indicator variables. Validation objectives, such as usability, operability and 'fit for use' have also evolved in long-term project success measurements schemes, which are assessed long into the post-project stage at varying post-project timelines, depending on which stakeholder is conducting the evaluation (Fahri et al., 2015; Khosravi & Afshari, 2011; Ramlee et al., 2017). These new measures are mostly in line with new regulation, standards, environmental concerns, property management and personal vulnerabilities in consideration of future disaster possibilities.

7.2.1 Project success indicator variables

Initially, the systematic literature review was conducted to capture the assessment indicators used by project stakeholders to determine a post-disaster reconstruction project's success or failure against personal or consensus objectives. The review identified 211 success strategies in 190 empirical studies. These strategies were open-coded into eight success measurement indicator types, namely: quality, safety, cost, change, scope, time, sustainability and satisfaction.

Success has had conscious and unconscious suppositions on project expectation among stakeholders. Table 7.1 provides a listing of the questionnaire's section on eliciting the perspectives of end-users' priority considerations on what constitutes a successful project. The questionnaire explained the literature's representation of these indicators types, and the Likert-type scale with 1 (not a priority), 2 (low priority), 3 (neutral), 4 (high priority), and 5 (essential priority) was used to quantify their opinion.

Table 7.1 Project success indicator types

Success indicator types	Statement made in the questionnaire survey, requiring a response from the interviewee on the five-point Likert scale
Quality	Project finishes with the highest possible standards
Safety	All precautions taken to avoid physical and emotional harm to all stakeholders.
Cost	The project must be executed strictly within the initial cost decided upon.
Change	Any reasonable stakeholder request that can even alter the project will be given the highest consideration.
Scope	If necessary, the scope of the project may change, even if the time or cost is affected.
Time	Even in strenuous circumstances, the project should be completed within the time allotted.
Sustainability	Critically important are the project's longevity concerns and environmental harmonisation.
Satisfaction	The project must be finished to the community's and researcher's likeness.

7.2.2 Empirical measurement indicator ranking

From Table 7.2, the mean values for the eight indicator groups were greater than 3.50 (on a five-point scale), indicating that the current sample of Caribbean end-users considered all indicators in these groups to be critical to their assessment of project objectives towards successful outcomes. Interestingly, the top-two indicator types are different from any in the traditional 'iron triangle' metrics. Safety emerged as the topmost assessment empirical indicator for end-users, while sustainability secured second place. Surprisingly, the frequently referenced metrics of time and cost secured positions five and six, respectively, out of the eight indicator types.

Scope and change ranked as the lowest two indicator types, which in practical terms, can directly impact each other in project management.

Table 7.2 Means and rankings of indicator types

Indicator type	Rank	Mean	Std. deviation
Safety	R1	4.313	0.822
Sustainability	R2	4.250	0.712
Quality	R3	4.100	0.852
Satisfaction	R4	3.929	0.923
Time	R5	3.804	0.877
Cost	R6	3.696	0.930
Scope	R7	3.588	0.849
Change	R8	3.525	0.877

N = 240

7.2.3 Measurement indicator analysis

The data obtained from the survey were analysed with the exploratory factor analysis (EFA) technique and structural equation modelling (SEM) to test the suggested hypothetical model of project success indicators to post-disaster reconstruction projects.

Exploratory factor analysis

Factor analysis is a statistical technique applied to a dataset that searches for relationships between the variables, to reduce the broad set of interrelated variables into smaller composites (Hair Jr et al., 2016). For this reason, exploring and understanding the relationship between the eight indicator types is paramount to inform the assessment of project objectives better. The indicator types were subjected to exploratory factor analysis (EFA) using the principal component analysis (PCA) method and the oblimin rotation, using the SPSS v.25 software. The oblimin rotation was adopted because of recommendations by several researchers as the first choice when the magnitude of correlations are unknown (Worthington & Whittaker, 2006). Factor loadings below 0.30 were assessed as having a weak correlation effect and therefore were not included in determining new composites (Pallant, 2013).

Upon verification of the data as being suitable for analysis, the relative importance of the eight indicator types extracted from the literature review was explored using a five-point Likert scale, with a 0.628 Cronbach's coefficient alpha. Though the index violated the recommended minimum 0.7 cut-off, it was deemed satisfactory according to suggestions made in Pallant (2013) that Cronbach alpha values are dependent on the number of items in the scale and can be quite small especially when items in the scale are small (fewer than 10). The Kaiser–Meyer–Olkin value was 0.721, exceeding the recommended value of 0.6 (Kaiser, 1974) and the Bartlett's test of sphericity was 174.667, significant at the .001 level (Bartlett, 1954), supporting factorability of the correlation matrix. The results of the PCA and oblimin rotation suggested two composite solutions that explained 43.257% of the total variance. These two composites are presented in Table 7.3, and classified as Adaptability and Competence indicators.

Table 7.3 Oblimin rotated composite matrix (where c = composite)

New composite indicator	**Empirical indicator types**		**C 1**	**C 2**
		Cronbach α	***.523***	***.552***
Adaptability	Change		**.682**	.017
	Satisfaction		**.645**	.053
	Scope		**.637**	.008
	Cost		**.575**	.075
Competence	Safety		.106	**.827**
	Quality		.083	**.774**
	Sustainability		.143	**.518**
	Time		.336	**.346**

Extraction: Principal component analysis, Rotation: Oblimin with Kaiser normalization

The results of the EFA, and particularly, the two new end-users summary perspective in measuring the success of post-disaster reconstruction projects, and shown in Table 7.3, informed the hypothetical model illustrated in Figure 7.1.

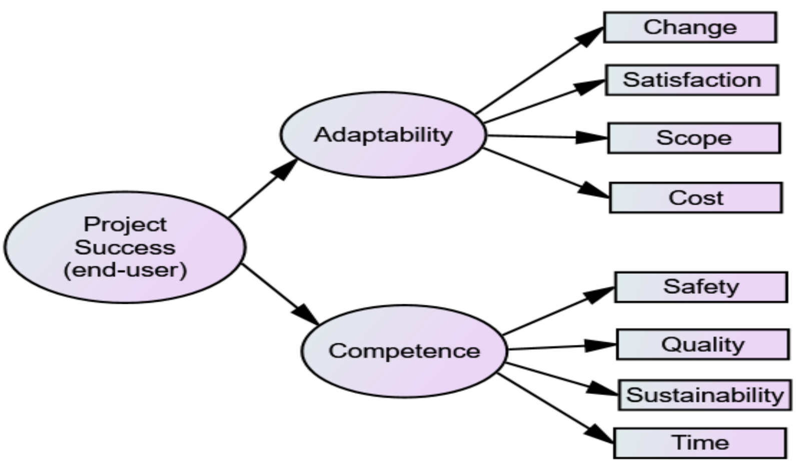


Figure 7.1 Hypothetical model for measuring reconstruction project success

Structural Equation Modelling (SEM)

SEM can be characterised as a combination of confirmatory factor analysis (CFA) and multiple regression, for exploratory purposes (Schreiber et al., 2006). The CFA technique is conducted to minimise the difference between estimated and observed covariance matrices expressed in a hypothesised model. Multiple regression is another statistical technique used to explore the relationship between one dependent variable (DV) and a number of associated independent variables (IV) or predictors.

The results of the EFA were utilised for further verifying the classification of the new indicator types, and the CFA technique was used to measure consistency, reliability, convergent validity, and discriminant validity. Convergent validity measures whether or not independent variables (IVs) of one construct are related, while discriminant validity measures how constructs (DVs) are differentiated (Kline, 2015). Understanding that the typical end-user's stakeholder group is remote to project management operations, success assessment is mostly predicated on metrics that assimilate their emotional considerations to being satisfied on socio-economic and psychosocial values. Consequently, the CFA model, shown in Figure 7.2, was constructed along this line of reasoning.

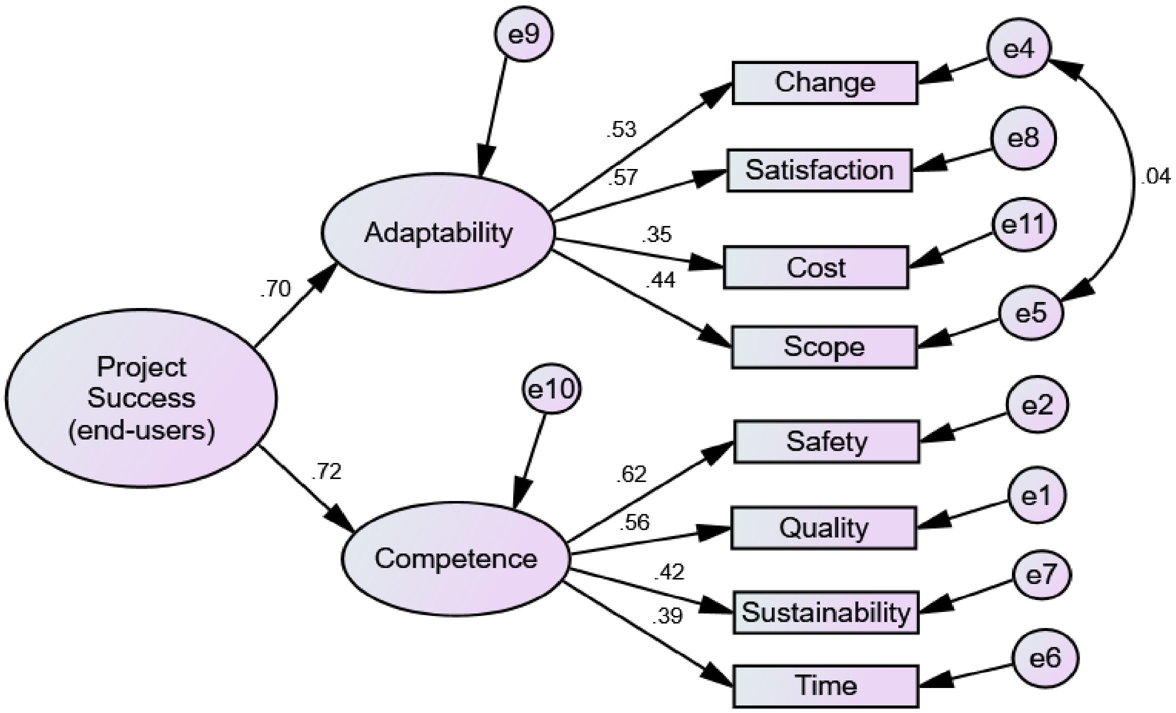


Figure 7.2 Standardised regression weights of the structural equation model

From the calculation of SEM, the results of convergent validity and discriminant validity are presented in Figure 7.2 and Table 7.4. The convergent validity score is 0.662, which revealed that the variables are reasonably related to their corresponding construct, and the discriminant validity is < 0.85 between each construct, according to the heterotrait-monotrait ratio of correlation (HTMT) recommendations (Ab Hamid et al., 2017; Kline, 2015).

Table 7.4 Goodness-of-fit (GOF) indexes for the structural equation model

GOF measure	Description	Recommended GOF measure	Final SEM	Condition met
Chi p-value	Probability	Close to 0.5 (<0.3:Underfitting, >0.7:Overfitting)	.430	Yes
CMIN/DF	Chi/degrees of freedom	1 – 2, but less than 5	1.022	Yes
NFI	Normed fit index	0 (no fit) to 1 (perfect fit) Above 90%	.896	Marginal
CFI	Comparative fit index	0 (no fit) to 1 (perfect fit) Above 90%	.997	Yes
PCFI	Parsimony CFI	Above 60%	.641	Yes
NCP	Non-central parsimony	Above 0	.389	Yes
RMSEA	Root mean square error of approximation	Less than 0.05 (0.05 – 0.08 : acceptable)	.10	Yes
PCLOSE	p-value for hypothesis test of RMSEA	Greater than 0.05	.890	Yes
TLI	Tucker-Lewis index	0 (no fit) to 1 (perfect fit)	.996	Yes

Note: GOF indexes adopted from (Byrne, 2016; Hair Jr et al., 2016; Kline, 2015; Weston & Gore, 2006)

7.3 Project success dependent indicators

Construction and reconstruction projects worldwide have one of two outcomes, either being a successful or failed venture. That outcome can be construed differently by stakeholders based on perspectives, objectives and expectations. Recognizing the volatility and dynamism within the industry, several researchers have investigated the factors contributing to either outcomes. With challenges that span technical issues, contextual issues and interpersonal issues (Duy Nguyen et al., 2004), researchers have explored different models (De Wit, 1988; Odusami et al., 2003; Pinto & Slevin, 1989) in an attempt to assist in the measurement of project performance at various stages in the project's cycle for positive outcomes. Models developed comprise combinations of key metrics, which include time, cost, scope, quality and safety (Korde et al., 2005). However, as mentioned before, Korde et al. (2005) concluded that "*there is no definitive model for predicting or explaining project performance*" (p. 8). Other researchers have also characterised these criteria or their combinations as limited and do not represent an accurate measure of project success (Belassi & Tukel, 1996). Though acknowledging the models and frameworks developed as exemplary, their limitations underscored the need to be assertive of the true range of a project's success factors, and encouraged the continuous efforts of researchers to further investigate additional metrics that can realise a more comprehensive model.

Traditionally, project success has been judged at the hand-over or close-out phase against cost, time and quality (Ada Chan et al., 2005; Idrus et al., 2011; Takim & Akintoye, 2002). More recently, factors involving constructability (Kifokeris & Xenidis, 2017), sustainability in project delivery (Hosseini et al., 2018), social and ecological sustainability (Oke et al., 2017), societal involvement (Kinawy & El-Diraby, 2010), organizational and client satisfaction (Bustani et al., 2012), maintainability and reliability (Tshiki, 2015), the absence of legal claims or proceedings from unsafe health and safety practices (Sanvido et al., 1992), and the timely addressing of critical project changes (Jaffar et al., 2011; Lebcir & Choudrie, 2011) have evolved. Validity objectives, such as usability, operability and fit for use have also evolved as long-term project success measurements, which are assessed long into the post-project stage at varying post-project timelines depending on which stakeholder is evaluating the process (Fahri et al., 2015; Khosravi & Afshari, 2011; Ramlee et al., 2017). Aggregating these new assessment metrics, success criteria add change, safety, scope, sustainability and satisfaction to be included as additions to the traditional project success measurement criteria together with cost, time and quality. A systematic review of the literature pointed to these eight success criteria as the mainstream measurement metrics that are primarily use to assess success or failure. Thus, this research uses these indicators to evaluate the outcome of reconstruction projects. It is therefore acknowledged that project success indicator are different, though project assessment may comprise combinations of these indicators.

7.4 Summary

Notably, safety is a top priority to end-users. Though not being integral to project operations, their concerns for project safety, which includes managing occupational health and safety risk, is profound. Recording a mean score of 4.313 on a five-point Likert scale speaks volume to the consensus within the region on this indicator. Change appears to be the least of the end-users' concerns, having a mean score of 3.525. This can be attributed to an expectation to efficiently and effectively deliver the project; however, if a project-related concern arises, a change management plan can address the concern to greater project quality and end-user satisfaction.

SEM and factor analysis of the eight indicators outputted two distinct project traits. Competence and adaptability describe the two basic summary characteristics on which a project is judged. Interestingly, both summarise essential operational procedures that if made integral to the project, can lead to positive outcomes at hand-over and beyond. Satisfaction and safety emerged as the two highest empirical factors loading at 60% and 56% explained variance, respectively, on the two new composite constructs. Cost (35%) and time (39%) received the lowest considerations across the two constructs, indicating that these two traditional metric and default components of the 'iron triangle' do not have significant bearing as end-users' assessment criteria.

Project end-user identified cpmpetence and adaptability as the critical success assessment parameters for post-disaster reconstruction projects. Furthert statistical analysis will determine the regressed relationship between and among the CSFs from Chapter 5 and the CRFs from Chapter 6 on the competency and adaptability expectations for successful outcomes.

Chapter 8: Discussion and recommendations

8.1 Introduction of the chapter

Having analysed the critical success factors for Caribbean reconstruction projects in Chapter 5, the critical reslience factors affecting resilient reconstruction in Chapter 6, and the measurement indicators for assessing project success in Chapter 7, the tripaite relationship needs further exploration, primarily for the development of a guiding framework for optimal use. Key to the development of the framework will be an avenue to operationalize the faucets of the relationship for ease of implementtion and monitoring. As such, in this chapter, establishing the need for 'critical factors' and an associated mechanism to operationalize the critical factors will assist in setting the foundation for mainstreaming resilience as a project success enabler.

8.2 A new resilience guiding framework for post-disaster reconstruction projects

8.2.1 Rationale for critical factors and sub-critical factors

The literature contains vast references and peer-critics to varying construction industry context-specific adoptions of Critical Factors (CF), primarily in describing perceived key operational metrics or measures within the project's management to assess the project's outcome. For example, W. Lu et al. (2008) identified general CFs for selecting and retaining a contractor, S. Thomas Ng and Tang (2010) later contend this generalising of CFs for selecting and assessing labour-intensive sub-contractors and equipment-intensive contractors are impractical because of their task-related speciality. (Gupta et al., 2013; Hardcastle et al., 2005; Jefferies, 2006; Osei-Kyei et al., 2017; X. Q. Zhang, 2005) itemised the CFs for effective procurement. Hans-Martin et al. (2010) recognised CSFs importance for optimising supply chain management.

Enterprise risk management in the construction industry was explored by Chileshe and John Kikwasi (2014), and Zhao et al. (2013) also added CFs for the management of risks. Lin and Lin (2006) advanced CFs for knowledge management in construction, while Hosseini et al. (2018) identified a list of contextual factors in a study that investigated the sustainability of megaprojects in Iran. The difficulty in defining critical factors for construction projects have even caused researchers to categorize them according to their origin or influencing strategy (Ogunlana, 2008; Toor & Ogunlana, 2008) with an intent to synthesize on commonalities.

Several studies maintain that, further classification of CFs may be necessary for adding granularity to the defining the work process. For example, X. Q. Zhang (2005) study explored CFs in public-private partnership and recommended a further division into Sub-Critical Factors (SCFs). Although the study concluded that the resultant ranking of both sets of factors compliments each other, it also suggested a level of redundancy. However, W. Lu et al. (2008) later explained in a similar process that having SCFs may be necessary to guard against the possibility of CFs changes in keeping in line with the construction industry's rapid development and turbulence.

It is recognised that CFs continues to be developed or identified for context-specific industry sectors and tasks. Therefore, this does not preclude post-disaster reconstruction from developing its own guiding CFs. Infact, the critical nature of post-disaster reconstruction projects and the post-disaster recovery setting encourages such a development. On this note, this thesis have analysed 26 empirical project success factors and 24 empirical resilience factors. The results of the analysis presented earlier (refer to Chapters 5, 6, 7) realised critical factors for project success and resilience development, which positively demonstrated that their strategic combinations could yield positive project outcomes or success. On the subject of possible SCFs for these critical factors, the prevailing project setting, project objectives and determined method can facilitate the empirical factors as Sub-Critical Success Factors (SCSFs) and Sub-Critical Resilience Factors (SCRFs) as relevant for this research exploratory analysis.

Critical success factors, critical resilience factors and success indicators

8.3 Critical success factors (CSF and SCSF)

According to Caribbean project end-users' perspectives, the findings of the factors analysis (Chapter 5) can be summarised with the conceptual framework presented in Figure 8.1. The framework identifies four critical success factors (CSF) and 18 sub-critical success factors (SCSF) that encompass the critical areas needing particular attention in order to achieve successful project management operations for post-disaster reconstruction projects.

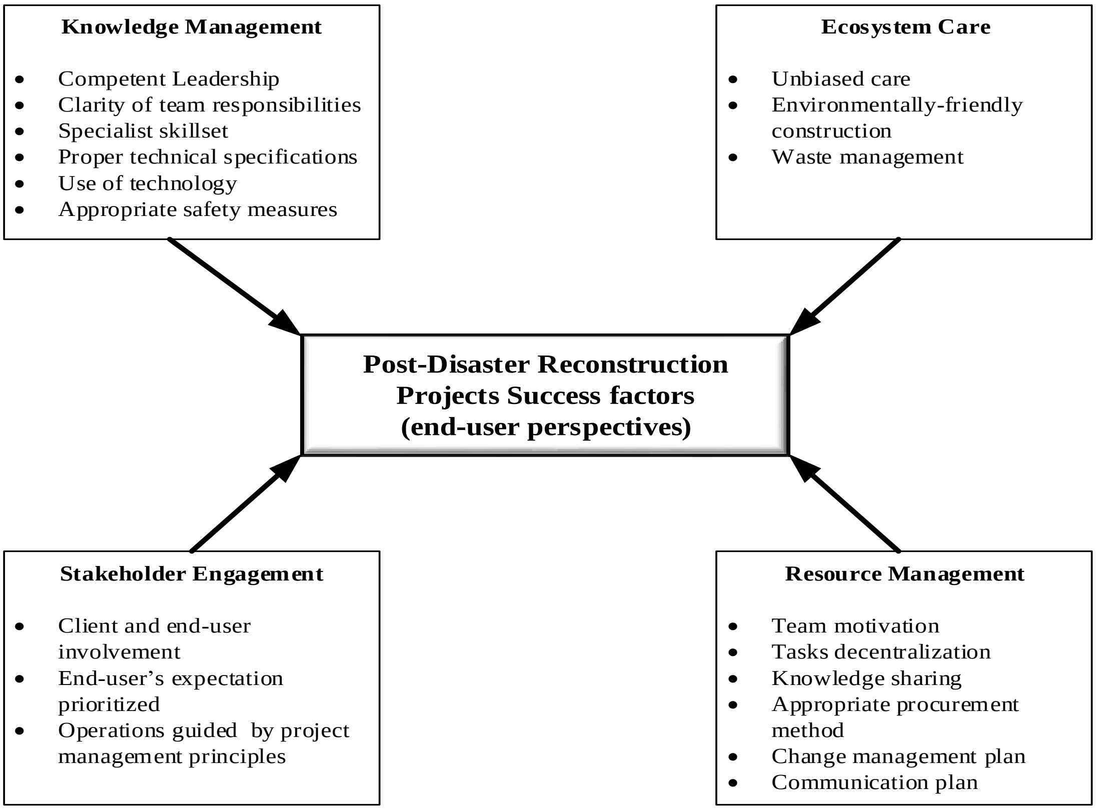


Figure 8.1 Four CSFs with associated SCSFs for project management practice

8.3.1 CSF for managing Caribbean reconstruction projects

Knowledge management and use

Knowledge management in construction refers to the management of experiences, and tacit and direct knowledge at personal or organizational levels (Ly et al., 2005). The failure of infrastructure projects in the Caribbean appears to have been attributed to a lack of knowledge as being integral in both feasibility analysis and construction processes. This shortfall has been recognised in Watkins et al. (2017) investigation of failed Caribbean projects as a lack of 'community mobilisation' (p. 5). Knowledge that informs cultural inclinations, developmental preferences and end-users' (community) satisfaction provide clarity to what could be ill-informed project objectives, if omitted. The Caribbean region stands to benefit significantly from a network of knowledgeable professionals and increased research outputs into the unnecessary recurring cost to already fragile economies, from failed projects and repeated disasters. Requisite knowledge, and ability to manage and execute project tasks from design to hand-over have profound prominence among the end-users, as evident in 90% of the empirical factors in this composite being in the top 10 priority ranked factors (refer to Table 5.3). Determining a project's buildability requires a great mix of both tacit knowledge and experience for factoring feasibility and practicality into the project's construction, towards satisfying project objectives according to stakeholders' aspirations. Integrating wider stakeholder knowledge and construction techniques in the pre-construction stages augers well for avoiding complicated errors in later project stages (Bustani et al., 2012).

Competent personnel for accurate engineering designs, drafting and technical specifications, managing strategic assignment of project tasks, ensuring that team roles and expectations are properly rolled-out, and reliable project progress monitoring are all indicators to assessing success. Competence with the application of knowledge in technology-related tasks and equipment use is also paramount to leveraging end-users' confidence, including the ability to communicate project particulars effectively (Ozyurt et al., 2019). In some world regions, including the Caribbean, which suffers from limited resources and communication on project particulars, a significant observation made by Teerajetgul et al. (2009) is that while there is limited research on knowledge management impact on project performance, there is a growing trend where 'owners [and clients] do not want to incur the expenditures of employing [knowledgeable] professionals to complement and enhance management competency' (p. 833). This reality challenges any attempt to meeting the requirements of knowledge-based project staffing. Key to advancing the need for expert knowledge across project phases is the need to clearly identify all stakeholder roles and responsibilities during the planning and procurement stages, with a keen eye for competency gaps.

Knowledge as a determining factor in reconstruction projects has been widely explored. Chou and Yang (2012) empirical study advances a concerted embracing of project management skills. Egbu and Robinson (2005) characterised the industry as 'knowledge-based'. Javernick-Will and Levitt (2009) encourage local and international knowledge development as a globalisation attribute in the industry, and Moles et al. (2014) stressed the need to understand the culture of the built environment, which relies on an intimate knowledge of end-users' experiences and expectations in disaster reconstruction. The significance of knowledge for disaster reconstruction has also been emphasised by D. Amaratunga and Haigh (2018) when they expounded on the use of scientific knowledge in policy development for channelling success.

Knowledge as a critical component of leadership, in this regard, characterises the management and decision-makers of the project, which is not limited to project sponsors and project managers, but revolves around all stakeholders that can influence the nature of a project (Larsson et al., 2015). Knowledge had been determined a critical factor in staff recruitment processes, procurement of resources and the execution of project tasks. The Cronbach alpha value for this component was very high ($\alpha = 0.920$), which apart from indicating a substantial degree of consistency in the way Caribbean people think, also shows their desire to have project staff that are knowledgeable and competent to carry out the project's functions. Certainly, not persons that simply assume project management positions through associations, friendship or possible nepotism.

Environment and ecosystem care

This new success factor relates to the preservation of the environment, and minimising risks that pose a threat to the ecosystem through sustainable construction. In the face of environmental degradation and several derelictions that are regularly levied on the construction industry, the end-users expressed keen interest in reducing any exacerbation that can arise from industry activities. Ecosystem care emerged as the second composite factor and surprisingly, 'unbiased care for the ecosystem' emerged with the highest loading factor (0.848) of the four empirical factors of this cluster, indicating that the sentiments are unanimous among Caribbean people.

The data suggests that Caribbean people are environmentally concerned and are quite interested in reducing any adverse impact of construction materials and practices with solutions that are supportive of existing ecological preservation frameworks and laws. New technologies such as 'green technology' (Zou & Couani, 2012) have intervened to allay some of these concerns. The Caribbean islands rely on the environment and the ecosystem for livelihood. In observing the case locations, tourism contributes significantly to their GDP and, in most instances, the largest. While infrastructure projects are often use as a proxy to national development, indiscriminate infrastructural advancement with traditional materials and techniques can reap havoc on natural habitats, the country's food chain and income sources. Several studies addressing the effects of the construction industry on the ecosystem converge on a sustainability theme that seeks to align these concerns and promote the use of environmentally friendly materials, energy-saving apparatuses, and technology that assimilates the short-term and long-term environmental effects of construction-related decisions (Akadiri et al., 2013; Banihashemi et al., 2017; Bocchini et al., 2014). Acknowledging that the global construction industry has received negative reviews as being responsible for impacting the environment during extraction (e.g. deforestation), processing and manufacturing, transportation, and the construction of buildings and infrastructure projects, there is an urgent need for the Caribbean islands to adopt new and innovative practices to alleviate these negative effects.

Indirect project stakeholders, such as environmentalists, make intense demands for green construction. These stakeholders strategized to fulfil specific mandates with evidence-based claims, such as lowering project lifecycle costs and lowering energy consumption costs. Initiatives can include government regulations, investments in material development and investments in green technology skills. The cost implication to accommodating the necessities for green construction may be seen as an additional cost risk to the mainstream stakeholders, especially by the political directorates. Consequently, they may attempt to allay any positive agenda because the motivation to generating a green construction climate is influenced primarily by end-users and clients' interests, and may not advance their political agenda. The technology is still in the infancy stage, and its slow uptake has been attributed to its perceived high upfront costs (Lockwood, 2006), however, the Caribbean region can significantly benefit from construction related policies and procedures that guide green project development at the institutional, national and regional levels.

The increased demand for sustainable developments and sustainable projects compels the industry toward introspection in both materials and all-round safety risk management. Several propositions have been suggested for improved material improvement, for example: capitalising on the many possibilities emanating from an understanding of traditional construction materials, even at the nanoscale level to assist in the longevity of buildings and infrastructure (Oke et al., 2017). Nanotechnology in the construction industry invigorates a technique in the quest for environmentally friendly construction, aiming to understand and improve the component structure of construction materials, even extending to the fabrication of alternatives. An example of this technique is the 20% carbon dioxide emissions reduction in the production of 'green cement', with the prospect of reducing to zero emissions in the near future (Imbabi et al., 2012). Though the Caribbean CO2 emissions are insignificant when compared to the rest of the world, any reduction in emission aids in reducing its own vulnerabilities, as one of the world areas most affected by climate change effects (Pulwarty et al., 2010). Additionally, modifications that enhance economic value with high reused content, free of unsafe contaminants and low reparable materials, will help in environmental sustainability. In the face of urbanisation, this technology advances the use of alternative materials that can reduce carbon emissions and create a new construction material economy. Other techniques include responding to environmental safety risks. Murphy and Nahod (2017) encourage the use of technology, such as BIM, in confronting the embryonic challenges of sustainability, carbon emissions and more resilient buildings and infrastructure – an imminent requirement for Caribbean islands' mostly coastal development.

Stakeholder engagement

The third composite factor centres on end-users' confidence concerns with optimisation of project tasks by having active stakeholder engagement. This engagement would be related to assuring ongoing consciousness towards structurally safe projects developed with professional engineering designs and competent personnel. Also, this suggests a need to have a clear presence of reputable companies or acclaimed skilled persons to communicate the plans and projections during all stages in the project cycle. In light of resource shortages in the Caribbean, the World Bank as a major financier of infrastructure projects strongly advocates for private–public partnerships (PPP) as a solution to the region's stakeholder engagement issues and developmental challenges (Martin et al., 2014). Recommendations for Caribbean governments and collaborations with international companies, supported through a regional PPP architecture with commonalities on a comprehensive building code, is suggested as a viable solution to minimising the number of failed projects resulting from technical incapacities and financing gaps (Martin et al., 2014). This knowledge also assists the non-technical end-users in attaining a level of confidence that feeds on the assumption that the necessary and applicable technical studies were completed and the relevant checks and balances administered according to local and international standards.

From the Caribbean end-user's perspective, the relative safety rating of a completed project is judged by the number of injuries or fatalities. As a remote stakeholder without intrinsic knowledge on all project operations, the end-user formulates opinions based on history or the expressed opinion of others. This leads to high-level subjectivity in project safety expectations that can range, for example, anywhere from no confidence to very confident. If specific measures are instituted, this subjective assessment can be transformed significantly towards higher objective confidence levels. These measures can include: 1) transparency of the project manager's and contractor's work history to be made publicly available, 2) continuous strategic engagement with the end-users, especially to address any developmental concerns, 3) publicly available clear scope of work and timelines, 4) evidence of a work climate that appeals to project management principles, and 5) positive assurances that the project's objectives are in line with stakeholders' expectations.

Notions of project success for the end-user involve ensuring that any form of contributions (e.g. tax dollars used by national and local governments) are not exploited, and safety will always be paramount during project task execution (Gimenez et al., 2017). Though oblivious to the day-to-day operations, the visual appeal of how project sites are managed can promote a feeling of contentment for end-users. Evidence of a competent governing authority engaging in focused checks and balances may also assist with end-user confidence. Even more critical, as project safety also extends beyond hand-over, the average Caribbean end-user will expect the project to fulfil its intended purpose for the optimal duration, with minimal maintenance costs. While a vaguely calculated perceived 'service period' looms over all projects on an anticipated longevity, failure to satisfactorily attain a positive outlook may classify the project as a failure. Understanding that end-users are not usually party to previews of first-hand project operation decisions, the results of this investigation point to a conscious demand by this stakeholder group to be integral in the planning process, especially for consensus on project objectives and a clear outline of post-handover expectations.

Resource management

The resource management factor converges on the ability to strategically identify, procure, distribute, influence and manage project resources throughout the project's life cycle. Caribbean end-users' expectations appear to culminate on receiving value for money. A sense of value can be achieved with programmes offering timely and strategic communication that offers information about the project's progress and the corresponding macro expenditures. End-user satisfaction can also benefit from eliminating any negatively assumed perceptions of labour productivity and equipment use.

Resource management is an integral work function required of the project's management team (Karaa et al., 1986), which include efficient cost control, labour and equipment usage. Issues surrounding these functions are practically remote to the end-users; therefore, other end-user assessment methods are warranted to boost confidence. While the strategies of staff incentives (Graboviy, 2016) and decentralising of project tasks (Hwang et al., 2018) may not directly relate to end-user confidence, the relationships among the local community of end-users are relatively intimate, as they usually involve family members' informal discourse about the project. The satisfaction of the project staff, by reasons of incentives, motivation or the economic spread of project resources (e.g. decentralisation of project tasks and engaging third-party service providers), encourages a conversation among the community that offers a sense of management control on the entire work processes, which may boost end-users' confidence.

Project-related knowledge, as a resource at all levels, encompasses the leveraging of decision-makers, employees and end-users' tacit and direct knowledge to aid flexibility in thoughts for transforming difficult project situations into timely solutions. This can signalling a level of stakeholder empowerment, especially with the use of Information, Communication and Technology (ICT). Availability of knowledge transfer mediums contributes towards making information readily accessible, consequently eliminating information silos and promoting capacity building (Razali & Manaf, 2005). Several solutions are advanced for information sharing amongst stakeholders; however, the use of the case-based reasoning (CBR) has been championed as a highly effective tool in the 'systematic transfer of expertise' in the construction industry (Loh et al., 2000). The increased mainstreaming of ICT into Caribbean people's 'way of life' augers well for more conversations across the islands as the learning process continues in a region where all stakeholders experience similar construction challenges. Challenges arising from the dynamism of the construction industry do not always accede to 'textbook' solutions and may rely on the CBR tool for leveraging the experiences of governments, professionals and end-users as a resolution.

The task of massaging end-users' confidence in achieving a satisfactory score in the optimal use of resources resides with the project management team and local governments. The establishment of policies and procedures that constrain project managers to adopt honest and transparent resource procurement methods and policies, timely addressing of end-users' concerns or objections, and ensuring that clear risk management plans to protect project resources are mainstream in all project endeavours, are possible considerations to optimising the Caribbean's scarce resources.

8.4 Critical resilience factors (CRF and SCRF)

Table 8.1 shows the three new critical resilience factors (CRF) and 18 sub-critical resilience factors (SCRF) that are identified as critical to improving resilience in post-disaster reconstruction projects.

Table 8.1 Critical and sub-critical resilience factors

New factors	**Empirical factors** (by factor loading size)
Collaborations	Stakeholder engagement in all project phases
	Public–private partnership
	Materials sourcing and salvaging
	Skillset development and training
	Unbiased procurements
	Engaging community past experience in new designs
Infrastructure indexing	Critical infrastructure designations
	Non-disparity in structural and non-structural attribute components
	Continuous design improvements
	Redundancy planning
	Designs that mitigate climate change effects and future hazards
Governance	Legislative support to developmental plans
	Clear short-term and long-term construction sector objectives
	Designs are congruent to cultural orientations and beneficiaries' expectations
	Established land-use plans
	Easily available project financing programmes
	Proactive maintenance programmes
	Leveraging modern construction techniques

8.4.1 CRF for managing Caribbean reconstruction projects

Collaborations

From the Caribbean end-user's perspective, reconstruction collaborations and partnerships connote a slightly different definition to the general concept of collaborations in mainstream construction. As a well-established factor to realising positive outcomes to construction projects, collaboration is traditionally touted as an operational risk-sharing technique, a supply chain relationship developer, a strategic-alliance generator, and a subcontractor's engagement scheme (Jin, 2009; X. Q. Zhang, 2005); however, the meaning of collaborative actions varies slightly to Caribbean project end-users. The end-users' impressions of collaborations for resilient reconstruction encompass 1) collective capacity development that include both personal skills training and functional skills development (Thayaparan et al., 2015), 2) integrated reconstruction solutions with community-based organisations (CBO) that usually focus on a) end-users' self-motivation (volunteerism), b) multi-sector national dialogue on collective welfare and social affairs initiatives, with support from nongovernment organisations (NGOs) (patriotism), and c) the influence of international donor agencies (IDA) that aid vulnerability assessments, sustainable reconstruction and essential human rights support for affected communities and countries (humanitarianism) (Y. Lu & Xu, 2015).

The World Bank as an IDA and its ongoing work in the Caribbean has adopted five classification reconstruction approaches that guide the recovery process into 1) requirements considerations and 2) fluid engagements with beneficiaries (A. K. Jha, 2010). While the bank may contextually apply any of its five approaches, their primary concern is the holistic recovery of the affected population without hindrances, diversion and misappropriation of the donated resources. In minimising these negative occurrences, several researchers have explored the benefits and shortcomings of either the agent-based approach or direct assistance to survivors in an owner-driven approach (Y. Chang et al., 2010; Santiago et al., 2018). Though both methods present significant opportunities to reconstruction, it was observed that the owner-driven approach underscores a collaborative development of the resilient nature of both the survivors and the rebuild systems, with the beneficiaries assuming more significant roles and more responsibilities in the reconstruction process (Carrasco et al., 2016). Chavda and Gupta (2014) also argued the benefits of the owner-driven approach over the agent-based approach to be more cost-effective and more efficient.

The essence of resiliency prides itself on maximising coping capacities, which can be manifested in the reconstruction of homes, in the aftermath of a disaster, even when external and professional assistance is not readily available. Pre-disaster training programmes to community members go a long way in developing and distributing skillsets that can be readily available for reconstruction, consequently, generating labour employment while advancing capacities. Skilled labour shortages in the Caribbean have been attributed to continuous migration to first-world countries (USA, Canada and UK) for livelihood reasons (Thomas-Hope, 2002); therefore, strong advocacy for a wider pool of skilled personal is advocated. With an improved labour security strategy, there can be an infused sense of comfort and satisfaction among the community, aiding overall confidence resource availability for the rebuild processes. Additionally, skills and knowledge acquired can enable identification of materials that will typically enable trash to be salvaged, reducing replacement/reconstruction cost with the possibility for fund reallocation to developmental reconstruction to their homes or infrastructure (Alexander, 2004).

Infrastructure indexing

Caribbean end-users somewhat consider some infrastructure projects as more critical than others. Their considerations have been assessed against the built environment's responsibility to supporting necessary human rights lifelines and amenities (Kaminsky & Faust, 2018), and minimising the cascading effect of infrastructure damage on essential services and livelihoods (Pitilakis et al., 2016). Attaching priority considerations to specific system components in the built environment has been dubbed 'critical infrastructure indexing' (CII). CII as a resilience factor is predicated on ensuring functional continuity of the critical roles endowed on specific built systems for uninterrupted support to socio-economic activities.

Regarding the resiliency of infrastructure as a human rights responsibility, phenomena such as urbanisation and increasing energy demand amplify the negative consequences of scant considerations to strategic development and maintenance programmes. For example, ignoring the demand capacity of water supply and wastewater systems against aggressive urban population growth can lead to an acute shortage of adequate water supply and possible health issues from effluent overflow, which can be summarised as a neglect of the state's responsibilities to fundamental human rights protection. This phenomenon is a real likelihood in Caribbean cities as existing infrastructure such as water and sewer networks are mostly over 100 years old and catered for a significantly lower population size. In light of Hromada and Lukas (2012) study on the multi-criteria responsibility of infrastructure projects, this responsibility extends to formulating applicable policies to protecting and improving the physical network systems such as roads, utility networks, information security such as ICT networks, for ensuring safeguards as a health and safety, and a business continuity requirement.

From the end-users' assertions, some infrastructure requires more considerable attention because of their critical importance in maintaining social and economic functionalities. Caribbean governments' responsibilities with maintaining the built environment's functionality, even during perturbation, is fundamental to resilient communities and national security. Acceding to this resilience-oriented responsibility, the indexing of infrastructural systems can be guided by Bruneau et al. (2003a) resilience definition matrix, which is represented in Figure 8.2. While priorities vary across jurisdictions, this graphical definition can assist in setting maintenance and reconstruction objectives. The Caribbean end-users expressed great concern in the preservation of critical assets by the relevant authorities, recognising that the built systems' resiliency influences the resilience of other non-structural aspects for the populace's socio-economic opportunities and psychological well-being.

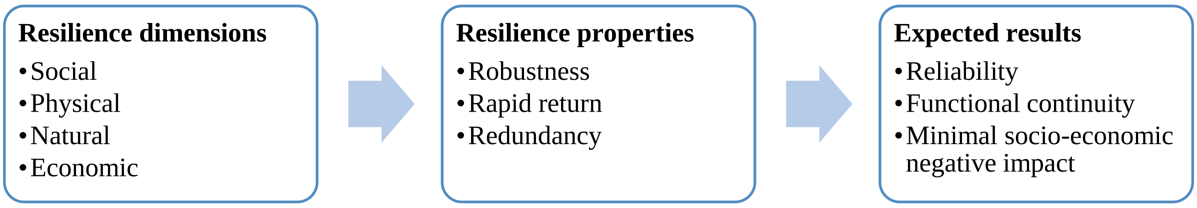


Figure 8.2 Resilience of the built environment graphical definition

Modified from Bruneau et al. (2003)

Redundancy is often nested within the business continuity's construct as a fundamental element to having uninterrupted services during and after a disaster. The undeniable reliance on information technology and utility services commands the need to reduce or eliminate downtime. Factoring redundancy during the planning and implementation stages of infrastructure projects was noted to be a key concern to the end-users. The redundancy alluded to in this thesis does not suggest that all systems must have a redundancy component; there are cost implications with this approach. However, the criticality phenomenon draws on identifying specific systems and their associated substructures as more critical. This determination bears significant reliance on the governance structure, according to the underlying culture of the business or community.

Governance

Governance in this thesis adapts the World Bank's definition as "the manner in which public officials and institutions acquire and exercise their authority to shape public policy and provide goods and services" (A. K. Jha, 2010, p. 285). Critical to Caribbean end-users is the mobilisation of the limited local or donated resources, in such a manner that its distribution represents fairness in 1) avoiding further marginalisation of the poor, and 2) avoiding substandard developmental outcomes. In Watkins et al. (2017) study on the failure of Caribbean projects done over a 40-year period (1986-2016), poor governance emerged as central to these failures, with 86% resulting from poor planning, 74% from inadequate consultations, 55% from unrealistic expectations, and 34% from corrupt and covert practices.

When inefficient institutional support and a lack of 'political will' prevail at various governance levels, adaptive capacity is stunted (Mycoo, 2014). Though Tompkins et al. (2010) asserted that "*just because* *individuals, organisations or regions have the knowledge, capacity and resources to undertake adaptation, this does not guarantee action*" (p. 628). It stands to reason that the need to set policies and directions for the Caribbean construction industry is unavoidable. Caribbean end-users envision that clear short-term and long-term objectives are essential to the industry's sustenance. They also identified pre-disaster resource planning and allocations as strategic to theirs and their community's resilience. It can be construed as a demonstration of their interest in ensuring that resources are optimised, especially in the face of scarcity. Adopting proactive measures such as pre-disaster identification of financial sources that can be easily accessible ex-post (Macaskill & Guthrie, 2018) will eliminate or reduce any scouting and negotiating time during the time-sensitive recovery period.

Governance also includes the enactment of policies oriented to strategic maintenance programmes that promote a proactive attitude to ensuring undesirable deterioration of the built environment, and more importantly, the application of lessons learnt from previous system failures. Strategic maintenance programmes, with a knack for proactively addressing critical infrastructure and building issues, is a preventative maintenance strategy (Andrić & Lu, 2017) that augers well for eliminating harmful outcomes that can be huge in rebuild cost and casualties, especially due to negligence. This is a testament to the perceived importance of effective and efficient government-led maintenance programmes with resilience-oriented adjustments to buildings and infrastructure. Though reconstruction works are somewhat predicated on end-users' personal, social and behavioural changes, Tompkins et al. (2010) advocacy for public policy intervention and support remains vital to built system's management.

Caribbean people recognise the need for institutional support as part of the enabling structure in facilitating resilience development. Bilau et al. (2015) case studies into post-disaster management affirmed the need and reliance of institutional frameworks to supporting end-users' input in reconstruction projects, thus boosting their confidence in the rebuilds. While the debate continues as to whether there is a decrease in world disasters due to new and innovative disaster management techniques or there is an increase because of new and emerging risks, the number of affected persons worldwide has increased significantly (EM-DAT, 2018). The continuation of disaster losses and its prevalence in the disaster-prone Caribbean region is purported by scientists' predictions to be the causalities of urbanisation, global climate change and a resource-challenged population's inability to escape their vulnerabilities (Baggerly, 2007). There is a need to guide developmental programmes that can better advise the population with decisive land-use planning, construction materials that mitigate the challenges of climate change, designs for smart housing initiatives, and buildability considerations influenced by informative hazard mapping.

There is a strong indication by Caribbean end-users to have their government institutions develop stringent building codes congruent to their prevailing environment and culture. Additionally, having the necessary enforcement agencies ensure and develop adherence programmes to the rules and procedures for more resilient buildings and infrastructure projects are desired. Another salient benefit from having effective government institutions is identifying, monitoring and addressing eminent resiliency gaps; consequently, adequate budgetary allocations can be made to improving the situation with strategic planning and management. Relevant authorities can facilitate effective communications between the affected population and the contractors, thus capitalising on an 'owner-led' reconstruction approach that has a higher propensity towards community participation than 'contractor-led' approaches – a key determination in Bilau et al. (2015) post-disaster housing rebuild programmes assessment.

A direct relationship exists between economic conditions and the economic impact of disasters (Padli et al., 2010). This reality amplifies the need for persons to access readily available funds that will afford them to adopt recommended remedial building upgrades before a disaster or have the financial resources to rebuild with greater robustness in the aftermath. It is incumbent on the government and financial institutions to develop and provide financial schemes that can facilitate this resource. The predisposition of Caribbean end-users to frequent disaster damages warrants such facilities that may reduce psychological burdens.

Prevalence of unethical acts can be a prominent feature during disaster recovery efforts, hence the need to ensure that capacities of law enforcement institutions are sufficiently positioned to prevent and, when necessary, sanction corrupt practices that seek to undermine and compromise resilient rebuilds. Understanding the local culture in designing reconstruction policies is also paramount. As an example, Mannakkara et al. (2018) investigations into the effect of 'build-back-better' attitudes as central to everyday activities in the Cook Islands have concluded the benefits gained as being 'good sense' for seamless application during disaster recovery times. Lessons learnt from the Cook Islands' strategy may be applicable to the Caribbean region: it is, therefore, incumbent on the Caribbean's governing institutions to provide the enabling mechanisms to promote the adherence or compliance to established policies for almost complete buy-in on the reconstruction approach adopted.

8.5 Project success measurement indicators

The structural modelling of project measurement indicators (refer to Figure 7.2) confirms that 'competence' is found to be the more critical measurement indicator ($\beta = 0.72$) over 'adaptability' ($\beta = 0.70$), explaining 72% and 70%, respectively, of success assessment variance of post-disaster reconstruction project success among end-users. This simply means that almost three-quarters of end-users assessment thinking on a project's success utilises the competency or adaptability criteria, or both, in their determinations.

Competence

Competence is found to be the most critical end-user measure for reconstruction project success because of the keen interest in project safety ($\beta = 0.62$) and quality ($\beta = 0.56$). While poor decisions by project team members are mostly unintentional (Kärnä et al., 2013), there is a need to consider the contributors to these poor decisions and the possible avenues to boosting confidence levels of all other stakeholders regarding their performances. Modern software and tech products increases the possibilities for achieving high confidence and trust levels, by leveraging information systems to demonstrate active safety practices in designing, executing and monitoring. Additionally, end-users desire to have quality projects cannot be understated, as 56% of the variance in competency can be explained by this desire. Proper construction safety protocols and a corresponding vibrant safety culture are unusual in the Caribbean. It is not surprising that this phenomenon is top on the priority list of end-users. In a safety culture comparative study, Peckitt et al. (2002) highlighted some deficiencies within the Caribbean construction industry in comparison to the UK. Applying Bandura's reciprocal model framework (Cooper, 2000) to understanding these deficiencies, Peckitt et al. (2002) point to:

1. An absence of a safety climate, which includes: poor safety risk perceptions, lack of supervisory safety management thus giving the employee a sense of individual control over own safety, and seldom to no communications and relations among their colleagues on safety-related matters.
2. Poor safety management practices, notable by seldom occurring risk assessments, insufficient safety policies, and documented safety management systems were practically absent in the Caribbean. Key management deficiencies include an acute absence of occupational health and safety legislation or international standards taken into consideration during the tendering process, and one of the most striking observations is that directors and project managers were often unaware of their responsibilities under health and safety legislation, including accident reporting.

These findings suggested that sustainability (β = 0.42) and time (β = 0.39) are necessary considerations to end-users; however, their loading factors onto the competency construct have not suggested overwhemlming interest. End-users expect practitioners to naturally adopt a more aggressive attitude towards embracing technological advances, as the industry transitions into a technology-driven era. Time as a factor of competency was the least important, suggesting that end-users are not willing to sacrifice safety and quality in achieving success. Typical of the post-disaster setting is a desire to return to normalcy quickly; however, compromising the rebuild process and structure because of time constraints is not acceptable. The finding related to 'time' in this end-user perspective research sharply contrasts Aliakbarlou et al. (2018) research on contractor services in post-disaster reconstruction, which identified time as the topmost important indicator, suggesting that the end-users and project participants have opposing views on time as a strong indicator. Though the sub-indicators in this model are independent, the model suggested the correlation, between change and scope, albeit almost insignificant, does improve the model's fit. This positive relationship indicates an alteration in either one directly affects the other.

Adaptability

Synonymous with the findings in Lopez del Puerto and Shane (2014) conclusion, this research associates 'adaptability' as the second critical measurement indicator, which acknowledges adapting to the dynamic work environment continues to be a major challenge for project teams. Satisfaction (β = 0.57) loaded the highest in this construct, indicating the feeling of success is personal to the assessor. End-users' satisfaction in post-disaster rebuilds are enhanced by 1) ensuring community involvement in discussing project objectives and building trust (Lima et al., 2009; S. T. Ng et al., 2014), 2) ensuring 'fitness for purpose' (Da Rocha et al., 2013), 3) creating or enhancing socio-economic conditions (Q. Shi et al., 2015), and 4) end-user engagement in all project stages (Horney et al., 2016; Mei-yung et al., 2014).

Change (β = 0.39) was the second-highest sub-indicator type, which corresponds to the importance of end-users' assurances for a change management plan to be an integral part of the project's management. Effecting reasonable change connotes an attitude of adaptability that speaks to accommodating rational requests, even if it means altering procedures or objectives. It is imperative to end-users that a channel exists to accommodate grievances, voice concerns and make recommendations on aspects of the project, primarily when their experiences before the disaster can assist with reconstruction improvements. Additionally, timely address of critical project recommendations have been heralded in previous research outputs as essential to stakeholder satisfaction (Lebcir & Choudrie, 2011). While crucial changes are mostly unavoidable on a project, frequent changes can be a source of dissatisfaction for end-users (Senaratne & Sexton, 2009).

Scope (β = 0.44) and cost (β = 0.35) had satisfactory loadings on this construct. Understandably, a reconstruction project scope is practically defined in a post-disaster setting, which is to quickly restore to the previous condition, and consequently, may not feature as effective a measure for success. However, acceptable project scope can be realised upon consultations with and among the end-users in gaining consensus on objectives, which may surprisingly generate some useful improvement suggestions. As it relates to cost, unless the project is personal, the cost of restoration and reconstruction is of minimal interest to end-users. Empirically, costs associated with reconstruction projects are primarily for information purposes and not necessarily an end-user's measure for success.

8.6 SCSF and SCRF used to generate performance indicators

This research process has identified the critical factors (refer to Figure 8.1 and Table 8.1) to guide the project management operations in both the strategic applications of success factors and resilience factors. The SCSFs and SCRFs can provide the foundation or benchmark for the development of indicators to assist in context-specific project management's performance measurement. Table 8.2 lists the factors that can be contextually applied to generate the indicators required according the project's approach and plan that has been decided.

Table 8.2 Sub-critical factors for generating performance indicators

Critical and sub-critical success factors		Critical and sub-critical resilience factors	
Knowledge Management		**Collaborations**	
KM1	Competent leadership	CO1	Stakeholder engagement in all project phases
KM2	Clarity of team responsibilities	CO2	Public–private partnership
KM3	Specialist skillset	CO3	Materials sourcing and salvaging
KM4	Proper technical specifications	CO4	Skillset development and training
KM5	Use of technology	CO5	Unbiased procurements
KM6	Appropriate safety measures	CO6	Engaging community past experience in new designs
Ecosystem Care		**Infrastructure Indexing**	
EC1	Unbiased care	IX1	Critical infrastructure designations
EC2	Environmentally-friendly construction	IX2	Non-disparity in structural and non-structural attribute components
EC3	Waste management	IX3	Continuous design improvements
		IX4	Redundancy planning
Stakeholder Engagement		IX5	Designs that mitigate climate change effects and future hazards
SE1	Client and end-user involvement		
SE2	End-user expectations prioritized	**Governance**	
SE3	Operations guided by project management principles	GO1	Legislative support to developmental plans
		GO2	Clear short-term and long-term construction sector objectives
Resource Management		GO3	Designs are congruent to cultural orientations and beneficiaries' expectations
RM1	Team motivation	GO4	Established land-use plans
RM2	Task decentralization	GO5	Easily available project financing programmes
RM3	Knowledge sharing	GO6	Proactive maintenance programmes
RM4	Appropriate procurement method	GO7	Leveraging modern construction techniques
RM5	Change management plan		
RM6	Communication plan		

8.7 Understanding the impact of resilience on reconstruction projects

8.7.1 Verifying the impact of resilience

The SEM approach was used to further assist in understanding the relationship between the latent variables of project success factors and project resilience factors and the overall success of reconstruction projects in the Caribbean. In statistical terms, SEM is called a second-generation multivariate method, with regression analysis called first-generation. However, limitations of the first-generation methods include limited correlation analysis, because their primary function is prediction analysis (Tabachnick & Fidell, 2013). While multiple regressions analyses were conducted in Chapters 5 and 6, the analysis was restricted to one-to-one construct relationship investigation. An improved understanding of the structural relationships and correlations among the variables can be an effective method to test the authenticity of the hypothetical model that summarises this research; therefore, SEM is recommended. SEM is a multivariate analysis technique that has the ability to estimate multiple interrelated relationships, while factoring measurement errors in its modelling (Kline, 2015). Another of its strength is the ability to provide a visual representation of the complex relationships for all measured and latent variables (Byrne, 2016). The technique is widely used in construction management practice in varying scenarios, for instance, investigating interrelationships among construction projects' critical factors (Chen et al., 2011), and understanding factors affecting disputes between clients and contractors (Molenaar et al., 2000). Xiong et al. (2015) produced a framework of guidelines to assist researchers in construction SEM after conducting a critical review of 84 articles that used SEM to address construction-related problems over the period 1998–2012.

SEM models two types of variables: observed or independent variables and latent or dependent variables. Measured variables are directly measured (e.g. responses to a survey), while latent variables are inferred measurements from the measured variables. As illustrated in Figure 8.3, the relationships between and among the variables are represented as path diagrams, where the causal flow of relationships is represented by lines with single arrows, representing a regression relationship or double arrows, signifying an intercorrelation, and the measured and latent variables are represented by rectangles and oval shapes, respectively. Analysis models in SEM are either a measurement model, which measures the relationship between the latent and measured variable, and the structural model, which shows the relationships among latent variables (Kline, 2015). Explained by Tabachnick and Fidell (2013), the principally two-step SEM process involves: 1) confirming the validity of the observed variables required to measure the latent variables (convergent and discriminant), which is in principle, the regression relationships, and 2) confirming the relationship by a goodness-of-fit index to ensure the observed variables (ground-truth data) and the latent factors can be established in the structural model.

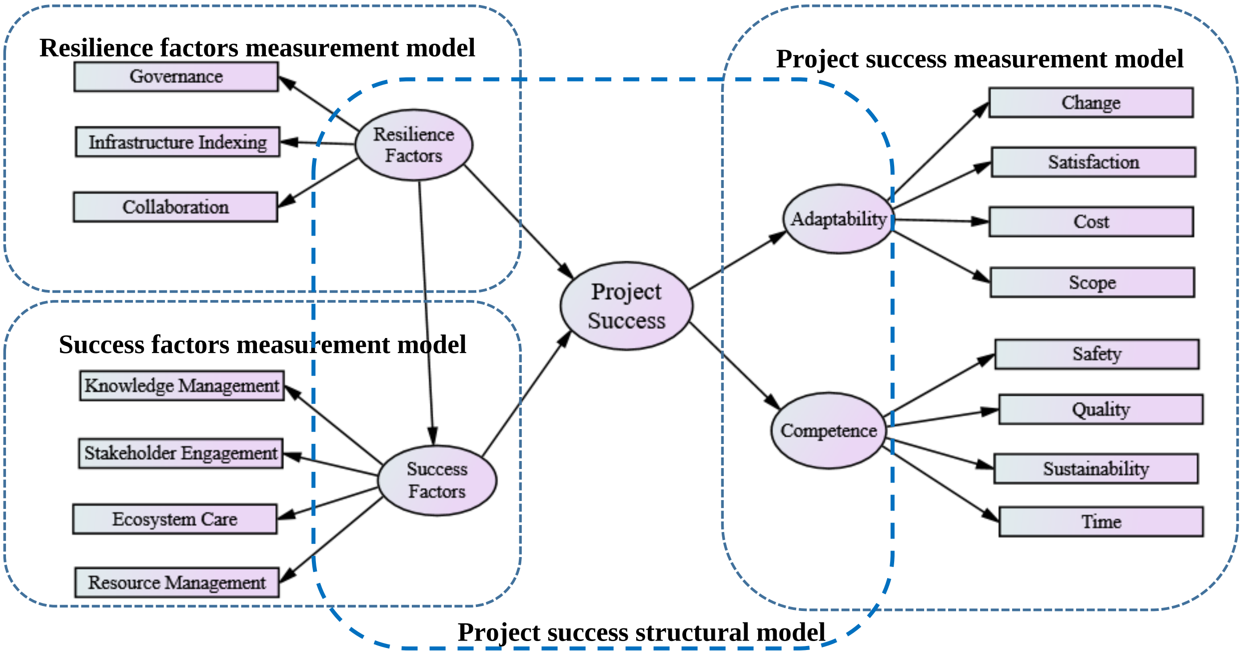


Figure 8.3 Disaster reconstruction project success structural model

Variables used in this SEM analysis were obtained from a mixed methods approach as explained in relation to the regression analysis earlier in Chapters 5, 6 and 7. Illustrated in Figure 8.4, three measurement models and the associated structural model explain the theoretical structure accompanying this research. In preparation for this analysis, unidimensionality was confirmed for the measurement models. The latent variables 'success factors' and 'resilience factors' were previously factor analysed and reliability checked, and their outputs were presented in Chapters 5 and 6, respectively. Mentioned earlier, eight measurement indicators for project success were obtained from the literature as the mainstream measurement metrics for assessing reconstruction project success or failure, but were subsequently factor analysed to further understand the end-users' applications of these metrics. The analysis suggested two new composites: competence and adaptability. These were presented in Chapter 7.

8.7.2 Hypothetical model

A hypothetical model (refer to Figure 8.3), which expands the conceptual model of Figure 1.1, was developed to reflect the assumed relationships based on project success factors (PSF), project resilience factors (PRF) and project end-user success expectations (PS). These three constructs were defined as the latent variables. Both PSF and PS are endogenous variables and PRF is an exogenous variable. All the measured values for the latent factors were derived from the end-user survey questionnaire.

The hypothesised model contains ovals representing latent variables, and rectangles representing measured variables. Any absence of a connection between variables implies the lack of a hypothesized direct effect. The model examined the predictors of project success. Project 'success factors' is a latent variable with four observed variables (KM, EC, SE, and RM). Project 'resilient factors' is another latent variable with three observed variables (CO, IX, and GO). It was also hypothesised that from an end-user perspective, project success is measured by the project's ability to adapt to any change request generated by internal or external project issues, and the competency composition of the project team members. These two success measures are latent variables with measurement indicators of scope, change, satisfaction and cost indicating adaptability, and quality, sustainability, safety and time measuring competency. The hypothesis claimed that success factors (H_1) and resilience factors (H_2) positively predict projects success (refer to Figure 1.1). Further, it was hypothesised that resilience factors also have a positive effect on success factors predicting project success (H_3).

The following three hypotheses (refer to Figure 1.1) analysed the effect of end-user analysed and perceived predictor success factors and resilience factors on project success:

- H1: Success factors (PSF) have a significant effect on project success (PS)
- H2: Resilience factors (PRF) have a significant effect on project success (PS)
- H3: Resilience factors (PRF) positively affect the relationship between success factors (PSF) and project success (PS)

8.7.3 Measurement model

SEM treats measured variables as functions of latent variables. The degree of model fit in a SEM follows a set of assumptions that must be satisfied to achieve exemplary results. Consequently, it is particularly essential to verify that the measured variables reflected in each latent variable are:

1. Satisfying the basic assumptions for model identity (identification)
2. Consistent on measurement scales with each other (scale reliability)
3. Reflected in the same latent variable of interest (convergent validity)
4. Statistically distinct from other latent variables (discriminant validity), and
5. Related to a specified latent variable and shares the variance with each item under that latent construct (unidimensionality).

A model having inadequate reliability, insufficient convergent and discriminant validity, or a significant lack of unidimensionality in output and conclusions from a statistical analysis can be deemed biased and unstable (Gefen et al., 2000; Kline, 2015; Tabachnick & Fidell, 2013). Following a thorough investigation of the above constraints, the model represented in Figure 8.4 can be measured.

Identification (evaluation of assumptions): Ensuring that the model meets the minimum assumptions for proper SEM analysis is another prerequisite. A summary of the assumptions are as follows:

- Adequate sample size
- Case and variable screening
- Degrees of freedom (df) = no. of observations – no. of parameters
- Constructs individuality
    - Convergent validity (AVE>0.5 / CR>0.7)
    - Discriminant validity (<0.85)
- Goodness of fit (Chi-Square value: CMIN. Goodness-of-fit statistic: GFI, normed-fit index: NFI, Comparative fit index: CFI, Root mean square error of approximation: RMSEA)

Sample size: Achieving the stability of a SEM, several rules of thumb have been suggested by researchers, which include having 15 cases per measured variables or 10 cases per independent variable with a minimum critical ratio of 5:1 (Hair Jr et al., 2016). Bentler and Chou (1987) previously argued that a ratio of as low as five cases per variable ratio is also acceptable if the collected data is reliable. However, as a general guideline, Kline (2015) suggested a sample size less than 100 as small, between 100 and 200 as medium, and greater than 200 as large. The sample size in this research collected 240 observations, which should be sufficient to support a stable model.

Case and variable screening: Verifying the quality of the data for the observed variables, nine rows in our dataset were removed as they were considered as not engaged (e.g. a similar Likert scale item as an answer for every question). There was one abnormal value in terms of years of experience being 2.7 years. This is not an acceptable range; therefore, it was replaced the value with 3.0, assuming typographical input error. There were observed abnormal distributions for our indicators of latent factors (success factors [e.g. knowledge management] and resilience factors [e.g. collaborations]), and fairly normal distributions for all other project success expectation variables (e.g., quality, safety, cost) in terms of skewness and kurtosis. For the dependent variables and the predictor variable, we observe the skewness values (Z) ranged from benign to -8.936 and kurtosis values (Z) ranged from benign to 9.682. While these do violate strict rules of normality, the value is within the more relaxed rules suggested by Kline (2015) in recommending a Z value 10 as the upper threshold for normality.

Degrees of freedom: The degree of freedom (df) is practically the number of independent pieces of information that are available in a model. It is a measure of the difference between the number of observations and the number of parameters. The requirement is satisfied when there is at least as many observations as parameters that can be expressed as df ≥ 0, as being identified or over-identified. It is represented by the formula:

$$df = A - B$$

*where: A is the number of observations (observed variables) = (N *(N+1))/2*

B is the number of estimated parameters (sum of unobserved and exogenous variables)

For this research model (refer to Figure 8.3):

Number of variables in model: 39

Number of observed variables: 15

Number of unobserved variables: 24

Number of exogenous variables: 20

Number of endogenous variables: 19

Therefore: df = (15(16)/2 – 20+24 = 120 – 34 = 86*

This model is over-identified, and suitable for analysis and tested with 86 df.

Scale reliability: Reliability and validity of the measurement models is a prerequisite to building the structural model. Observed variables on the resilience factors and success factors constructs were measured on a seven-point Likert scale, while success indicator observed variables were measured on a five-point Likert scale. The values on the latter were normalised to the seven-point scale. The measurement models (identified in Figure 8.3) were examined and the results indicate the measurement indicators for each construct were consistent with the structural model specified in this research.

Constructs individuality: Convergent and discriminant validity: Tables 8.3 and 8.4 present the results of measurement models' examination (convergent and discriminant validity). Convergent validity assesses agreement intercorrelations of indicators of the same construct, while discriminant validity verifies the magnitude of intercorrelations among constructs and measures their difference from one another empirically (Ab Hamid et al., 2017; Kline, 2015). Table 8.3 shows the results of the convergent validity. All the factor loadings are higher than 0.3, indicating that the indicators' reliability were acceptable. Similar to the Cronbach alpha, except composite reliability (CR) measure's error in its evaluation, CR scores were higher than 0.6. Though a minimum CR score of 0.7 is desired, the internal consistency reliability was considered satisfactory. Two constructs, namely success factors and resilience factors, had their average variance extracted (AVE) with scores higher than 0.5, indicating that convergent validity of their data was satisfactory. However, the AVE score for the project success construct's AVE was 0.178 and classified as poor. According to Kline (2015), poor convergent validity within a set of indicators for the same construct suggests that the model may have too few constructs. Additionally, Hair Jr et al. (2016) explained that convergent validity measures the degree of positive correlation of one indicator and other indicators within the same construct, since indicators within the same construct should share a comparatively high proportion of commonality. They also advise that factor loadings <0.7 should be removed only if the factor score increases the CR or AVE value. These two guides on poor convergence confirm the exclusive measures for project success. The low score (AVE=.178) on this construct can be translated to be a desired set of unique indicator measures for the respective construct (PS), by having insignificant correlations. This realisation may support the aggregation of the eight success indicators into two new measurement indicators, as developed in Chapter 7 (adaptability and competence).

Table 8.3 Measurement models' evaluation – convergent validity

Construct	Indicator	Factor loading	Cronbach alpha (α)	Composite reliability (CR)	Avg. variance explained (AVE)	Convergent validity
PSF	(KM)	.858	.862	.865	.616	Yes
	(SE)	.769				
	(EC)	.706				
	(RM)	.799				
PRF	(GO)	.826	.803	.805	.58	Yes
	(IX)	.711				
	(CO)	.744				
PS	Safety	.446	.628	.631	.178	No
	Cost	.312				
	Change	.441				
	Scope	.422				
	Time	.434				
	Sustainability	.409				
	Satisfaction	.466				
	Quality	.425				

***PSF**: Project success factors, **PRF**: Project resilience factors, **PS**: Project success*

The results of the discriminant validity test are presented in Table 8.4. The discriminant validity can be evaluated using 1) cross-loading of indicator, 2) Fornell and Larcker criterion (Fornell & Larcker, 1981) and 3) heterotrait-monotrait (HTMT) ratio of correlation (Henseler et al., 2015). The preferred measure for discriminant validity in this analysis is the heterotrait-monotrait (HTMT) ratio of correlation. This measure proposes a superior performance by the method's ability to achieving higher specificity and sensitivity rates (97% to 99%) when compared to the cross-loadings criterion (0.00%) than Fornell-Lacker (20.82%) (Ab Hamid et al., 2017; Henseler et al., 2015). Using the HTMT value involves comparing it to a predefined threshold, when values closer to 1 indicate a lack of discriminant validity. Some researchers suggest a threshold of 0.85 (Henseler et al., 2015; Kline, 2015). However, Gold et al. (2001) argued that a value up to 0.9 is acceptable. Refer to Appendix 10 for an explanation of the HMTM calculation. If the value of the HTMT is higher than this threshold, it is safe to conclude that the model lacks discriminant validity. Overall, the HTMT results from this analysis confirm achieving discriminant validity based on HTMT inference, as shown in Table 8.13.

Table 8.4 Measurement models' evaluation – discriminant validity

Constructs	HTMT value	Discriminant validity
PS <--> PSF	0.579	Yes
PS <--> PRF	0.734	Yes
PRF <--> PSF	0.732	Yes

Unidimensionality

Unidimensionality actually summarises the output of convergent and discriminant validity. Also termed nomological validity, it is aimed at determining indicators relative to particular variable and latent constructs that are unique in dimension and are specific or distinct in their measurement (Kline, 2015).

Goodness of fit: This metric assesses how a hypothesized model best represents the data and reflects the underlying theory, known as model fit. The term goodness of fit is used interchangeably to characterise the range of fit indices that are available and the choices in selecting the best collection, including the recommended cut-offs, that may represent the data most appropriately (Yuan, 2005). Goodness-of-fit indices assist with determining how well a theory fits the data collected. The indices are not to be compared with other models, except to compare with suggested modification improvements within the same model.

The Chi-squared value retains its legacy status as the traditional measure for assessing the goodness of fit (Kline, 2015). However, researchers have highlighted severe limitations in its use, primarily on its sensitivity to sample size (Bentler & Bonett, 1980), and the test's assumption on multivariate normality making it also sensitive to seemingly normality variations that can likely cause the rejection of well-specified models (McIntosh, 2007). Consequently, researchers have proposed several alternatives for a more pragmatic approach to assessing model fit (Byrne, 2016). For this SEM analysis, the most widely accepted and commonly reported indices will be prioritised, which are CMIN, CFI, GFI, NFI, and RMSEA (Hooper et al., 2008).

CMIN: Chi-square

The CMIN value is the minimum discrepancy between the unrestricted sample covariance matrix and the restricted covariance matrix. It represents the likelihood ratio test statistic, most commonly expressed as a chi-square ($\chi 2$) statistic. Adjunct to the Chi-square is the probability statistic (ρ) that indicates the significance of the CMIN, and ideally a non-significant value indicates adequate model fit. Also associated with the CMIN value is the CMIN/DF value ratio between the chi-square value and the degrees of freedom (df) that minimise the impact of sample size on the model's chi-square. Ideal CMIN/DF indices are between 1 and 2, however, some researchers have argued up to 5 as acceptable (Wheaton et al., 1977).

GFI : Goodness-of-fit index

Though Henseler and Sarstedt (2013) discourage the use of the GFI index because of its inability to distinctly differentiate between valid and invalid models, several other researchers still advocate its use as a general assessment criterion, also as an alternative to chi-square (Hair Jr et al., 2016; Kline, 2015). S. Sharma et al. (2005) also advised on the dependency of the GFI values on sample size having complex bias issues, however, a value >0.9 is considered reasonably satisfactory to assessing model fit (Hooper et al., 2008).

NFI: Normed-fit index

The NFI statistic assesses the model by comparing the chi-square value of the model to the chi-square of the null model. The null model represents a worst-case scenario on the basis that all measured variables are uncorrelated. Again, though this index is sensitive to sample size and may underestimate model fit for samples under 200 observations, Hu and Bentler (1999) argue for values =>0.95 amidst other researchers accepting >0.9 as an acceptable fit index.

CFI : Comparative fit index

The CFI can be characterised as a revised form of the NFI. As one that is least affected by sample size (Fan et al., 1999), for it seamlessly accommodates small sample sizes (Byrne, 2016). Using a similar approach to the NF in assuming that all latent variables are uncorrelated as a null model, except that it compares the sample covariance matrix with this null model. The values for this statistic also range between 0.0 and 1.0 with values closer to 1.0 indicating a good fit. Hu and Bentler (1999) also advocate for values much greater than 0.9 to ensure that misspecified models are not accepted.

RMSEA: Root mean square of approximation

Regarded as one of the most informative fit indices, the RMSEA value estimates how well the model fit uses the number of estimated parameters, suggesting that fewer parameters may yield better statistical results. When this index was introduced, values in the range 0.05-.10 were considered a fair fit, and above 0.1 was a poor fit. After several revisions, from 0.08, then 0.06 as upper limit cut-off, it is widely agreed that RMSEA values near 0.05 and below represent a good fit (Hooper et al., 2008; Kline, 2015).

The above mentioned indices are integral in this research and while they are cited as the frequently reported ones, there are other supporting indices that assist in guiding model fit conclusions. For more detailed definitions of these indices and others, see (Bentler & Bonett, 1980; Byrne, 2016; Hox & Bechger, 1998; Kline, 2015; Tabachnick & Fidell, 2013). Table 8.5 provides a list of all indices captured in this test, and shows the results of the initial and final model fit indices for the hypothesized model in Figure 8.3.

Table 8.5 Goodness-of-fit table summary

GOF measure	Description	Recommended GOF measure	Initial SEM	Final SEM	Condition met
Chi p-value (CMIN)	Probability	Close to 0.5 (<0.3: Underfitting, >0.7: Overfitting)	.000	.002	No
CMIN/DF	Chi/degrees of freedom	1 – 2, but less than 5	143.59	127.209	Yes
GFI	Goodness of fit	0 (no fit) to 1 (perfect fit) Above 90%	.929	.939	Yes
NFI	Normed fit index	0 (no fit) to 1 (perfect fit) Above 90%	.879	.893	Marginal
CFI	Comparative fit index	0 (no fit) to 1 (perfect fit) Above 90%	.946	.960	Yes
PCFI	Parsimony CFI	Above 60%	.766	.786	Yes
NCP	Non-central parsimony	Above 0	58.59	43.209	Yes
RMSEA	Root mean square error of approximation	Less than 0.05 (0.05 – 0.08: acceptable)	.054	.046	Yes
PCLOSE	p-value for hypothesis test of RMSEA	Greater than 0.05	.330	.627	Yes
TLI	Tucker-Lewis index	0 (no fit) to 1 (perfect fit)	.933	.950	Yes

Note: GOF indexes adopted from (Byrne, 2016; Hair Jr et al., 2016; Kline, 2015; Weston & Gore, 2006)

8.7.4 Results of hypothesis test and SEM

The model examines the predictors of project success. Project ‘success factors’ is a latent variable with four indicators (KM, EC, SE, RM). Project ‘resilient factors’ is another latent variable with three indicators (CO, IX, GO). Project success is also represented by two latent variables (adaptability and competence). With reference to section 8.2.1.1, three hypotheses were forwarded. These hypotheses claimed that success factors and resilience factors directly predict projects success (H_1 and H_2). Further, it was hypothesised that resilience factors also have a positive effect on success factors predicting project success (H_3). Additional to these hypotheses, it was determined that project success is measured by the project’s ability to adapt to any change request generated by internal or external project issues, and the competency composition of the project team members. These two measures are also latent variables with measurement indicators of scope, change, satisfaction and cost measuring adaptability, and quality, sustainability, safety and time measuring competency.

Illustrated in Figure 8.4, the final model and its variables' correlation coefficients are presented. Table 8.6 also presents the standardized coefficient estimates of the model's hypothesised relationships. The two-tailed significance ($p < .05$) is used to assess the impacts of the latent variables on each another, in accordance to the hypotheses outlined earlier. As shown in Figure 8.4 and Table 8.6, two of the hypotheses (H_1 and H_3) were significantly supported at a 99% confidence level ($p < .01$). It can be concluded that project success factors directly impact project success, and resilience factors can directly assist project success factors in achieving positive outcomes. Hypotheses H_2 was rejected and therefore concludes that resilience factors have no significant direct impact on project success.

Essentially, the hypothesised model and the SEM results have, in principle, confirmed the global idea of the resilience concept and construct to supporting the new paradigm of disaster risk resilience. This paradigm is purported as an adaptable and robustness developing strategy for entity response to hazards. The level of influence resilience is estimated to have in improving the applications of success factors is seen as overwhelming. Accounting for 72% of the variance expressed in success factors' application, resilience factors have shown to be a significant partner in achieving project success. The SEM results also demonstrate a notable relationship between safety and quality as measurement indicators. This suggests that a significant collinearity exists between them as predictors to competency. It also suggest that satisfying the competency construct, employing competent personnel can aid the risk-averse nature of reconstruction projects.

Table 8.6 Standardized coefficient estimates of final SEM

Hypothetical path	**Standardized coefficient**	**Standard error**	**Sig. (ρ)**	**Interpretation**
H1: PSF <--- PRF	0.71	.080	< .01	Supported
H2: PS <--- PRF	0.16	.128	.215	Reject
H3: PS <--- PSF	0.72	.147	< .01	Supported

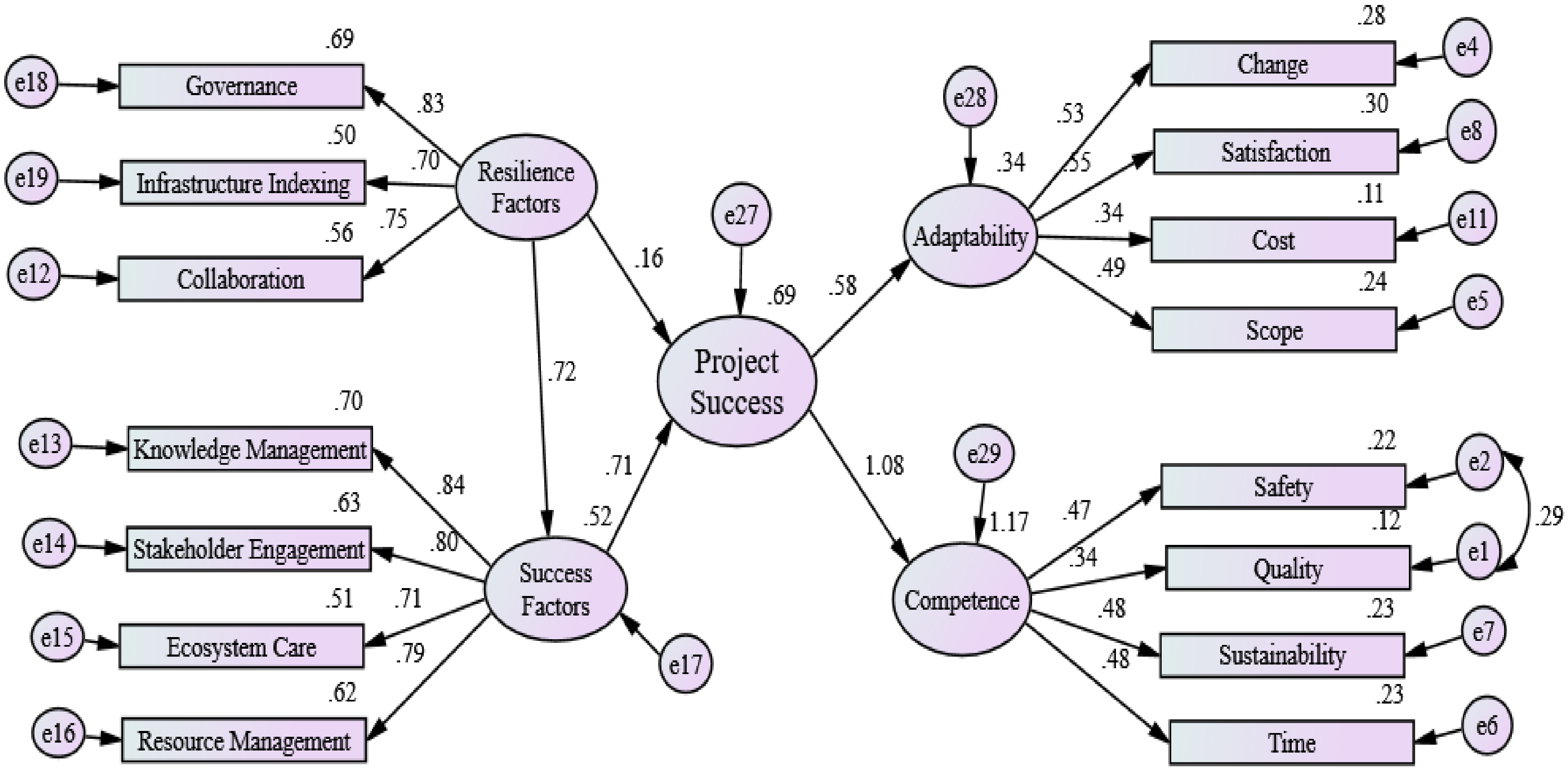


Figure 8.4. Final SEM showing standardised relationship coefficients among all variables

8.8 Analysing the relationships between resilience factors and success factors

When using the regression technique in statistical analysis, there are, in principle, three kinds of regression analyses, namely, simple, multiple and logical regressions. Key outputs from these analysis are coefficients and statistical significance values. Referring specifically to coefficients, four types of coefficient values are realised: unstandardized 'B', standardized 'beta', partial and semi-partial coefficients. The fundamental difference between a standardised (beta) value and unstandardized (B) value is the scale unitisation dependency of the beta value, especially when the variables are measured in different scales, as opposed to unstandardized values, which is just the raw regression results reported in its native scale.

In a simple regression, the beta coefficient reflects the strength of relationship between the predictor or independent variable (IV) and the outcome or dependent variable (DV). With multiple regression, the IVs beta's interpretation is not simply the representation of the amount of change in the DV given a one unit change in an IV; it actually represents the amount of change in the DV given a one unit change in an IV, assuming that all other IVs in the construct are held constant.

For example, with reference to Table 6.6 (Equation 8.1):

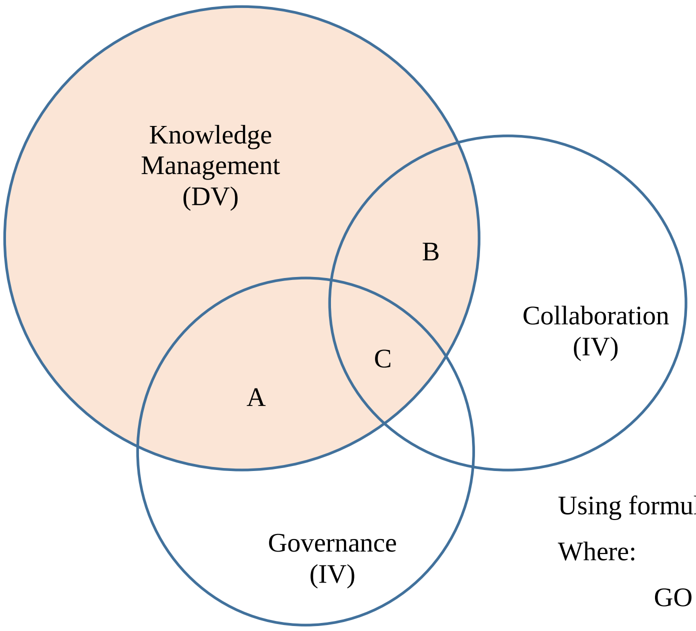
Knowledge Management (KM) = 2.173 + 0.290*CO + 0.326*GO

Where: CO = Collaboration, GO = Governance

Specifically relating to the equation above, a simple interpretation concludes that Knowledge Management is impacted positively by Collaboration and Governance. The B value (2.713) is the amount of change in the unit variance in Knowledge Management for each unit variance change of either Collaboration or Governance, once the other is held constant. Also, Governance has a comparatively larger impact or loading factor (0.326) on Knowledge Management, than Collaboration (0.290).

Partial coefficients

These factor loading values represented in Equation 8.1 are the partial regression scores for the strength of the relationships represented in the equation. The partial coefficient is the expected change in the DV associated with a unit change in a given IV, while controlling for the correlated effects of other IVs in a model or construct. In a supposedly ideal situation, the partial coefficient of correlation is designed to eliminate the effect of one variable on the other variables, when assessing the correlation between quantities of variables. Illustrated in Figure 8.5 is a representation of the relationship among three variables (2 IVs and 1 DV). Values A, B and C are partial coefficients.



Using formula***: KM = 2.173 + 0.290*CO + 0.326*GO***

Where:

GO explained variance in KM = A + C

CO explained variance in KM = B + C

Figure 8.5. Illustrated bivariate relationship among three variables

However, the realities with coefficient values are slightly different. When IVs are correlated, a change in any one will effect or cause a change in all other IVs; so in reality they cannot be ‘held constant.’ Consequently, none of these coefficients accurately reflect the specific IV’s importance when it is part of a multiple regression. The fundamental reason for this is predicated on the fact that multiple regression treats multiple IVs as uncorrelated or strictly non-convergent, when in actual sense they are, because they are describing the same DV. To address this issue, semi-partial correlations, and changes in R^2 assist with an understanding of the unique behaviour of the IVs. This test assists with possible misinterpretations of the partial coefficients to assess an IV’s unique strength that can result in an over-estimation of the IV’s importance, when in reality it has a relatively low correlation with the other IVs.

Semi-partial coefficients

In understanding the unique impact of an IV on a DV, the semi-partial regression coefficient, also called the part correlation in SPSS, is used to express the specific portion of variance explained by a given IV in a multiple linear regression analysis (see Appendix 11). In other words, the semi-partial coefficient, when expressed in standardized form, represents a measure of the unique ability of an IV to explain variation in a

DV that cannot be explained by any other IV in the model. Using Figure 8.6 to explain the concept, it is important to investigate the individual contribution of each resilience factor towards project success, when the effect is controlled by a success factor. The importance of this coefficient is mostly understood in the reverse manner; that is, if a particular IV is not a conscious predictor in the model, ‘Is the loss significant?’ or ‘What is the percentage loss in unexplained variance?’

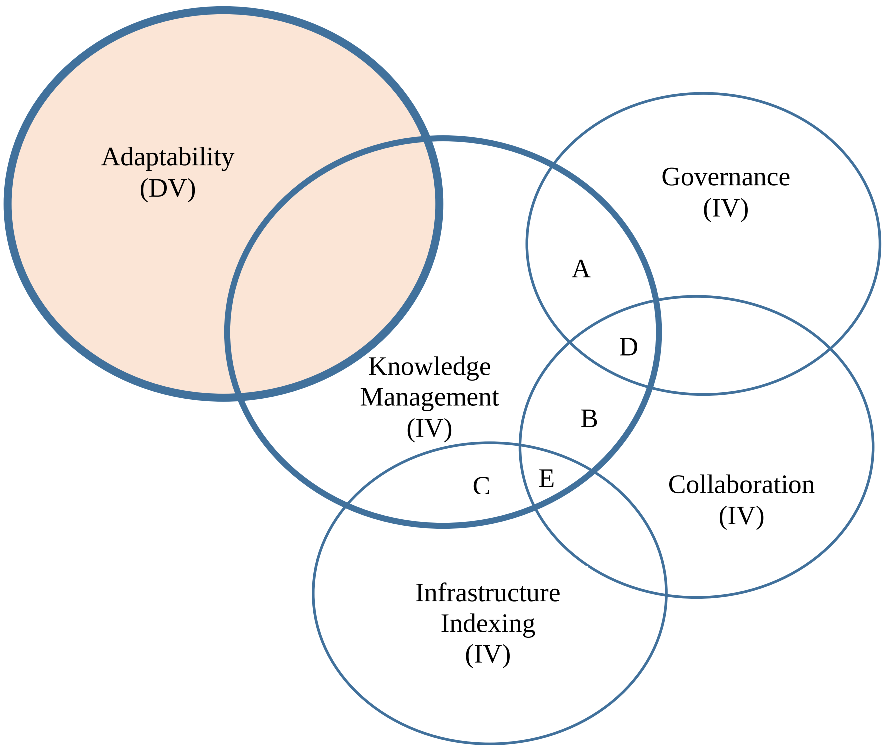


Figure 8.6 Illustrated multivirate relationship of IV regression on a DV, with a controlled IV

Refer to Appendix 10:1A

Using the regression equation (Equation 8.2)

$$\textbf{Adaptability} = \mathbf{2.869 - 0.71*CO - 0.71*IX + 0.371*GO}$$

Where:

Partial coefficient for Governance = A + D = 0.371

Partial coefficient for Collaboration = B + D +E = -0.71

Partial coefficient for Infrastructure Indexing = C + E = -0.71

Part (semi-partial) coefficient for Governance = A

Part (semi-partial) coefficient for Collaboration = B

Part (semi-partial) coefficient for Infrastructure Indexing = C

Referencing the formula shown above (Equation 8.2), each resilience factor was analysed to assess their unique contribution or impact on the DV. In an actual sense, the coefficient 'A' is the unique variance explained with the 'Governance' resilience factor, influencing the 'Adaptability' project success indicator, controlled by 'Knowledge Management'. Knowing the variation that is uniquely accounted for in Adaptability by Governance (A) can assist in determining the critical nature of the resilience factor to the model. Likewise, all the other relationships in the model can be analysed. Importantly, while all bivariate relationships are characterised by a factor loading, its significance level determines its impact on the model, if removed. Therefore, a ρ value <0.05 will signify that the related IV has a significant effect. Appendix 10 presents the results of all bivariate relationships between the resilience factors and the success indicators, being controlled by each success factor. The significant effects are listed in Table 8.8.

Equation 8.3 (below) shows the bivariate correlation to calculate partial correlations

$$r_{xy.z} = \frac{r_{xy} - (r_{xz} r_{yz})}{\sqrt{(1 - r_{xz}^2)(1 - r_{yz}^2)}}$$

Where: r_{xy} = measured correlation between x and y

r_{xz} = measured correlation between x and z

r_{yz} = measured correlation between y and z

Note: Only three variables represented in this equation (x = IV, y=DV, and z = Controlling variable)

Table 8.7 presents the results of the semi-partial coefficients from the analysis of the unique variability of the resilience factors in impacting project success, using the indicators Adaptability and Competence, and controlled by each of the four project success factors. With reference to Appendix 10, eight analyses depicting the combinations of a unique test are summarised. The Governance resilience factor was observed to be the only independent variable that significantly affects the outcomes of resilient successful projects.

Table 8.7 Model summary of part (semi-partial) coefficients

Resilience factor (IV)	Success indicator (DV)	Controlling (success factor) variable	Part (semi-partial) coefficient	Sig.	R^2	F Change	% variance unaccounted for, if removed
Governance	Adaptability	Knowledge Management	0.222	.000	.110	7.262	22.2 %
Governance	Adaptability	Ecosystem Care	0.225	.000	.106	6.957	22.2 %
Governance	Adaptability	Stakeholder Engagement	0.195	.001	.145	9.949	19.5 %
Governance	Adaptability	Resource Management	0.214	.000	.137	9.310	21.4 %
Governance	Competence	Knowledge Management	0.179	.001	.299	25.079	19.9 %
Governance	Competence	Ecosystem Care	0.190	.001	.262	20.866	19.0 %
Governance	Competence	Stakeholder Engagement	0.167	.002	.313	28.755	16.7 %
Governance	Competence	Resource Management	0.211	.000	.245	19.044	21.1 %

The results shown in Table 8.7 establish ‘Governance’ as the most impactful resilience factor, from the perspective of the project end-user, more so, when competency matters most. Governance is recognised as most significant when Knowledge Management is applied and the project is assessed on the competency of project participants and teams. However, if proper Governance is not applied as part of the project’s management, when Adaptability is a critical success measure, there can be a 22.2% unexplained variance void, when Knowledge Management and Ecosystem Care are deemed essential to achieving the project’s objectives. Governance is least influential when the project objectives are affiliated to Ecosystem Care, by only accounting for 10.6% of the variance in Adaptability. Overall, Table 8.7 outlined the direct effects of Governance as a resilience factor and if it is not applied as a mainstream management practice. With reference to Section 8.3 and Table 8.1, Governance considerations include effective legislative support to developmental plans for enabling short-, mid-, and long-term initiativies of the community or country, and the establishment of construction sector objectives to meeting minimum standards in compliance with regulatory and international sustainability oriented treaties and conventions. Additionally, Governance commands a deliberate effort to ensure new designs or modifications are congruent with cultural orientations and beneficiaries’ expectations. Proper management control also includes effective governance in the establishment of land-use plans, especially when hazard maps provide valuable information on hazard-prone areas, including the accessibility to finance by government or self-initiated reconstruction programmes in both the public and private sector. Last but by no means least, good governance demands the effective and efficient roll-out of proactive maintenance programmes for critical infrastructure projects and the creation of an atmosphere that is receptive to leveraging modern construction techniques.

8.9 Caribbean context-specific research findings on reconstruction

The essence of this research seeks to establish a focused resilience reconstruction strategy that is primarily oriented to the Caribbean region. Consequently, the dynamics of the region were explored to develop the optimum solution. In the process, several context-specific cultural anthropogenic findings emerged that assisted in framing the research analysis; including, the implications of the Caribbean end-users' perspective, from an understanding of the populace aspirations for more resilient reconstruction projects. From these two components, the following stand out as lessons learnt in this research, as applicable to Caribbean islands' reconstruction resiliency considerations.

- ✓ Indigenous knowledge is scant in reconstruction projects because the indigenous people are normally not active participants in the reconstruction process. Oftentimes, new and modified designs are remotely completed on what is believed to be the best solution for the affected community. One can appreciate the time constraints with returning to normalcy in the post-disaster setting; however, the end-users seem to be willing to sacrifice completion time for a project that satisfies their usability and long-term sustainability concerns, project feasibility and practicality assessments.
- ✓ Having competent personnel as project team members appears to be a great source of confidence for end-users. Highly ranked empirical success factors including leadership capabilities, clarity of contractor and sub-contractor responsibilities and exploration of proper safety measures were assessed as critical (refer to Table 5.2). Competency was also identified as one of two composite indicator criteria in assessing project success (refer to Chapter 7). Competency with designs and execution, and competency with clearly articulating and explaining the project's objectives will aid comprehensive Caribbean stakeholder satisfaction.
- ✓ Caribbean people are generally keen on the environment's preservation, particularly because tourism is central to their economies. With tourism being central to most island GDP, the environment must be critically central to all development programmes. Strategic reconstruction of buildings and infrastructure ought to be against the perils of environmental and ecosystem decay. An urgent need to

legislate and regulate construction practices with alignment to sustainable development goals is lacking in the region, including the availability of requisite training opportunities in alternative materials and practices.

- ✓ Lack of informed procurement mechanisms prevail in the Caribbean. Knowledge is critical to successful projects and competency must be factored into the recruitment process. However, associations, friendship and nepotism are typical. An urgent need to rid this anti-resilient attitude is recommended.
- ✓ Short-term inactions relating to key policy decisions can lead to long-term deterioration of the built environment. The political directorate needs to be decisive on embracing resilient-oriented initiatives, even if they appear unpopular. Decisions that affect the construction sector may have significant cost and adoption consequences, and may disenfranchise key players in these small economies. This challenge is real with Caribbean governments, and these business entities, especially when political parties' financing is dependent on these business entities and long-standing business practice will be disrupted to invest in innovative and sustainable construction materials.
- ✓ The region has a limited pool in both technical and financial resources. The need to engage more competent stakeholders is evident, and the scarcity has manifested in several failed projects. The recommendation here is that developing a guiding protocol for regional public–private partnership will assist in leveraging resources. A data repository on skillsets may be an interim solution to regional skills sourcing.
- ✓ Case-based reasoning is postulated as a viable technique for enabling knowledge transfer in the Caribbean. Knowledge as a resource is still largely personalized; however, the prevalence of technology encourages sharing experiences among stakeholders. Leveraging a user-friendly digital platform can be a critical source of Caribbean-specific building practices or lessons learnt centre for improving resiliency.
- ✓ Collaboration from Caribbean end-users' perspectives involves volunteerism, patriotism or humanitarianism. While project participants focus collaboration on improving operational efficiencies and effectiveness relating to time management, cost containment and resource procurement, the community members understand collaboration to be assisting a fellow community member in constructing a home or a small stretch of road. This attitude is central to Caribbean culture. As such,

this collaboration is hurriedly manifested in the post-disaster recovery process. It is therefore necessary to assist with skill development to improve capacity and rebuilding standards, especially with a diverse skilful reconstruction labour force.

- ✓ Scarce financial resources typify the Caribbean islands. Strategic preventative maintenance programmes targeting key infrastructure would not only improve resiliency, but improve budgetary allocations. Effective maintenance posits minimizing devastation during hydro-metrological hazard strikes. Prioritizing and monitoring buildings and infrastructure can promote a register of critical facilities that may allow people to recognize when a particular facility is approaching capacity limits or is being exhausted. Addressing this can be considered a governance strategy.
- ✓ Proper governance mechanisms are urgently required in both public and private sectors of the Caribbean's construction industry. Proper mechanisms that support administering oversight on the distribution of national or donated reconstruction resources is lacking. Stringent oversight is not prevalent in the region, therefore, proper structure can potentially stop the disproportionate distribution of essential recovery assistance of both construction materials and labour.
- ✓ The region enjoys a casual attitude to most construction operations, with minimum engineering input and regulations are few or lightly enforced. Ensuring resiliency improvements requires a paradigm shift among all stakeholders to adhere to resilience-oriented policies, regulations or procedures, and a system of checks to communicate and ensure compliance. Paramount will be the legislative 'teeth' to command a level of seriousness.
- ✓ Caribbean people generate significant levels of confidence when a project is known to be administered by a competent team. It is therefore essential to be transparent in communicating the origin of project resources and qualifications of the team members. Additionally, in this new age of the 'sustainability' mantra, the need for competent project practitioners capable of addressing issues of climate change, innovation, and technology uptake have shown to score high as an end-user expectation.
- ✓ Feeling involved and part of the development process, end-users are encouraged when their opinions matter. Bearing this in mind, those inhabitants in the affected communities possess knowledge that may be unknown to the developers. The psychological and emotional satisfaction in providing input may go along way with resilience naturalness.

- ✓ There is disparity with resiliency knowledge among Caribbean stakeholders. Especially among the experts, their agreement levels can be enhanced with more strategic training programmes and policy standards that can promote mainstreaming resiliency into practice.

8.10 A complex adaptive guiding resilience framework

This thesis has explored resilience in Caribbean disaster reconstruction projects, notwithstanding the vagueness surrounding a single industry definition of resilience. Though varying context-specific definitions have emerged within various disciplines over the past four decades (Hassler & Kohler, 2014; McAslan, 2011), the multifaceted and often chaotic disaster recovery period amplifies the difficulty of defining the concept. Resiliency is not a static construct, but a constant change agent that should be receptive to the dynamisms of the construction industry. Modern resilience measures within the disaster management sphere seek to mitigate hazards, absorb disturbances, systematically undertake recovery activities and implement relevant changes to reduce future disturbances, while improving a system's function and maintaining structure (Bhamra et al., 2011; Bruneau et al., 2003b). Research into the resilience concept, particularly as related to post-disaster reconstruction indicators, has increased considerably over the last decade, however, the strategic relationship between resilience factors and applicable measures has received little attention and has not been fully established.

This research garnered information from a cross-sectional data capture. This one-time analysis is important for situation analysis, and to understand the eminent gap to mainstreaming resilience in project management practice. Conclusions from the analysis in previous chapters suggest a major gap in the strategic application of resilience factors and an acute absence of resilience measurement indicators. Earlier in section 8.1, the possibilities for developing resilience measures were discussed, with the assistance of the sub-critical resilience factors listing. Observations from the literature reviewed showed that resilience measures introduced are generally reactive, and do not appear to be aligned to strategic long-term resilience development against underlying socio-economic conditions and built systems deterioration issues. This reactionary approach relies on impromptu responses to an observed issue, and occurs when the relationships among the resilience factors are unknown or largely fragmented. This gap is somewhat sustained in two parallel bodies of literature, where resilience orientations are biased to either proactive measures (eg. (Oien & Nielsen, 2012;

Sousa et al., 2006) or reactive measures (e.g. (Di Gregorio & Soares, 2017; Norris et al., 2008). Filling this gap can significantly assist in mainstreaming resilience into project management practice. It is recommended that there is a development of a guiding framework with particular emphasis on promoting the continuous assessment of resilience measures that are aligned to strategic resilience factors for the built environment. The framework should address and explain the selection of resilience measures in such a way that the average end-user can apply the tenets of the framework to any prevailing condition or project.

Built environment resiliency in this thesis connotes the ability of the built environment to maintain functional fitness and provide a supportive role to the other pillars (natural, economic and social) of the community's existence (Bosher, 2014). Though varying pathways can be advanced to mainstreaming resilience in reconstruction, this thesis acceeds to Mohamed et al. (2019) combined characterisation of resilience as anticipation, absorption, recovery and adaptability, and draws on the 'adaptive capacity' theory in combination with the principles of the complex adaptive systems approach (CAS) to bridge this gap. The application of the CAS approach serves to continuously assess resiliency status to proactively address the community's systems planning, construction, reconstruction and maintenance programmes. This approach to disaster management follows Janssen and Ostrom (2006) recommendations on continuous adjustments (structural and non-structural) in response to actual, perceived, or expected 'environmental' changes and their impacts. Such relevance to maintaining a community's structure ascribes pivotal roles to the wider resilience factors as disaster management practitioners and policymakers conjure the resilience indicators associated with governance, innovation, reconstruction approaches, resource management and stakeholder management in eveyday resilience policy settings, project planning, and project execution (refer to Table 3.1).

Notwithstanding the novelty of this integration for the built environment, it is hypothesised that through an underlying CAS approach (Aritua et al., 2009) applied in all facets of development adaptations, particularly reconstruction and recovery, it can lead to significant improvements in the overall built resiliency movement. Figure 8.7 proposes an adaptive capacity conceptual framework with the application of the CAS principle for the continuous assessment of resilience factors and how they can strategically assist in explaining resilience measure selection. Fundamental to the applications of resilience measures are the guiding factors operating within the relms of the four-stage CAS evaluation process for the built environment's adaptations. The CAS approach's cross-cutting influence are fed with relevant data on the required progressive changes among the community's characteristics (e.g. demographics, investment opportunities, social adaptations, etc…), and their developmental prospects with the intent to accommodate potential built system's robustness capacity scaled improvements. Resilience measures that influence new design standards or modifications to existing built components are transformative in nature and should be guided by context-specific policies, procedures and standards.

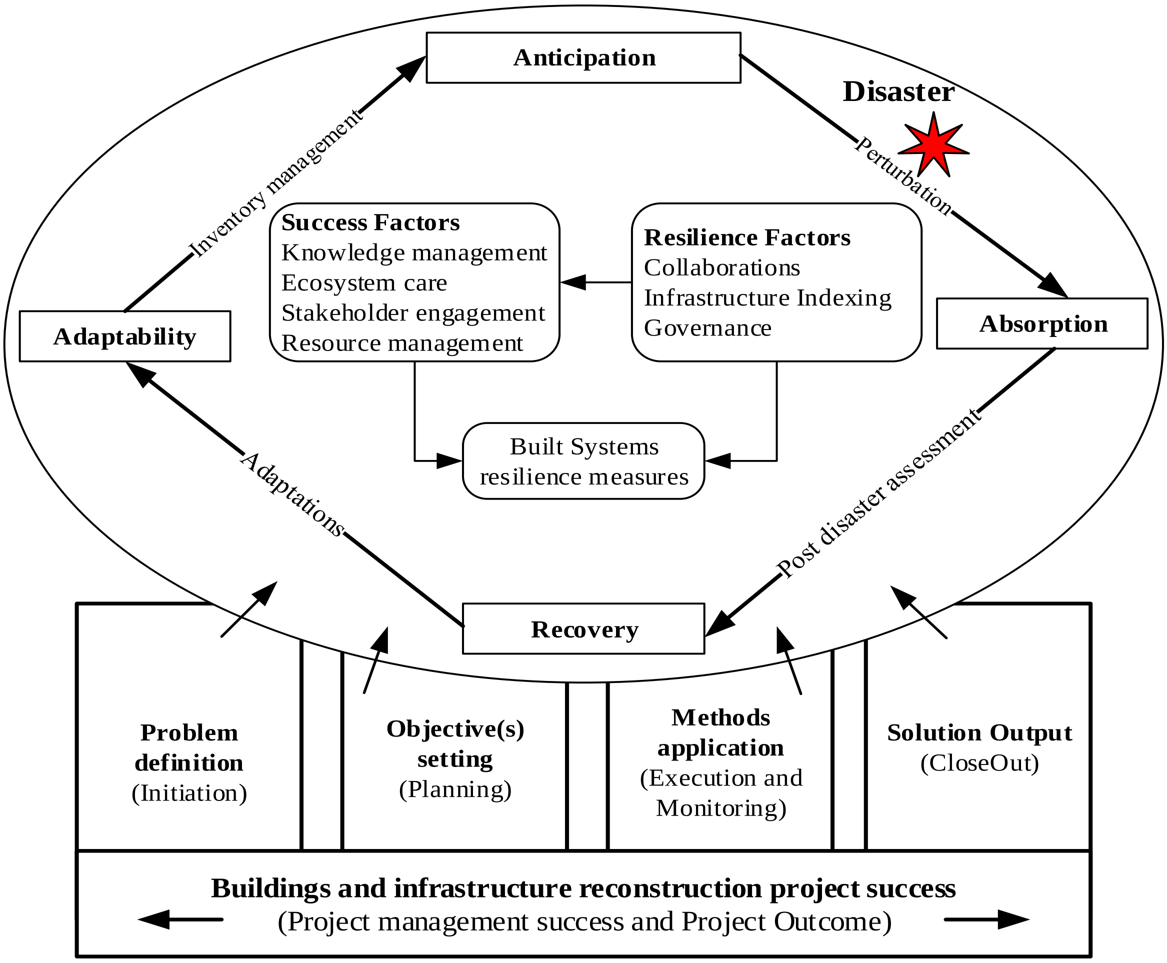


Figure 8.7 CAS approach framework for built environment resilience

The adaptive capacity theory thrives on progressive leadership styles for maining an inventory of likely solutions to unforeseen problems and unpredictable variations (Engle, 2011), which is postulated to be insightful for disaster managers and policymakers. The CAS technique encourages an understanding of actual or potential chaos arising from unmanaged complex interactions of networks, structures and patterns with aims of guiding reconstruction practices, policies and procedures for improvements (Folke, 2006).

This framework offers a wholistic approach to built environment resilience. With reference to the four-stage continuous process of the framework, several empirical initiatives and solutions seem to have dominated the ‘absorptive’ and ‘recovery’ literature. However, mechanisms to foster disaster ‘anticipation’ and ‘adaptability’ are still under-researched. The proactive development of a procedural mandate, which ensures equal attention to the four-stage CAS approach, should guide all pertinent reconstruction resilience strategies, guide individual and departmental roles and responsibilities with continuous assessment and reporting, and guide evidence-based policy decisions, especially in fragile economies. The framework’s effectiveness relies on the ability to operationalise the four stages with a centralised data repository foundation, which can support the advancement of adaptive capacity modelling. Prior to this thesis, quantifying resilience has been a challenge (Angeler & Allen, 2016) and in the absence of proper measurement indicators, some researchers have supported modelling ‘resilience surrogates’ for understanding and addressing system-wide resilience. However, most surrogates (e.g. trust, communication, cooperation) concentrated primarily on specific cause and effects (Bennett et al., 2005; Carpenter et al., 2005). It is therefore advanced in this thesis that actual resilience measures can be developed and be used to model resilience of the built environment (refer to section 8.2.4), and serve as direct input in project management practice. Operationalising this framework offers a more ingrained approach into complex systems modelling that leverages actual resilience measures, not surrogates, to include facets like historical hazard profiling, stakeholder involvement, and computer-aided models to better understand, and also mainstream, adapatibility and anticipation aspects of resilience development, as part of a comprehensive approach.

8.11 Proposed framework’s reliability: Expert judgement

Confirming the quality of reseach findings is a critical validation step in the research process. With reference to Figure 8.5, the results obtained from achieving the research objectives, which included systematic literature reviews, four case studies with questionnaire surveys and interviews in four Caribbean islands, and developing a practical approach to mainstreaming the resilience construct into project management practice, there is a need to validate the reliability of the findings and recommendations. Evaluating scientific validity is a process using methods such as experiment and observation. However, validity of this thesis resilience development framework and the resilience factors’ applicability in the post-disaster reconstruction context, when applicable data for more objective assessment is absent, expert judgement with interrater endorsement can assist with obtaining approval. As such, group expert judgment with statistical techniques has assisted with quantifying subjective or qualitative data in an objective and systematic manner. In the absence of data that is specific to a project, most construction simulation models depend on historical data collected either from other projects or from expert judgement. Cooke and Goossens (2000) describe the technique as enhancing rational consensus. This research applied the structured expert judgement technique.

In this research, the researcher employed group expert judgment and statistical techniques to assess the reliability of the proposed subjective framework in a systematic way, aiming to reduce subjective bias with assessing agreement among the industry experts. To reduce any potential bias arising from the researcher or any individual judgment, a questionnaire was sent to Caribbean experts (refer to Appendix 12). The experts (project participants) were randomly chosen through a peer-request questionnaire distribution targeting persons at the project design and management levels. Two assessments were conducted, namely: 1) level of agreement with the assertions of the research recommendations among the respondents and 2) level of agreement among two named groups among the experts. Five questions formed the bases of the data capture. The researcher divided the participants into two groups for generating an inter-rater reliability assessment. The first group was labelled ‘Engineers’ and the other was ‘Non-Engineers’, comprising consultants, academics, project managers, and contractors.

With reference to the framework of Figure 8.5, the five statements or questions, called variants, were asked of the experts’ judgement to solicit their level of agreement. Their level of agreement was assessesed on a five-point agreement scale, being 1-Disagree, 2-Somewhat Disagree, 3-Neither Agree nor Disagree, 4-Somewhat Agree and 5-Agree. Further details can be found in Appendix 12, with the central theme of the variants. Table 8.8 lists a summary of the variants.

Table 8.8 Statements (variants) requiring agreement assessment

Variants	Description
#1	The factors identified in the framewok represent the pertinent issues challenging resilience
#2	From experience, the potential impact on resiliency if the relationship depicted in the framework holds true
#3	Are there resilience mainstreaming possibilities through adopting this framework?
#4	The end-user’s project success assessment indicators as adaptability and competence
#5	The framework’s ability to assist with the development of policy standards.

Level of agreement among raters on the variants

Thirteen experts expressed their agreement level on the five variants in the survey. The raw data responses are listed in Appendix 12. The responses are coded as 0-Disagree and 1-Agree for the simple purpose of calculating the percentage agreement, using the traditional method. Table 8.9 shows the coded responses of the experts' agreement judgements, and the corresponding percentate agreement on the variants. A '0' value corresponds to a 'Disagree', 'Somewhat Disagree' or 'Neither Agree nor Disagree' response, while a '1' reflects either an 'Agree' or 'Somewhat Agree' rater's response. The output of this traditional method shows almost perfect agreement of the experts across the variants, except on Var#2 with 85% agreement.

Table 8.9 Summary of responses and conventional calculation of percent agreement

Expert ID	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**Raw % Agreement**
*Expert type **	*C*	*E*	*E*	*E*	*C*	*A*	*E*	*E*	*E*	*S*	*P*	*S*	*E*	
Var #1	1	1	1	1	1	1	1	1	1	1	1	1	1	100%
Var #2	1	0	1	1	1	1	1	1	1	1	1	1	0	85%
Var #3	1	1	1	1	1	1	1	1	1	1	1	1	1	100%
Var #4	1	1	1	1	1	1	1	1	1	1	1	1	1	100%
Var #5	1	1	1	1	1	1	1	1	1	1	1	1	1	100%

** A: Architect, C: Consultant, E: Engineer, P: Project Manager, S: Construction Supervisor*

Level of agreement among inter-expert groups on the variants (Engineers vs Non-Engineers)

While the conventional method provided an agreement measure among the experts, the method does not factor in errors due to chance. With reference to McHugh (2012) approach and measurement scale, the Kappa coefficient statistic provides a more accurate agreement measure by removing error responses due to chance, and it is generally thought to be a more robust measure than the traditional simple percent agreement calculation. Kappa usually employs one of two measurement methods: Cohen's kappa or Fleiss' kappa. For this analysis, the Fleiss' kappa proved more appropriate as Fleiss' kappa assumes the raters are randomly selected from a specified group, while Cohen's assumes the raters are specifically chosen (Kılıç, 2015). The experts in this agreement analysis were randomly selected from the Caribbean experts' group. Table 8.10 provides a typical guide summary of the inter-rater agreement scale as aligned to the result of the kappa statistic.

Table 8.10 Interpretation of kappa values

Level of value of kappa	Agreement	% of data that are reliable
0 - .20	None	0-4%
.21 - .39	Minimal	4-15%
.40 - .59	Weak	15-35%
.60 - .79	Moderate	35-63%
.80 - .90	Strong	64-81%
Above .90	Almost Perfect	82-100%

Adapted from McHugh (2012)

For a more detailed analysis of the agreement levels, the experts were divided into two distinct groups: Engineers and Non-Engineers. The raw data from the questionnaire survey (refer to Appendix 12) were agregated and coded into binary responses to represent the two groups. Table 8.11 shows the aggregation and coding using the guide provided in Table 8.10 above.

Table 8.11 Raw data conversion to binary agreement assessment

	Raw data [a]		% of reliable data [b]		Agreement [c]	
	Engineers	***Non-Engineers***	***Engineers***	***Non-Engineers***	***Engineers***	***Non-Engineers***
Var #1	4.4	4.5	0.90	0.90	Almost Perfect	Almost Perfect
Var #2	3.9	4.3	0.77	0.87	Moderate	Strong
Var #3	4.3	4.7	0.86	0.93	Strong	Almost Perfect
Var #4	4.3	4.5	0.86	0.90	Strong	Almost Perfect
Var #5	4.6	4.7	0.91	0.93	Almost Perfect	Almost Perfect

Note:

a: The mean values of the two groups from the five-point Likert questionnaire measurement scale on each of the variants

b: The corresponding percentage data reliability according to McHugh (2012) scale (refer to Table 8.10)

c: The corresponding agreement description according to McHugh (2012) scale (refer to Table 8.10)

Using the Fleiss kappa statistical coefficient to measure the true agreement values, while compensating for chance probability from the experts' responses, the results point to a 42.9% agreement level that is not staatistically significant ($p>0.005$) at the 95% confidence interval. According to McHugh (2012) interpretation, this represents a weak agreement between the two expert groups. The kappa value also returned a negative value indicating the two groups agreed less than expected just by chance: in other words, greater disagreements than expected, even though the differences in agreements are on the positive side of the measurement scale. Figure 8.8 shows the results of the analysis using the SPSS aoftware.

Table 8.12 Analyis result using Fleiss kappa method

Overall Kappa

	Kappa	Asymptotic standard error	Z	P Value	Lower 95% asymptotic CI bound	Upper 95% asymptotic CI bound
Overall	-.429	.447	-.958	.338	-1.305	.448

Interpretations

a. The Engineers' group assessment suggests that there is almost perfect agreement on the factors identified (Var #1) and the framework's potential for policy development (Var #5). While there is strong agreement among the Engineers on Var #3 and Var #4, Var #2, moderate agreement suggests that they are not optimistic based on experience with reconstruction projects and the proposed framework.

b. Within the Non-Engineers' group assessment, there is almost perfect agreement on all variants except on Var #2. There appears to be a slight doubtful outlook when matching their experience with the proposed framework.

c. With the between-group assessment, there are general agreements among the variants. A closer analysis shows agreements between the group of experts are not 'almost perfect' across the five variants. The groups in principle agreed that the factors identified in the framework are pertinent to the Caribbean (Var #1) and the framework can be instrumental in the development of policy standards for reconstruction and the industry. However, slight disagreements exist with Var #2, Var #3 and Var #4, which correspond to benchmarking the framework's potential to experience, the framework's potential to mainstream resilience and end-users' project success indicators, respectively.

d. Resiliency particulars and development in construction and reconstruction projects may have been interpreted differently by the stakeholders in the Caribbean. This suggests the need for programmes that can enlighten and train the region's stakeholders on the fundamentals, its application and potential outcomes in the rollout of resilience development strategies and mainstreaming its practice.

8.12 Mainstreaming resilience in project management: Recommendations

8.12.1 Policy considerations for the Caribbean based on research findings

This research focused on Caribbean end-users' perspectives and assessment criteria for post-disaster reconstruction projects. Several aspects of resilience development were explored. First, resilience regarding post-disaster reconstruction was analysed from the points of views that included: knowledge management, ecosystem care, stakeholder engagement and resource management. Overall, the research points to a deep desire for proper governance policies and mechanisms to ensure that resilience is central to the application of the success factors. To this end, the following policy directions are recommended for germinating and maintaining a resilience-oriented attitude for the construction and reconstruction industry in the Caribbean.

Policy recommendation #1: Project management and construction activities oversight

a. Project management as a practice is not structured in the Caribbean, and is also not a firm pre-requisite before project execution. While stipulations for a project plan are often required for international donor-funded projects, on the local level, the requirements are not fully enforced. Recommendations for a detailed project management process include planning (appraisals, feasibility, and preliminary design studies), design specifications (final designs), and construction execution from inception through completion should also be approved by the client, and if necessary, the financier.

b. There is insufficient oversight of approved projects during construction. In the region, after approval is granted, the construction work roll-out is left up to the contractor's honesty to follow the approved designs. Establishing a structured project review process to ensure effective oversight from project start through to completion is recommended. The process will entail documented procedures and processes, with expectations at project milestones. While this can be implemented easily at the national level, it is anticipated that an uptake at the local and personal level can be somewhat challenging at the beginning.

c. There is a need to make construction management knowledge more present and easier available in the region. Construction management and project management are disciplines requiring specific knowledge and skillsets, towards, at minimum, keeping abreast with the dynamic world of construction and reconstruction. It is recommended that the local and regional institutions develop programmes that promote modern construction management, including suggested modern alternatives to facilitate new regulations and sustainability issues. Also, at the local level, mandatory training programmes that incorporate basic project management and stakeholder engagement strategies should be developed and required of contractors who offer their services to the general public.

Policy recommendation #2: Skills outsourcing

a. While the region suffers from a diversity deficiency in construction skills, probably due to the relatively small population at the local and regional levels, and the absense of structured training programmes, this does not negate the responsibility to provide technically sound projects to the populace. Recommended as part of the project's development plan is an identification of skills necessary for construction tasks. First, scouting at the local then regional level should be the initial search. For extra-regional level scouting, the regional governing body, such as CARICOM or the OECS, should develop an electronic portal that advertises for required construction-related skills and assists applicant vetting, if skills are not available within the region.

b. Outsourcing offers several opportunities for cost management and innovation, as well as disenfranchisiment of the local work force, especially with large reconstruction projects. Stringent policies should be established at national and regional levels that clearly outline the conditions for outsourcing and proportions of work to be outsourced. There are two salient benefits to be derived: 1) the local workforce can be employed, and 2) the possibility exists for skill and knowledge transfer.

Policy recommendation #3: Legislative support

Notwithstanding that every island in the Caribbean has taken steps to have a National Building Code, their genesis makes primary reference to seismic response. While acknowledging the diversity of construction influences and building design types, it is incumbent, at the national level, to legislate for compliance. Notably, the northern Caribbean islands are influenced by American construction styles, and the southern Caribbean continues to pattern designs according to their respective English, French or Dutch colonial occupants. Adherence to normal building code procedural stipulations are encouraged; however, a chronic form of negligence looms over the industry. Also recommended is the following: the drafting of a legislative template for adoption throughout the region that makes provision for individual country-code systems, but places legal obligations to appoint agencies or authorities to: 1) police the observance of national building standards, 2) ensure or mandate the continuous adherence to long-term objectives set for the construction industry, 3) ensure that cultural norms are not adversely violated, and 4) ensure land development plans are adhered to, especially with the development plans that are influenced by hazard mapping.

Policy recommendation #4: Client protection contracting

Contracting services in the Caribbean region require urgent attention. In most instances, contracts are loosely made without any legally binding arrangements. Often times, the client or end-user suffers the consequenses of poor workmanship, without legal recourse. The industry offers different contracting approaches, and uses a variety of contracting methods to acquire materials and labour. As a resilient development mechanism, the protection of the client ensures placing a sense of responsibility onto the contractors to ensure adherence and compliance to national laws and industry standards. It is recommended that there be an establishment of clear procedures, and a central repository and portal for contract-specific templates that clearly outline prerequisites and established terms of payment disbursement and award of contracts. An important component of the portal will be to have a lessons-learned section for educating on the strengths and weaknesses with the application of some contract approaches.

Policy recommendation #5: Community engagement

It is generally recognised that a return to normalcy is the foremost desire in the aftermath of a disaster. As such, the chaotic recovery setting does not guarantee effective community meetings or clear thinking processes for objective setting related to strategic reconstruction projects. Policies that guide continuous strategic community engagement that informs and educates on trending building and construction practices, materials and alternatives are recommended. This strategy assists with improving community members' confidence, especially when scenario planning is part of the discussions. Having intrinsic knowledge on the preferences of the community before a disaster augers well for post-disaster rebuild with resiliency and satisfaction.

Policy recommendation #6: Adaptive capital and maintenance programmes

Having acknowledged the complex adaptive systems (CAS) approach as a viable mechanism to sustain a resilience development movement, and the researcher's own experience as a Caribbean citizen, adopting the four iterative activities of the approaches framework (refer to Figure 8.7) highlights the need to continuously monitor existing policies and assist in developing new ones. Making CAS central to policy decisions in disaster management discourse, particularly in the development of short-, mid- and long-term community goals, can yield positive results with prospecting for future generations. The establishment of procedural theme assessments and reporting on key buildings and infrastructure according to the CAS approach is recommended. The themes are: absorption capabilities, recovery plans, adaptable possibilities to include modifications, and anticipation by way of preparedness and mitigation plans. In principle, the iterative assessment will assist with hazard identification and mapping, disaster management plans and procedures, retrofitting and other methods of resilience improvement, and inventory management in anticipation of the next disaster. This approach may significantly mimimise the damage to buildings and infrastructure, thus minimising post-disaster reconstruction time and costs.

8.12.2 Resilience contribution to project management

According to the Merriam-Webster online dictionary, 'mainstreaming' is associated with 'a prevailing current or direction of activity or influence'. The concept of mainstreaming resilience into project management practice conjures the notion that resilience is not a default attribute of the practice and needs to be incorporated. Mainstreaming as an actionable phenomenon can be applied within the industry on either horizontal or vertical levels. The application of the resilience concept has been explored within the operational sphere of several disciplines on horizontal levels, such as Giuliani et al. (2016) considerations of resilience in five sectors: the environmental, institutional, economic, social and technological, and also Seneviratne et al. (2010) considerations of resiliency in eight sectors: the social, environmental, technological, functional, economical, institutional, legal and political. When the successes of the resilience concept's application are replicated across sectors, it is referred to as horizontal mainstreaming. Vertical mainstreaming therefore refers to the concept's introduction into administrative, policy and legislative procedures that guide the direction of influence.

Mainstreaming resilience into project management practice should adapt both horizontal and vertical incorporation to become effective. The framework (Figure 8.7) promises to strategically support multiple administrative vertical levels of resiliency infiltration, while supporting industry-wide, interdisciplinary, and cross-sector collaborations on resilience objectives. Within project management practice, resilience should be levied vertically through the five phases of the project's life cycle: initiation, planning, executing, monitoring and control, and closeout. Its application from the horizontal perspective pertains to the eight knowledge areas of project management: integration management, scope management, cost management, quality management, resource management, communications management, risk management, procurement management, and stakeholder management, and the additional recommended innovation management. Due to the dynamism of the construction industry and the continuous search for more efficient and effective resilience techniques for affecting work processes and products, this thesis advocates for a new addition to the project management list of the knowledge management area to be 'Innovation Management'. The following has been advanced: innovative ideas and testing should be an ongoing activity within project management, for refining or modifying traditional practice to accommodate modern resiliency expectations. Mainstreaming resilience will therefore require a guiding strategy for both its horizontal and vertical levels incorporation.

8.12.3 'Innovation management' as a new project management knowledge area

The CSFs and CRFs identified in this research accede to project management knowledge areas and associated principles as the 'vehicle' to successful project rollout. Using the *Project Management Body of Knowledge: PMBOK Guide* (PMI, 2017) as a reference to these knowledge areas and principles, the critical and sub-critical success and resilience factors (refer to Figure 8.1 and Table 8.1) are all aligned to the project management knowledge areas. Noticeable during the review process in Chapters 2 and 3 was that the success of several projects has been attributed to a creative technique or process improvement strategy originating from a novel idea, with a convergence on safety management, e.g. (Murphy & Nahod, 2017; Sing et al., 2016). For the purpose of this thesis, novel contributions are termed innovations. The consideration of innovations as a project management knowledge area stems from the notion that if current knowledge areas such as time, cost and risk are conduits for planning, managing, and monitoring project activities for success, then innovations can also be likened to such success conduits. Ehrbar (2016) and Oke et al. (2017), who have affirmed the positive results from adopting new methods and paradigms to achieving project success, support this assertion.

Project management knowledge areas are not static. Only recently, stakeholder management and resource management have been added as new knowledge areas in the sixth edition of the Project Management Institute's (PMI) signature guide book (PMI, 2017). Varajão (2016) recommended a discussion and subsequent inclusion of 'success management' as a new knowledge area. Table 8.13 shows the changes in knowledge areas covered by the PMI over the past 17 years. With reference to the descriptive structure of the already eight confirmed knowledge areas, as identified in the PMI guide book, possible subcomponents of the 'innovation management' area can include;

- Plan innovation
- Acquiring innovation
- Integrating innovation
- Managing innovation

Table 8.13 PMI management knowledge areas (2004-2017))

Project Management Knowledge Areas				
Edition	3rd	4th	5th	6th
ISBN (978)	1-93069945-X	1-933890-5-17	1-935589-67-9	1-62825-184-5
ANSI (PMI)	99-001-2004	99-001-2005	99-001-2013	99-001-2017
Year published	2004	2008	2013	2017
Confirmed Knowledge Management Areas				
Integration management	√	√	√	√
Scope management	√	√	√	√
Time management	√	√	√	-
Cost management	√	√	√	√
Quality management	√	√	√	√
Human resource management	√	√	√	-
Communications management	√	√	√	√
Risk management	√	√	√	√
Procurement management	√	√	√	√
Stakeholder management	-	-	√	√
Schedule management	-	-	-	√
Resource management	-	-	-	√
Suggested Knowledge Management Areas				
Success management	-	-	-	(Varajão, 2016)
Innovation management	-	-	-	**This Thesis**

As alluded to earlier, recent industry trends indicate the need for innovative techniques and tools in diverse sectors within the industry. Innovative solutions affect relatively all aspects of construction practice and therefore, require the attention of stakeholders for their selection and application. The need to acknowledge innovation as a project management knowledge area traverses all the success and resilience factors towards improving their efficient and effective execution. Similar expositions on innovations being critical to modern construction practices have been elaborated upon (Björnfot & Jongeling, 2007; Shan et al., 2017). Additionally, innovation as a dynamic knowledge area encompasses the non-abstract aspects of a project's practicality and technology uptake (e.g. (Mahalingam et al., 2010; Oke et al., 2017), and the abstract inclinations of sustainability and satisfaction (e.g. (Fahri et al., 2015; Ozer, 2014). The combined effects of abstract and non-abstract techniques to project development and execution can be summarized as the innovative ideologies and methods to modern project success.

8.12.4 A method to mainstreaming resilience

The method proposing to mainstream resilience is a three-component rubric that seeks to guide practitioners on the strategic application of the resilience factors. Demonstrated in Table 8.14, the critical subfactors of both success and resilience are aligned to the project management knowledge area and the likely project phase where it is most applicable. Embedding the factors' application within the project management structure serves as a checklist to ensuring that the resilience concept continues to be a strategic solution to realising more resilient built systems. Table 8.14 provides a strategic guide to applying the three-component rubric: 1) project phases, 2) project management knowledge areas, and 3) success and resilience factors for post-disaster reconstruction projects.

Table 8.14 Application of sub-critical success and resilience factors in project phases

	Project cycle / Phases									
	Initiating		**Planning**		**Executing**		**Montoring and control**		**Closeout**	
Project Management Areas	*SCSF*	*SCRF*	*SCSF*	*SCRF*	*SCSF*	*SCRF*	*SCSF*	*SCRF*	*SCSF*	*SCRF*
Integration management	KM1									
Scope management		CO1	KM4 EC1 RM4	CO6 IX2	RM2	CO6	RM5	CO6		
Schedule management			SE3	CO2 GO1	SE3 RM2	GO2	SE3 GO7	GO2		
Cost management			SE3	CO2 GO2 GO5	SE3 RM2	GO5	SE3 GO7	GO5		
Quality management			KM6 RM4 RM5	CO5 IX1 IX4	EC1 EC3 RM6	CO5 IX1 IX2 GO6	KM6 EC3 RM5	CO5 IX3 GO1 GO6		
Resource management			KM1 KM2 KM3 EC2 EC3	CO2 GO1 GO5 GO6	KM5 EC2 RM2 RM3	CO2 CO3 IX1 GO6 GO7	EC2 RM2	CO3 CO4 IX3 GO6		
Communications management	SE2	CO6	SE2 RM6	GO2 GO3 GO5	KM2 RM1 RM3 RM6		SE2 RM6	IX5 GO5		
Risk management			SE3 GO6	CO2 IX4 IX5 GO3	KM6 SE3 RM2 RM6	IX5 GO6 GO7	SE3 RM5 RM6	CO4 GO3		
Procurement management			EC3 RM4	CO2 CO5	KM2 RM2 RM4	CO2 CO5 GO4	RM4			
Stakeholder management	SE1	CO1 CO6	SE1 SE2	CO1 CO2 CO6 GO3	KM3 SE1 RM1 RM3	CO1	SE1 RM1	CO1 CO4	SE1 SE2	CO1 CO6
Innovation management			KM5	IX4 GO6 GO7	KM5 RM3	KM5 GO6 GO7		IX4 GO6 GO7		

***Note**: Management areas are congruent with PMBOK 6th ed (PMI, 2017) with added 'innovation management'*

***SCSF**: Sub-critical success factor, **SCRF**: Sub-critical resilience factor*

Factor assignments are not exhaustive, and can be contextually applied based on project's objectives

Chapter 9: Conclusions

9.1 Summary of the research

This research followed the pragmatic research methodology, which is an established methodology with a philosophical orientation that appears to be somewhat superior to the other three leading philosophies due to its ability to leverage its positives. These positives include: theorising through reductionism, analysing an entity's or process' subjective nature by understanding its behavioural properties and offering an assessment of the internal structure of a person or process to help in determining and improving its behaviour. This methodology has proved useful in previous construction-related research (Scott, 2016; Wuni & Shen, 2019). The design of this research was aligned with the methodological structure proposed in Figure 1.1.

9.2 Review of objectives

In Chapter 1 (section 1.5) of this thesis, the objectives of this research were outlined to guide the development of a pathway to incorporating resilience in project management practice for disaster reconstruction projects. To help achieve this, the following seven objectives were recognized:

Objective #1: ***To investigate the factors that contribute to successful outcomes for normal construction projects and draw on applications to post-disaster recovery projects.***

This objective was achieved using a systematic review approach in regard to the literature on success factors for managing residential building and infrastructural reconstruction projects. The review identified 26 project success factors that were further categorised into 11 project success categories using the open-coding method. The review points to new dimensions of project success, suggesting that new factors have evolved and been added to the traditional mainstream operational success factors. It was observed that in addition to the triangle 'cost, time and scope' targets in conventional project management, pursuits of project's sustainability, maintainability and 'fit for purpose' have become increasingly important to end-users. Existing project success frameworks were also identified. The review revealed newly observed success criteria, namely client and end-user satisfaction, project sustainability, technological adaptation, and change management, which characterise the application of new success factors.

As the involvement and expectations of industry stakeholders have grown, especially with clients and end-users, the demand for successful projects has also grown proportionally. This objective provides insights for project stakeholders and researchers about how the practice of project management could evolve to address these increased complexities for all project sizes. While addressing this objective, key outcomes were the realisation of the scant considerations of relevant stakeholders' views, the infrequent investigation and observance of non-operational success strategies, and the care that is required in contextually applying success strategies.

Objective #2: ***Understand project end-user perceptions of successful projects.***

This objective elicited and analysed the perceptions of project end-users regarding project success. A questionnaire survey investigation into 26 empirical success factors having the potential to affect building and infrastructure reconstruction project outcomes was performed through a study of interrelationships, using the factor analysis technique. These empirical factors were initially ranked according to the perceived importance by the end-users, using the mean score across the factors on all 268 respondents. Following the factor ranking, factor analysis produced four composites of correlated factors that emerged as the critically new success factors from the perspective of the Caribbean end-user. These composites are Knowledge Management and Use, Environment and Ecosystem Care, Stakeholder Engagement and Resource Management.

The end-users' perceptions on project success appear to be significantly influenced by several recent global phenomena that directly affect end-users, including climate change, urbanisation and energy management. The findings, while achieving this objective, provide decision-making support to relevant stakeholders by expanding their understanding of the factors that add to more representative assessments on construction project outcomes, and therefore should be embraced as the critical factors that will serve as additions to the checklist in project planning and executing.

In satisfying this objective, the output also provides a framework for addressing and incorporating the end-users' expectations in planning post-disaster reconstruction projects. The four critical factors deduced from the analysis can be used to fact check the planning and implementation process for future projects, with respect to meeting and exceeding expectations. The objective accentuates end-user opinions; therefore, an argument can be had on the subjectivity of the responses and conclusions. However, these new factors can provide valuable assessment guidance and support to major project sponsors, donor agencies, and the project management team during all phases of the reconstruction process.

Objective #3: ***To investigate how prevalent resiliency has been central to reconstruction projects and its contribution to stakeholders' satisfaction***.

This objective was also realised using a systematic literature review. Resilience as an operational technique in disaster management was observed as becoming increasingly popular in post-disaster reconstruction, since 2011. This is mainly because of its potential to assist the built environment in maintaining stability during perturbation. However, transforming its concepts into practice remains mostly vague in the literature. The investigation identified 24 factors that were open-coded into five resilience criteria groups. The resilience strategies embarked upon have been deployed globally, and while some may not have yet been fully proven as successful, since the articles did not report on any post-implementation reviews, their description and expected outcomes conform to known disaster risk-reduction initiatives.

The topic of built systems resilience has received adequate attention in research and discussions, in so much as to recognise the diverse applications of the resilience concept. The investigation into this research objective indicates that the identification of the appropriate application of resilience strategies and factors in any reconstruction project must be conceptualised in relation to both the short-term and long-term strategic goals of the affected community. Thus, any reconstruction project's resilience initiative is reliant on an understanding of the desired project output, for allocating the scarce resources and the use of tactical project management techniques in this chaotic recovery period.

A significant output from this objective is a novel conceptual framework of resilience factors affecting project outcomes. Listed in Table 8.1, the factors highlighted within the three resilience categories emanate from the literature as distinct, yet interrelated, resilience factors. These factors formed the basis for further analysis on their criticality to reconstruction projects. The relationship among the factors suggests that there are synergistic opportunities in the wider resilience context. For example, the designation of an entity as critical infrastructure would have garnered influence from state and governance responsibilities to ensure citizens' health and safety according to stakeholder expectations. Consequently, it will drive innovations and reconstruction techniques based on available resources, including maintenance priorities.

Objective #4: ***Understand end-users' perceptions regarding what a resilient project means to them.***

This objective sought an understanding project end-users perceptions of resiliency. This objective was achieved using a survey questionnaire that solicited the resilience perceptions of Caribbean end-users, and subsequently, the responses were factor analysed to determine each factor's criticality and interrelationships. It was deduced from the responses that their concerns with resiliency in post-disaster reconstruction of building and infrastructure projects are focused on the impact on their social, economic and psychological survival. The factor analysis of 24 empirical resilience factors resulted in three new factor composites accounting for 57.689% of the overall variances between these new factors on project resilience. The first factor accedes to the essence of collaborations to include training and multi-stakeholder engagement. This factor emphasises the desires and expectations of the project end-users' involvement in all stages of project planning, designing and executing with an end game for meaningful stakeholder dialogue and capacity development. Critical infrastructure indexing factor is second. The idea of placing special attention on specific build systems, from a functionality perspective with supporting lifelines and socio-economic facilities, can influence strategic maintenance programmes and long-term development planning for critical buildings and infrastructure. Governance emerged as the third factor to improving the resilience of the built environment by way of the adoption and application of policies to guide reconstruction programmes, with effective support of the legislature or regulator. This factor also encourages a desire to be surrounded by institutions that support an atmosphere that makes technical advice and financial resources readily accessible, within the ambit of progressive policy determinations.

The importance of a resilient built environment has been explored in this objective's investigation, including the list of critical resilience factors influencing reconstruction projects. Further conclusions suggest that end-user perspectives are under-researched and have received little to no attention in the context of formulating a comprehensive resilience outlook within the industry.

Objective #5: ***To understand what the measurement indicators for end-users' expectations of project success are.***

This objective centred on researching the typical end-user's assessment criteria for successful project outcomes and expectations. As the social and economic improvement value of disaster reconstruction projects continues to be central to personal and community development, Caribbean project end-users and other global end-users will consciously or unconsciously exhibit a desire to measure project success, because it is vital to achieving comfortability and mental stability with their anticipation of future disasters. The importance of eight literature-identified empirical indicator outcome measures were ranked, according to the end-users' perspectives. Further analysis using a structural model to investigate any relationship among the indicator types revealed the critical success measures for end-users are competent project team members and an adaptive attitude to accommodate and dynamically adjust project objectives in line with stakeholders' interests.

Practically, industry practitioners and project managers should continually apprise themselves of imminent development trends. A reluctance to be familiar with the industry's advancements can exacerbate competency challenges, and their ability to be proactive with identifying and addressing both internal and external project influences and risk. The industry is continuously growing; hence, there is a critical need to ensure that education and training prominently feature in this era of technological transformation within the construction sector, to improve the adaptive capabilities of stakeholders and boost confidence levels of end-users. Though the research centred on Caribbean end-users and respective perspectives, the findings can be useful to the wider community of project developers and planners to strategically associate these measures with project objectives. While a number of lessons can be learnt from this objective, according to project end-users, the key measures to successful outcomes are safe and sustainable reconstruction projects that increase value by enhancing socio-economic stability.

Objective #6: *Determine the interrelations and the major contributors among the factors to assess and achieve end-users' success expectations.*

Critical to this objective was the initial development of a conceptual model that depicts the hypothesised relationships among success factors, resilience factors and success expectations. These relationships were summarised in three assumptions:

1. *There are significant relationships between project success factors and project success.*
2. *There are significant relationships between project resilience factors and project success.*
3. *There is a significant relationship between resilience factors and project success, when the relationship is controlled by project success factors.*

These hypotheses were analysed. The results showed: 1) there are significant relationships between success factors and success, 2) the relationships between resilience factors and success are insignificant, 3) end-user project success is measured with a combination of indicators and not necessarily on a single criterion, and 4) there is a significant relationship between resilience factors and success factors as combined predictors of successful resilient projects.

General conclusions are: 1) end-users are not highly sceptical of project cost as an assessment criterion, 2) knowledge management and use are significant components to project management, 3) stakeholder engagement should be all inclusive, and 4) governance is a critical resilience factor that transcends all project operations. Further assessment, shown in Table 8.7, confirms the unique contribution of effective governance with achieving improved resiliency in successful projects.

Confirming the interrelationship findings of the regression analysis, a structural equation modelling (SEM) analysis was also conducted. The SEM was applied to better explain the correlations among all the variables used in the regression analysis. The SEM confirmed the limited direct impact of resilience factors on project success, however, showed the significant impact they exhibit when used in combination with success factors (refer to Figure 8.4). The SEM also highlighted competency of project team members as biasing end-users' expectations in assessing project success.

Objective #7: To develop a guiding framework to serve as a pathway to mainstreaming resilience into project management practice for disaster reconstruction.

Satisfying this objective is at the heart of this research. The development of a hands-on pathway to mainstreaming resilience as a project management practice in post-disaster reconstruction projects is undoubtedly a needed addition to management actions for achieving positive resilient outcomes. The pathway to resilience mainstreaming, which was advanced in Chapter 8, relies on three principles: 1) accepting that resiliency, as a relatively new construct in the construction industry, needs to be supported by innovative methods and techniques, 2) adopting an approach that incorporates the resilience construct as central in the project's management cycle, and 3) mainstreaming an unambiguous method that can seamlessly integrate the proposed resilience development actions into 'everyday' practice, which is supported by the project management knowledge areas. These three principles encompasses the guiding framework to mainstreaming resilience, as presented in Figure 8.4.

9.3 Research contributions

Resilience perspectives of Caribbean project end-users have been formalised, with implications for adding to project management knowledge management areas and the associated body of knowledge. This contribution provides a guide to the essential considerations for the development of resilience indicators and embedding resiliency in project management practice. It has the potential to address a variety of issues in the reconstruction of buildings and infrastructure projects that have been largely under-investigated, in particular, the end-users' expectations. Though the data represents the opinions of Caribbean project end-users, the research findings and recommedations can provide both conceptual and procedural guidance to worldwide construction practice. More importantly, governments can apply this novel framework to revisit existing regressive policies and inform new construction-related policies towards an agenda that gives credence to the expectations of the wider stakeholder groups.

In this research, a clearer understanding of the relationships among reconstruction project success factors, resilience factors and success expectations were established, from the perspectives of the project end-users. It is well established that a global consensus on what constitutes a successful project is still debatable (S. W. Hughes et al., 2004); however, this research contributes to knowledge by revealing the success factors that appeal to project end-users' (beneficiaries) assessment criteria. It was also established that the disaster risk-reduction approach used to guide policies and construction practices for reducing the effect of damage to the built environment has not generated the intended outcomes and a disaster resilience approach uptake may yield more significant results (Aitsi-Selmi et al., 2015). However, the prime contribution of this research is the empirical illumination on the combined applications of success and resilience strategies that will significantly influence greater probability for successful projects.

The research's contribution to knowledge will assist the disaster recovery period by reducing the chaos that normally exists by quickly forming linkage between reconstruction scope and end-user expectations. It is anticipated that this linkage will lead to more informed project management practices and improved project planning and execution. As this area of study (end-users' contributions and expectations for project outcomes) is relatively under-researched, there is an encouraging scope for which this research can be a foundational resource. The traditional use of objective metrics (time, cost, quality) to assess project success suggests that traditional project success assessment was limited to project participants (e.g. engineers and contractors). However, the research output promises to widen the success assessment criteria to include factors that can be applied by end-users.

It is intended that the findings of this research will inform theoretical, practical and policy considerations to mainstreaming resilience in post-disaster project management. Contributions are summarised according to increased knowledge and practical considerations for reconstruction resilience.

Contributions to the body of knowledge

1. Evaluating project success has been confirmed to be beyond the traditional metrics of the ‘iron triangle’, and includes abstract assessment criteria such as satisfaction, sustainability and maintainability.
2. The findings of this research provide decision-making support to relevant stakeholders by expanding their understanding of the factors that add to a more representative assessment framework on construction project outcomes, and therefore should be embraced as the critical factors that will serve as additional to the existing checklist in project planning and executing.
3. The resilience approach addresses the internal structure of entities and the operational process for improving robustness to perturbation, unlike the risk reduction approach that focuses on external influences.
4. The development of a novel resilience factor framework seeks to strategically guide resilience improvements with context-specific applications.
5. The suggestion regarding the consideration and subsequent inclusion of ‘Innovation Management’ as a new project management knowledge area, speaks directly to an acknowledgement of the dynamism within the construction industry and a method towards ensuring technological infiltration is optimally managed.
6. There is a need to train key stakeholders on the resilience concept, including its application to reconstruction. This training could consist of development programmes and their rollout in the region’s tertiary institutions.

7. The knowledge gained from this research will assists the international community in three distinct, yet related, ways:

    1. It will support the objectives Sendai Framework for Action (SFA) with distinct possibilities to develop contextual measurable goals for its comprehensive implementation, as much as the resources in various global settings allows.
    2. It will support the buttom-up resilience approach that is projected as a more practical amd proactive approach over the top-down approach that do not necessarily engage the disaster affected people.
    3. Assist the humanitarian aid agencies, such as NZAid, AusAid, USAid, DFID, etc…, to be better guided and more provide informed aid packages for both technical and financial assistance.

8. The overall contribution to knowledge is the provision of an essential guide to resilience improvement and the development of applicable adaptive measurement indicators. The recommendations advanced have the potential to address a variety of issues in the reconstruction of buildings and infrastructure projects that have been largely under-investigated.

Contributions to the DRR or project management practice

1. This research advanced an understanding of the mechanisms and project set-ups that may lead to the success of construction projects. It is crucial for project managers to move beyond the task/process-based (objective) measurement of project success to include satisfaction/perception-based (subjective) streams to achieve the 'success' perceived by all stakeholders.
2. An inclusion of the resiliency factor in reconstruction projects extends safety measures beyond injuries and fatalities into economic, social and environmental safety management that promises to reshape project management into encapsulating the need for both technology supported work process innovations as a solution-finding continuum to steadily achieving construction project success.
3. The factors identified and their combinations can provide valuable information to major project sponsors, donor agencies, and the project management team during all phases in the reconstruction process. While these factors are representative of the Caribbean region, they can significantly assist

in the development of policies that shape the local and international construction industry regarding materials, sustainability and stakeholder satisfaction.

4. More importantly, governments can apply this framework to revisit existing regressive policies and inform new construction-related policies towards an agenda that gives credence to the expectations of end-users. The conceptual resilience framework presented in Figure 8.7 can provide the guidance required to assist in mainstreaming resilience practice.
5. The conceptual framework suggested can assist in guiding procedural arrangements at the management decision levels for reducing wastage resulting from competing programmes, maximising donated financial and technical resources and fostering psychological resilience among community members, government officials, policymakers and donor agencies.
6. From a disaster management prespective, the resilience-oriented Sendai Framework strategizes on the objectives of multi-risk analysis, effective planning for strengthening disaster risk governence, timely implementation of policies and mechanism towards people and asset protection, and continuous risk monitoring for risk treatment and policies and proceedures improvement. The heart of this research encompasses these four objectives. The practices of disaster management can significantly benefit from the solution offered to translate the resilience concept into resilience measurement indicators for more informed implementation and its continuous evaluations.

9.4 Research limitations

The findings presented in this research project can be applied in most jurisdiction and contexts, since the perspectives of project end-users' expected project outcomes may be similar and the solutions can be relatively generalised proactively adressing disaster management concerns. However, there are some limitations in this research process that must be considered.

- The data and perspectives featured are from the Caribbean region. The mindset of the end-users are framed relative to their socio-economic and cultural inclinations, and the prevailing political will to advance the disaster management agends. Therefore, these may not reflect similar conditions in other disaster-prone world regions.
- The general focus was on the reconstruction of disaster damaged buildings and infrastructure projects, in a post-disaster setting. These were investigated because of their direct impact on

individual lives and livelihoods after a disaster. Commercial and industrial projects were not investigated.

- The success factors elicited from the literature mostly reported on intended or anticipated outcomes. It is therefore unknown whether the degree of success achieved from the strategies applied differs significantly from the expectations. The literature on success factors for reconstruction projects are generally scant on reflexivity.
- Only English language studies were accessed in the research investigations. Therefore, care needs to be exercised in any notion that the success factors are comprehensive. The possibility exists that other project success factors, not discussed in this research, may be identified in non-English studies.
- A large percentage of articles were generalised in the context of the construction industry without specific references to a construction type or sector. The applicability of the factors identified are in principle generalised for the industry, however, there may be unique specificity of factors to particular sectors. Further investigations may highlight any factor's broad or limited application.

9.5 Further research directions

Though explored in several disciplines, resilience as a disaster management tool and its recent uptake in the construction sector (within the last two decades) show encouraging signs for its mainstreaming. It presents itself as a multi-sectoral and multi-faceted interrelational facility that traverses several phenomena that support the existence of people and entities. Some of these include social resilience, economic resilience, psychological resilience, and physical resilience. Looking into future, broader areas of research are recommended for its continued impact. These include exploration into:

1. comprehensive stakeholder management, as a project management governance requisite, to ensure that all stakeholders, including the end-users' satisfaction and divergent expectations, in the context of project's practicality and sustainability, are considered.
2. the application of technology in addressing the social, economic and environmental constraints in normal, post-disaster or post-conflict construction settings, with implications towards understanding the fundamental boundaries of the three settings for more effective project management.

3. an understanding of the degree of contextualisation required in adopting and aligning success factors to key reconstruction objectives.
4. the degree to which resilience factors and measures can be developed for global consensus, for making the applications of resiliency less imprecise, such that post-implementation assessment can be factored into preventative maintenance programmes that are required for budgetary and redundancy considerations.
5. reciprocal strategies and methods emanating from the other three pillars of a community's existence (social, natural and economic) that can influence the designs and compositions for a more resilient built environment.
6. the applications of resilience factors as an initial benchmark for developing a safety culture among construction planners and practitioners.
7. designing a foundational system dynamics model for understanding the real-time effects of applying resilience factors in reconstruction projects, or lack thereof, and the projected outcomes.
8. comparatively analyse the expectations of project participants on project success, with an aim to developing a more comprehensive project success outlook that will aid significantly with a global definition for project success.

9.6 Summary of thesis

Several attempts to operationalise the resilience concept were observed through the literature; however, the lack of a guiding framework, particularly for reconstruction projects, tantamount to guessing. Identification of appropriate resilience measures that are strategically aligned to resilience factors must be formulated in relation to both the short-term and long-term strategic goals of the susceptible community. Further research has been recommended as an exploratory start to establishing clearer indicators. Applicability of resilience factors is still quite imprecise at this time; therefore, its documented contextualisation and post-implementation assessment will assist with its refinement. This research identified gaps in gaining an improved understanding of resilience factors and their potential impact in achieving successful project outcomes.

Against the findings laid out in this thesis, the contextual identification and strategic use of resilience factors in managing diverse reconstruction projects should be of critical importance to all stakeholders, especially national and community project planners and practitioners. Recognising resilience as a relatively new phenomenon in the construction industry, mainstreaming resilience in project development and management practice proposes optimal success and sustainability outcomes. The benefits of resilient builds have been identified, and the future research suggestions also posit a relatively clear pathway for quicker and sustainable resilience mainstreaming. Notably, as the advancement of models and policies that can guide the adaptive development of resiliency ensues, the resilient built environment continues to gain increasing prominence as an essential support pillar for a community's existence. Absolutely clear from this research, governance as a management function traverses all project operations, if resiliency is to be achieved, and competency in all project responsibilites and tasks are consequential to positive outcomes.

The thesis offers immediate practical solutions to advancing the objectives of the Sendai Framework. Having concluded that the traditional metrics for measuring project success is quite limited and does not consider the wishes of the wider stakeholders, this thesis advances the process-driven resilience approach that accomodates new success metrics like satisfaction, and the determined engagement of the people affected by these disasters. Understanding what the people need by understanding their risks, strengthening disaster risk governance to manage those disaster risk, investing in disaster risk reduction for resilience, and enhancing disaster preparedness for effective response will benefit the local, regional and international community for improved resilience. While the thesis focus was on post-disaster reconstruction projects, it's recommendations can assist with conscious improvement in the world's fragile economies to be more independent in managing their disaster preparedness, response and rehabilitation.

Appendices

Appendix 1. Definitions of key terms used in this research

Construct / Variables	Definitions
Mixed methods	An integrated research approach that draws on the strengths of quantitative research (assessing magnitude and frequency of constructs) and qualitative research (exploring the meaning and understanding of constructs), framing the investigation within philosophical and theoretical positions (Creswell, 2009; Terrell, 2012)
Successful project	Reconstruction project success is achieved when there is continuous functionality of the built structure(s) in supporting the social, natural and economic recovery process, as they are component pillars of an inhabited environment, in the aftermath of a disaster (Le Masurier et al., 2006).
Resilience	The ability of a structure to absorb disturbance and maintain continuous functionality though being adversely affected by a hazard, then able to reorganise while its environment changes (Norris et al., 2008)
Project management characteristic	The efficient use of project management concepts and principles to maximise on the effective execution of project tasks towards achieving the project's objective to the satisfaction of all stakeholders (Mir & Pinnington, 2014)

Appendix 2: Summary of previous project outcome factors framework

Source (researchers)	Categorisation of factors	Framework/model description
(Schultz et al., 1987)	Strategic related Tactical related:	Project success hinges on three key factors in the strategic/planning phase and seven in the tactical/execution phase.
(van Duin, 1992 as cited in (Terwel & Vambersky, 2013)	Macro (External factors: Cultural/Socio-political/Economic/ Technical/Legal/Physical): Meso (Project factors: Safety/Controls/Risks/ Communication/Collaboration/ Planning/Knowledge/Instruments): Micro (Human factors: Technical and managerial skills/Attitude/ Mental and physical resilience)	Primarily focusing on structural safety, the success factors' categorisation emanated from this literature review draws on the notion that a structural failure may not be solely on engineering or personal deficiencies, but on external and organisational factors.
(Belassi & Tukel, 1996)	External environment related: Project manager related: Team member related: Organisation related: Project related	Rather than individualising success and failure factors, common themes are suggested with an aim to form associations at a top-level for easier factor relationship analysis and categorisation.
(Lim & Mohamed, 1999)	Macro (Users and Client related: Project objectives convergence): Micro (Project management and Contractor related: Time, Cost, Quality, Safety, etc…)	Projects as judged separately as successful or not, firstly by clients and users with regards to meeting the overall objective; considering the macro viewpoint, and secondly, by the developer and contractors in achieving operational competence; considered the micro level viewpoint.
(Chua et al., 1999)	Project characteristics related: Contractual arrangements related: Project participant related: Interactive processes related	The categorisation of 67 success factors into four project aspects; this hierarchical model accentuates the inter-dependency of factors in framing overall project success.
(Toor & Ogunlana, 2009)	Human related: Project related: Project management related: External environment related:	Aiming to capture the divergent interest of stakeholders to consolidate on the project's objectives by capturing the high-rated critical success factors into common themes.
(Thi & Swierczek, 2010)	Management competency related: Project members related: Environment stability (Economic, political or social contexts)	Building on the work of Belassi and Tukel (1996), this framework highlights the implementation stage as the most critical for determining project success, adding manager competences, member competences and external stability.

Appendix 3: Article relevance rubric for inclusion in literature review

Category	Description guide
Very relevant	• Very relevant to the topic • Established basis for future research • Key relevant literature cited throughout • Very updated/modern concepts and terminology
Relevant	• Supportive of the topic • Useful material for supporting or contradicting an argument related to the topic • Concept and terminologies may be outdated, but relevant
Marginally relevant	• Potential relevance to the topic • A narrow view of the topic • Research conclusion bordering the topic • Material content is somewhat time constrained
Irrelevant	• Abstract and title are good, but the content does not provide support to the topic • Outdated concepts

Appendix 4: Classification of construction industry stakeholders

Group/ Category	Stakeholder titles in included literature	% of articles containing the titles
End-user	General public, pressure group, non-governmental organisation, esteemed persons, dwellers (5)	3%
Client	Project owner, owners, government, government representatives, construction client, property developers, housing developer firms, building owners, developers, investors, public sector authorities, public owners, decision makers, government departments (14)	14%
Contractor	Contractors, grade 1 contractors, native contractors, experienced contractors, contractor representatives, construction companies, micro-scale companies, contractor companies, SME contractors, real estate professionals, contractors experienced in rail construction, sub-contractors, design-build contractors (13)	15%
Consultant	Consultants, senior executives, client consultant, experienced consultants, project organizers, consulting firms (6)	7%
Project manager	Project manager, construction managers, supervisors, SME managers, senior project managers, field supervisors (6)	13%
Practitioner	Managers, industry practitioners, industry professionals, industry experts, project members, engineers, designers, architects, quantity surveyors, professionals, builders, business chiefs, procurement specialist, lean practitioners, physical planning professionals, experienced public housing experts, PPP professionals, project financiers, government procurement officers, government officials, building professionals, planning engineers, informed seniors, government engineers, policy formulators, CEO, experienced construction experts, PPP experts, PPP practitioners, railway construction experts, specialist suppliers, field workers, design team, company managers, executives, planners, project management professional, project operatives, leading construction professionals, informal workers, experienced health care facility manager, alliance leadership team members, executives in DB projects, lawyers (44)	45%
Researcher	Academic experts, researchers, lecturers (3)	30%

Note: Stakeholder classifications informed by Stakeholder Identification Framework (Aapaoja & Haapasalo, 2014)

Appendix 5: Personal Information Sheet (Assisting Organisation)

ENGINEERING

Faculty of Engineering

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The University of Auckland
Private Bag 92019
Auckland, New Zealand

PARTICIPANT INFORMATION SHEET
(ORGANIZATION)

Research Project Title: **Building resilience into practice in managing disaster recovery projects**
Name of Principal Investigator/Supervisor: **Dr. Alice Chang-Richards**
Name of Student Researcher: **Shawn H. Charles**

Researcher Introduction

My name is Shawn Charles. I am a doctoral student in the Department of Civil and Environmental Engineering at the University of Auckland, New Zealand. My supervisors for this research are Dr. Alice Chang-Richards and Dr. Kenneth Yiu, both from the Department of Civil and Environmental Engineering.

Project description and invitation

You are invited to assist in disseminating an advertisement and the questionnaire survey for the research project titled **"Building resilience into practice in managing disaster recovery projects"** undertaken at the University of Auckland, New Zealand. The intended population for the survey are your organisation's subscribed or affiliated members who possess relevant knowledge and experience in post-disaster recovery projects. This research project aims to develop a guiding framework that can assist relevant stakeholders in ensuring that the residential and infrastructural re-builds are not only just restored but the essence of social, economic, environmental and technological resilience are incorporated within their reconstruction.

The information obtained, if your organisatoin agrees to participate, will be used solely for this research purpose. Your membership will be required to provide answers to an online questionnaire survey through a link in the attached email advertisement which we ask that you forward. We seek their best knowledge response in both their perspectives and experiences with post-disaster reconstruction projects. The researchers request your assurance that your members participation or non-participation will not affect their membership status nor the relationship with the organisation, which you may indicate on the consent form.

Why is the study being carried out?

This research output will make a substantial contribution to the body of knowledge by developing a guiding framework that can provide for improving the project management governance aspects of the reconstruction

projects. This will translate to reconstruction improvement by adding resilience as a practice within the rebuilding process for the post-disaster residential and infrastructural restoration projects.
The research seeks to answer the following questions;

a. What factors contribute towards achieving successful outcomes in disaster recovery projects?
b. What role can resilience play in post-disaster reconstruction projects?
c. How can the resilience concept be mainstream as a project management practice in post-disaster recovery construction project?

How is the study being conducted?

The study uses the online questionnaire survey methods of data collection. Professionals who have had managerial or supervisory responsibilities and relevant experience with post-disaster reconstruction projects for affected places worldwide are invited to participate in this online questionnaire survey. Your contribution to this research is the outreach to your membership base with the attached Participation Information Sheet and the accompanying link to the questionnaire.

Why are your members important to this research?

Your members tacit knowledge and experience will assist in;

a. The development a guiding framework that ensures resilience as a project management principle during all the stages of the project cycle.
b. Outputting successful projects with optimal solutions between cost, time, quality, customer satisfaction, safety and practicality, with the resilience factor for both near-term and long-term sustainable reconstruction.
c. Aid any proactive effort in ensuring that the necessary factors are considered and utilized in addressing a more resilient individual, community and country, through the strengthening of your built, social, economic and environmental habitat.

How is confidentiality addressed?

The survey does not request any personal or demographic details of participants. We are obligated in this research to ensure the survey responses are entirely anonymous. If any member opts to provide contact details, it will be collected separately with no association to the responses. Your members' contact information, if provided, is only for facilitating their request for a copy of the published results via email or post. The results of the research will be published in reports and/or academic journals.

Your organization's name and details will never be divulged to anyone, nor used in any written or published material from this research. All collected data responses and consent forms will be separately and securely kept in a locked cabinet on the University of Auckland, New Zealand premises, for a period of six years and then appropriately destroyed by February 2027.

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON __/__/__ FOR THREE YEARS. REFERENCE NUMBER: 022084

Appendix 6: Personal Information Sheet (End-User)

ENGINEERING

Faculty of Engineering

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The University of Auckland
Private Bag 92019
Auckland, New Zealand

PARTICIPANT INFORMATION SHEET
(INTERVIEW SURVEY)

Research Project Title: **Building resilience into practice in managing disaster recovery projects**
Name of Principal Investigator/Supervisor: **Dr. Alice Chang-Richards**
Name of Student Researcher: **Shawn Charles**

Researcher Introduction

My name is Shawn Charles. I am a doctoral student in the Department of Civil and Environmental Engineering at the University of Auckland, New Zealand. My supervisors for this research are Dr. Alice Chang-Richards and Dr. Kenneth Yiu, both from the Department of Civil and Environmental Engineering.

Project description and invitation

You are invited to participate in the interviews for a research project entitled **"Building resilience into practice in managing disaster recovery projects"** undertaken at the University of Auckland. This project aims to develop a guiding framework that can assist in ensuring that the residential buildings and infrastructural reconstruction projects are restored with social, economic, environmental and technological resilience. Resilience is described by the United Nations as the concept that quantifies an exposed system or community to resist, absorb, adjust to and recover from the effects of hazards through the preservation and restoration of the basic structures and functions.

Why and how are you invited to the interviews?

Your selection to participate in this interview is based primarily on your willingness to participate and your knowledge and experience in relation to the infrastructural and housing reconstruction works that affected you, following the [XXX disaster(s)]. Your insights in this interview will be valuable for enhancing our understanding of the issues and challenges facing disaster recovery projects with the need to improve responses for greater resilience in future disasters.

The information obtained, through your assistance, will be treated with the strictest confidentiality and will be used solely for this research purposes only. You will be interviewed on a number of questions that seek to gain your perspective on what is most important to you, your family and your community, for having a successful project.

The information obtained will benefit the construction industry in identifying exploring different strategies, techniques and methods of ensuring that our buildings and infrastructure are re-constructed with resilience.

When is the interview happening?

The interview will be undertaken between the months of January and April 2020.

Why is the study being carried out?
This research output will make a substantial contribution in providing a framework that can improve the project management governance aspects of the reconstruction projects. This will investigate the adoption of resilience as a project management practice within the rebuilding process for the post-disaster residential and infrastructural restoration projects.

How will the interview be conducted?
The anticipated time for answering the questions, is estimated to be 30 minutes and will be at your convenient time and place. The interview will mostly be semi-structured close-ended questions.
You reserve the right to withdraw at any time during the interview without needing to provide a reason. You may withdraw any information provided up to two weeks from the date of the interview.

Is there audio recording during the interview?
There will not be any audio recordings during the interview. The researcher will write all records of the interview and kept completely confidential.

What are the benefits of taking part in the interview?
Your invaluable knowledge and experience with this study will aid in ensuring that the necessary resilience measures are considered and utilized in developing a more resilient individual, community and country, through the overall strengthening of post-disaster reconstruction best practice and assisting construction stakeholders with ensuring that post-disaster reconstruction projects are more resilient, in preparation for future disasters.

How would the confidentiality be guaranteed?
Your identity will be kept confidential. Names and personal details will never be divulged to anyone, nor used in any written or published material from the project. You will be asked to read and sign the Consent Form before the interview is conducted. The results of the research will be published in a thesis publication, report and/or academic journal. . All collected data responses and consent forms will be separately and securely kept a locked cabinet within the University of Auckland, New Zealand premises for a period of six years and then appropriately destroyed by February 2027.

Thank you.

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON __/__/__ FOR THREE YEARS. REFERENCE NUMBER: 022084

Appendix 7: Survey Participant Consent Form

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Private Bag 92019
Auckland, New Zealand

CONSENT FORM (Volunteer Interview Participant)

THIS FORM WILL BE HELD FOR A PERIOD OF 6 YEARS

Research Project Title: Building resilience into practice in managing disaster recovery projects

Principal Investigator: Dr. Alice Chang-Richards

Researcher: Shawn Charles

I have read the **Information Sheet** concerning this project and understand the context of the study. I understand that I am free to request further information at any stage.

I understand that:

1. I agree to take part in this research.
2. My participation in the project is entirely voluntary.
3. I am free to withdraw from this interview at any time without giving a reason.
4. I can withdraw any of this interview data within two weeks after the interview.
5. The interview will take place in in the time and place convenient to me.
6. Personal identifying information will be securely stored independently of the interview data, which itself will be stored confidentially on the University's server which will be regularly backed up and protected. Data will be retained in secure storage for six years after the research completion.
7. The interview will take approximately 30 minutes, and the researchers will analyze the interview results without the involvement of a third party.
8. The interview will not be audio recorded.
9. I wish ☐ / do not wish ☐ to have my interview notes returned to me, and I understand that I have the right to edit my interview responses within two weeks on receipt of the copy.
10. The results of this research will be published in a thesis and academic journals, but my identity will be kept confidential at all times. My name and personal details will never be divulged to anyone, nor used in any written or published material.
11. I wish to receive a summary of findings, which can be emailed to me at this email address:

Email: ________________________________

Name_________________ Signature__________________ Date____________________

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN ARTICIPANTS ETHICS COMMITTEE ON __/__/__ FOR THREE YEARS. REFERENCE NUMBER: 022084

Appendix 8: Questionnaire Survey

Building resilience into post-disaster reconstruction project management

About the survey

You are invited to participate in the questionnaire survey for the research project titled **"Building resilience into practice in managing disaster recovery projects"** undertaken at the University of Auckland, New Zealand. This project aims to develop a guiding framework that can assist the relevant stakeholders in achieving resilience in managing post-disaster recovery/reconstruction projects. Resilience is described by the United Nations as a key component that drives communities to adapt and recover from the effects of natural disasters.

This questionnaire survey is anonymous and will take 15-20 minutes of your time. The information you provide will be treated with confidentiality. The survey is approved by the University of Auckland Human Participants Ethics Committee with reference number 022084. Your participation and your perspectives will help improve our understanding of what is required to ensure resilience can be embedded in project management practice in post-disaster environments.

We appreciate your support and participation.

For further information, please contact

Shawn Charles (Researcher)
PhD Candidate
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Email: scha726@aucklanduni.ac.nz
Telephone: +64 20 416 04228

Dr Alice Chang-Richards (Principal Investigator)
Senior Lecturer
The Department of Civil and Environmental Engineering, the University of Auckland
Email: yan.chang@auckland.ac.nz
Telephone: +64 9 923 8558

SECTION A: Participant Information (Anonymous)

1. How many years have you experienced post-disaster reconstruction?

☒ 0 - 5 ☒ 6 – 10 ☒ 11 - 15 ☐ 16– 20 ☐ 20 - 25 ☐ 25+

2. What type(s) of re-construction projects were you mostly involved in?
Tick all that applies

(a) Residential building ☐ (b) Water/Wastewater ☐
(c) Energy ☐ (d) Transportation (Road/Air/Sea) ☐

(e) ICT (Information, Communication and Technology) ☐ (f) Health/Education ☐

(g) Climate Change ☐ (h) Other: ………………….

3. Which hazard(s) caused the disaster(s)?
Tick all that applies:

(a) Flood ☐ (b) Fire ☐

(c) Hurricane/Cyclone ☐ (d) Storm Surge ☐

(e) Terrorism ☐ (f) Earthquake ☐

(g) Tsunami ☐ Other ………………

4. A. What role do you play in previous or current reconstruction project?

(a) International Relief/Support Agency ☐ (b) Private Contractor ☐

(c) Non-Governmental Organisation ☐ (d) Community-based Organisation ☐

(e) National Government Agency ☐ (e) Self ☐

(f) Other: ………………….

B. With reference to Q4a, what type of labour offered?

(a) Paid labour ☐ (b) Unpaid labour ☐

5. How did you first learn about the hazard that caused the disaster?

(a) Radio ☐ (b) Television ☐
(c) Internet ☐ (d) Friend ☐

(e) Other: ………………….

6. What were your greatest concerns when you heard about the possible disaster?

1. …………………………………………….
2. …………………………………………….
3. ………………………………………….....

SECTION B: Your experience with post-disaster reconstruction projects.

Project expectations

4. **Researchers have concluded that success indicators have had conscious and unconscious priority considerations in projects executions. Please indicate according to how well these statements reflect your expectations.**

(Likert scale 1-5 where 1 means Not a Priority and 5 Essential Priority).

Priorities	1 Not a Priority	2 Low Priority	3 Neutral	4 High Priority	5 Essential Priority
Quality: Project finishes with the highest standards					
Safety: All precautions taken to avoid harm to all stakeholders.					
Cost: The project must be strictly within the initial cost decided upon.					
Change: Any reasonable stakeholder's request that can alter the project will be the highest consideration.					
Scope: If necessary, the scope of the project may change, even if the time or cost are affected.					
Time: Even in strenuous circumstances, the project should be completed within the time allotted.					
Sustainability: Critically important are the project's longevity and environmental harmonisation.					
Satisfaction: The project must be finished to the community's and my likeness.					
Other:………………….					

SECTION C: Factors affecting project outcomes and resilience in reconstruction.

Project success outcomes

5. Based on the literature, we have identified several factors that influence construction project outcomes. The following list of indicators measure these factors. **Please tick according to how important you think these strategies are towards project outcomes.**

(Likert scale 1-7 where 1 means strongly disagree and 7 strongly agree).

Success strategies	1 Not a Priority	2 Low Priority	3 Somewhat Priority	4 Neutral	5 Moderate Priority	6 High Priority	7 Essential Priority
Client and end-user engagement at all stages							
Consideration for end-user expectations							
Project operations guided by project management principles							
Environmentally friendly construction							
Unbiased care for the ecosystem							
Waste Management (e.g. materials, time)							
Management of project risks							
Cost management at all stages							
Optimisation of project success factors							
Assessment of work processes and output							
Engineering designs with technical specifications							
Assessment of project feasibility and practicality							
Use of new technology and tools							
Exploration and deployment of safety measures							
Adoption of best procurement method							
Clarity of contractors and sub-contractors responsibilities							
Competent leadership of project managers							
Project-related knowledge at all levels							
Use of specialist skillset							
Project staff incentives							
Efficient use of project resources							
Decentralisation of project tasks							
Staff motivation that fosters openness							
Knowledge sharing amongst team members							
Change management plan							
Communication plan							
Others: ….......							

Built environment resilience factors

6. Based on the literature, we have also identified factors that improve buildings and infrastructures ability to be resilient to future extreme events. **Please tick according to how strongly you agree or disagree with each strategy as essential to the 'Built environment' resilience development.**

(Likert scale 1-7 where 1 means strongly disagree and 7 strongly agree).

Resilience strategies	**1 Strongly disagree**	**2 Disagree**	**3 Slightly disagree**	**4 Neutral**	**5 Slightly agree**	**6 Agree**	**7 Strongly agree**
Strict national laws and policies to promote compliance							
Clear government short-term and long-term objectives for the construction sector							
Supportive public and private sector institutions (e.g. Banks, NGOs)							
Established and defined land-use and development plans							
Understanding of the local culture for coordinated designs							
Some infrastructure is more important and should be treated accordingly							
Continuous design improvements and modifications							
Avoiding or delaying structure collapse							
Active assessment of structures with intent to repair and improve							
Availability of alternative systems or structure (redundancy)							
Reliance on past experiences during reconstruction							
Reconstruction is highly influenced by future demographic or anticipated development changes							
Reconstruction design based on possible future hazards							
An equal focus in the structural and non-structural components during recovery							
Establishing construction policies and actions that mitigate the effects of climate change							
Reconstruction with equal focus on environment, social and economic improvement							
The need to understand the beneficiaries' wishes in reconstruction or relocation							
Ensure funds or funding sources are readily available for reconstruction							
Strategic development and deployment of construction skills							
Salvage materials that can be re-used during recovery							
Public and private stakeholders collaboration							
Community engagement at all times during reconstruction							
Collaboration among all sectors during the rebuilding process							
Ensure unbiased interest from either the public or private sector							

Appendix 9: Request for Volunteers - Local Radio Advertisement

Request for volunteer participants for a research project

You are invited to participate in an interview survey for the research project titled "Building resilience into post-disaster reconstruction project management", undertaken at the University of Auckland, New Zealand. The ideal participants are those who experienced housing and infrastructure damages from recent disasters.

The research aims to develop guidelines that can assist in achieving resilience in managing these reconstruction projects. Your voluntary participation in this survey will be anonymous and confidential, and will only require 15-20 minutes of your time.

Thank you greatly.

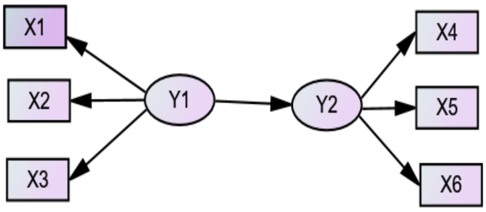
Note:

A. *To be aired commencing Wednesday 15th May for seven (7) segments. Particularly the morning and midday slots.*
B. *The University of Auckland Human Participants Ethics Committee approved this research on 15/10/2018. Reference No.: 022084*

Appendix 10: The Heterotrait-Monotrait (HTMT) Statistic

Very recently, Henseler et al. (2015) proposed using the heterotrait-monotrait ratio (HTMT) of correlations as a remedy to improving the discriminant variability statistic determination. HTMT is in principle the ratio of the between-trait correlations (heterotrait-hetromethod) to the within-trait correlations (monotrait-hetromethod) of two constructs. For more detailed definitions of the HTMT statistic, see (Henseler et al., 2015) and (Ab Hamid et al., 2017). In a nutshell, the HMTM approach to verifying discriminant validity produces an estimate of what the true correlation would be, if perfectly reliable. A true correlation is also termed a disattenuated correlation. A disattenuated correlation between two constructs achieving closer to 1 indicates a lack of discriminant validity.

Exhibit 9.1 illustrates the HMTM approach. Using the model diagram below, an explanation of the HMTM calculation between two constructs (Y1 and Y2) is provided.



		Y1					
		X1	X2	X3	X4	X5	X6
Y2	X1	1					
	X2	b1	1				
	X3	b2	b3	1			
	X4	a1	a2	a3	1		
	X5	a4	a5	a6	c1	1	
	X6	a7	a8	a9	c2	c3	1

HTMT (Y1, Y2) = $a/sqrt(b * c)$

Where: a = mean of all pairwise heterotrait-hetromethod correlations between Y1 and Y2 (a1 – a9)

b = mean of all pairwise monotrait-heteromethod correlations within Y1 (b1 - b3)

c = mean of all pairwise monotrait-heteromethod correlations within Y2 (c1 - c3)

Appendix 11: Part and Partial Regression Results for Controlling Effect of Success Factors

The following results represent the regression results of a resilience factor on project success, being controlled for by a success factor. This analysis will assist with understanding the individual significant or non-significant effect of the resilience factors on specific success factors.

Note: *a. 'Part' is the term used in SPSS for 'semi-partial'*

b. The bolded variable significantly impact the DV, while controlled by a success factor

c. Assumptions: Collinearity Tolerance (>0.1), and VIF (<10).

A1. Resilience factors (IVs) impact on Adaptability (DV), controlled by Knowledge Management

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	2.869	.566		5.065	.000					
	Collaboration	-.071	.106	-.055	-.673	.502	.167	-.044	-.041	.558	1.792
	Infrastructure Indexing	-.071	.098	-.058	-.727	.468	.151	-.047	-.045	.600	1.666
	Governance	**.371**	**.103**	**.313**	**3.613**	**.000**	**.308**	**.229**	**.222**	**.503**	**1.987**
	Knowledge Management	*.152*	*.082*	*.134*	*1.858*	*.064*	*.233*	*.120*	*.114*	*.727*	*1.375*

a. Dependent Variable: Adaptability

*Adaptability = 2.869 - 0.71*CO - 0.71*IX +0.371*GO*

A2. Resilience factors (IVs) impact on Adaptability (DV), controlled by Ecosystem Care

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	2.943	.564		5.222	.000					
	Collaboration	-.061	.106	-.048	-.579	.563	.167	-.038	-.036	.562	1.778
	Infrastructure Indexing	-.061	.098	-.049	-.621	.535	.151	-.040	-.038	.606	1.651
	Governance	**.377**	**.103**	**.318**	**3.652**	**.000**	**.308**	**.232**	**.225**	**.501**	**1.994**
	Ecosystem Care	*.112*	*.073*	*.108*	*1.532*	*.127*	*.214*	*.099*	*.095*	*.763*	*1.311*

a. Dependent Variable: Adaptability

A3. Resilience factors (IVs) impact on Adaptability (DV), controlled by Stakeholder Expectations

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	2.771	.544		5.091	.000					
	Collaboration	-.092	.103	-.071	-.889	.375	.167	-.058	-.054	.565	1.769
	Infrastructure Indexing	-.109	.097	-.088	-1.126	.261	.151	-.073	-.068	.592	1.690
	Governance	**.326**	**.101**	**.276**	**3.225**	**.001**	**.308**	**.206**	**.195**	**.499**	**2.005**
	Stakeholder Engagement	***.282***	***.078***	***.261***	***3.627***	***.000***	***.326***	***.230***	***.219***	***.704***	***1.420***

a. Dependent Variable: Adaptability

A4. Resilience factors (IVs) impact on Adaptability (DV), controlled by Resource Management

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	2.824	.546		5.176	.000					
	Collaboration	-.105	.105	-.082	-1.006	.315	.167	-.065	-.061	.554	1.804
	Infrastructure Indexing	-.095	.097	-.077	-.980	.328	.151	-.064	-.059	.597	1.676
	Governance	**.354**	**.100**	**.299**	**3.534**	**.000**	**.308**	**.225**	**.214**	**.512**	**1.955**
	Resource Management	*.251*	*.076*	*.233*	*3.293*	*.001*	*.299*	*.210*	*.200*	*.734*	*1.363*

a. Dependent Variable: Adaptability

B1. Resilience factors (IVs) impact on Competence (DV), controlled by Knowledge Management

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	1.731	.464		3.727	.000					
	Collaboration	-.016	.087	-.014	-.188	.851	.320	-.012	-.010	.558	1.792
	Infrastructure Indexing	.018	.080	.016	.222	.824	.309	.014	.012	.600	1.666
	Governance	**.276**	**.084**	**.253**	**3.285**	**.001**	**.432**	**.210**	**.179**	**.503**	**1.987**
	Knowledge Management	*.398*	*.067*	*.380*	*5.931*	*.000*	*.499*	*.361*	*.324*	*.727*	*1.375*

a. Dependent Variable: Competence

B2. Resilience factors (IVs) impact on Competence (DV), controlled by Ecosystem Care

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	1.941	.473		4.104	.000					
	Collaboration	.012	.089	.010	.134	.894	.320	.009	.007	.562	1.778
	Infrastructure Indexing	.046	.082	.040	.562	.574	.309	.037	.032	.606	1.651
	Governance	**.294**	**.087**	**.269**	**3.395**	**.001**	**.432**	**.216**	**.190**	**.501**	**1.994**
	Ecosystem Care	*.284*	*.061*	*.298*	*4.647*	*.000*	*.437*	*.290*	*.260*	*.763*	*1.311*

a. Dependent Variable: Competence

B3. Resilience factors (IVs) impact on Competence (DV), controlled by Stakeholder Engagement

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	1.927	.451		4.274	.000					
	Collaboration	-.002	.085	-.002	-.024	.981	.320	-.002	-.001	.565	1.769
	Infrastructure Indexing	-.011	.080	-.010	-.138	.891	.309	-.009	-.007	.592	1.690
	Governance	**.259**	**.084**	**.236**	**3.088**	**.002**	**.432**	**.197**	**.167**	**.499**	**2.005**
	Stakeholder Engagement	*.411*	*.064*	*.410*	*6.370*	*.000*	*.522*	*.384*	*.344*	*.704*	*1.420*

a. Dependent Variable: Competence

B4. Resilience factors (IVs) impact on Competence (DV), controlled by Resource Management

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	2.144	.472		4.546	.000					
	Collaboration	.008	.090	.007	.089	.929	.320	.006	.005	.554	1.804
	Infrastructure Indexing	.028	.084	.025	.340	.734	.309	.022	.019	.597	1.676
	Governance	**.323**	**.087**	**.296**	**3.731**	**.000**	**.432**	**.236**	**.211**	**.512**	**1.955**
	Resource Management	*.261*	*.066*	*.262*	*3.965*	*.000*	*.408*	*.250*	*.225*	*.734*	*1.363*

a. Dependent Variable: Competence

Appendix 12: Expert Judgement Analysis

Request for volunteer industry's expert judgement

Researcher Introduction

My name is Shawn Charles. I am a doctoral student in the Department of Civil and Environmental Engineering at the University of Auckland, New Zealand. My supervisors for this research are Dr. Alice Chang-Richards from the Department of Civil and Environmental Engineering at the University of Auckland and Dr. Kenneth Yiu from the School of Built Environment at Massey University, both in New Zealand.

Description and invitation

You are invited to participate in this assessment of a recommendation arising from research analysis conducted in the research project titled "Building resilience into post-disaster reconstruction project management". The research aims to develop guidelines that can assist in promoting resilience in managing post-disaster reconstruction projects. As an expert in the construction sector, your voluntary participation in this assessment process remains anonymous and seeks your professional judgement on the application of the recommended resilience development framewok for implementation within the Caribbean setting.

An explanation of the framework and its components, followed by an assessment is provided below. Your assistance will provide relevant support in my doctoral output in finding solutions towards improving our costruction landscape and resiliency in our buildings and innfrastructure projects.

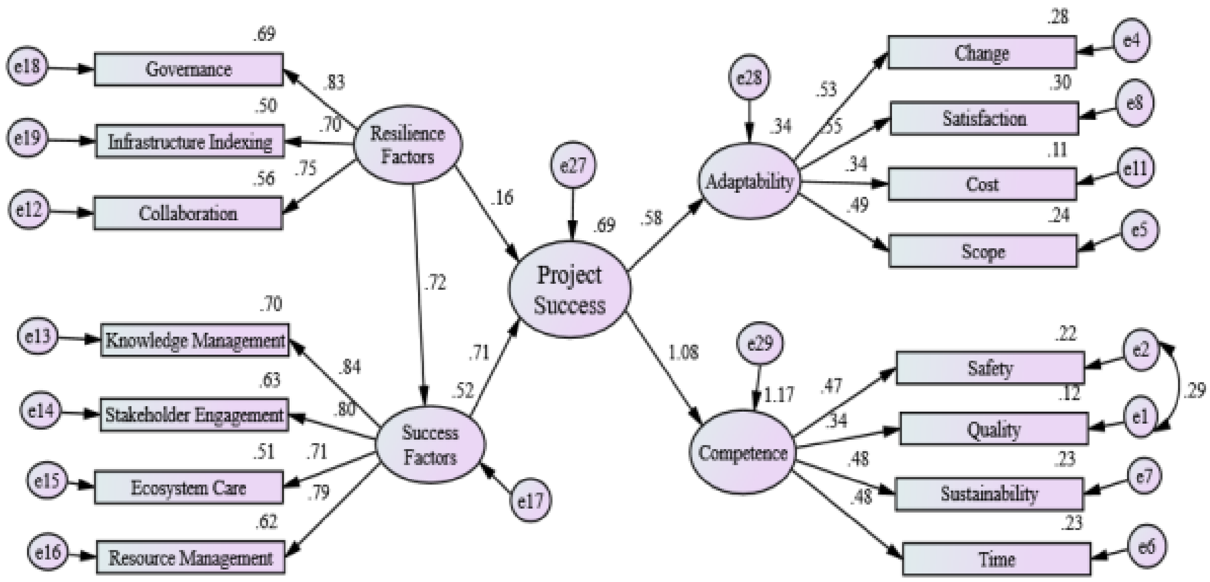
Thank you kindly and a response ASAP will be greatly appreciated.

Shawn Charles (Researcher)
scha726@aucklanduni.ac.nz

Research analysis output

Figure 1 represents the results of analysis on the relationship and effects of project success factors, resilience factors and project end-users (beneficiaries) expectations for obtaining positive project outcomes. The factors and projects success expectations used in this research were first obtained from systematic reviews into the literature, then the perspectives of the Caribbean end-user were elicited using a semi-structured questionnaire. The questionnaire survey was conducted during May – August 2019, in the islands of Antigua, Dominica, Grenada and St. Vincent.

Fig.1. SEM showing standardised relationships coefficients among all variables



This framework points out the strengths of relationships and the relative influences in the tripaite correlation, following statistical analysis from the data obtained from the survey questionnaire responses. Regarding the expectations of end-users (non-project participants), the model show that project success is primarily assessed on 1) the ability of the project team to adapt or modify project objectives according to end-user's recommendations (when necessary), and 2) an assurance that competent personnel are involved in the project's management. Project success factors affect project success with a 71% impact factor. However, the analysis suggests that resilience factors do not have significant direct impact on project success (16% impact), but the application of resiliency in combination with project success factors is significant (72% impact). Regarding this research conclusion and recommendation, your opinion on the effectiveness of this framework towards assisting in policy and proceedure development for the Caribbean's construction and reconstruction sector is solicited using the expert judgement technique.

Expert judgement

The goal of applying structured expert judgement techniques is to enhance rational consensus, by generating an estimate of possible project management outcome. Expert judgement has always played a large role in science and engineering. Increasingly, expert judgement is recognised as just another type of scientific data, and methods are continuously developed for treating it as such. The technique is deemed reliable when relevant information on the specific topic is non-existant or scant, and it very instrumental with project management activities.

As such, your expert judgement matters. Please indicate, using the following scale, your opinion on the following questions / statements, with reference to Figure 1:

Scale: *Disagree, Somewhat Disagree, Neither Agree not Disagree, Somewhat Agree, Agree*.

Question / Statement	Level of Agreement
1. The component factors represented in the framework summarises the issues pertinent to the Caribbean's construction and reconstruction landscape.	.
2. From your understanding and experience with resiliency in building or infrastructure construction, resiliency techniques have directly impacted project success?	.
3. Are there avenues with this framework to gain Caribben concensus in formulating a unified strategy to mainstreaming resiliency in building and infrastructure projects?	.
4. Adaptability with addressing project concerns and having competent project team members summarieses the salient assessment criteria for end-users judgement towards successful project outcomes.	.
5. The identified relationships elicited in the framework can provide significant information in generating policy standards that can influence project management practices at national and regional levels.	.

.

Select what best describes your professional capacity.

Submit response

If experiencing problems using the submit button, please save the completed form and email to: scha726@aucklanduni.ac.nz

Particulars of 'Caribbean experts' responding to the questionnaire

Expert ID	Professional title	Affiliation	Public / Private	Country
1	Consultant	University of the West Indies	Public	Trinidad and Tobago
2	Planning and Engineering Manager	Grenada Electricity Services Ltd.	Private	Grenada
3	Chief Engineer (Electrical)	Grenada Electricity Services Ltd.	Private	Grenada
4	Engineer (Civil)	Tourism Development Company Ltd.	Public	Jamaica
5	Consultant Engineer (Civil)	United Nations Development Programmes (Caribbean)	Public	Grenada / Antigua / Dominica
6	Architect	Government of St. Vincent	Public	St. Vincent
7	Engineer (Electrical)	Grenada Electrictiy Services Ltd	Private	Grenada
8	Engineer (Civil)	Ministry of Works	Public	St. Vincent
9	Project Engineer (Water / Electrical)	Dominica Geothermal Project	Public	Dominica
10	Project Finance Manager	Basic Needs Trust Fund	Public	Dominica
11	General Manager	Housing Authority of Grenada	Public	Grenada
12	Construction Supervisor	Ministry of Housing Authority and Development	Public	Grenada
13	Engineer (Electrical)	President of Grenada Institute of Professional Engineers	Puiblic	Greanda

Questionnaire responses: Raw data of from the experts with reference to Figure 8.5.

Expert ID	Factors identified relate to pertinent issues	From experience, resiliency impact project success	The framework provided avenues for mainstreaming resilience	Adaptability and competence are salient end-user assessment indicators	The framework provides sufficient information for developing policy standards
1	5	5	5	5	5
2	4	2	4	5	5
3	4	5	4	4	5
4	5	5	4	5	4
5	4	5	5	5	5
6	5	4	4	5	5
7	5	4	5	4	5
8	4	4	4	4	4
9	5	4	5	4	5
10	5	5	5	4	5
11	4	3	4	4	4
12	4	4	5	4	4
13	4	3	4	4	4

***Five-point Likert scale**: 1-Disagree, 2-Somewhat Disagree, 3-Neither Agree or Disagree, 4-Somewhat Agree, and 5-Agree*

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