A FRAMEWORK FOR PRIORITISING CAPABILITY MECHANISMS FOR ENVIRONMENTAL DISASTER RISK MINIMISATION WITHIN GHANA'S PETROLEUM SECTOR

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DECLARATION

I declare that this work or any part herein has not been previously submitted in any format to this University or to any other body, whether for the purpose of publication, assessment or for any other purpose. Except for any express acknowledgements, citations and or bibliographies referenced in this work, I affirm that the intellectual content of the study is the result of my own independent efforts and investigations and that of no other person.

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ABSTRACT

Petroleum disasters, such as the 1988 Piper Alpha incident, and more recently, the Gulf of Mexico Macondo well blowout, have left a legacy of environmental impacts with catastrophic effects. While these events evoked global apprehension and public outcry, there appears to be lesser proportion of concern towards similar events within the developing world, for examples, African jurisdictions, such as Angola, Sudan and Nigeria's Niger delta, and other locations such as Colombia, Venezuela and Brazil. Reflecting on weak environmental governance systems and institutional capacity, which has bedevilled Ghana's gold mining and downstream petroleum sectors, there has been extensive stakeholder apprehension over the current state of Ghana's institutional capacity to deal with potential factors of petroleum related disaster, and to pre-empt threatening incidents. This study, therefore, aims to establish the critical underlying disaster risk factors and the related institutional capability needs of Ghana's nascent petroleum sector, and to prioritise these mechanisms for the development of a framework towards improving public sector capacity, for minimizing environmental disaster risks within the petroleum sector of Ghana.

A sequential multiphase approach, pursuing a multi-methodological strategy consistent with pragmatist philosophy was adopted in a four-phase process of investigation. The process commenced with a systematic review of petroleum disaster literature (n=90), which revealed key underlying risk factors (12), and a range of capability improvement mechanisms (16). This was followed by a literature verification/ validation process, together with a mapping of institutional structures for addressing the underlying causes of petroleum disaster, via the instrumentation of recognised academic and industry professionals (n=12 experts). Next, a survey was deployed to key industry related stakeholders. This was aimed at a scoring process, towards ranking and prioritising: (i) the twelve key underlying risk factors at the root of petroleum environmental disasters, and (ii) the sixteen critical capability mechanisms relevant for addressing identified risks. The analysis of survey data (n=78 participants) and prioritization process was facilitated by application of statistical testing, including the one-sample T-test, Mann-Whitney U test, among others, and also, through deployment of the Weighted Average Scoring *(WASi)* protocol; to attain a robust ranking of critical elements surveyed, and underpin the creation of a Capability Improvement Framework (CIF). Finally, semi–structured interviews were conducted to gauge opinions on the usefulness of the CIF towards achieving environmental disaster risk minimization (EDRM) goals within the petroleum sector of Ghana.

Findings from this study reveal, addressing the following: 'risk management shortcomings', 'emergency preparedness planning challenges' and 'socio-environmental accountability' are the most critical disaster risk minimisation indices; whilst improving 'risk management', 'early detection and warning', and 'legal/regulatory mechanisms' are the topmost capability interventions to achieve EDRM. It is proposed that, the CIF established from this study, could support policy, strategy and decision making towards prioritising and configuring critical mechanisms of public sector institutional capability, to attain the goal of EDRM, within Ghana's petroleum sector. The study concludes by suggesting direction towards a critical need to improve capability in the more technical and governance-oriented capability mechanisms comparative to the traditional functions of disaster response, for public sector institutions to achieve EDRM goals within the petroleum sector of Ghana.

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LIST OF ABBREVIATIONS

BOEM	Bureau of Ocean Energy Management
BOEMRE	Bureau of Ocean Energy Managment, Regulation and Enforcement
BPR	Business Process Reengineering
BSC	Balanced Scorecard
BSEE	Bureau of Safety and Environmental Enforcement
CD	Capacity Development
CEO	Chief Executive Officer
CIA	Capsized Iceberg Approach
CIDA	Canadian International Development Agency
CIF	Capability Improvement Framework
CIM	Capability Improvement Mechanisms
CMMI	Capability Maturity Model Integration
DECC	Department of Energy and Climate Change
DM	Disaster Management
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EDRM	Environmental Disaster Risk Minimisation
EDR	Environmental Disaster Risk
EMDAT	Emergency Events Database
FREC	Faculty Research Ethics Committee
GEG	Global Environmental Governance
GIWACAF	Global Intiative for West, Central and Southern Africa
HSE	Health and Safety Executive
IFRC	International Federation of the Red Cross
ISO	International Standards Organization
JIT	Just In Time
MCA	Maritime Costguard Agency

MMS	Minerals Management Service
NEA	Norwegian Environmental Agency
NIDM	National Institute of Disaster Management
NMA	Norwegian Maritime Authority
OCC	Organizational Capacity for Change
OCS	Outer Continental Shelf
OD	Organizational Development
OGA	Oil and Gas Authority
PIM	Process Improvement Methodologies
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PSA	Petroleum Safety Authority
RMI	Risk Minimizations Indices
SEMS	Safety and Environmental Management System
TQM	Total Quality Management
UNISDR	United Nations International Strategy for Disaster. Reduction

DEDICATION

God Almighty alone receive the praise and honour for this thesis, and for how far He has brought me. I further dedicate this thesis to my entire family and loved ones who have kept faith in my potential.

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CHAPTER ONE: INTRODUCTION

1.0 BACKGROUND

Environmental disasters through the medium of well-blowouts, hazardous spillages and emissions are periodic occurrences within the oil and gas industry globally, bearing devasting and fatal consequences to biological life and socio-economic infrastructure (Beland and Oloomi, 2019). Despite remedial clean-up campaigns and compensations costing billions of dollars, resulting from such disasters, the environmental and human impacts often remain, decades after (White and Robyn, 2016). The Nowruz platform incident in 1983, spilled over 80 million gallons of oil into the Persian Gulf, causing widespread degradation to the ecosystem. The 1988 Piper Alpha platform incident caused 167 fatalities, extensive damage to the Scottish coastline, and damage to property, totalling over $1.7 billion (Hendershot, 2013). Crooks (2016), highlights in the Financial Times (FT) that, the cost for the 2010 BP deep-water horizon Macondo disaster, has been projected at over $60 billion; that is, beside considerable loss of life and livelihood. These records, are but a few of such incidents within the sector.

Though Ghana has not experienced environmental emergencies or a disaster of any significant proportions in the petroleum sector (Glover, 2017; Obeng-Odoom, 2018; EPA, 2020), there are grave apprehensions over the likely devastating impact, such an incident could exert on the local communities and stakeholder institutions responsible for disaster management, should this occur (Amponsah-Tawiah *et al.*, 2015; Osei-Hwere, 2015; Yirenkyi, 2017). Some countries, with relatively developed/ tested petroleum production infrastucture, such as Norway, Canada and United Kingdom, have evolved capacity by way of governance systems and institutional mechanisms for pre-empting and mitigating the risk of such disasters (Nilsen and Stokersen, 2018; Hovik *et al.,* 2009): it is uncertain however, if similar capacity exists within countries like Ghana which are comparatively new to oil production. Furthermore, it cannot be assumed that the governance frameworks and institutional structures for these other countries would outrightly, be fitting models for minimising disaster risks within Ghana's context. (Hovik *et al.,* 2009; Edelstein, 2011 There is a need therefore, to explore capacity issues with regard to the state of public sector capability, requisite for addressing potential challenges, relating to underlying risk conditions of environmental disaster within Ghana's petroleum sector.

A critical and recurring question has been, 'how can Environmental Disaster Risk Minimisation (EDRM) capability of the mandated public sector organisations within the petroleum sector of countries, such as Ghana be assessed and improved'? Fundamentally, The Hyogo Framework for Action (HFA) 2005 - 2010, and the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015 - 2030, proffer pivotal mechanisms directed at reducing vulnerability, and building resilience towards reducing disaster risks (UNISDR, 2019). Appreciably, contemporary disaster management literature and research interventions can be identified as principally modelled in line with the HFA – 2005, and SFDRR - 2015 concepts. The key challenges pertaining to such frameworks however, are the shortfall of mechanisms and conceptual models which are industry/ jurisdictional specific, or tailor fit for gauging, as well as improving capacity and institutional capability (Al-Quhtani, 2015; Van-Niekerk, 2015). It has been suggested further that, interventions aimed at disaster risk reduction (DRR) and management (DRM, have been relatively focal on natural disasters, within such frameworks and past research activity (Al-Quhtani, 2015).

1.1 JUSTIFICATION FOR THE RESEARCH

The UN has projected on average over 200 million persons are affected annually by disasters (UNISDR and WMO, 2012). Over a twelve-year period 2000 - 2012, loss of life to disaster amounted to over 1.1 million, while revenue loss stood well over USD 1.3 trillion. The trend of revenue losses to disaster is projected to exceed the previous average of USD 100 million per year (UNISDR, 2012). Socio-technologically generated disasters (excluding naturally induced occurrences) have over the period 2010 - 2020 caused over 7000 deaths maiming or affecting about 700,000 persons directly, with costs running over 40 billion dollars in direct losses alone (EMDAT, 2021). It is identified that, a sizable proportion of these disasters emanate from incidents relating to heavy industrial activity, such as oil and gas exploration, mining and other related operations (Chang *et al*., 2015; EMDAT, 2021). According to the Smithsonian Institute (2016), an estimated 3.19 million barrels of oil leaked into the Gulf of Mexico from the Macondo Deep-water horizon Bp well explosion in 2010. Colossal quantities of oil and related chemicals have been spilled into the earth's oceans and land-space over the past century to date; and well over a billion barrels of these chemicals have been spilled into habitable environment just over the past four decades (Chang *et al*., 2015; Anejionu *et al*., 2015).

1.1.1 The Ghana Petroleum Environmental Risk Context

Concerns have been raised over reports of considerable amounts of oil sleek close to the shores of Ghana's first Floating Production Storage and Offloading (FPSO) facility (Badgley, 2012): this and occasional sightings (by fishermen, environmentalists, among other stakeholders), of oil floating close to the shores of Ghana's petroleum production fields, amid concerns over increasing number of dead whales within the vicinity, have heightened apprehension in this regard (Badgley, 2012; Platform, 2012, Amponsah-Tawiah, 2015). Environmental, Health and Safety (EHS) standards violations in the downstream petroleum sector, which resulted in fire/ explosion disasters in Ghana recently, have elicited heightened agitation and aggravated the apprehension pertaining to potential disaster risk projections over Ghana's upstream petroleum sector (Sakyi *et al.*, 2012; Yirenkyi, 2017; Obeng-

Odoom, 2018; Ghana National Fire Service, 2019). With reflection on recent occurrences of massive environmental pollution, frequent accidents leading to high casualty levels, and extensive degradation of the ecosystem within the local mining sector, there is consequently, massive apprehension from the communities, national and global stakeholders, industry watchers and experts among others, over the future of Ghana's petroleum set-up (Osei-Hwere, 2015; Obeng-Odoom, 2018; Acheampong and Akumperigya, 2018).

The consternation over this sector is not far-fetched and could be justified, considering that, stakeholder institutions designated for environmental risk governance in the petroleum sector, are quite the same or analogous to the ones that have borne oversight regulatory responsibility towards the mining environment for decades (Sakyi *et al.*, 2012; Yirenkyi, 2017; Mantey *et al.*, 2020). Evidently, the aforementioned shortcomings of the environmental governance structures, as well as weaknesses in institutional capacity, have not helped situations much here; owing primarily to the haste with which Ghana as a country, and her 'perceived exploitative' industrial partners moved to commence commercial production at the Jubilee oilfields, off Cape three points (Badgley, 2012; Platform, 2012). It has been suggested in a way, that, Ghana was taken by surprise with the relatively massive oil discovery, rendering key stakeholder institutions somewhat under-prepared with the trajectory of development (Badgeley, 2012; Osei-Hwere, 2015; Amponsah-Tawiah, *et al.,* 2015). Clearly, the dearth of research literature and theoretical models (Kabari, 2016; Glover, 2017), which reflect the vital linkage between robust institutional structures and disaster risk reduction within the petroleum sector of Sub-Saharan Africa, can likewise be viewed as contributory to the uneasiness over the state of Ghana's institutional capability towards petroleum disaster risk minimisation (Mayorga, 2010; Eregha and Mesagan, 2016).

1.1.2 Knowledge Gaps

Research indicates, some progress has been made on post HFA-2005 and SFDRR-2015 projections in some countries (Van-Niekerk, 2015; Juanzon and Oreta, 2018); howbeit, with a shortfall of consistent conceptual models and systematic processes for assessing these impacts universally (Enia, 2013; Jamieson, 2016; Johannsonn, 2017). Additionally, research and literature in this regard has been skewed towards natural disaster as compared to man-made, technological and other forms of disaster (Richardson, 1994; Al-Qahtani, 2014; Van-Niekerk, 2015). Further deficits in research and related conceptual models can be identified within this subject domain, pertaining to environmental management frameworks, directed at disaster reduction within the petroleum sector of Sub-Saharan Africa (Mayorga-Alba, 2010; Kabari, 2016; Obeng-Odoom, 2018). In the case of Ghana, the aforementioned deficiency appears rather amplified, particularly, with regard to assessment of institutional capacity/ capability for disaster pre-emption and risk reduction within the petroleum sector (Osei-Hwere, 2015; Glover, 2017): this is heightened among other reasons, by the knowledge that, Ghana's environmental disaster management and response mechanisms have not been critically tested, thereby inducing stakeholder apprehension.

Research undertaken recently (Eregha and Mesagan, 2016) reveals, institutions designated for environmental risk governance within Sub-Saharan Africa, are nowhere near robust, or resilient. Studies further suggest that, the correlational impact these identified weaknesses could bear on the quest for environmental disaster risk reduction within petroleum producing African countries, have not received substantial research and governmental attention (Mayorga, 2010; Eregha and Mesagan, 2016; Obeng-Odoom, 2018). Furthermore, it can be identified that public sector approach to environmental incidents or threats within the petroleum sector of Ghana, has been skewed towards oil spill response and recovery or analogous processes, as compared to addressing underlying/ root causes of incidents (Reportingoilandgas.org 2011; Badgley, 2012; Platform, 2012; Achaw *et al.*, 2013, GIWACAFF, 2020). There appears to be a tacit conception that, capability for addressing socio-technical challenges such as trigger well blowouts, oil rig collapse, and underlying factors resulting from, 'human error', 'equipment failure' among others, fall principally within the responsibility domain of the Exploration and Production (E and P) operators and third-party private sector agencies (Mills *et al.,* 2015; Edelstein, 2011). The regulatory or supervisory roles of governmental (public sector) organisations in Ghana e.g., appear to be more of the post incident; suggesting institutional gaps and capacity deficits for managing root cause and underlying triggers of such environmentally threatening incidents (Sakyi *et al.*, 2012; Osei-Hwere, 2015; Amponsah-Tawiah *et al.*, 2015; Acheampong and Akumperigya, 2018; GIWACAFF, 2020). While it may be true that the critical responsibilities of public sector institutions are not the core technical risk factors within the E and P environment; to suggest that building oversight capacity or capability towards mitigating such challenges and threats is mutually exclusive to, or incumbent on private sector operators, could be a counterproductive and defective approach, as past disaster incidents have shown (Edelstein, 2011; Tierney, 2012; Mills *et al.*, 2015). Also, research interventions and theoretical models for minimising disaster risks have been tilted towards hazard reduction, vulnerability mitigation and more recently resilience building (Granot, 1998; Vatsa, 2004), compared to capability development.

Though the strategic approach to managing disaster risks from the perspective of capacity/ capability development is exponentially evolving globally (Tierney, 2012; Lee, 2017); there is no known major academic work that has critically investigated capacity conditions and the capability improvement mechanisms of public sector institutions, towards managing underlying environmental disaster risks within the petroleum sector of Ghana. Identifiably, a limited number of research interventions within this field, have been directional towards hazard mitigation, enhancing socio-environmental responsibility/ accountability and reducing vulnerability, aside local content inclusivity and improving disaster response (Amponsah-Tawiah *et al.,* 2015; Glover, 2017; Obeng-Odoom, 2018). Clearly, the shortfall of custom-made, consistent and conceptually credible capability improvement mechanisms for gauging disaster risk pre-emption or preparedness within institutions, especially in developing nations like Ghana, is a common shortcoming for both HFA - 2005 and SFDRR - 2015 as well as some contemporary, generic research frameworks and interventions for DRR (Kabari, 2016). Studies further suggest, disaster management institutions are rather inclined towards, or preoccupied with addressing incidents of a predefined, instantaneous, and homogenous nature (Fischer, 2002; Rautela, 2006; Tierney, 2012; Obeng-Odoom, 2018). Fundamentally, the criticality of this study is underpinned by the fact that, Ghana does not have the fortune or 'luxury' of time, faced with copious competing needs in the area of capacity/ capability development for the petroleum industry (Achaw *et al.,* 2013; Osei-Hwere, 2015; Acheampong and Akumperidya, 2018): therefore the crucial need to prioritise key capability improvement sectors of importance towards safety, sustainability and exponential growth within the sector.

A crucial need arises from the foregoing, for knowledge addition, by way of establishing a custom-made mechanism, i.e. a framework, supported by recommendations to aid policy, planning and strategy, towards addressing environmental disaster threats from the perspective of the root or underlying factors, through improving public sector institutional capacity/ capability.

1.2 RESEARCH QUESTIONS

The study addresses the following research questions:

(a) What are the key institutional capability indicators, and mechanisms requisite for minimizing environmental disaster risks within the petroleum sector of Ghana? (b) How can the identified capability mechanisms be prioritized successively and improved within relevant public sector institutions of Ghana.

1.3 AIM AND OBJECTIVES

The study is aimed at establishing a framework for improving public sector institutional capability towards minimizing Environmental Disaster Risks (EDRs) within the petroleum sector of Ghana.

This aim, would be accomplished by meeting the following objectives:

1. Evaluating the theories, and concepts that underpin Disaster Risk Reduction, towards identifying existing models and concepts that bear impactful relationship to achieving the aim of the study.

2. Reviewing of existing frameworks, approaches, and strategies for capability and performance improvement, as potential adaptable models.

3. Reviewing the literature to identify: (i) key underlying disaster risk factors (that is; the root factors of incidents that engender environmental disaster), and (ii) Capability Improvement Mechanisms (CIMs) for addressing (i), EDRs within the petroleum sector.

4. Rank and prioritize in order of importance, the identified underlying risk factors, and the Capability Improvement Mechanisms, requisite for achieving environmental disaster risk minimisation, within Ghana's petroleum sector.

5. Develop and validate a capability improvement framework for enhancing public sector capacity, towards minimizing environmental disaster risks within the petroleum sector of Ghana.

6. Provide recommendations for policy and practice, with the aim of improving institutional capability pertaining to environmental disaster risk reduction, for the petroleum sector of Ghana.

1.4 RESEARCH SCOPE

The domain of this study is situated within the upstream oil and gas sector of Ghana, particularly the western offshore petroleum infrastructure, off Cape three points and surrounding communities. The concepts within this study can however be applicable or adaptable to other petroleum infrastructure within Ghana, Sub-Saharan Africa, and to some extent globally. The West African sub-region has experienced considerable levels of environmental disturbances, in the petroleum sector, with regard to incidents in e.g. Nigeria, Gabon and Cameroun; some of which is as a result of conflicts and industrial activity among others (Mayorga-Alba, 2010; Obeng-Odoom, 2018). The global community, more especially stakeholder agencies and institutions such as the UN, are observing Ghana as a test case, to ascertain if conditions and lessons derived from neighboring petroleum producing countries, would steer Ghana off those turbulent paths which have led to ecological disasters, societal disintegration, conflict, and violence, such as evident within the Niger delta of Nigeria (Okpanachi and Andrews, 2012).

1.4.1 Target Stakeholder Institutions

The major institutional setting and stakeholder organizations of interest towards which this research has been undertaken is primarily the Ministry of Energy and Petroleum, and key subsector, as well as stakeholder agencies, such as the Petroleum Commission (PC) of Ghana, and the Ghana National Petroleum Corporation (GNPC) etc. Also, the study findings are aimed at supporting and guiding policy planning and strategy within institutions such as the Environmental Protection Agency, Security and Emergency Response Organizations among others.

1.5 METHODOLOGICAL APPROACH TO THE STUDY

Pragmatism is the philosophical underpinning for this study; as such multi-methodological techniques have been deployed towards realizing the objectives and aim of the research**.** The approach to deploying capability assessment/ improvement mechanisms within environmental, health, safety and disaster management systems is considered, a critically evolving area of research interventions (Jones, 2003; Asah-Kissiedu, 2020), therefore demanding multi-dimensional knowledge enquiry within consistent triangulation methods to establish validity and acceptability of findings. Pragmatism enables the use of multiple strategies and related techniques to attain answers to research questions and the various objectives of the research, according to what is suitable for each phase of the study (Cresswell, 2012). The capacity to straddle both positivist (quantitative) and interpretivist (qualitative) paradigms, enhances richness and balance of perspectives (Amaratunga *et al.*, 2002). In this regard the multiphase sequential strategy has been adopted, composing of: (a) a qualitative process of enquiry within a systematic review of literature (n=90), in order to generate key underlying environmental disaster risk factors, and capability mechanisms for addressing these risk factors (b) a literature verification process, deploying industry experts (n=12) within semi-structured written interviews, to validate findings in literature (c) An expert survey of professionals and key industry stakeholders (n=78) towards ranking and prioritizing of the: (i) risk factors identified, and (ii) the capability interventions for tackling risk factors within Ghana's petroleum sector, and finally; (d) a semi-structured interview (n=8) process for validation of proposed framework, and research findings.

Various statistical measures mainly through the deployment of Statistical Package for the Social Sciences (SPSS) version 27, to assess reliability and validity were carried out. Also, analytical methods mainly non-parametric, including Mann-Whitney U test, Kruskal-Walis anlaysis, and related inferential statistical measures were deployed to test the levels of consistency and statistically significant differences on various items with respect to responses, within independent variables. The Adjusted Weighted Average Score (WAS_i) formula, was deployed towards attaining the weighted importance of various elements of 'risk' and 'capability' measures, and to prioritise the relatively critical functions for environmental risk minimization within Ghana's petroleum sector.

1.6 ORGANISATION OF THE STUDY

The thesis is organized and presented within 10 chapters, as shown below, and illustrated in Figure 1.1.

Chapter. 1: This chapter covers the background of the study, with emphasis on the justification for the study, as well as knowledge gaps, aim and objectives, and research questions to be addressed. Highlights, on the threats within the petroleum industry and conditions within the Ghanaian context, reflecting on institutional weaknesses and challenges within this sector, is also outlined. A general overview of the research, including methodological approach is presented.

Chapter 2: The second chapter brings into perspective, the historical background, definitional contexts of disaster attribution and the general evolvement of disaster conceptualization. Appraisal of the various attributes and constituents of disaster risk reduction (DRR) and related concepts is made herein. This chapter does not only provide the fundamental considerations pivotal for appreciating the subject matter, but also a theoretical framework within which the study can be situated.

Chapter 3: Chapter 3 considers the nature of the petroleum sector, the general evolvement of the industry infrastructure, and the governance systems relating to environmental risk and sustainability within the global and localized systems. Consideration is given to reflection on institutional structures within the global context, and the state of Ghana's institutional mechanisms, with regard to functionality and gaps therein.

Chapter 4: Chapter 4 is assigned to the review of strategies, frameworks and processes of capability improvement employed generally in the past, and in contemporary industry/ organisational settings. This is aimed at identifying key capability development mechanisms, towards the proposal of an appropriate tool of capability assessment and improvement for the DRM capability measures identified.

Chapter 5: Chapter 5 is dedicated to showing the methodological approach employed within this study. The philosophical path and related methods, as well as techniques and tools deployed towards objectives and aim, are detailed in this chapter. Justification for the selected strategy, and methodological approaches presented in this chapter, provide general underpinning for reliability and validity of constructs, procedures, and final outcomes of the study.

Chapter 6: Chapter 6 focuses on the process of a systematic review of literature towards realizing objective 2 (two). This is, to identify the key risk factors and underlying causes of incidents that culminate in environmental disaster. The paramount objective here being, the identification of key capability measures or mechanisms that can be deployed to address the risk factors identified beforehand.

Chapter 7: Chapter 7 provides a synthesis and summary of findings through analysis of the data collected from: (i) Systematic review of literature (n=90), (ii) Verification and validation process on the constructs and mechanisms identified from the systematic review process, by industry experts (n=12), (iii) Expert survey undertaken with key professionals/ industry experts (n=78). Findings of analysis of the progression phase from verification of literature, is presented here.

Chapter 8: This chapter encompasses the discussion of various concepts, key items of criticality identified from the various phases of the research, and the generation of elements, pivotal to construction of the proposed Capability Improvement Framework (CIF). Reflection is made on diverse theories and concepts of disaster management and risk reduction, as well as reference to previous studies and frameworks, towards assessing strengths, weaknesses, merits and gaps within the body of knowledge synthesised thereby. This crucial discussion process provides the fundamental reasoning and direction for the key elements of the study and serves as a guidemap for constructing the proposed CIF, as well as establishing recommendations.

Chapter 9: Chapter 9 presents a discussion pertaining to methods employed towards ensuring that appropriate philosophical principles have been followed, and an appreciable level of analysis has been undertaken towards attaining the outcomes. This objective (chapter 9) is supported and accomplished by the process and outcome of the validation of the proposed Capability Improvement Framework.

Chapter 10: This chapter provides conclusions and a summary of recommendations, based on the research findings. Within this chapter also, the contribution of the study to knowledge and theory development is highlighted; as well as gaps and unaddressed issues which may form the basis for future research undertaking.

1.7 GLOSSARY OF KEY TERMINOLOGY AND CONCEPTS

1. **Petroleum Sector:** Petroleum sector within this study, refers to the exploration, production, storage and pipeline transportation of oil and gas resources, and interconnected infrastructure. This represents the upstream and integrally connected midstream petroleum infrastructure. *Where reference is made specifically to 'the Ghana petroleum sector', this relates generally, to the offshore Exploration and Production infrastructure.
2. **Environmental Disaster:** Aligns with the National Institute of Disaster Management (NIDM, 2014) definition of environmental disasters (EDs) as, "the realization of hazards to serious

impacts, damages and losses, initiating in some or the other environmental systems or resources".

3. **Disaster Risk Minimisation:** This study adopts the composite UN definition of Disaster Risk Reduction (DRR): "The concept and practice of reducing disaster risks through systematic efforts to analyse and reduce the causal factors of disasters"; and, Disaster Risk Management (DRM): "The systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster" **.**
4. **Disaster Risk:** Aligns with the annotated UN (2009) definition: "The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity". Annotation*: "The definition of disaster risk reflects the concept of hazardous events and disasters as the outcome of continuously present conditions of risk".
5. **Capability Mechanism:** Refers to the ability, competence, resources available to institutions for performing assigned functions and responsibilities (Except otherwise differentiated, this term is used synonymously to capacity).

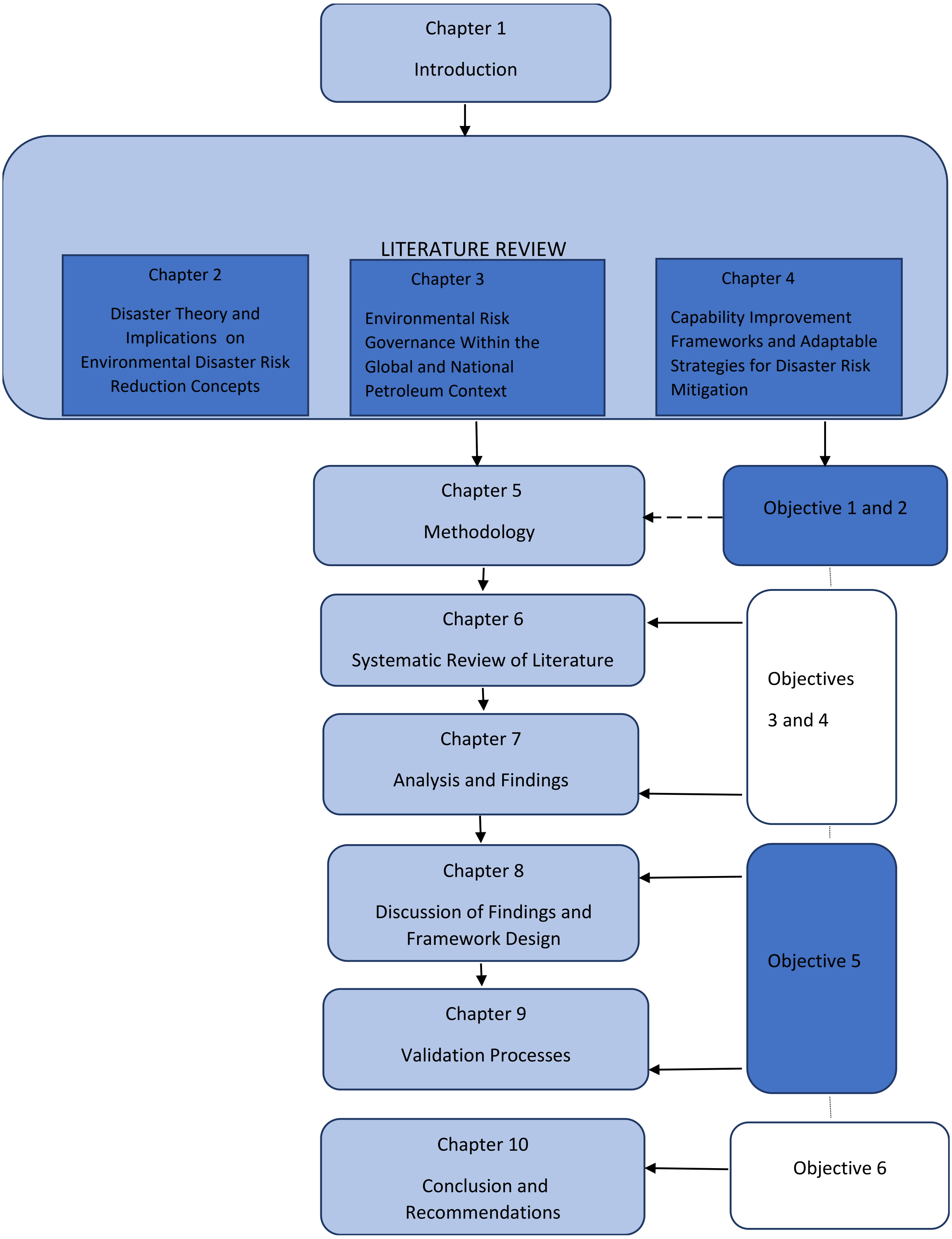


Figure 1. 1 Organisation of the Chapters in the Thesis

1.8 CHAPTER SUMMARY

A background, highlighting the challenges within the upstream petroleum industry globally, and related potential risk implications within the Ghanaian context has been provided. The critical need to build conceptual and operational interventions to address the threats and underlying risks from a more anterior perspective has been proposed. Also, the need to synthesise knowledge within existing frameworks towards a custom-fit model for addressing environmental disaster risks within the petroleum sector of Ghana, has been established.

CHAPTER TWO: DISASTER THEORY AND IMPLICATIONS ON DISASTER RISK REDUCTION CONCEPTS AND THE ENVIRONMENT

2.0 INTRODUCTION

Chapter two looks at the definitional context, historical background, debates on, as well as general evolvement of disaster theory and related fundamental concepts. This is aimed at providing added insight on the significance and impact of theory on evolving disaster management concepts and integral relations to phenomena under study. Appraisal of the literature on the integral concepts of the topic under investigation, particularly theoretical frameworks, is aimed at providing a tangential view on the state of the art, as well as offer direction towards narrowing gaps in knowledge, and supporting a conceptual framework, pivotal for attaining the aims of this study.

2.1 DISASTER THEORY AND CONCEPTUALISATION

This section appraises the historical underpinnings, evolving debates, concepts and modification of theory and practice: and followed by the conceptual framework, within which the study is situated.

2.1.1 Disaster in the General Context: To Define or not to Define

Quarantelli (1998), as does Shaluf (2007), identify attempts to define disaster in a universally acceptable format, as a highly elusive quest. This position could stem from the fact that, no two 'disasters' can ever be the same, as the basis of such definitions, emanate from divergent contexts and perspectives (Alexander, 2002). Evidently, the literature is heavily congested with varying definitions of disaster; these emanate from academia, global organizations such as the UN, stakeholder institutions, disaster occupational bodies, among others (Shaluf, 2007, Malalgoda *et al.,* 2010). Notwithstanding these divergent perspectives, a vast number of definitions which are widely in use, do have some common characteristics and attributes (Blanchard, 2008). A more rational approach to a definitional construct for 'disaster', some academics concede, could however be by classification or categorization on the basis of comparability of incidence, rather than a universally acceptable definition (Barton, 1969; Lindell, 2011).

2.1.2 Reason for Assessing Definitions

Drawing from the words of Carl Von-Clausewitz (1976, p.132), "Not until terms and concepts have been clearly defined can one hope to make any progress in examining the question clearly and simply and expect the reader to share one's views." From this tangent, one cannot discount or overstate the significance of contextualizing definitions in the appropriate perspective within academic research.

It has been suggested, challenges within disaster management functions/ operations, could be linked or traced to fundamental definitional constructs and theories (Fischer, 2002; Rautela, 2006). Fischer (2002) e.g., identifies that, disaster management and stakeholder institutions typically encounter complex challenges in determining the appropriate approach to threatening conditions and emergencies, in situations where there is lack of fundamental appreciation of the causes and conceptual dynamics of such phenomena. While it would be quite simplistic to suggest that humanity or institutions operate fixatedly within definitional constructs; however, the role of definitions in providing theoretical direction and influencing consequence is quite pivotal (Von-Clausewitz, 1976; Zeb-Obipi and Harcourt, 2007; Iezzoni and Freedman, 2008; Phillips, 2015; Wang *et al.*, 2017). It can be conceded that definitions and evolving discourse, assume integral roles towards shaping identity and action (as represented in Figure 2.1) Invariably, this argument could be stilted with an illustration as e.g. A person identified or 'defined' as 'autistic' is likely to receive reciprocally specialized attention/ suitable interventions, as compared to those labelled as mentally challenged, deranged, sick etc. (Iezzoni and Freedman, 2008).

Figure 2. 1 Sequential Effect of Definitions

Source: Author Construct (2018)

2.1.3 The U.N. Definition as Premise for Assessing Generic Disaster Definitions

The United Nations General Assembly (UNGA, 2017) definition for 'disaster', widely cited in a considerable range of literature, is in this tangent, applied for an academic undertaking, as a reference case for discussion on other definitions identified in general use, (sourced mainly from Blanchard, 2008: dictionary of disaster/ emergency terminology) (Table 2.1.). The essence of making comparative appraisal of definitions in table 2.1 therefore, is chiefly to gain insight on the extent to which capacity issues have been addressed in the literature (compared to other elements of disaster attribution, i.e., Hazard and Vulnerability), since capability is the pivotal variable, key to attaining the aims of this study. Within a similar approach, the assessment and summary of findings on definitions for 'capability' was undertaken by Lindbom *et al.* (2015) as a precursor to analyzing capability in relation to risk.

United Nations definition: "A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts" (UNGA, 2017, p.13). It can be particularly noted in the process of comparative assessment of definitions that, the UN definition considers the following:

(a) Causative/ contributory factors to disaster (i.e., Hazard (H), Vulnerability (V), and Capacity (C), and not just outcomes.

(b) Considers the subjectivity of scale/size/magnitude ('at any scale').

(c) Avoids the contentious 'Instantaneous' and 'suddenness' of event/ occurrence or time frame.

Table 2. 1 Ten Definitional Concepts of Disaster Assessed

Source	Definition	Central Concepts					Other Perspectives
		H	V	C	Magnitude/ Scale/ Impact	Suddenness	
Alexander (1993, cited in Blanchard, 2008)	Disaster can be defined as some rapid, instantaneous or profound impact of the natural environment upon the socio–economic system		√		√	√	
Blanchard (2008)	An event that requires resources beyond the capability of a community and requires a multiple agency response			√			Multi–agency response
CA, OES, SEMS Guidelines (2006)	A sudden calamitous emergency event bringing great damage loss or destruction				√	√	
Carter (1991)	An event, natural or man–made, sudden or progressive, which impacts with such severity that the affected community has to respond by taking exceptional measures		√		√		Reflects the UN perspective of progressiveness. *
FEMA (1992)	An occurrence of a natural catastrophe, technological accident, or human–caused event that has resulted in severe property damage, deaths, and/or multiple injuries				√		
ISO:2239	Event that causes great damage or loss				√		
UNDHA (1992) (Adapted by EEA (2007)	A serious disruption of the functioning of society, causing widespread human, material, or environmental losses which exceed the ability of affected society to cope using only its own resources.		√	√	√		
IFRC (nd)	a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or		√	√	√	√	

	society's ability to cope using its own resources.						
Rubin and Dahlberg (2017)	A sudden event with grave consequences, often used synonymously with catastrophe				√	√	
Cutter (2001)	A singular event that results in widespread losses to people, infrastructure, or the environment. Disasters originate from many sources, just as hazards do.	√	√		√		Singularity of incidence
Cumulative Representation		1	5	3	9	4	

Source:Adapted and Modified from Blanchard (2008)

2.1.4 Comparison of Generic Definitions with UN Definition

Comparing concepts within table 2.1 above with the United Nations definition, the following considerations on emerging themes can be summarized:

(A) The functional/ integral factors of disaster, i.e., Hazards, Vulnerability and Capacity have varied representation within the 10 generic definitions:

(i) 'Hazards', clearly highlighted within the UN definition, is only clearly represented in just 1 (one) definition out of 10. Though it could be argued that hazards are inferred in all 10 definitions, the UN definition emphasizes this factor, by a clear indication. Acceptably, there has been a shift of focus within academic literature from 'hazards', representing the critical factor of disaster theorization, through the 'vulnerability' construct towards 'resilience' concepts in more recent times (Kemp, 2003; Vatsa, 2004; Borbeau, 2015): this notwithstanding, loss of the integral identification with the underlying 'hazard' conditions within our conceptualization of disaster could engender a disconnect between the criticality of this factor as a function of the ultimate attribution for this phenomenon.

(ii) Vulnerability which is a key construct within this study is relatively higher represented, compared to the 2 other major factors (Hazards and Capacity). This lines up consistently with contemporary DRR principles and academic literature; since vulnerability is agreeably the critical factor, and ostensibly the major determinant of disaster (Vatsa, 2004; p.1). The fair representation of vulnerability within the 10 definitions (i.e. 5/10), bears crucial linkage to this study, as this element is likewise a key component in focus, and integral to discussing as well as interpreting disaster theory.

(iii) The pivotal function of disaster i.e., 'capacity' (synonymous to capability), which is central to this study, is a 'central' issue identified in only 3 definitions (out of 10). The criticality of this function appears not to be significantly projected, as a key factor of disaster attribution. While it may be argued that the 10 definitions are not exhaustive of the projections of definitional dimensions; these (sampled in Table 2.1) are indicated chiefly as representative of a cross-section of disaster definitions within Blanchard dictionary of disaster terms (2008). It is instructive to note further that, several other definitions of disaster were assessed (Fritz, 1969; Alexander, 2002; Malalgoda *et al.*, 2010 among others), which chiefly reflected comparable tangent of construction (as represented in Table 2.1)

(B) The contentious concepts of 'magnitude' or 'impact', as well as:

(C) 'suddenness' of occurrence is explored further in 2.1.6 and 2.1.7 respectively, as these constructs appear to have been overstated within generic definitions, when compared to that of the U.N. disaster definition.

Against the backdrop of criteria (B), and (C) outlined within the UN definitional construct (2.1.3), a qualitative examination, is hereby made, reflecting on Table 2.1, and the pivotal implications regarding the aim of this study.

2.1.5 Critique on the Severity/ Magnitude of Impact Concept of Disaster

Magnitude of impact is highlighted or inferred from the wording of all definitions in Table 2.1, which is also consistent with generic definitional constructs of 'disaster' (Quarantelli, 2005; Blanchard, 2008). The UN definition of disaster does suggest however, size is in a way immaterial or relative. This could represent a prudent shift towards subjectivity of standpoint on this concept; as this (construct) provides a key undergirding for endless debates, controversies, dissentions and interjections into the topic of what is, or is not a 'disaster' (Quarantelli, 2005, Furedi, 2007). Though acknowledged by a significant group of experts and academics that, size, scale and magnitude may not be the determinant factor for disaster realization; the conception regarding incidents having to be on a massive scale to be qualified or categorized as disaster, appears pervasively represented in classical definitions and discourse on the subject (Fischer, 2002; Quarantelli, 2005; Rautela, 2006).

Rautela (2006), in alignment with the UN perspective, advocates for increased attention towards preemptive action, by way of equating the cumulative impacts of seemingly "non-extensive" incidents and pockets of accidents that are recurrent or periodic in outlook, to disaster situations. The aggregate impact or complex evolvement and escalation of these accidents, most of which are under-reported, therefore not given needed publicity and sympathy; generate effects which could be more 'disastrous', as suggests Rautela (2006). A summary breakdown of oil spillage and the impact of pollution within the Niger Delta catchment and surrounding areas would indicate, the recurrent incident of spillage from various operators on weekly, monthly, and annual basis, the majority of which have not gained publicity; by far outweigh the totality of the volume of 'sudden' spillage situations, projected as tragic or publicized as disaster incidents in the locality, and global context (Kadafa, 2012). For instance, "Less than two weeks after BP's rig exploded in the Gulf of Mexico, thousands of miles away, an ExxonMobil pipeline burst in Akwa Ibom state Nigeria, spilling more than one million gallons into the Delta environment before it was patched two weeks later" (Chen 2010: p.1). However, this occurrence and myriad comparable incidents within the petroleum sector of developing countries, particularly the 'global south', generate little or negligible attention, and concern (Sam *et al.,* 2018; Obeng-Odoom, 2018). (Refer to 2.8.2.1 for typical occurrences).

It could be appreciated from the foregoing projections (Rautela, 2006; United Nations, 2009; Kadafa, 2012 amongst others), that the conceptual and governance frameworks, strategic and operational approach of some institutional bodies assigned for disaster management, could have been flawed, as these may have been 'misaligned' to the epistemology of 'disaster' having to be 'colossal' in proportions, to be addressed or managed as such (Lee, 2017). What could be broadly accepted from this philosophical contention, is the unanimity of thought, and theory pertaining to the subjectivity of scale and extent of actual or gradual impact on human infrastructure, and not as much, the size/ magnitude of the causative process or triggering event (Quarantelli, 2005).

2.1.6 Critique on the Suddenness Concept of Disaster

Five out of ten definitions assessed in table 2.1, as well as most other generic definitions of disaster, not included in Table 2.1 (e.g. Fritz, 1969; Kemp, 2007; Alexander, 2002 among others) attribute suddenness as conditions surrounding disaster: portraying a situation of the unexpected, unforeseen as well as unpredictable, therefore unavoidable (Blanchard, 2008, Furedi, 2007). An examination of the literature however, on representations made by some experts, backed by practical proof from real life experience indicate, disasters do not abruptly spring out of the 'blue or grey': the sudden occurrence of massive misfortune is not always the case as some sources would want to claim (Allinson 1993, pp 168-169). Studies carried out (Grow-Sun and McCormick, 2015; Lee, 2017) from the past two decades to date, project the concept that, not all forms of 'disasters' are unforeseen or sudden in nature. With the proliferation of cutting-edge technology, management and information systems and other interventions pertaining to research and knowledge dissemination, it is envisaged that disaster would be more, and increasingly so, foreseeable, tractable, and extreme damage/loss mitigated (Grow-Sun and McCormick, 2015; Lee, 2017).

Not being able to foresee and therefore making attribution of 'suddenness' and 'unavoidable circumstances' to most forms of human induced or some natural calamities, is considered somewhat duplicitous and in contradiction to the state of knowledge, prior to their occurrence (Little, 2010; Lee, 2017). Citing the example of the Sewol disaster, Lee (2017) highlights a chronicle of how safety mechanisms and oversight regulatory systems where exponentially compromised in the process of a deregulation exercise within the marine sector. Central government and other stakeholder agencies including international partners, turned blind eyes to warning signals over what ostensibly portended danger, as cost cutting measures and private business interest gained preeminence (Lee, 2017). It can be conceived from the positioning and arguments beforehand (Bottom and Mehra 2006; Grow-Sun and McCormick, 2015; Lee, 2017;) that, governance institutions and designated agencies as well as some stakeholder bodies are gifted a pretext, or 'smoke screen', to garner excuses for ostensible management shortcomings pertaining to avoidable incidents, on grounds of 'un-foreseeability' and 'unavoidability'.

There is no denying rapid onset or instantaneous occurrence of calamity does occur, however a re-evaluation of the trajectory of some disasters occurring in the last two decades, could unfold rather gradual developments and complication of relatively minimal or non-extensive risks/ occurrences, whereby timely action could have mitigated levels of casualty and loss (Rautela, 2006; Zucharo *et al.,* 2018). Blanchard (2008) citing Allinson (1993, pp 168-169) proffers an attribute of the 'reprehensible' towards some disaster events bearing extremities of loss, in this regard: "The label 'disaster' rather than 'accident' carries with it, not only the implication that an event was of extraordinary misfortune…but also the implication that it could (unlike most accidents) have been prevented…disasters are events which fall within our scope of concern to prevent and in principle are events which may be prevented, and that we have a consequent obligation to attempt to prevent them".

The foregoing representations in synthesis with Fischer's position (2002; see 2.1.2) concerning the ostensible ineptitude of mandated disaster management agencies, would suggest that pro-active or purposive action in a timeous manner may have been lacking in the management of some portending and actual disaster situations. After all which organizations would act or respond to issues which seemingly do not fall within the definitional context, or operational concept for which they were established. It could be considered also that, the massive incidence of such complex phenomena as identified beforehand, fall within the category of 'cascading disasters', discussed under types of disaster (see 2.5.1). In fact, one would likely agree with a suggestion by Grow-Sun and McCormick (2015) that, disasters may be in some ways, and on certain occassions 'unexpected' but not 'unpredictable'; and that, a distinction ought to be stamped between the two.

2.2 ADOPTED DEFINITIONAL CONCEPT

The definitional concept of disaster for this study, draws chiefly from the UN annotated definition and expatiation of disaster and disaster risks, as inherently related (indicated in Glossary of Key Terminology and Concepts Within This Study: 1.7). This study also aligns principally with the findings and definitional constructs of disaster, projected by Fischer (2002), Rautela (2006), Grow-Sun and

McCormick (2015), and Lee, (2017) among others, which suggest, disaster and disaster risks can in some circumstances be interchangeable.

2.3 DISASTER THEORY EVOLVEMENT

Disaster theory has evolved over several centuries, deriving basis from beliefs, doctrines, philosophies etc. prevailing within a particular dispensation. Contemporary disaster discourse acknowledges that, what people do, or do not do about a potential or actual disaster is contingent on their epistemological leanings over what disaster, and disaster risk is (Smith, 1996; Steinberg, 2000; Tierney *et al.,* 2001; Martinet, 2002; Fischer, 2002; Zeb Obippi and Harcourt, 2007). A basic understanding of the trajectory of disaster conceptualization from historical perspectives, to present times, holds pivotal value towards apprehending a fitting approach to disaster and disaster risk management, on the basis of academically tested principles.

2.3.1 Fundamental Concepts of Disaster Attribution

Contemporary disaster studies have sought to draw a distinction between, the real causes of disaster, and 'types' of disaster, as well as the triggering sources (Lindell, 2011; Sawalha, 2018). In keeping with works of earlier disaster scholars, such as Carr (1932) and Kemp (2003), the literature dominantly reflects the concept that disasters are not 'naturally caused' but rather, 'made-up' and by anthropological 'choice' (Carr, 1932; Kemp, 2003; Turner, 1994); whereby they are viewed from the sociological perspective, as socio-technical failures bearing influence on human and institutional vulnerability as well as inherent shortcomings (Tierney, 2012; Drabek, 2013).

2.3.2 Integrative Evolvement of Disaster Attribution: A Conceptual Appraisal

Having pre-established a basic concept that disasters are realizable from a sociological perspective (further expatiated within section 2.7 and 2.8), it would be instrumental to consider the evolvement of the underlying principles, and the development of concepts on causative, contributory and central issues pertaining to the phenomena.

2.3.2.1 First Stage - Pre-historic Approach to Disaster Concepualization

Within the pre-historic dispensation, supernatural influences were seen as the predominant variable, while other variables were considered peripheral (e.g. hazard and vulnerability). The approach to addressing disaster, was one of endurance, fortitude, and quiescence as it was considered, 'nothing much could be done against the supernatural forces' (Kemp, 2003; Furedi, 2007). "Accordingly, repentance or human sacrifice were regarded as the means to appeasing Deity" (McEntire 2003, p. 3). 'Resilience' and 'capacity' attributes in theory and practicality of disaster conceptualization could be considered, latent concepts or considerations under this dispensation (Furedi, 2007).

2.3.2.2 Second Stage - Historical Dispensation of Disaster Conceptualization

Evolving from the late eighteenth century, and through to the earlier sections of the twentieth century, the attribution of disaster begun to shift from supernatural factors to natural hazards, or what was termed 'acts of nature'. This paradigm was the tangent, as enlightenment and secularism emerged, and the supernatural connotations of disaster were exponentially discounted from the attribution and conceptualisation of this phenomenon (Quarantelli, 2001 p.3); whereby the model of attribution (Quarantelli, 2001; Kemp, 2003; Furedi, 2007; Alexander, 2012), within that era, juxtaposed to the contemporary conceptualization of disaster, would be viewed as very disparate. Within this dispensation, hazards or particularly natural hazards, were considered the predominant factors, and other elements of disaster, subsidiary. The response to managing disasters at this time, was mainly through adopting a reflexive/ kneejerk form of resilience and response mechanisms in order to cope with the forces of nature. From this dispensation, one can identify a relation whereby the relative magnitude or impact of the reflexive resilience form, reciprocally affects the outcome of disaster. It can be noted that, capacity consideration or attributions towards the development of institutional structures, were latent in the theoretical tangent of disaster management construction (Adger, 2000; Quarantelli, 2001; Furedi, 2007, Alexander 2012).

2.3.2.3 Third Stage – Post-historical Dispensation of Disaster Conceptualization

From the mid-portions towards the latter part of the twentieth century, the emphasis on disaster causation and centrality of interventions, begun to shift from hazards to vulnerability mitigation, as highlighted (Carr, 1932; Kemp, 2003, Vatsa, 2004). 'The earliest human ecological models of disaster were considered linear in conception: hazard acted upon vulnerability to produce disaster' (Alexander, 2012, p.36). It followed that, as hazards were at the start of the process, they received the lion's share of attention. This was also in line with the dominance of physical over social sciences at the time. Within this dispensation, resilience and capacity issues were considered more integral with the passage of time, thereby massive research attention and disaster management models projected these hitherto latent elements exponentially (Quarantelli, 2001).

Here, though the criticality of vulnerability had just begun receiving increased attention, the concepts of resilience and capacity impacts were however not fully appreciated or configured within disaster attribution and management (Quarantelli, 2001).

2.3.2.4 Fourth Stage – Evolving Dispensation of Disaster Conceptualization

Evolving further from the latter part of the twentieth century towards the first decade of the twenty first century, the attribute of human influence and the concept of vulnerability being ascribed as a major contributory factor and not just peripheral or complementary factor, gained critical prominence (Granot, 1998); and academic investigations into disaster, was directed from this perspective (Vulnerability); as the growing importance of resilience in its theoretically projected form was increasingly subjected to debate and criticism (Quarantelli, 2001; Furedi, 2007;). "Vulnerability has emerged as the most critical concept in disaster studies, with several attempts at defining, measuring, indexing and modeling it" (Vatsa, 2004; p.1). 'Over the period 1979-83, researchers working in developing countries produced the so-called "radical critique," which argued that in the explanation of disaster, vulnerability carries more weight than hazard' (Alexander, 2012, p.36). 'As a result of feedback loops, hazard can be regarded as a trigger for the social processes that create vulnerability, which is the principal determinant of disaster' (Alexander, 2012, p.37). Under this dispensation, the significance and vital role of capacity was projected more significantly, however the centrality and crucial nature of capacity concerns and exigency to develop conceptual frameworks for addressing disaster issues had only just begun to gain prominence (Edelstein, 2011; Tierney, 2012).

2.3.2.5 Fifth Stage – Contemporary Dispensation of Disaster Conceptualization

Furedi (2007), further highlights that within contemporary dispensations, the critical role of 'capacity' has been assigned greater significance, and the causation aspect being more attributable to composite factors, i.e., 'acts of man' or socio-technological factors in configuration with vulnerability, compounded by a compromised or weak capacity status. Disaster conceptualisation for this dispensation would be quite reflective of the UN (2009) and IFRC (2019) models of disaster attribution, with consideration of the various interactive factors, against the backdrop that the concept of resilience is regaining attention within current disaster theory and functions, despite persisting debates and criticisms (Borbeau, 2015; Rogers, 2017).

2.3.2.6 Sixth Stage – Conjectural Evolving Dispensation of Disater Conceptualization

From the tangent of theoretical evolvement identified beforehand (within preceding dispensations) and the developing discourse impacting disaster management frameworks (Aven, 2011; Wilson and McCreight, 2012; Shavell, 2014: Wang and Kuo, 2014; Lee, 2017), it can be identified that: as resilience mechanisms are exponentially deployed to mitigate the effects of vulnerability plus hazards; the multiple/ exponential effect of resilience interventions on 'capacity', could catalyze/ evolve stakeholder bodies into better prepared, pro-active, and more resilient institutions (Rautela, 2006; Lee, 2017). From this position invariably, disaster conceptualization and interventions would exponentially be pivoted on, and addressed from the perspective of capacity enhancement and institutional resilience, just as disaster management conceptualization has in the past been approached from the perspectives of: (1) supernatural, (2) hazards (3) moderate hazard/ vulnerability (4) Vulnerability centered and finally, (5) composite element attribution, respectively (Lindbom *et al.*, 2015; Cheese 2016). This therefore underpins the rationale for approaching this study from the perspective of 'capability' development, as pivotal to attainment of EDRM goals (see 4.1, for the integral relationship between capacity and capability).

2.4 TYPOLOGY AND TAXONOMY OF DISASTER

Disasters are typically categorized under three main groupings, which are, (a) Natural, (b) Man made and (c) Hybrid (Shaluf, 2007) Natural disasters are those that emanate from the cyclical undetermined occurrences i.e. the forces and elements of nature acting upon living and non-living things. These occurrences are termed as "acts of God". Whereas Man-made disasters are those that involve causalities based on human involvement: Socio-technical and warfare situations, are identified as the major subcategories of man-made disaster. Hybrid type of disaster are those that proceed out of a combination of naturally caused and those of anthropogenic or socio-technical origins.

Richardson (1994) provides further illustration of socio-technical disaster classes and attributes, as occurring within organisational or societal settings under four main subcategories. System failures or breakdown of physical integrity such as occurring within a factory, industrial and related settings (e.g., involving explosions, toxic waste leakages structural collapse of infrastructure). These attributes highlighted by Richardson (1994) are chiefly upheld and subscribed to by Shaluf (2007) as well as Haddow and Bullock (2003). From the attributes and indices outlined hereby (1994), it would be justifiable to place this study as belonging under the domain of socio-technical disaster, though in some complex scenarios such as occurring in the Niger delta of Nigeria, ramifications of the hybrid form of disaster could be established (Natural seepage of oil is known to occur on land and sea without human influence).

2.4.1 Cascading Disasters: Are These a Different Disaster Category?

Cascading disasters do not fall into another class or other category of disaster but can be identified as the dynamic evolvement of disaster or emergency situations into increasingly complex disaster progressions and impacts (Alexander, 2012). Deeper and wider investigation into the debates, dimensions and perspectives of past events, would indicate that disaster preparedness and response go further beyond conducting of rescue and relief. Regarding ramifications and integral aspects of this subject, a critical examination of some popular definitions and literature on disaster, would indicate that, phenomena such as cascading disasters have not attained substantial attention, consideration, and integration into our disaster management systems (Rautela, 2006; Alexander, 2012).

2.4.2 Stages of Disaster: The Disaster Cycle and Disaster Management

Academics and practitioners typically identify four main stages or phases of disaster (Kimberly, 2003; Shaluf and Ahamadun, 2008): This comprises: 1. The mitigation stage; 2. The preparation stage; 3. The response stage and 4. The recovery stage. Disaster management is defined as 'a collective term encompassing all aspects of planning for and responding to disasters, including both pre-disaster and post-disaster activities' (CERO, 2004). This refers to management of all facets of disaster including risks, response, recovery and others. The aim of academics, practitioners, disaster management institutions etc., particularly towards DRM, is to break the chain of disaster process or stop the cycle from evolving unto the response stage (Frumkin, 2010) see Figure 2.2. Should this aim not be realizable, the subsequent processes from response to recovery serves to provide adaptable mechanisms for redefining and re-engineering the mitigation process.

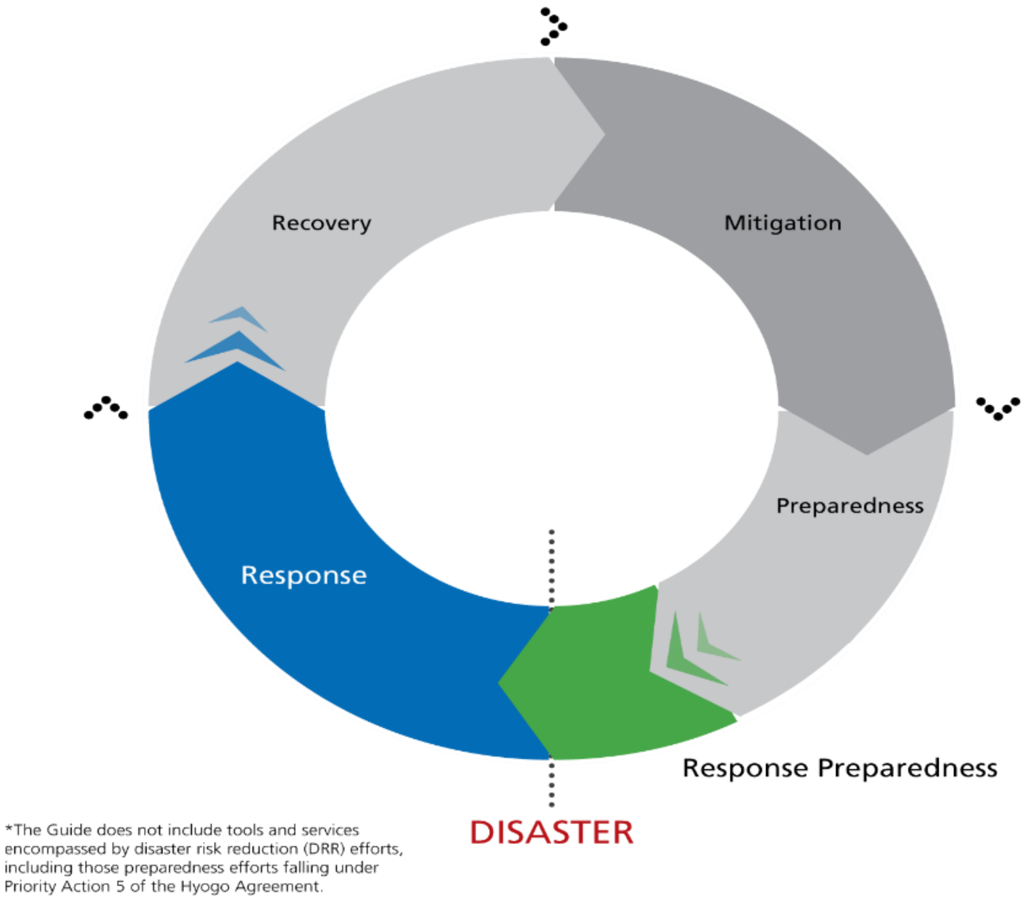


Figure 2. 2 The Disaster Management Cycle

Source: UNOCHA (2020)

The cycle or developmental stages in the disaster process is not necessarily linear, neither is one stage of a certainty, mutually exclusive from another (Lindell, 2011). Indeed, it is identified that the various stages overlap in concept and practice (Levinson and Granot, 2002); and while a directional template for the different stages of disaster management is considered instrumental for clearer understanding and conceptual guidance: over-classification or segregation of stages as uniquely sequential occurrences, could compromise some required actions and overall effectiveness. The non-linear interlinkages and overlapping modes in operation can be demonstrated from one phase to another within the cycle (Lindell, 2011): during the response stage for instance, 'mitigation' or 'preparedness' activity may be required, more especially where secondary impacts (e.g., cascade events) are envisaged. Invariably the recovery process may likewise demand 'preparedness' for unforeseen residual impacts, as well as deploying interventions for 'mitigating' some socio-cultural vulnerabilities etc. (Lindell, 2011).

As indicated beforehand, disaster management (DM) encompasses the entire range of activities involved in minimizing the impacts of hazards on vulnerabilities (CERO, 2004), beginning with disaster risk reduction (DRR), and disaster risk management (DRM). It is however not uncommon to see within contemporary literature, 'disaster management' frequently associated with or referring to actual execution of the response and recovery process, as distinct from DRR or DRM (UNISDR, 2019) The distinction between DRR/DRM and disaster management (DM), is viewed more as a matter of rhetoric and emphasis, rather than a conceptual variance, as DM embraces both (DRR and DRM) (Van-Niekirk, 2015). In much the same way as the various stages of disaster management processes (mitigation, preparedness, response, recovery) are interconnected and complimentary, so are the complementary concepts of DRR, DRM and DM (2006).

2.4.3 Variability in Disaster Management Modelling

Some disaster management studies, and interventions have been modelled from composite perspectives; while others have focal perspectives, such as emphasis on vulnerability, resilience or some other standpoints: for examples: (i) risk reduction and (ii) emergency management, among others (Nojavan *et al.*, 2018). Weichselgartner (2001) for instance, developed a model that considers vulnerability as the focal and key concept for apprehending DM interventions (Figure 2.3), and this can be compared to the model proposed by Nojavan *et al.* (2018), which projects a more comprehensive approach to DM (Figure 2.4).

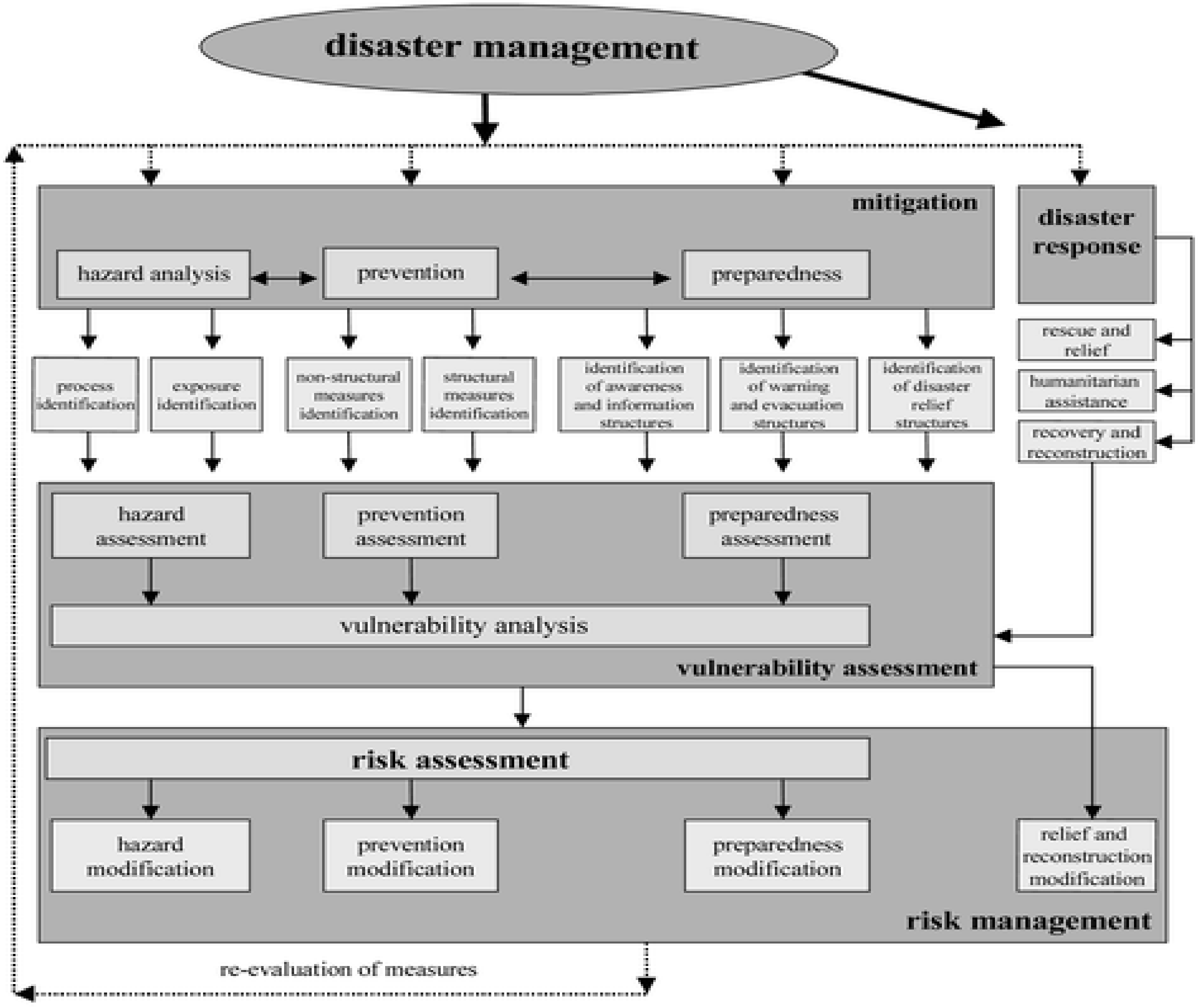


Figure 2. 3 The Weichstelgartner Model of Disaster Management Process

Source: Weichstelgartner (2001)

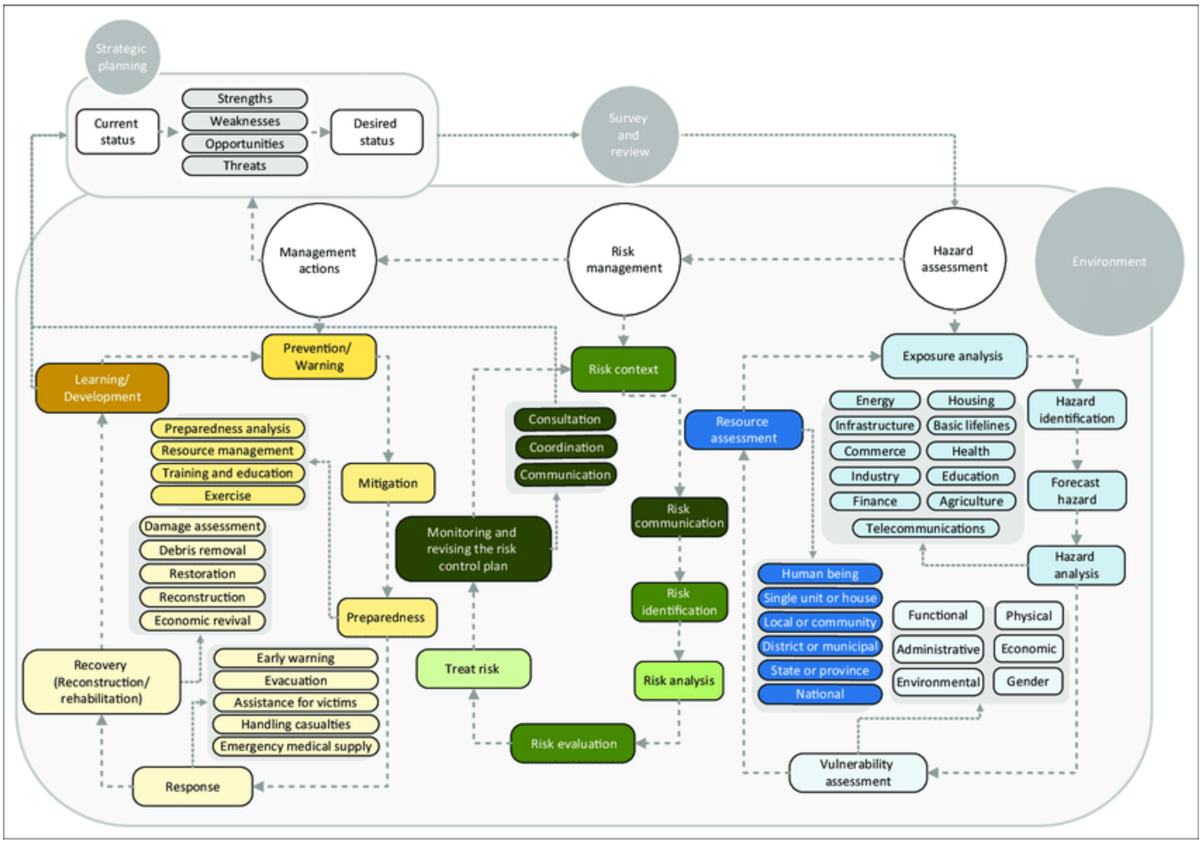


Figure 2. 4 The Integrated Model of Disaster Management

Source: Nojavan et al. (2018)

2.5 THEORETICAL BACKGROUND

Theoretical framework relates to the structure that sums up various concepts and theories, which have been established from previously tested and published knowledge base, which can be reflected on, and synthesized to help guide a research process, thus providing fundamental guideposts for data analysis and interpretation of concepts, contained in research findings (Kivunja, 2018). Swanson (2013, p. 122) simply states, “The theoretical framework is the structure that can hold or support a theory of a research study”. The main significance of adopting a theoretical framework within which to pursue research is to have a scholarly foundation towards making meaning of knowledge as it relates to data accessed in the process of the study, and how this substantiates, disproves or builds upon gaps in the theory and sub-constructs (Neuman, 1997). Kelly (1998), towards defining four main reasons for the necessity of developing theory or theoretical models for natural disaster management, highlighted that: a model can simplify complex events by helping to distinguish between critical elements.

2.5.1 Disaster Risk Conceptualization and Management

Disaster risk conceptualization and its management functions are corollary appendages and evolving constructs, which subsist under the broader disaster theory and disaster management concepts (Shaluf *et al.,* 2003). To better appreciate these concepts, it is informative to gain exposure and familiarity with the broader disaster theories, evolvement and related concepts, definitions and contexts within which these models have been developed over the years. Observe that related concepts that are crucial for attaining the aims of this study, such as vulnerability, risk, etc. have further been discussed in appreciable depth (see 2.8.3 and 2.8.4). Disaster management models evolve from some definitional, contextual, philosophical or other constructs, which have the potential to provide better understanding of the phenomenon and synchronizing of efforts at maximizing DRR/ DRM objectives (Quarantelli, 2001; Asghar *et al.,* 2006)*).*

Prevalently, DM conceptualization and modelling have in the past been approached from unitary and focal perspectives (Nojavan *et al.*, 2018). Frameworks and models were based mainly on addressing particular elements of variability in disaster causation and processes, such as tackling hazards, vulnerability and quite recently resilience. (Wilson and McCreight, 2012; Shavell, 2014; Nojavan *et al.*, 2018). While previous studies were more focal on DM modelling approach, such as the Weichselgartner model (2001); more recently studies have been aimed at increasingly integrative constructs, such as the combinatorial model and the comprehensive model projected by Asghar *et al.* (2006) and Nojavan *et al.* (2018) respectively. Aside the various elements of disaster causation and stages of management activity, Nojavan *et al.,* identify three key components of disaster management process termed 'organizing themes' (2018, p.1). These themes namely (i) hazard assessment (ii) risk management and (iii) management actions, have in the past been investigated mainly 'one-dimensionally' in disaster management research, according to Nojavan *et al.* (2018, p.1). Those that have two-dimensional coverage of the organizing themes, also tend to be focused on one component more than the other.

Notwithstanding the need to consider disaster management within a comprehensive context, this does not discount the approaches of placing emphasis on particular dimensions and themes. For example, Kimberly (2003) developed a four-dimensional model of disaster management, however, emphasis has been placed on emergency management in that model. Rationally, the aim of the research, context and desired impact, shape the outlook of the model, as do the theoretical standpoints of the researchers. In respect to the foregoing, composite appraisal of conceptual models of disaster management is therefore made to identify constructs that reflect the aim of this research, in order to aptly contextualize and discuss more explicitly the proposed model. Asghar e*t al.* (2006) made a review of various models of disaster management, incorporating proposals in Weichselgartner (2001); however, the study on multiple models made by Nojavan *et al.* (2018) is comparatively, more comprehensive. The review by Nojavan et al (2018) is therefore deployed as a reference material towards discussing and identifying relevant theoretical models and concepts underpinning this study.

Table 2. 2 : Composite Theoretical Models for Disaster.Management.

Classification of model	**Model Title**	**Source**	**Summary**
Logical Models	Traditional model: sequences of action	DPLG–2 (1998)	The different disaster management phases, rather than in a sequential manner, run parallel to each other, albeit with varying degrees of emphasis.
	Expand and contract model	DPLG–2 (1998)	The difference with the traditional model is also often observed that the sequences of action occur simultaneously
	The four–phase model of disaster	Kimberly (2003)	This model emphasises emergency management. The most important phase of this model is the response phase.
	The four–stage model of Tuscaloosa	Tuscaloosa (2003)	This model starts and ends with the response stage
	Circular model of disaster	Kelly (1998)	The main feature of this model is its ability to learn from real disasters
	Lechat Model	Lechat (1990)	This model starts with anticipation of disaster and ends at the rehabilitation stage
	The 5stage model of Mitroff and Pearson model	Mitroff and Pearson (1993)	This model emphasises the detection and learning phases
	Gupta stair model	Gupta (2010)	This model does not pay much attention to pre–disaster phases
	Mitroff Model	Mitroff (2000)	This model is a proactive model that emphasises the learning stage
	Two–part model of disaster management	Hosseini and Jedi (2006)	This model includes a series of operational and logistic measures. So, this model is called a two–part model.
	Iceberg model	Heinreich (1941)	The main feature of this model is its attention to the structure and showing seeming template of model.
	Contreras model	Contreras (2016)	In this model, a number of indices have been developed for measuring vulnerability to disasters. The main feature of this model is its attention to the reconstruction after disaster
Integrated Models	Manitoba model	Manitoba Health Disaster Management (2002)	Advantage and feature of this model is establishing a balance between preparation and resilience, in order to respond to the specific needs of the disaster.
	McConkey linear model	McConkey (1987)	McConkey model pays special attention to pre–disaster management in four stages
	Weichselgartner integrated model	Weichselgartner (2001)	The overall objectives of this model are the assessment of probable damage and the planning of future measures to reduce this damage.
	Integrated model of Moe and Pathranarakul	Moe and Pathranarakul (2006)	The results of this model show the importance of proactive and reactive strategies in natural disasters management.
	McEntire *et al.* integrated model	McEntire *et al.* (2010)	An integrated approach for modelling the vulnerability should consider social science research, engineering and physics simultaneously.
	Onion model	Mitroff, Shrivastava and Udwadia (1978)	This model provides a framework for preparing organisations in the crisis
	Deming cycle model	Aguayo, (1991)	The PDCA cycle with the continuous improvement cycle of plan, do, check and act was advocated after the Second World War.
	Integrated system–oriented model	Meshkati and Tabibzadeh (2016)	The main feature of this model is its attention to the emergency response
	Monitoring and evaluating model of disaster risk management	Scott *et al.* (2016)	This model is a unique framework for monitoring and assessment of disaster risk management plans for use by disaster risk management programmes to track the outcomes of their interventions and ultimately raise standards in this area.
Cause Models	Crunch cause model	Asian Disaster Preparedness Centre (2000)	This model is a causal model that provides a framework for understanding the causes of disaster; its structure is formed by the following equation: Disaster Risk = Hazard *Vulnerability
	Pressure and release model	Blaikie, Mainka and McNeely (2005)	Unlike the Crunch model, and employs preventive measures, to reduce the disaster risk.

	Fink's comprehensive audit model	Fink (1986)	This model determines what events could cause a crisis in each functional area. Once scenarios are developed, action plans should be prepared.
	Littlejohn six stage model	Littlejohn (1983)	This model is a framework that provides basic directives for disaster management
Combinatorial Models	Risk management proactive model	Australian Development Gateway (2008)	This model tries to combine logical and integrated model
	Disaster risk management framework (DRMF) model	Baas *et al.* (2008)	This model has the following three steps: – Risk reduction (Normal) – Emergency response – Recovery.
	Risk management model	BPDMP (2013); Zimmermann and Stössel (2011)	The objective of this model is increment of community resilience and risk reduction using combination of logical and integrated models.
	Wheel shape disaster management model	Rowshandel Arbatani, Purezzat and Qolipoor (2008)	One of the comprehensive disaster management models is the wheel–shape model that is based on the life cycle of disaster and crisis, as well as its various stages. Also, it is formed by combination of logical and integrated models.
	Cuny comprehensive model	Cuny (1998)	Cuny proposed a cycle for disaster management that is one of the complete cycles. This model considers administrative and management measures that are necessary in disaster management using a combination of logical, integrated and cause models.
	Saldana–Zorrilla model	Saldana–Zorrilla (2015)	This model provides a set of policy suggestions for integrating risk management and increasing risk reduction measures and planning.
	Institutional model for collaborative disaster risk management	Tau, Niekerk and Becker (2016)	This model combines the theoretical, political and technical dimensions of collaboration to enhance buy–in for the disaster risk management and reduction function of governments.
Other Models	Ibrahim *et al.* model	Ibrahim *et al.* (2003)	This model represents the technological disaster pre–condition stages
	Gonzalez, Herrero and Pratt model	Gonzalez, Herrero and Pratt (1996)	This model states that with the pre–disaster measures, we can change the consequences of the crisis.
	Fink model	Fink (1986); Penrose (2000	This model includes prevention components and crisis analysis
	Statoil model	Statoil (2013)	This model is a reactive model because it starts the activities after the occurrence of disaster and lasts until returning the condition to the pre–disaster normal condition.
	Pagoda model	Okada (2004	City has been considered as a vital five–stage system in this model
	Octopus model	Shi *et al.* (2011)	As disasters have complex systems, mutual risk management should be based on multidimensional system for achieving success from policy–making viewpoint. This model is proposed based on this viewpoint.

Source: Adapted from Nojavan et al. (2018)

2.5.2 Considerations Underpinning Choice of Theoretical Model for This Study

It is instructive to note the following, as a guide towards better appreciation of the approach and goal of this section/ study:

(i) The purpose of this section is not to pursue an exhaustive discussion or debate on disaster management models, but to give readers a basic appreciation of the evolvement of the subject from multi-dimensional and multidisciplinary perspectives, over the concepts underpinning D.M. Consequently, no in-depth evaluation and discussion would be made on the merits, demerits, relevance and applicability etc. in this section.

(ii) As the major aim of this study is not a disaster management framework in the sense of a comprehensive disaster management model (covering all phases of disaster), but rather a disaster risk reduction mechanism: as such, the focal mechanism and approach for this study is directed towards the pre-disaster phase and related risk management concepts rather than the ‘disaster’ or post-disaster context.

2.5.2.1 Assessment of Various DM models

- **Logical Models**: Taking a summary of the concepts discussed in the theoretical models above, it can be appreciated that the logical models do not bear massive reflection on the disaster risk minimization focus for this study, particularly the Gupta staircase, circular, and four phase models which do not give significant and focal attention to the pre-disaster phase (Kelly, 1998; Gupta, 2010).
- **Integrated Models:** The integrated models seek to look at disaster management in a sequence of interconnected events and processes. In some ways much like the combinatorial models (Ashgar *et al.,* 2006; Nojarvan *et al.,* 2018), they consider DM in a holistic manner, however with relative emphasis on some aspects than others. McConkey model (1987) for example, gives particular attention to pre-disaster management, while McEntire model (2010) considers vulnerability and social dimensions of disaster management. The Onion model model (1987) provides a framework for preparing organizations towards crisis management. The monitoring and evaluation model of disaster risk management (Scott *et al.*, 2006) is a guided framework for monitoring and assessment of disaster risk management mechanisms applicable towards monitoring performance in that regard, and their consequential impact on emergency/ crisis management, which ultimately reflects on improvement of disaster management standards.
- **Cause Models**: In some respects, ‘Cause models’ are indicative of and composite within the ‘Integrated Models’, in the way these look at underlying factors and disaster risk management processes, as aforementioned (Nojarvan *et al.,* 2018). The ‘Crunch Cause Model’ for instance could be a typical reflection of the proposed framework for this study, howbeit this study is projected to be much more focal within a particular perspective, that is on, capacity/ capability.
- **Combinatorial Models**: The combinatorial models are more comprehensive and holistic in approach, and mainly directed at merging Logical and Integrated models (Ashgar *et al.*, 2006; Nojarvan *et al.,* 2018). These models though appear to be the ideal set of constructs for disaster management modelling, are rather holistic in coverage, giving massive attention to the varying stages of D.M. (Cunny, 1998), and would therefore not reflect the focal dimension of this study.
- **Other Models**: Concepts which fall among ‘Other models’ classification appear to bear more significant linkage to the disaster risk minimization aim of this study, in its unique perspective (Nojarvan *et al.,* 2018). A fair proportion of ‘Other model’ concepts are focal on risk mitigation much like the integrated models. Within this category of models, the Gonzales, Herrero and Pratt model (1996) aptly reflects the aim of this study, which seeks to establish the overall impact of pre-disaster risk management as quintessential to the outcome of a crisis or

threatening incidents. It can also be conceded that the Ibrahim *et al.* (2003) model, which immensely reflects the risk minimization aim of this study, also captures the focal discipline of technological disasters projected within the framework envisaged.

2.6 MODULAR CATEGORIZATION OF THIS STUDY

Having considered and compared the various D.M. modelling features (Table 2.3), it can be predicated that, the disaster risk minimization projection for this study, fits largely within the 'Other models' classification: however, this could also fit within some significant constituents of the 'Integrated Model' class, such as the 'Monitoring and evaluating model' of disaster management. It is however circumspect to place this study under the classification of 'Other models' of disaster management, since the proposed framework, bears its own unique features not akin to components and processes identified within the pre-indicated models. As previously highlighted the proposed framework for this study encapsulates the constructs of the Gonzales, Herrero and Pratt model (1996) and the Ibrahim *et al.* (2003) model (largely components of 'other models'). It is identifiable that, whereas this study recognizes, and considers the intricate interconnectedness of the various elements of the DM process from risk management through response to recovery, the emphasis or fulcrum of operationalizing this goal is through risk minimization and management from the pre-incident or root factor context.

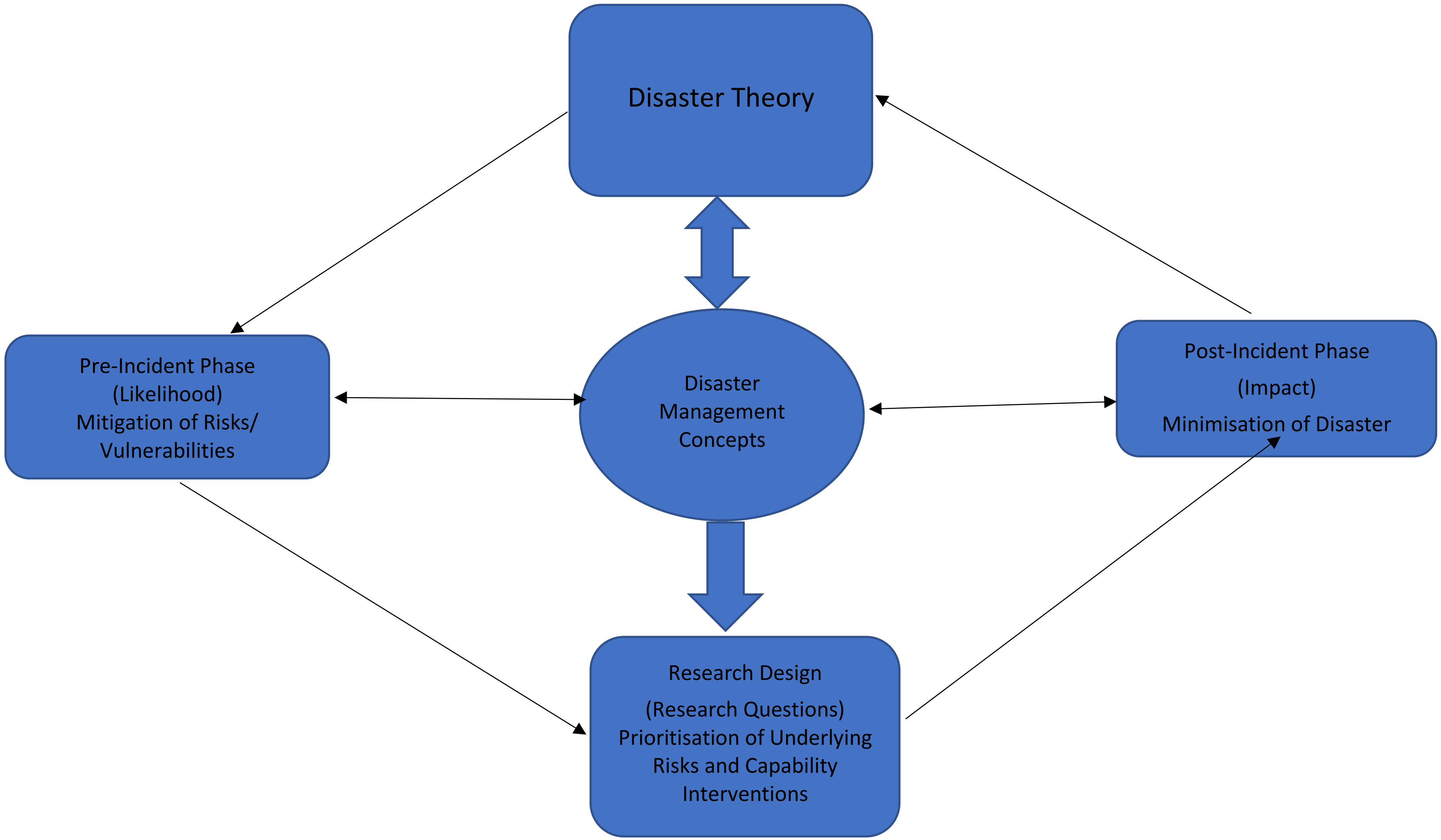


Figure 2.5 Conceptual Framework

2.6.1 Conceptual Framework

Figure 2.5 outlines the conceptual underpinnings for this research. This (Conceptual framework) draws generally from principles of the 'Cause', 'Combinatorial' and 'Other' Models of disaster management (2.5.1). With exemplary reference to the Gonzalez, Herrero and Pratt - 1996 Model (Table 2.2), the conceptual framework for this study projects that; though disaster risks and impacts can be managed from the emergency or response stage, the impacts of a disaster is largely determined from the perspective of managing of underlying risks and vulnerabilities at the pre-incident stage (See 6.4 and 10.5 for added synthesis).This underpins the approach to prioritise underlying risk factors and capability interventions (Research questions/ survey questionnaire), to be deployed towards minimising disaster risks and potential environmental impacts, within the upstream petroleum sector of Ghana.

2.7 DEBATES AND CRITIQUE OVER THE CONCEPT OF ENVIRONMENTAL DISASTER

The concept of disaster has been, and continues to be a subject of debate and controversy (Furedi, 2007; Quarantelli, 2001; Little, 2010; Rautela, 2012). There has been disagreement over (i) whether socio-technical disasters are really different from natural disasters; (ii) as to what extent social constructionism can be applied in the interpretation of disaster, (iii) the real contribution or impact of climate change, and others (Clarke and Short, 1993; Drabek, 2013). The major controversies on disaster however relate to definitions apparently, as it can be identified 'disasters' occur in varying forms, settings, locations, contexts etc. For instance, in situations of warfare, in economic activity, scientific failures in medical experiments, impact of extreme natural force action on human life/ livelihood among others; all of these aspects having further underlying or related implications or interpretations, based on personal, group, community, country setting etc. and assessment of impact and loss (Sawalha, 2018). Aside these disagreements another aspect of dissent and debate, is on conception of size, magnitude and impact of incident (see 2.1.6), and the dynamic effect on victims and stakeholders, i.e., responders etc. (Alexander, 2002).

Another yawning debate having wide range of perspectives, and impactful ramifications, is the concept that disasters are categorically massive impact related phenomena (Carr, 1934, Kemp, 2003, Furedi, 2007); invariably, 'disasters' ought to be distinctly delineated from 'disaster risks' (Rautela, 2006; Furedi, 2007; Quarantelli, 2011). Contrary to the United Nations annotated definition, some schools of thought suggest, disaster and disaster risks are mutually exclusive (Rautela, 2006). However a critical examination of the literature (Rautela, 2006; Alexander, 2012; Lee, 2017; Obeng-Odoom, 2018 among others), and contemporary phenomena such as the Tullow Oil Plc. turret mooring incident in 2016; could demonstrate, 'disasters' and 'disaster risks' are not always mutually exclusive contructs, but periodically intercovertible, as preambled in the following: "In 2016 there were 327 disaster events, of which 191 were natural disasters and 136 man-made disasters. Natural catastrophes accounted for $46 billion in insured losses, while man-made disasters resulted in additional losses of about $8 billion. Turret failure in a floating storage and offloading vessel in Ghana and steam generator failure at a French nuclear power plant were the worst man-made disasters in 2016" (Insurance Information Institute, 2020).

Despite statistical indicators identifying the Tullow Ghana FPSO turret failure as the worst (jointly) man-made disaster in the world for 2016: (i) there was no cataclysmic/ epochal outcome of a massive force event (ii) there were no recorded/ observed biological/ socio-environmental impacts, which arguably, 'are' the major determinants of disaster of attribution (Fritz, 1969; Quarantelli, 2001; Furedi, 2007). (iii) Strangely, as the worst disaster of global scale, there was no global apprehension/ alarm, sympathy or massive external capacity response common with disasters, and associated with disaster definitions. Apparently within Ghana, only a minute fraction of citizens heard about or took notice of this occurrence. The following observation could serve as a synopsis on fundamental arguments and counter-arguments for the foregoing antithesis.

(a) It could be contended that disaster adduced within the case above is (was) contextualised within economic/ financial dimensions of insurance losses, and not 'disaster' as generically defined (Carr, 1934; Furedi, 2007). While that contention to some appreciable level may be true, it would be somewhat a simplistic explanation underpinning reasons for the subdued levels of concern towards the foregoing occurrence ('worst man-made disaster), considering that generically 'disaster' has largely and intrinsically been linked to massive economic, and financial impacts/ ramifications, as demonstrated in Ghana's FPSO turret failure.

(b) Whereas within the classical definition of disaster, the turret failure would not be attributed as a 'disaster' (especially when there was no total collapse), it would also be simplistic and highly debatable to discount this as a 'non-disaster', considering that disaster definition/ attribution has ostensibly been a subjective phenomenon underpinned by divergence and multiplicity of perspectives (Fischer, 2002; Rautela, 2006; Furedi, 2007; Alexander, 2012)

(c) For example, arguments such as 'a marine vessel or helicopter crash on an oil rig, is merely an accident and not a disaster', could be flawed on the basis of the foregoing (contextuality). Whilst such arguments may hold some form of validity, it could similarly be contended e.g. that the Fukushima earthquake 'was not' a disaster, which would violate the constructivist dimensions of disaster attribution/ definitions (Lee, 2017; Grow Sun and McCormick, 2015; Alexander, 2012)

(d) What this study identifies with, based on synthesis of knowledge (chapter 2 and 6) is that: The terminal point of a 'disaster' can portend or be the 'inception of a disaster risk' and vice-versa. Put in other terms, the endpoint of a conceived ‘disaster risk’ such as: (a) the Fukushima earthquake; is the beginning of (b) a Fukushima Daicii nuclear reactor incident’. Evidently, (a) and (b) are interchangeable: However the vexatious debate could be over, which of the two occurrences caused greater harm and or environmental impacts for instance, to establish disaster attribution. Also contentious, is the conception that disaster ‘risks’ generically ought to be delianated from disaster.

(e) Reflecting on the Tullow Turret mooring failure, one could adduce or argue that: (i) This occurrence was a ‘disaster risk’, though within some techno-economic dimensions this was considered ‘worst man-made disaster’ (Insurance Information Institute, 2020). (ii) If the turret mooring had collapsed totally, especially with disintegration of interconnected infrastructure, plus destruction to human life; this could have been categorised a ‘disaster’: whereas other schools of definitional perspectives would class this as a disaster incident ‘trigger or medium’. (iii) Ultimately, if a total collapse of the turret mooring had caused massive structural failure, loss of life and environmental devastation resulting from HCR and other chemical pollution, this may have been termed ‘the real’ disaster; whereas however, all 3 foregoing conditions could justifiably, be classed as disasters (Fischer, 2002; Rautela, 2006, Lee, 2017).

(f) In quite the same vein, (a) the Fukushima earthquake per the perspectives of classical disaster conception (Carr, 1932; Fritz 1969; Kemp, 2003) would be classified as merely a disaster risk; and (b) the Fukushima Daicii nuclear reactor breakdown could be assigned as just a disaster medium or trigger (on this basis: ‘just because a nuclear reactor got involved in an accident/ breakdown, does not connote a disaster’). (c) The ‘real’ disaster could be attributed; where the nuclear reactor damage and radio-active fallout, caused massive destruction to infrastructure and biological life (reflecting conditions of vulnerability). However the conditions of vulnerability existed long before the earthquake, therefore (postulation): if conditions of vulnerability, which are the key determinants of disaster, were pre-existing conditions; it can be rationally adduced in a way that, disasters are ‘more’ pre-incident related phenomena than consequence/ residual impact phenomena.

The critical concern and bone of contention has however been over ramifications for the preoccupation of disaster management literature and operational concepts/ interventions within more post-incident and impact related domains (Tierney, 2012; Obeng-Odoom, 2018); and the conception that, disaster management ought to be distinctly delineated from accident/ safety management concerns (Rautela, 2006; Lee, 2017; Grow-Sun and McCormick, 2015). Also, whereas the UN definition/ expatiation suggest that, ‘disaster risks’ are quite analogous to disaster (which is largely in agreement with concepts identified in this study): there appears to be a conceptualized approach in research and practice which considers disaster risks as mutually exclusive phenomena, detached from ‘disasters’ (Fischer, 2002; Rautela, 2006; Lee, 2017). Other areas of contention which relate to the environment, and the ramifications regarding whether the ‘environment’ can be harmed or not are expatiated on below (Section 2.7.1; 2.8).

2.7.1 The Environment and Environmental Context

The environment is the totality of all the external conditions affecting the life, development, and survival of an organism (OECD, 2005). The Oxford Dictionary (2018) defines ‘Environment’ as “The surroundings or conditions in which a person, animal, or plant lives or operates”. A second definition provided by Oxford which appears more pertinent to this study states, “The natural world, as a whole or in a particular geographical area, especially as affected by human activity” (Oxford Dictionary 2018). Various other definitions (Merriam Webster Dictionary 2018; Collins Dictionary, 2018) provide comparable or analogous meanings: one can identify from the literature and definitions that, the environment represents the surroundings or conditions in or under which a process pertaining to functions and activities of life take place (Frumkin, 2010; Frondel *et al.,* 2018). Social environment, political environment, regulatory environment, economic environment, cultural environment, among others are all varied facets, forms or processes through which human life functions, on the basis of express or psychologically agreed principles (Bracci and Maran, 2013; Campbell and Marian, 2013; Adomako and Danso, 2014). The environment may imply or mean different things to different entities, depending on the context or perspective under study: what can be generally identified as representing this concept is; the setting, location, conditions or systems that give support to life in the natural or man-made ‘world’.

‘Environmental’, is the adjective corresponding to the word ‘environment’ (Collins Dictionary, 2018, Merriam Webster dictionary, 2018): This represents the context, scope, setting of the complex interrelationships between humankind and other existential elements, especially the natural environment as well as peer to peer man-made structures and systems (Frondel *et al.*, 2018). The context in focus for this study pertains to the interrelationship within the natural environment including the ecosystem and man-made institutions, technological infrastructure, *vis a vis* the socio-economic set-up and how this is impacted upon by the petroleum industry.

2.8. THREATS TO THE ENVIRONMENT: GLOBAL OUTLOOK

A surreal question that could come to mind in relation to disaster is whether the ‘environment is at risk?’ or ‘threatened?’ Why bother about the environment in the first place? Some have considered the natural environment as fragile and delicate and needing to be handled with mildness and tender care for enduring coexistence (UNISDR, 2019). There are opposing schools of thought, who believe, the natural environment is the most toughened and resilient system in existence (Holling, 1973). Drawing inference and evidence from ecological principles, they point out the enduring and regenerative capacities of the natural environment and its ability to sustain the ecosystem (Carr, 1932; Taleb, 2012; Bendell, 2016).

These conceptual projections, stem from philosophies of earlier scholars such as Carr (1932) and Kemp (2003): Carr (1932, p. 211) for instance argues that, the natural environment is not harmed, destroyed or subject to calamity, just because some seismic activity, tornado or tsunami occurs. 'Disaster' or harm is attributed to the natural system, only where there is human involvement, influence, and dependence. Disaster, harm or misfortune is reckoned only when human existence is at risk and by implied extension, other living things; bearing emphasis on the fundamental argument, that the natural system has its own inbuilt mechanism of regeneration or 'resilience' when subjected to extreme impact. These arguments are emphatically reflected in investigations by Blaikie *et al.* (2004) on vulnerability as the key factor of disaster risks. To answer the question on whether the environment is 'endangered' and therefore providing basis for the concern, apprehension, global advocacy etc., the following positions can be considered:

1. Inferences and interpretations could be made following the arguments posed beforehand, that, humanity or human systems is what is at risk and endangered, not the natural system of nonliving elements (refer to vulnerability concept). 'The disaster itself occurs within society and not within nature' (Weichselgartner, 2001).

2. It can be considered that, beside humanity other living things are affected by disaster, and more so due to intricate interdependencies (Shaluf *et al.*, 2003).

3. Since non-living things are not harmed by disaster e.g. if the ozone layer is 'exponentially depleting the sky is not harmed' (Carr, 1932, p. 211); it can be conjectured that living things experience the harm and not some 'environment' 'somewhere': therefore, 'environmental disaster' can be equated to 'living things disaster' (Holling, 1973; Kemp, 2003).

Having considered these basic arguments over 'Natural', 'Man-made' or the 'socio technical' disasters etc. and the relations with the 'environment', the question that still recurs is; why in recent times, has there been so much agitation, apprehension, contention and debate within academia, global institutions such as the UN/ member countries, stakeholder communities etc. over 'environmental' issues? The sharp interest and apprehension relating to environmental disaster and connected incidents are not unwarranted, as the consequences of these events have in the past, generated extensive and severe impact on the natural environment and human infra-structure (Tierny, 2012; Alexander, 2012). The growing importance of environmental risk assessments and the related consequence of circumventing this necessity in human and developmental activity, cannot be discounted. Sharfman and Fernando

(2008) draw positive correlation between enhanced environmental risk management and exponential economic benefits, including reduced cost of capital. These findings were based on a study of two hundred and sixty-seven firms in the United States of America, which provides backing to earlier research by Bansal and Roth (2000) who made a comparative study of fifty-three United Kingdom and Japanese companies, in relation to environmental responsiveness. The researchers (2000) identified aside other socio-economic benefits that, companies which were more environmentally responsible, acquired not only "social licence" or "social capital" in value addition, but gained some competitive edge over less environmentally responsive firms. The foregoing could be considered in part, a reflection on the gravity and currency, society and the economic world places on environmental good governance.

Frondel *et al.* (2018) strongly support the foregoing position as also do Bracci and Maran (2013), having conducted investigations on various institutions, which suggest that the application of functional/ resilient environmental management systems as well as relevant certification yielded enhanced corporate growth and financial performance: "In Italy, the number of ISO 14001 certifications and EMAS registrations has progressively increased. The increase in ISO 14001 certifications and EMAS registrations was fostered by a series of political discourses on the advantages of having an environmental management system: reduction of the environmental costs, normative compliance, enhancement of the relationships with banks, financial and insurance markets and improvement of the organization competitiveness and image" (Bracci and Maran 2013).

2.8.1 The Environment and Petroleum Disaster

For the purpose of attaining the aims of this study; disaster in other environmental contexts such as economic disasters, medical and related socio-biological threats, warfare conditions etc. would not be the perspectives of invesitigation, though the ramifications exist. The focus would be on harmful incidents that have, or could occur in the petrochemical setting embodying natural and man-made system of operations.

2.8.2 Indices of Petroleum Disaster

To gauge what constitutes petroleum disaster, a random search relating to petroleum disaster incidents, was made within industry authority/ organizational databases, such as those of the Health and Safety Executive (HSE), Insurance Information Institute (III), European Union (EU). From these sources, eight basic forms of disaster incidents were identified, and itemised in columns 1 and 2 of Table 2.4 below using the search words: (i) "List petroleum accident disaster records statistics" and (ii) 'causes of Offshore petroleum disaster'. Secondly, a random overview (Grant and Booth, 2009) through a basic literature search from four main databases, i.e. Emerald insight, Ebscohost, Science direct and Wiley online Library was conducted, using the search terms indicated beforehand. This phase was conducted mainly to identify whether academic literature agrees with industry and institutional databases on the eight identifiable petroleum related disasters. Findings from cross-sectional literature within these databases, indicated references to the 8 PD forms identified within the industrial databases: breakdown of indicators within the academic records are juxtaposed within columns 3 – 24 of Table 2.4, together with the cumulative number of times these (8) forms of PDs were highlighted (in column 25).

2.8.2.1 Complementary and Corroborative Search of PD literature

Subsequently, two major research undertakings which have comprehensively investigated various causes of petroleum disasters were identified and compared to the indicators from the industrial and academic databases: these are Vinnem *et al.* (2010) and Asad *et al*. (2019). The 8 constructs identified in the preceding databases as PDs, were largely represented within the 2 studies (Table 2.5). From the comprehensive breakdown of indicators outlined beforehand, it can be identified from synthesis of findings that:

(i) Immediate cause factors or triggering sources and mediums of PDs were categorised in analogous identity with petroleum disaster impacts. Put in another way for instance, triggering force incidents such as well-blowouts on one hand, and consequential effects, like hydrocarbon releases were itemised analogously as PDs.

(ii) Though 'causes' of PDs were applied within the random literature search words, there were quite marginal or minimal references to underlying risks/ root causes of such incidents from records sampled, contrasted to some more focal studies which have projected underlying or root cause factors of these disasters. Some studies which have appraised causes of PDs from a more anterior context are for examples: (i) 'Human error' (Agyekum-Mensah *et al.*, 2017); (ii) 'Socio-environmental accountability shortcomings and breaches' (Sam *et al.*, 2017; Obeng-Odoom, 2018); and (iii) 'Risk management shortcomings' (Halim and Janardanan, 2018) among others. The foregoing further premises a critical need to pursue a more focal and systematized investigation to establish a fairly comprehensive and expert validated identification of root/ underlying causes of petroleum disasters (which aim has been undertaken within chapters 6 and 7).

Table 2. 3: Major Attributed Causes/ Mediums of Petroleum Disaster

Sources / **Disaster Incident**	HSE; III; EU (2019)	Skogdalen *et al.* (2011)	Pranesh *et al.* (2017)	Lindoe *et al.* (2012)	Roelen *et al.* (2011)	Vinnem *et al.* (2012)	Mendes *et al.* (2014)	Liu (2014)	Gulas *et al.* (2017)	Knol and Arbo (2014)	Vinnem *et al.* (2010)	Martinez (2016)	Cruz and /Krausman (2009)	Burke *et al.* (2012)	Oke *et al.* (2006)	Attwood *et al.* (2006)	Taber *et al.* (2009)	Nilsen and Storkersen (2018)	Amos (2011)	Liu (2015)	Gros *et al.* (2016)	Sarwar *et al.* (2018)	Kaiser (2015)	**Total References/ PDR**
Well Blowout	√	√	√	√			√		√	√	√	√						√	√	√	√			12
Marine Vessel Accident	√			√			√	√			√													4
Helicopter/ Aircraft Crash	√			√	√												√							3
Uncontrolled Hydrocarbon Releases	√		√	√		√	√	√	√	√	√		√	√	√	√			√	√		√		15
Explosion/ Fires	√		√	√			√			√	√	√			√		√							8
Associated Chemical Pollution	√											√	√							√				3
Floating Vessel Collapse	√			√			√				√		√		√								√	6
Pipeline Rapture	√								√															2

Source: Author Construct, from Reviewed Industrial/ Academic Literature (2019)

Table 2. 4: Comparative Assessment on Attributes of Petroleum Disaster Causes

Petroleum Disaster Type	**Petroleum Disaster Incident Precursors (Vinnem *et al.*, 2010)**	**Petroleum Disaster causes (Asad *et al.*, 2019)**
Well Blowout	Well Kicks and Loss of Well Control	Blowout Explosion
Marine Vessel Accident	Collision with field-related vessel/installation/shuttle tanker	Ship collided with platform
Helicopter/ Aircraft Crash	Vessel on Collision (Inferred*)	Helicopter caught fire and crashed
Hydrocarbon Releases (HCR)	Hydocarbon Leaks	Oil spill
Explosion/ Fires	Fire/explosion in other areas, flammable liquids	Fire explosion
Associated Chemicals Pollution	None Indicated**	**
Floating Vessel Collapse	Structural damage to platform/stability/anchoring/positioning failure	Unstable Rig sunk
Pipeline Rapture	Damage to subsea production equipment/pipeline systems/diving equipment caused by fishing gear	Fire during pipeline maintenance

Source: Adapted from Vinnem et al. (2010) and Asad et al. (2019)

Having outlined the immediate causes and more apparent triggers of petroleum disaster (2.8.2: and column 1 of Table 2.4), one can seek to unpack the integral concepts that underpin disaster causation, by way of their underlying risk factors.

2.8.3 Risk Concepts: Hazard Identification

Risk is identified as a product of the likelihood of an adverse or harmful event occurring and the related impact (Aven, 2011). Risk is immanent in every sphere of existence, some are internally inherent, others external of origin, or derived from both sources (Cheese, 2016). Risks may take different forms, contingent on the source or setting, thereby attaining identity as variants i.e. social, geopolitical, financial, security, environmental, disaster risks, and others. Though 'Risk' has been defined in several ways, from varying perspectives, i.e. from the economic, sociological, political and in terms of disaster occurrence, among others (Vatsa, 2004): this investigation and discussion hereby, focusses on disaster risks or risks to the 'environment' and in particular the petroleum environment. A basic appreciation of the concepts and intricate interconnectedness of risk and the relations to vulnerability, and other disaster components, could be helpful in apprehending the gaps in literature and interventions for DRR.

Aven (2011) argues that, a more reliable and dynamic form of assessing and managing resilience could be attained with consideration and understanding of risk factors and how these interplay within the known and uncertain environmental system. In his view, risk is not self-existent but a product of a system and the environment that generates that system. It can be identified in research undertaken recently by Aven (2011, 2017) and Lindbom *et al.* (2014) that the concepts of risks, hazards, vulnerability and resilience have been jointly investigated and discussed and their dynamic interrelationships *vis a vis* correlation to disaster re-emphasized. Aven (2011) notes that while uncertainty/ probability has perennially been associated with the definition of risk, this has not been the case for generic definitions for other components of disaster such as vulnerability and resilience. Lindbom *et al*. (2014) posit that it would be deficient and even risky, to define or assess disaster capacity and preparedness without linking the concepts to probability or uncertainty (which is akin to dynamic risks). From these premises the pivotal and definitive role of risk in relation to understanding vulnerability, resilience and capacity cannot be over-emphasized, as a better understanding of 'risks' would support a quest for addressing the conceptual gaps and apprehending interventions for DRR capacity/ capability enhancement

2.8.4 The Concepts of Risks in Relation to Vulnerability

Vulnerability has been defined as, 'The quality or state of being exposed to the possibility of being attacked or harmed, either physically or emotionally' (Oxford Dictionary 2018a).

Alexander (2006) identifies that vulnerability constitutes a more defining factor, even than hazards, when considering the phenomenon of disaster. This stems from the concept that, disaster is realizable from the perspective of the socio-biological. Hazards, for instance earthquakes can be assessible as a source or potential for damage, but without any life being harmed or 'vulnerability' in that regard, there is no disaster (Cannon, 2008). This is amply reflected in the predication of the socio-biological or ecological functions of 'environmental disaster' (see 2.7.1.1) and disaster in general. It comes as no surprise therefore that several studies, discussions and varying definitions premised on a vulnerability perspective can be derived from the literature, as this concept, has been a crucial point of debate within academia, socio-political and other stakeholder settings (Cannon and Muller-Mahn 2010). Though there could be multiple dimensions, vulnerability as discussed here in this context, is directed at disaster situations in particular, and not as it relates to for instance criminal activity, gender, religion, race, etc.

Bankoff and Frerks (2013) and Lindbom *et al.,* (2015) in separate investigations, identified critical linkages between capacity and vulnerability, and invariably, capabilities of institutions and magnitude of disaster impact on incident communities. In tandem with the integral concept of resilience, vulnerability can be seen as heavily impacted by inherent or adaptable/external capacities. Lindbom *et al.,* (2015) argue that capacity/ capability cannot be appropriately defined or assessed in the absence of the dynamic determinants of vulnerability; inversely it can be aptly identified that, vulnerability would similarly be contingent on capacity and capabilities. Given the vital role and ramifications of the impact capacity and capabilities have on the key attributes and determinants of disaster (risks, vulnerability, resilience), it would be worth examining why capacity issues have not constituted the central perspective from which concepts of disaster risk reduction and related theoretical mechanisms have been modelled until quite recently.

2.9 CHAPTER SUMMARY

This chapter has underscored, the critical linkages between disaster theory/ conceptualization, risk reduction and environmental sustainability. This undertaking, has crucial ramifications on the aim of this study as well as contribution to knowledge; as this would guide the approach to the key perspectives and critical factors that need to be investigated in order to access vital inputs towards establishing the proposed Capability Improvement Framework. Adittionally, assessment of a theoretical framework of disaster management, has provided the context within which to fit this study. It is identified within this chapter that, the criticality of capability is attaining exponential dimensions of importance within the DRR/DRM process. The foregoing review of literature, has hereby provided further impetus on the aim of this study, towards delivering interventions for DRR/DRM capability enhancement within the petroleum sector.

CHAPTER 3: ENVIRONMENTAL RISK GOVERNANCE WITHIN THE GLOBAL AND NATIONAL PETROLEUM CONTEXT: CONTEMPORARY MODELS AND CHALLENGES

3.0. INTRODUCTION

This chapter provides an appraisal of the evolvement and current state of global governance mechanisms applicable within the petroleum industry, with highlights on intricate ramifications towards human existence and ecological systems. In this chapter, oil and gas environmental risk governance systems applicable in the global context, with emphasis on international best practices is examined. This is followed by an exposition on the environmental governance frameworks for the petroleum sector of Ghana; covering the developmental process and an outlook on the institutional mechanisms designated towards environmental risk governance, locally. This is particularly aimed at appraising the appropriateness of current environmental governance systems and applicability of global best practices within the petroleum context of Ghana.

3.1 INTERNATIONAL ENVIRONMENTAL LAW

Environmental law is considered as the general system of laws and regulations that govern the environment. Though this term may connote a specialized and well defined taxonomy of legal instruments, it is acknowledged that there is no unitary body of laws that define the institution of 'environmental law' (Birnie *et al.*, 2009). The concept of Environmental Law constitutes a complex constellation or system of laws, statutes, conventions, regulations, treaties etc. which are applicable and employed towards ensuring environmental integrity: such laws may emanate from economic, political, and other settings that are not necessarily socio-environmental in nature, but bear impact on this dimension. The environment (see 2.7.1) is defined by the European Union as: 'The combination of elements whose complex interrelationships make up the settings, surroundings and conditions of life of the individual and society, as they are felt'. Though relativism and implications can be derived from most definitions of the environment, and the need for environmental safety and protection, it is unmissable that the justification, rationale, motivation etc. for environmental protection, has largely been anthropocentric, as reflected in the Stockholm 1972, Rio 1992 protocols and the EU definition above.

It is further realizable that 'international environmental law' is not as universally binding or applicable as the term suggests. A vast range of these laws, statutes etc., have been subject to evolvement, debates and controversies (see 3.1.1). It is recognized that most of these laws are 'soft laws', treaties, and protocols which are pursued by conventions, rather than being binding in nature (Najam *et al.*, 2006; Birnie *et al.*, 2009). This condition however is continually evolving in a positive direction as laws become more enforceable and universal in nature. It is also noted since 1992, that significant proportion of the disputes brought before the International Court of Justice (ICJ) and the International Tribunal on the Laws of the Sea (ITLOS), and related bodies, have been linked to environmental issues (Birnie *et al.*, 2009). The foregoing has contributed immensely to the exponential evolvement of international environmental law over the past three decades (Gillespie, 2014).

3.1.1 Global Environmental Governance Systems

The UN describes the concept of 'risk governance' in the following manner: 'How governments, civil society and other actors organise DRM, for example through institutional arrangements, legislation and decentralization, and mechanisms for participation and accountability is termed risk governance' (UNISDR, 2011). Linkages have been identified between levels of a nation's income and reciprocal systems of risk governance: 'There is clear evidence to suggest that low income countries with weak governance are more vulnerable and less resilient to disaster risk' (UNISDR, 2013, p.1; 2015a). At the forefront of environmental risk governance at a global stage is what Global Environmental Governance (GEG) is about: this refers to the sum of organizations, policy instruments, financing mechanisms, rules, procedures, and norms that regulate global environmental protection (Najam *et al.*, 2006).

Research in the area of environmental governance, highlights the view that, the concept is not mainly a unitary or authoritarian application of some defined laws, but constituting an intricate and evolving system of institutional and societal processes geared at sustainable interdependence within the 'environment' (Wood and Valler, 2001). For some scholars, environmental governance implies: "institutional capacities, the coordination and coherence of economic processes, and social action" (Bridge and Perreault, 2009, p. 475); with a developmental outlook that has sustainability as a shared goal. Global Environmental Governance is the vehicle by which environmental policies, politics, financing etc., is carried out, driven by the main body of the United Nations Environmental Program' (UNEP), this being the focal body instituted from the Stockholm 1972 UN conference. The GEG system has formed a pivotal point towards developing policies relating to key UN strategies, such as Sustainable Development and Climate Change Agenda among others (Najam *et al*., 2006). A constellation of environmental management and coordinating bodies have evolved, most of which operate under the coordination of UNEP. With the proliferation of such global, regional and national bodies, have emerged multiple streams of funding, based on global and regional treaties, as multi-agency commitments. The vast number and multiplicity of agencies, some with unique/ specialized roles, as well as roles outside mainstream environmental issues, have led to miscoordination and some level of conflicting positions and 'watering down' of the roles of UNEP and interconnected agencies. However, several campaigns and strategies towards reform in this direction is slowly and steadily yielding some dividends (Najam *et al*., 2006).

3.1.2 Pollution Principles and Regulatory Mechanisms for Global Environmental Governance

Some key regulatory instruments for oversight governance of environmental concerns particularly employed by public sector agencies include among others: (i) Precautionary Principles and (ii) Polluter pays principles. The Precautionary principle is a globally subscribed mechanism, which ensures that public sector organisations and industrial operators, apply the greatest of caution, accountability and prudence before and during the process of any industrial activity (Birnie *et al.*, 2009). Where prospective industrial undertakings have the potential to impact socio-environmental integrity negatively, it is incumbent on operators, regulatory/ stakeholder bodies to raise caveats or inhibit such activity, regardless of economic benefits (Najam *et al*., 2006). The Polluter pays principle, is a complementary mechanism which serves as a safety net/ safeguarding measure, and is more remedial in nature, however, is employed as a deterrent to prospective and operating industrialists; as this mechanism is applied by global bodies and national regulatory agencies to impose payment penalties on operators who are convicted or considered to be responsible for harmful impact on the environment, due to pollution, greenhouse gas emissions and related damage (Birnie *et al.*, 2009).

3.1.3 Legal and Institutional Structures (International Systems and Best Practices)

The structures, systems, processes that national and international authorities put in place to lessen environmental risk and the impact of potential disaster, through institutional policy, legislative mechanisms, local governance and stakeholder entity monitoring activities etc. encapsulate the principle of environmental risk governance (UNISDR, 2011). Institutional structures and operations geared at environmental risk governance within the petroleum sector of some countries such as the United Kingdom, Norway, USA, Australia etc. date far back into history (Shapovalova, *et al.*, 2020), and these tested and tried systems will be appraised as critical industry references towards guidance for environmental governance of Ghana's petroleum sector. Prevailing within the environmental governance system of major petroleum countries have been, two major approaches. These are mainly:

(i) The prescriptive system of governance

(ii) The performance-based systems

The prescriptive regimes chiefly practiced by countries such as Russia, United States of America, Brazil, etc. are based on compliance to and meeting some basic/ critical guidelines and requirements, ensuring safety, integrity and sustainability, under a 'worst case scenario'. While the performance-based approach, increasingly pursued by countries such as Norway, U.K, Australia among others indicate, a shift from prescriptive systems of governance to peculiar risk assessment and management approaches (Barua *et al.*, 2016). Comparative assessment of both systems indicate advantages and disadvantages for either approaches (DNV, 2010; Dagg, 2011). As highlighted, prescriptive regulatory requirements were largely based on worst case scenario, reflecting consequence and impact minimizing approach, and not from a more continuous/ systematic risk analysis-based perspective as pursued within performance-based regimes. Key parameters and constraints related to prescriptive approaches are: these operate best within confined technological contexts, and impedes evolvement of peculiar technologies and context-based risk management approaches. Invariably, the dimensions of flexibility and limited levels of defined parameters, specified standards etc. associated with performance-based systems, could be a potential for inordinate interpretation, evasion and abuse of governance system structures (Barua, *et al.*, 2016). Though performance-based systems have not been established as ultimately superior to prescriptive systems, there appears to be some marginal shifting towards more performance-based approaches, such as developed within the 'safety case' systems (Dagg, 2011; Hopkins, 2012). See comparative dimensions of the two major systems of safety and environmental governance within the petroleum sector in figure 3.1.

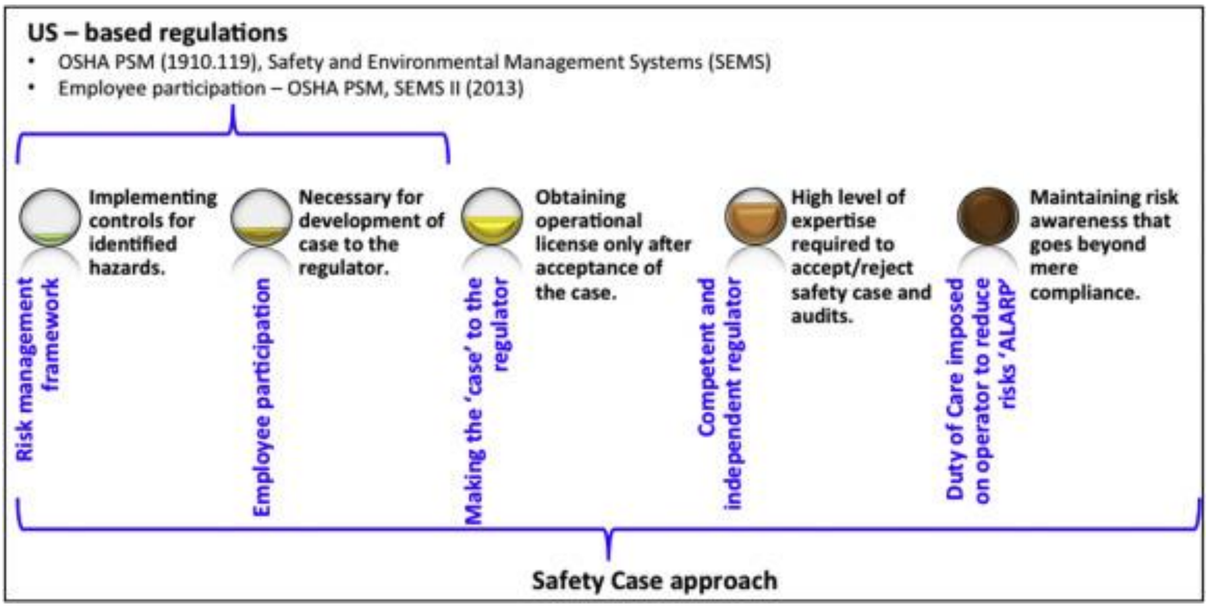


Figure 3. 1 Comparison between the Major Safety and Environmental Governance Systems
Source: Hopkins (2014)

3.1.4 Inception of the Safety Case

Owing to some key shortcomings identified within prescriptive regimes of the petroleum safety, health and environmental governance; advocacy and recommendations gradually begun shifting towards more performance-based systems of governance (Dagg, 2011; Nilsen and Storkersen, 2018). Particularly, within the post Piper Alpha incident era, deployment of the safety case approach initiated in Norway, attained exponential acceptance/ deployment within a diverse range of national jurisdictions. Though previous studies (Fitzgerald *et al.*, 2010; Jain *et al.*, 2017; Nilsen and Storkersen, 2018) suggest the 'safety case' is the more viable and effective means of regulating hazard industries such as petroleum production, it is instructive however to note the following:

- There are however some caveats to incautious application of the safety case system of governance, due to some shortcomings, as highlighted beforehand. For example, it is noted that regulatory indicators that are too broad could be open to wide-ranging interpretations and misinterpretations, circumvention/ evasion of some unspecified regulatory conditions (Hopkins, 2014; Nielsen and Storkersen, 2018).
- The Det Norske Veritas (DNV, 2014), has another perspective regarding this issue; indicating that, a blend of performance-based regulation with prescriptive mechanisms could provide enhanced benefits, since both regulatory systems have different and unique strengths not realizable in unitary approaches.

- A further caution on the adoption and deployment of the prevailing regulatory systems, is provided within (Nielsen and Storkersen, 2018, p.38): 'Our findings send an important message to governments that are striving toward ensuring the safety of industries: If regulation is to be efficient, it must be supported in terms of resources and political will, especially in industries with challenging conditions, and the authorities should be aware and prepared for possible changes in the industry´s context'.

- Also careful consideration ought to be taken with regard to the following: 'A safety case regime will almost certainly fail where safety cases are not scrutinised by a competent regulator' (Hopkins, 2012, p.5).

On the basis of the foregoing cautions and suggestions, summary discussion and recommendations have been made within chapters 8 (8.2.1) and 10 (10.6.1) of this thesis.

3.1.5 The United Kingdom Petroleum Industry Environmental Governance Systems

The United Kingdom (U.K.) petroleum industry environmental governance set-up has been supervised mainly by three key regulatory institutions: The Health and Safety Executive (HSE), the Maritime Coastguard Agency (MCA), and Department of Energy and Climate Change (DECC) (Maitland, 2011; Shapovalova, 2020). In 2015 however, some responsibilities of the DECC were assigned to the Oil and Gas Authority (OGA), with respect to regulating of licences for exploration and production/ decommissioning; enforcing environmental regulations as it applies to the petroleum sector among others. This falls in line with the global trend of continuous evolvement of governance systems within the sector, underpinned by past disaster incidents, post event recommendations: e.g. the 'Lord Cullen Report', and the exigency for periodic revision and upgrading of legislative and operational regimes (Alexander, 2002; Jennings, 2019). It can be identified beside these three key agencies that other institutional bodies such as Business Energy and Industrial Strategy (BEIS), Scottish Environmental Protection Agency (SEPA), United Kingdom onshore oil and Gas (UKOG), among a constellation of other agencies which play major or complementary roles in line with ensuring safe and effective governance of environmental systems within the petroleum sector, do exist.

While there appears to be several institutional structures ensuring checks and balances within the system of safety and environmental governance, the HSE is the focal supervisory body that spearheads the various departments towards management and enforcement of the relevant legislation. The HSE is responsible for assembling and coordinating the establishment of the 'Safety Case', the key regulatory document, with requisite inputs from all relevant regulatory agencies (Thomson-Reuters, 2020). While the role of the HSE is the oversight governance of internal safety and environmental integrity, i.e. the immediate operating environment of the industry; its role is considered critical, since effectiveness would to a large extent determine the impact to the external environment in the event of threatening incidents (UKOG, 2019).

The external environment of petroleum operations in the UK, are governed through the designated/ complementary functions of key institutions, i.e. OGA, SEPA, MCA, in critical collaboration with the HSE. That gives indication, the HSE is not an over-arching body for administration of environmental governance of UK petroleum sector, though it plays a pivotal role. With awareness of some limitations within the Safety Case' regime for instance, there have been processes underway to establish what is known as the Environmental Assurance Plan (EAP) which would be complementary to the Safety Case' and incorporate a wider range of considerations, making these more operator owned and even less prescriptive (Maitland, 2011).

3.1.6 The Norway Petroleum Environmental Governance System

As a major oil producing country Norway's environmental governance system is considered one of the best in the world (Nielsen and Stokersen, 2018; SGI, 2021). The Norwegian system of governance for petroleum resources, including environmental regulations, has served as a model for several oil producing countries, including Australia, Nigeria and Ghana (NORAD, 2021). With respect to the petroleum industry, the Ministry of Climate and Environment is responsible for initiating, developing and supervising environmental legislation, actions, promoting/ coordinating the government's environmental protection policies. The actual oversight implementation and enforcement agencies are however The Norwegian Environmental Agency (NEA), The Norwegian Maritime Authority (NMA), and the Petroleum Safety Authority (PSA), which serves as the key regulator and spearhead of implementation/ enforcement, as far as petroleum safety and environmental issues are concerned (Norad, 2021; SGI, 2021).

In principle, the Norwegian petroleum regulatory regime operates on analogous systems, compared to the UK governance system: multiple agencies operate in independent and coordinated functions, towards attaining safety and environmental integrity of Norway's petroleum infrastructure. The key distinction between the UK and Norwegian models is the relative power and span of control of the PSA, compared to the HSE, as the PSA operates with a degree of independence and overarching authority less operable within the scope of responsibility for regulating petroleum environmental and safety, by the other Norwegian entities (Nilsen and Storkersen, 2018).

In 2004, the Norwegian Petroleum Directorate was later divided into (i) the Norwegian Petroleum Directorate and (ii) the Petroleum Safety Authority, after the former body had institutionalized the HSE culture concept within Section 111 of the HSE framework regulations, with the intention of improving safety, and environmental concerns and also as a response to the negative trend of serious accidents that had occurred (Nilsen and Storkersen, 2018). This underscores the consternation and advocacy for reforms in the non-detached structure/ functions of the Ghana's Petroleum Commission, with regard to SHE and some other regulatory functions (Acheampong and Akumperigya, 2018).

3.1.7 The United States of America Environmental Governance System

The system of governance for environment and safety within the USA petroleum sector, is primarily a tripartite mechanism, having some key variations from the UK or Norway models, with respect to responsibilities of petroleum companies (Sundback *et al.*, 2020). The oversite governance authorities are 1. The state regulatory bodies, pertaining to onshore petroleum resources; 2. The Federal governance/ regulatory institutions having oversight responsibility for offshore petroleum resources and 3. A combined federal/ state mechanism for managing coastal based petroleum operations, or activity which involve multiple states or deemed to be of strategic security importance. In all the 3-pronged system of governance, the role of petroleum operators is considered key with regard to environment and safety, as they are more or less co-regulators.

The US approach to governance has both prescriptive and performance-based aspects, howbeit more prescriptive in perspective. The regulations outline minimum criteria of design, maintenance, and reporting to be achieved by each facility (Jain *et al.,* 2018; Shalovalova, *et al*., 2020). The Minerals Management Service (MMS) was created in 1982 to manage oil, gas and mineral resources on the Outer Continental Shelf (OCS). It assumed responsibility to administer execution of activities in the OCS. The Macondo incident in 2010 led to major organizational reforms and discussions. Suggestions were made to adopt a performance-based regulatory system. The Minerals Management Service (MMS), which was renamed the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), and reorganized into two separate agencies – the Bureau of Safety and Environmental Enforcement (BSEE) and the Bureau of Ocean Energy Management (BOEM). The BOEM was assigned authority to manage environmental and economic development of offshore resources, while the BSEE assumed the role of ensuring safety of offshore operations, permitting conditions, inspections, and the regulatory process. The Environmental Protection Agency (EPA) does not have a direct role in the regulation of oil and gas extraction, however, it does have regulatory jurisdiction over the release, or threatened release, of hazardous and toxic substances, such that once a release or threatened release occurs, EPA has remedial enforcement powers under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

3.1.8 The Australian Environmental Governance System

The Australian regulatory system for petroleum environmental sustainability, is more performance-based, however, with prescriptive elements. There are diverse regulations on safety critical equipment and safety projections for exploration and production activities pertaining within various states in Australia. Among these are the Petroleum (Submerged Lands) Act 1982 for Western Australia; Offshore Petroleum and Greenhouse Gas Storage Act 2010 relating to Victoria; Petroleum (Submerged Lands) Act 1981 for the Northern Territory; Petroleum (Submerged Lands) Act 1982 for South Australia; Petroleum (Submerged Lands) Act 1982 for Tasmania; Petroleum (Submerged Lands) Act 1982 for Queensland; Petroleum (Offshore) Act 1982 relating to New South Wales; and Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009, in general (Jain *et al.,* 2017).

The regulatory systems and mechanisms of governance within the aforementioned countries, have been previewed, as they are considered among best practice regulatory systems globally (Nilsen and Storkersen, 2018; Hovik, *et al.,* 2009; Shapovalova, *et al.,* 2020) though best practice jurisdictions outlined above are not comprehensive. The foregoing has been presented therefore as a precursor of potentially adaptable models for the Ghanaian context.

3.2 NATIONAL ENVIRONMENTAL LAWS AND GOVERNANCE SYSTEM

3.2.1 Brief History of Ghana's Petroleum Activity

In terms of legal/regulatory documentation and frameworks for ensuring health, safety and environmental sanity and integrity in Ghana's upstream petroleum operations, the Legislative Instrument 2258 (Petroleum exploration and production-HSE 2017); stands as the pivotal framework geared towards DRR objectives (GNPC, 2018). Like the UK petroleum environmental governance frameworks, Ghana's has undergone some evolvement and amendment, though not as radical. Ghana's upstream petroleum activity has been mainly offshore operations within the south western coast, particularly off Cape Three Points, located within the area demarcated as the 'western basin' (GNPC, 2018): other operational demarcations, include the 'central basin', the 'Accra keta basin' and the 'onshore Volta basin' (see map: Figure. 3.1). Oil exploration activity in Ghana dates as far back as the latter parts of the 17th century: The West Africa oil Company however, undertook the first officially documented petroleum exploration here in 1896 (Petrocom, 2018).

The main base of petroleum operation was off the coast of Saltpond, within the central basin, which operations had to be suspended by 1985 due to the dwindling potential of hydrocarbon resources here. The discovery of oil in commercial quantities in 2009 brought renewed hope; this was after the repealed Exploration and Production law (PNDCL 84) had mandated the GNPC to intensify regulations and exploration of petroleum resources. The Petroleum Commission Act, 2011 (Act 821) established this body (PC) which subsequently assumed the role of licensing, regulating and related activity, thus ensuing in a re-designation of the GNPC towards the focus on Exploration and Prodoction business (E and P), prospecting, identification/ demarcation of hydro-carbon deposits and other related commercial activities. Hitherto, the GNPC was operating as a player/ referee, as was seen to be involved in E and P business and simultaneously responsible for licencing and regulating other operators (Acheampong and Akumperigya, 2018).

With regard to ensuring safety, health and environmental sanity and sustainability within the upstream operations, the main legal frameworks were the various environmental statutes under the Environmental Protection Agency, Act Act 490 of 1994, governing all industries; the Mining and Minerals Regulations 1970 (LI 665), sections of which where applicable to the budding petroleum industry; and the Factories, Offices, and Shops Act 1970 (Act 328) among other auxiliary laws. The Ghana National Petroleum Corporation Act, 1983 (PNDCL 64) was the foremost instrument that dealt particularly with upstream petroleum regulations, albeit the provisions therein for environmental governance and safety concerns were seen as marginal and lacking clear guidelines and mechanisms of sound environmental governance. Ghana was also signatory to and compliant with provisions in various global/ multinational statutes, conventions, and protocols such as (1). The International Convention for the Prevention of Pollution of the Sea by Oil, 1962; (2). International Convention on Civil Liability for Oil Pollution Damage, 1969; (3). The International Convention for the Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, 1981 (Abidjan Convention); and a host of others identified by Kloff and Wicks (2004): These served as guidelines and fundamentals upon which national laws and regulations meant to preserve the offshore petroleum environment where framed, as well as complemented by.

It was considered also that the various regulations, standards, codes etc. governing the downstream petroleum sector could be conveniently applied in combination with the aforementioned provisions, until specific and comprehensive environmental governance and safety laws for the upstream sector became operational. However, within months of active production under this dispensation, signs of imminent danger and potential disaster from spillage/ pollution begun to show. Noteworthy among such incidents is e.g. the reported spillage of six hundred and ninety-nine (699) barrels of contaminated mud into the operational environment by Kosmos Energy Ltd. (Reportingoilandgas.org 2011), which culminated in Kosmos Energy refusing to pay a fine of $35 million imposed by the government of Ghana. This infraction was attributed to weaknesses in Ghana's institutional structures and legal/ regulatory frameworks. Periodic sightings of oil sleek on location, and considerable levels of gas flaring by Tullow Oil Plc., generated consternation among industry watchers, environmentalists, global stakeholder bodies and others (Reportingoilandgas.org., 2011; Badgley, 2012).

With consistent campaigns and advocacy from civil society organizations, academia, the stakeholder community among others the exigency for passing the Petroleum Exploration and Production Act, 2016 (Act 919) came to realization (Tawiah *et al*., 2015; Acheampong and Akumperigya, 2018), which further paved the way for the premier environmental governance instrument, tailored specifically to Ghana's upstream petroleum sector, i.e. The E and P- EHS law, 2017, LI 2258. Other pending legal/ regulatory provisions targeted at safety and environmental management and ultimately DRR are the Marine Pollution Act, Hazardous Waste Act, Waste Regulations and the Oil Pollution Preparedness and Response Regulations, mainly projections from the E and P act, 2016 (Act 919).

3.2.2 Critical Considerations within Ghana's Petroleum Infrastructure

The intricate interconnectedness and interdependencies within the region makes operations here quite delicate in terms of:

(i) The closeness and conflict prone posture of Cote-D'voire in the vicinity (figure 3.2), resulting in an almost endless legal tussle between the two countries (Which was barely settled by an ITLOS ruling in favor of Ghana- August 2017). Cote-D'Voire has reproached Ghana recently for being the cause of pollution of shared water bodies through unconventional and unmitigated disregard for environmental statutes in the mining setup and operations of the latter. Any significant environmental disturbances or related conflicts within this shared boundary could be exploited by ill seeking elements to foment further chaos, it is feared.

(b) The coastal terrain is home to thousands of native farmers and predominantly fisher-folk, who rely extensively on the marine resources within which petroleum exploration/production takes place. Nzuleze a nearby town is a major tourism destination, considered a global heritage site. The area is also home to several rare biological species within the extensive mangrove swamps and interconnected water bodies. The occurrence of environmental disturbances or threatening emergency situations within this enclave, could portend grave consequences,

(c) Tullow oil plc and Eni plc with headquarters in United Kingdom and Italy, respectively, are the major operators here, beside a number of other players, including giants such as EXXON MOBIL, KOSMOS oil plc. AKER energy, among others have acquired bases here recently. The interconnectedness of operations and infrastructure between the operators here and the coastal communities are complex and delicate: For example, Tullow oil Plc. has massive pipelines and infrastructure connected on-shore to the mid-stream facility of Ghana Gas Company. Any form of environmental disturbances resulting from conflicts, leakages, explosions, threatening environmental emergencies within or around Ghana Gas infrastructure could have crucial repercussions on the facilities of Tullow oil, invariably the reverse case could also apply.

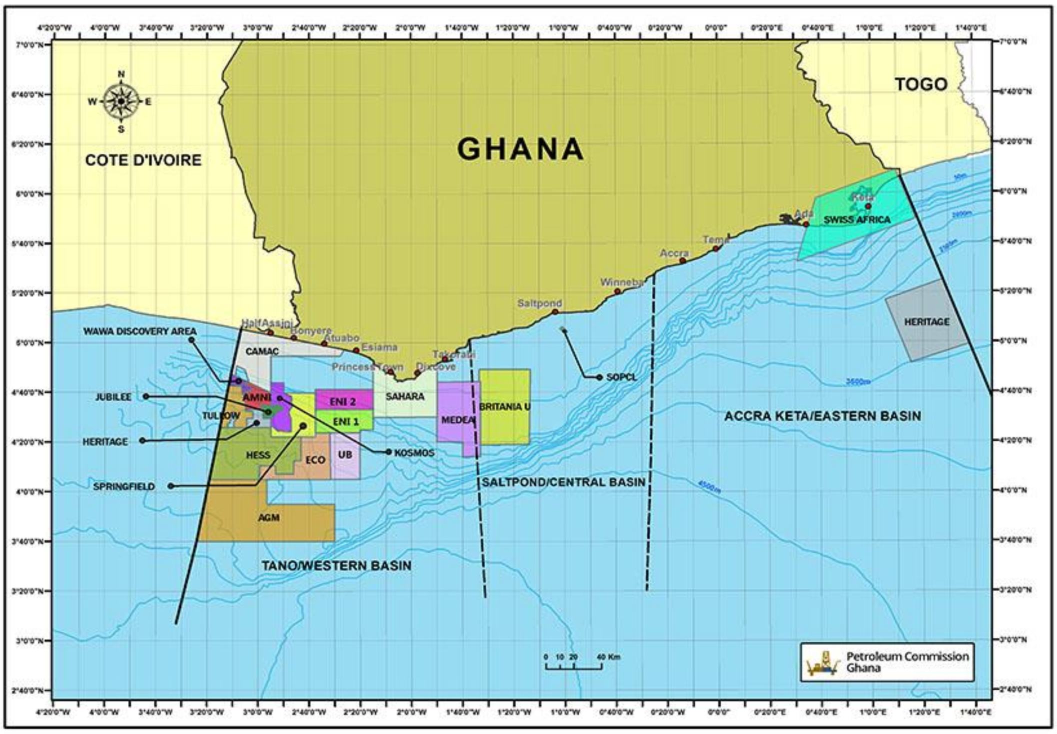


Figure 3. 2 Ghana's Offshore Petroleum Basins

Source: Petroleum Commission (2018)

3.3 ENVIRONMENTAL RISK GOVERNANCE SYSTEMS PERTAINING TO GHANA'S PETROLEUM SECTOR

The importance of environmental governance particularly in the context of heavy industrial activity within the sensitive ecological and geopolitical dispensation pertaining to Ghana's cape three points offshore petroleum operations, can in no way be overstated; as this borders on sustainability of local and international life and livelihood as well as peaceful mutual coexistence (Skaten, 2018). The United Nations (UN) has been at the forefront of advocacy and action for propagating good environmental governance "We support strong laws and institutions for a healthy planet and healthy people" (UN, 2018, p1): as backed by the UN SDG.

Consistent consternation has been expressed and advocacy raised from civil society organizations, local and international community as well as a broad cross section of stakeholder bodies, to as a matter of exigency bring governmental action to bear decisively on heavy industrial activity, which have the potential to cause calamity and irreversible harm to the natural and built environment in some communities of Ghana (Amponsah-Tawiah *et al*., 2015; Okpanachi and Andrews, 2012). This has been with reflection on some unconventional mining practices and ill-regulated downstream petroleum activity, which has triggered extensive ecological degradation, massive water body pollution and frequent fires/ explosions of hydrocarbon products within the operational communities respectively; leading to several hundreds of deaths within the last decade alone (Addai, *et al.*, 2016; EPA, 2019; GNFRS, 2020). To this end calls have been made for radical reviews and holistic reengineering of existing environmental laws and institutional structures pertaining to Ghana's upstream petroleum sector, with the aim of preempting portending replications and recurrences of the chaotic conditions and disastrous trajectory of the mining and downstream petroleum sectors (Annan *et al.*, 2015).

3.3.1 Structures and Mechanisms for EDRM within Ghana's Petroleum Sector

Extensive debate has been ongoing over whether Ghana's institutions for environmental risk governance are well structured and appropriately resourced to contain and mitigate imminent threats from petroleum exploration and production (Glover, 2017). Advocacy has been rife over the last decade towards restructuring Ghana's petroleum institutional mechanism designated for commercial participation, regulating, and risk governance, with consistent calls for detaching as well as realigning institutions to specific roles best suited for optimum performance in line with international best practices (Osei-Hwere 2015; Acheampong and Akumperigya, 2018). Key among recommendations in this regard, is the critical need to decouple the commercial/ industry participating entities from regulatory/ oversight institutions.

Obeng-Odoom (2015, 2018) extensively reviewed the state of knowledge on Ghana's petroleum sector and petroleum accident causation respectively: these investigations, identified deficiencies within "oil theorization" in Ghana's energy sector; as well as demerits of delinking the political economy from disaster causation in the petroleum sector. Acheampong and Akumperigya (2018) assessed the structure and state of mechanisms in place for safety and sustainability within the operating environment of Ghana's petroleum infrastructure in comparison to best practice regimes, such as that of the UK. Findings indicate shortcomings in structure and systems of governance, and lack of apposite laws and regulations (2018). Carlson *et al.* (2015) conducted a systematic review of academic databases and general information on petroleum pipe-line explosions within sub-Saharan Africa; and identified that, the phenomenon was grossly underreported/ under-researched within academic literature. Horbah *et al.* (2017) undertook a survey pertaining to the upstream petroleum sector of Ghana to assess the safety climate within organizations and the workforce. Findings indicate, safety climate indices could be instrumental to gauging safety and disaster risks within Ghana's petroleum sector, though providing caution on the shortcomings of theoretical underpinnings and dearth of research on these constructs. The research (2017) also affirms / supports Carlson *et al.*, (2015) and Obeng-Odoom (2018) regarding the need to deepen studies on underlying causes and latent antecedents of disaster causation in the petroleum sector.

Understandably, Ghana's upstream petroleum operations is at an infant stage comparatively (Glover, 2017), and has not been tested with significant disaster threats compared to sub-regional neighbours i.e. Nigeria, Gabon etc. Research interventions and frameworks peculiar within this context would not, arguably be massive and robust compared to that of more developed jurisdictions; invariably capability or preparedness towards disaster risks would ostensibly be at a developing stage. Research (Sakyi *et al.,* 2012; Yirenkyi, 2017) however shows that the mid-stream and downstream petroleum sector, has been operational over several decades within Ghana; invariably capability and research mechanisms in this regard should expectedly be quite robust. The picture of Ghana's downstream petroleum safety, sustainability, and governance mechanisms, as well as institutional capability conditions however, appear to be that of a heavily challenged and critically dysfunctional system; owing to frequent disaster incidents here (Osei-Hwere, 2015; Yirenkyi, 2017). The foregoing largely constitutes the underpinning of the apprehension and concerted advocacy towards prudent redesignation and clarifying of institutional roles/ mandates to forestall potential disasters and environmental threats to the upstream sector (Acheampong and Akumperigya, 2018).

3.4 CHAPTER SUMMARY

Various systems of environmental governance in general domain and particularly for the petroleum industry, have been reviewed. Best practice systems for petroleum safety/ environmental sustainability, of some jurisdictions have been appraised: There is indication, more countries are subscribing to the 'Safety Case' system of governance, which has been adopted by Ghana as well, with a gradual shift from the rather prescriptive system, pursued by the US. However, it is identified, some gaps and shortcomings within the safety case culture are a key concern which requires careful attention by Subscribing/ adapting nations.

CHAPTER 4: CAPABILITY IMPROVEMENT FRAMEWORKS AND ADAPTABLE STRATEGIES FOR DISASTER RISK MITIGATION

4.0 INTRODUCTION

This chapter takes a look at capability, performance assessment and improvement mechanisms applicable for achieving effective and value-added objectives and aims within organisational settings. It is recognised that developing capability or capacity towards disaster risk mitigation goals, can be facilitated via adaptation of existing, as well as evolving models and strategies, for examples through organisational re-engineering and process improvement mechanisms. A typical reference of such interventions is the adaptation of the Capability Maturity Model (CMM) for the Emergency Management Capability Assessment Framework by Jones (2003). Discussions on the evolvement of various strategies and frameworks commonly in use for capability assessment and improvement would sequentially be made, encompassing the older concepts of organisational development, to the more contemporary process improvement models. This would provide a guide on the more applicable models of capability development for the Ghana petroleum sector.

4.1. CONCEPTS OF CAPACITY, CAPABILITY AND PERFORMANCE

The terms capability, capacity and performance have been defined or described in very disparate ways and within varying contexts; apparently these are very much related constructs, and in most ways, used synonymously (Holsbeeke *et al*., 2009; Racela and Thoumrungroje, 2019). It can be appreciated that the concepts of capability, capacity, performance, etc., applied in this study, relate to organisational capacity/ capability and performance within this setting, especially within the public institutional context; and not to parallel concepts such as absorptive capacity, coping capacity and other variable terms. The multiplicity of definitions, meanings and relations to analogous words such as ability, competence, among a host of others, make attempts to acquire clear definitions for these terms rather humongous.

The OECD (2006, p.12) defines Capacity as: 'ability of people, organisations/institutions and society as a whole to successfully manage their affairs'. This definition as relates to development of organizations and analogous bodies, is further deployed by the UNDP (2008) in defining Capacity Development (CD); and subscribed to, by other researchers (Christensen and Gazley, 2008; Manu, *et al.,* 2019). Though there are quite marginal differences between the definitions for both Organisational capability and organisational capacity; rather than dwell on these (as this dimension does not constitute a key objective for the study), this study focusses on the crucial linkages within these constructs, which project into the shared goal and integral concept of performance improvement. Various research undertakings have identified correlations between organizational capability/ capacity and performance (Devece *et al.*, 2017; Strand, 2017; Mahamadu *et al.*, 2019). Strand (2017) illustrates this diagrammatically as: (i) complementary (ii) interdependent and (c) integral relationships, which undergird organizational performance. From the conceptual diagram below (Figure 4:1 improvised from Strand, 2017), it can be considered that 'Process' (represented by the hub) and Process Improvement (represented by the spokes), is the engine/ impeller, that drives capability in composite evolving dimensions, from a conjectured improvement stage 1(P1) to improvement stage 8 (P8), towards optimising performance.

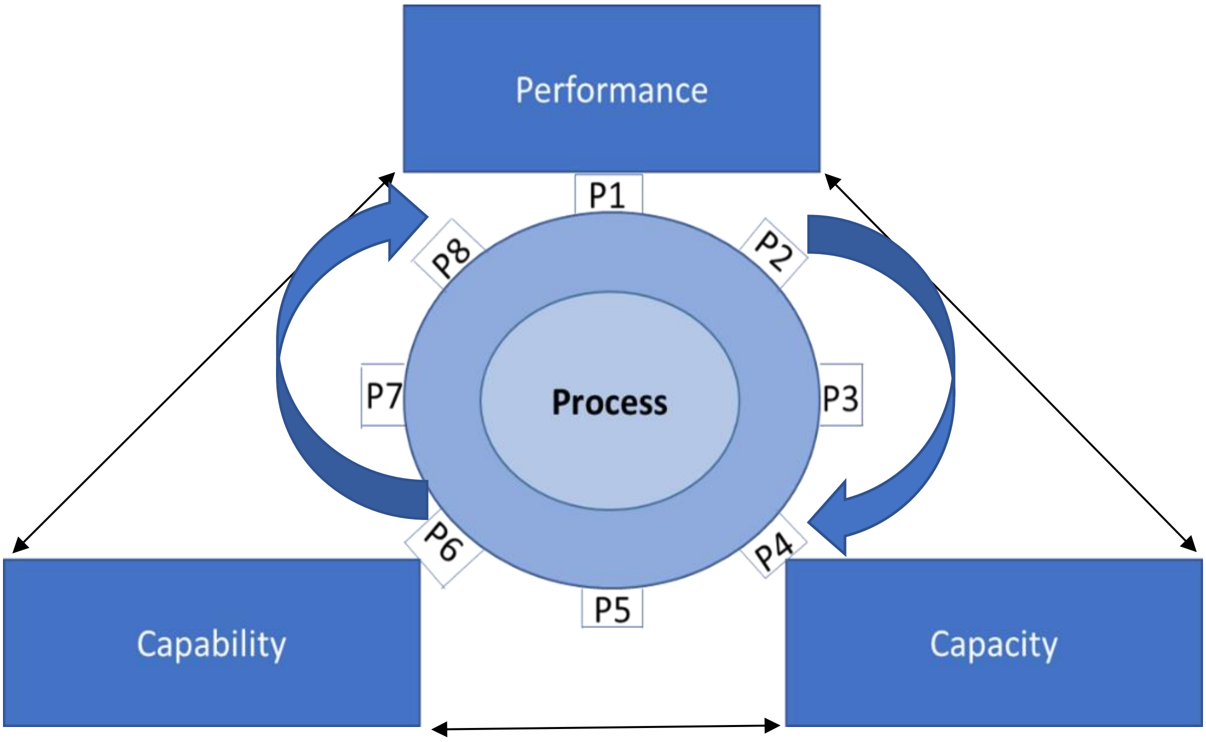


Figure 4. 1 Integral relations between Capability, Capacity and Performance

Source: Author Construct, Improvised from Strand (2017)

For example, as process improvement mechanisms/ strategies are deployed through stages (i.e. stage 1 (P1) to stage 2 (P2) through stage 3 (P3), up to hypothetical stage 8 (P8)), this generates interactive/ reciprocal impact on Performance and optimises Capacity; as: (i) Capability improves and bears impact on Capacity, *vice versa* and (ii) as Performance improves this enhances Capability, *vice versa*, until the optimal performance stage (P8) is attained. Capability improvement via Process Improvement therefore, drives performance and enhances capacity, likewise as reversible.

4.2 INTRODUCTION TO CAPABLILITY IMPROVEMENT MECHANISMS

Performance improvement (PI) mechanisms have been employed largely within business or commercial settings, plausibly due to the intent for which they were devised (Bateman, 2005; Garzas-Reyes, 2015): PI, is however gaining greater recognition and applicability within public and not for profit organizations, with the passage of time (Radnor, 2010; Andersson, 2016). Among these performance enhancement subcategories in common use within industry as well as the public sector, are the ISO standards, total quality management (TQM) and in recent times, Capability Maturity Models (CMMs) and their hybrid variations or modifications (Rebelo *et al.*, 2012; Eadie *et al*., 2012; Babatunde *et al.*, 2016).

Previously the more traditional forms of capability and performance assessment/ improvement within the public and not for profit sector, were undertaken via instrumentation of organizational development (OD) tools and or capacity development (CD) mechanisms endorsed by the World Bank and other global financial institutions (Lusthaus *et al*., 1999; Hubbard, 2006; Danquah, 2017). In more recent times these (ODs and CDs, etc.) have been complemented with or integrated into the more profit-oriented business type process improvement systems, such as LEAN, Six Sigma, and others like the CMMs (Sarshar *et al*., 2000; McCuen *et al.*, 2012). The traditional capability and performance improvement mechanisms continue to remain viable and integral systems of organisational growth and progress (Danquah, 2017): this study would therefore make an overview of some of these interventions, such as ODs, CDs, Balance scorecard etc. prior to evaluating the more contemporary measures for capability development.

4.2.1 Organizational Development

Organisational development has been described in varied ways, based on the perspective or context from which this is being defined. These descriptors though diversified in terms of wording, emphasis and approach, etc. however have common features and aims; key among which are processes towards achieving improvement and or growth in organizations. Cummings and Worley (2009, p.1) define Organizational Development as, 'Organization development is a system-wide application and transfer of behavioral science knowledge to the planned development, improvement, and reinforcement of the strategies, structures, and processes that lead to organization effectiveness'. This definition is supported by a parallel definition cited in Elwyn and Hocking (2000, p.2); 'effort, that is planned, organisation-wide, managed from the top to increase organisational effectiveness and health through planned interventions in the organisation's processes using behavioural science knowledge'. While holding complementary perspectives that, OD is behavioural science based. Organizational development, Capacity development and variants of these terms have at various times and contexts, been used synonymously, analogously or interchangeably (Lusthaus *et al.,* 1999a). While there are some similarities in construct, procedure and objectives (OD. CD etc.), there appear key differences which are generally based on the size, mission/ functions and perspectives among others, of stakeholder bodies involved. Some characteristics that distinguish OD and CD are identified in Table 4.1.

Table 4. 1: Distinct Attributes of Organisational Development and Capacity Development

Organisational Development	Capacity Development	Sources
Tend to be externally motivated	Tend to be internally motivated	(SMC, 2003)
Has Long term mode of operation	May have short to medium-term mode of operation	(Morgan, 1997; CIPD, 2019)
Generally, encompasses the gamut of organizations	Tend to involve sectors, resources, departments, considered key to achieving aims	(Kaplan, 2000; CIPD, 2019)
Generally directed at culture attitude	Usually directed at resources, knowledge/ skills base, systems, etc.	(Kaplan, 2000; SMC, 2003; CIPD, 2019)
Behavioural science based	Resource management orientated	(Yachkaschi, 2008; Danquah 2017)
Directed at organizations	Diversified in span of coverage (e.g. from National agencies to unitary departments of private entities or individuals)	(Lusthaus *et al.*, 1999a; Danquah *et al.*, 2017)
An evolving/ continuous process	A means to an end	(Lusthaus *et al.*, 1999a; Danquah et al., 2017)

Source: Author Construct from Sources Acknowledged (2019)

In a previous study, Pelletiere (2006) highlights that about 70% of organizational change endeavours, encounter failures due to unavailability of, or unreliable mechanisms for assessing the organizations' capacity or adaptability to change. To this end, Judge and Douglas (2009) improved on other organizational development (OD) models, with the inclusion of a more systematic and quantitative mechanism of measuring organizational improvement over different time frames. What the OCC model (Judge and Douglas, 2009) quite clearly projects, is a reliable tool for measuring OD: what it does not provide, is the process or stage by stage means of enhancing OD or nurturing this quintessential component of OCC into organizational strategy. Conjecturally the deficiency identified in some OD tools and models could be offset by the complementary and more integrative concept of capability Maturity Modelling (CMM), which is discussed further under 4.3.7.

4.2.2 Capacity Development

The Canadian International Development Agency (CIDA, 1996, p.2) defined Capacity Development as 'Activities, approaches, strategies and methodologies which help organisations, groups and individuals to improve their performance, generate development benefits, and achieve their objectives over time'. This definition agrees with the concepts of the United Nations Development Programme

(UNDP, 2008) in terms of broad span of entities involved. Capacity development has proved to be an integral concept with wide ranging importance and usage (Lusthaus *et al.,* 1999a). This concept (CD) was seen as relatively new, having emerged in prominence from the 1980s; in comparison to terms such as institution building, institutional development, development management and institutional strengthening etc. Over the years CD has gained importance, not only as complementary, but integral towards undertaking a broad range of globalized functions such as, organizational development, community development, integrated rural development and more recently, sustainable development (1999a). Despite the gain in prominence (CD) *vis a vis* parallel concepts; this has been downplayed over the years, due ostensibly to overuse or misuse of this and related terms to the state of clichés. Another reason for seeming devaluation of this concept, is the divergent mode of definitions and superfluity in approach to implementation, making understanding of these interventions, vague (Lusthaus *et al.,* 1999a).

Capacity development or building, emerged as an intervention for developmental agenda, due to shortcomings identified in the concept and practice of technical cooperation, prevailing over the 1950s into the 80s (Franks, 1999; UNDP, 2008). Despite increasing downplay of emphasis on capacity development in macro/ micro developmental discourse due to some of the aforementioned distortions, it can be realised that CD, OD and other closely related concepts continue to be viable as complementary and integral strategies and tools, more inherently, within process improvement mechanisms. Recognisably, CD focusses on developing resources and ability, but does not provide a methodological guide that can be used for assessing the quality and potential of developed capacities.

4.3. PROCESS IMPROVEMENT MECHANISMS

Laguna and Marklund (2005, p.9) define a business process as ‘a network of connected activities and buffers with well-defined boundaries and precedence relationships, which utilize resources to transform inputs into outputs for the purpose of satisfying customer requirements’. Process Improvement Methodologies (PIM) have been used in wide range of strategies and operations, particularly within the services and manufacturing sector (Bendell, 2005); in recent times however there has been growing interest and application of PIM in governance activity within the public sector, such as the Miltary, Police and Fire Services (Radnor and Boaden, 2008; Radnor, 2010; Al-Ibrahim, 2014). Quite a number of PIMs have been identified in use with varying approaches and foci on areas of improvement, however bearing similar objectives of enhancing efficiency and effectiveness (Dedhia, 2005; Hasenjager, 2006; Roderburg and Rey, 2016). Key aims and attributes of

PIM are (i) growth (ii) continuous improvement and (iii) avoidance of waste; executed via instrumentation of (a) assessment (b) improvement and (c) Monitoring (Bendell, 2005; Radnor, 2010).

The CIPD (2019), identifies that, 'More recently, organisation development has included more systematic approaches such as systems thinking, business process re-engineering, total quality management, continuous improvement, and human factors engineering'. Indeed, PIMs cannot be considered standalone concepts that are mutually exclusive to ODs, CDs, and BSCs etc., rather they (PIMs) are complementary and provide an integral machinery, which can be deployed within all the varying methodologies of capacity/ capability improvement for organisational development. Some key process improvement mechanisms in contemporary use, are hereby reviewed, briefly.

4.3.1 Total Quality Management

The need for customer satisfaction and retention as well as maintenance of competitiveness in an increasingly competitive localised, as well as globalized market, compelled the need for injecting quality and efficiency in business undertaking (Hackman and Wageman, 1995; Murali *et al*., 2016). The shortcomings associated with interventions such as OD, CD etc., prompted a search for complementary and alternative models of operation, with the aims of achieving continuous improvement, efficiency and growth. Ostensibly, organizations tended to stall or plateau in performance, once it was observed that organizational development goals had been achieved or capacity had been developed (Andersen *et al.,* 2006). Early generation PIM techniques and mode of operation from around the 70s upward, included Just in Time (JIT), process re-engineering, Kaizen and similar philosophies (Radnor and Boaden; 2008; Dale *et al.,* 2016).

Total Quality Management in alignment with OD, was targeted at the entire business function, and incorporated a strategy of enhanced productivity and quality towards all processes and organizational resources (Wruck and Jensen, 1994; Hackman and Wageman, 1995) The underpinning objectives of TQM, has been: a means of enhancing quality, avoiding waste through efficient use of resources/ stock, and cutting down on unnecessary expenditure, while sustaining customer satisfaction and market share (Anderson *et al*., 1994). The deployment of TQM techniques and strategies across business and various organisational functions, has yielded some progressive results in profitability and customer satisfaction (Watson and Gallagher, 2005; Kumar *et al.,* 2009), however, certain shortcomings have been identified, in terms of the adoption and implementation, being time demanding, and also lacking in rigorous structures and methods of assessments (McAdam *et al.,* 2008). As a tool for internal performance enhancement, TQM is pivotal, yet lacks the consistently adaptable, metrics and tools of benchmarking, such as identified with BSCs and CMMs (Basu and Wright, 2004). Though the ISO standards, particularly 9001 could be deployed to offset some shortcomings, such as benchmarking, this would have to be added on a voluntary basis and extra financial/ managerial commitments made in this regard (Mehra and Ranganathan, 2008; Al-Ibrahim, 2014).

4.3.2 ISO Standardisation

The International Standards Organization (ISO) was founded in Geneva, Switzerland 1947, with representation from 25 founding countries: the aim was to create a forum and a platform for instituting uniformity, clarity/ transparency in industrial processes in a universal context (ISO, 2019) A key objective was the aim to ensure that products/ services conform to guided specifications, particularly with regard to calibration, quality, effectiveness and durability. Though quality concerns had been always key objectives of the ISO, such concerns were mainly addressed within individual countries, such as through the British Standards (BS) in the UK. With increasing need for quality and competitiveness in global industry, the need arose to establish standards not only of products and services, but also the key operational processes involved (Garzas *et al.*, 2013). The Quality Management Standard, ISO: 9001:1994, was primarily structured around the UK's BS5750, and comparable frameworks from the USA and other jurisdictions. ISO 9001 provided an integral system of monitoring key organizational processes, such as customer/ staff relation management, records management, continuous improvement management, and leadership commitment, especially to quality control and compliance (Ingason, 2015). ISO 9001 was not considered a novel or competing concept, but rather a complementary framework for bridging the gaps in other models like CD, BSC, TQM etc., especially in the area of uniformity in process quality assessment and organizational benchmarking (Chiarini and Vagnoni, 2014).

Paulk (1994) draws several similarities between ISO quality management systems and the CMM, considering these as somewhat complimentary. For example, he considers that the fulfilment of requirements for levels 4 and 5 on the CMM system could provide pivotal direction towards fulfilment of ISO 9001 requirements. Despite the numerous similarities identified within the ISO 9000 series and the CMM, key disparities are noted within the finer details of the various parts and sections of both. The key points of divergence lie in the identification that; (i) ISO 9000 series lack the rigour quantitatively detailed measures related to the CMM; (ii) ISO 9001 for example is a framework showing minimum criteria that must be attained to achieve compliance, not optimal levels of performance as required in the CMM; (iii) The CMM provides a procedural path or methodology towards improvement from stage to stage, which is not apparent within ISO 9001; and (iv) The CMM ostensibly is an encompassing framework, that integrates various aspects of ISO 9001, broadly (Paulk, 1994; Garzas *et al.,* 2013).

4.3.3 The Malcolm Baldridge National Award

This award was introduced in 1978 by the US Congress, as a process of enhancing performance and inducing excellence in industry. The focus of the award process was to build capacity ultimately towards customer satisfaction (Prybutok *et al.*, 2011). Seven key performance criteria were assessed based on the following: 1) leadership, 2) strategic planning, 3) customer and market focus, 4) measurement, analysis, and knowledge management, 5) work force focus, 6) process management, and 7) results. Critical requirements of this performance enhancement tool is the level of management and leadership commitment to the process and the impact on staff within a system of evidenced based improvement (Patterson *et al.*, 2002). As it can be identified, this award system, has been customised to US standards of quality and excellence, though it can be applicable to some extent within other global jurisdictions (Pannirselvam and Ferguson, 2001; Prybutok *et al.*, 2011).

4.3.4. Balanced Scorecards

Balanced scorecards (BSCs) have been used as a performance measurement tool ever since it was popularised by Kaplan and Norton (1992), in the early 1990s. This framework stemmed from the advocacy by Peter Drucker in the mid 50s, for comparable set of metrics by which one could evaluate performance of organisations; by comparing similar resources across organisations for example, it should be possible to assess profitability, market share, management and staff performance, social responsibility etc. of one firm with another (Kaplan and Norton, 1992).

This concept (BSC) has been considered complementary to OD/ CD mechanisms through integration of measurement/comparison tools; is operationally transitory, by way of providing linkage from the traditional means of performance and capacity assessment, to the more modern growth oriented and continuous improvement approach for process improvement strategies (Norton, 1999; Niknazar, 2009). The transitory nature of BSCs is also evidenced in the numerous revisions/ modifications to this integral tool, to what appears in the contemporary context. Towards addressing weaknesses in previous generations of BSCs more strategic interventions not identified in the former, have been incorporated into modern BSCs (Poureisa *et al.*, 2013). While BSCs have been projected as instrumental tools of performance measurement, they are viewed as lacking in depth as decision making tools for strategic direction (Maisel, 1992; Poureisa *et al.*, 2013), which happens to be the aim of this study.

4.3.5 LEAN

LEAN has been one of the viable alternative interventions that has been deployed to bolster some weaknesses in Total Quality Management (TQM) technique; with its key concept being the elimination of waste (Klotz *et al.,* 2007). Comparatively, though TQM served in inducing growth, quality and profits; in terms of waste minimisation and speed in functions, there were gaping deficiencies (Mehra and Ranganathan, 2008; Andres-Lopez *et al.,* 2015). LEAN has been a pivotal strategy towards efficiency and effectiveness in meeting end-user expectations, and not only quality and growth. The LEAN model has been propped upon Just in Time (JIT), Kaizen, prudent stock control, process re-engineering, and comparable concepts. Salient tenets of LEAN include speed, improvement in repetitive tasks, automation and use of Information Technology, deployment of minimal resources to achieve maximum output and essentially collective coordination and control measures (Radnor and Boaden; 2008). ,

LEAN techniques are driven by five key watchwords or functions, that is: (i) Sort; (ii) Straighten; (iii) Scrub; (iv) Systematize; and finally (v) Sustain (Chiodo and Rosenhauer, 2011; Rashid and Ahmad, 2013). Lean methodologies have been employed in both the manufacturing and service industries with increasing levels of success to attain expedited and quality standard products at relatively reduced prices that meet customer or end user expectation (Womack and Jones, 2003) Some shortcomings however, have been observed with LEAN applications, as in various other systems and models of performance improvement (Cusumano, *et al.,* 2016). It has however been identified that consolidation or infusion of complementary systems, such as Six Sigma, 'Sustainability' principles, process re-engineering among others, is able to mitigate the observed shortcomings. The growing popularity of LEAN-Six Sigma, an amalgamation of the two vibrant systems, though sometimes seen as competing models is attestation to the aforementioned concept (Banawi and Bilec, 2014; Garza-Reyes, 2015)

4.3.6 Six Sigma

Since its inception around the late 1980s, Six Sigma, much like various other process improvement mechanisms, has proved cost effective and impactful, towards quality improvement, efficiency and general stakeholder satisfaction (Nakhai and Neves, 2009). Six Sigma has been defined or described in multiple ways, contingent on the nature of organizations concerned. Despite the lack of a standard definition, there is some agreement that Six Sigma provides capacity for organizations to multi-task more productively, by facilitating a 'switching structure', which enables the organization to operate more 'organically' with projecting innovative concepts, and yet moving 'mechanistically' when implementing these objectives (Daft, 2001). Compared to other process improvement strategies, arguments have been raised to the effect that Six Sigma is not significantly new or different, indeed it is criticized as having gleaned heavily from preceding frameworks (Clifford, 2001; Schroeder *et al.,* 2008) Viewed as the more contemporary intervention among the PI mechanisms, Six Sigma has attained exponential popularity ever since being out-doored by Motorola in 1987 (Folaron, 2003; McClenahen, 2004). The comparative potency of Sigma Six apparently is attributed to its robust and organized process of implementation (Schroeder *et al.*, 2008)

Described as a rigorous and a statically intensive approach, Six Sigma applies the Greek symbol Sigma (σ) to gauge variables in performance of organizational processes (Hahn *et al.*, 2000; Gershon, 2010) In this regard, thorough statistical algorithms are employed to measure the degree of performance; the higher sigma levels, indicating superior performance and improvement. The process utilizes the Define, Measure, Analyze, Improve and Control (DMAIC) and the Define, Measure, Analyse, Design, and Verify (DMADV) principles in a sequence of corrective and quality control measures complemented by innovative techniques to eliminate defects, and areas of incongruence to the defined parameters, until the optimum sigma level is attained (Kaswan and Rathi, 2020). Having become the methodology of choice for relatively larger multi-national corporations, the concepts and techniques pertaining to Six Sigma are becoming increasingly attractive to other medium to large scale enterprises, Governmental agencies and even not for profit organizations. Variations of this concept, such as LEAN-Six Sigma, and modifications/ mutations of this strategy with TQM and ISO 9000 QMSs are progressively being deployed in various organizations globally, with significant levels of success being reported (Zu *et al.*, 2008; Kaswan and Rathi, 2020).

Despite these identified strengths, some deficiencies or shortfalls are inherent in this model, chiefly being the cost input required for a veritable Six Sigma process, especially involving multiple layers of coordinators and consultants. The gestation process can also be time consuming, aside costs, towards training and mentoring green belts/ black belt coordinators to the ultimate levels (Swink and Jacobs, 2012).

4.3.7. Capability Maturity Modelling Mechanisms

“A maturity model is a framework describing the ideal progression toward desired improvement using several successive stages or levels” (Man, 2007, p.2). Maturity modelling enables organizations to gauge and benchmark its internal performance, capabilities, resources etc. against that of parallel best industrial or institutional bodies, with the aim to mapping out a progressive path to optimal improvement (Pennypacker and Grant, 2003). Maturity Models (MMs) are not only tools applicable within institutions or organizations but are useful likewise within sub-units such as departments, sections and other micro units of organizations (Man, 2007). Chai and Qi (2003) identify parallel attributes common to MMs and Business Process Reengineering (BPR). Capability Maturity Models (CMMs) have since the late 1970s been adapted and deployed in organisational capability development processes, drawing from the works of Crosby (1979) with the Quality Management Maturity Grid, and that of Carnegie Mellon University Software Engineering Institute (SEI) Capability Maturity Model (Curtis and Paulk, 1993). Key features of MMs are the identification of critical process areas within organisational undertakings on one hand, and essential capability attributes on the other, prescribed within a progressive order of improvement, until full maturity is attained (Eadie *et al.,* 2011; Tahri and Kiatouni, 2015).

Though originally designed towards process improvement within the software engineering sector, the applicability and use of MMs within a much-diversified spectrum of industrial sectors and organisational settings, provide weight to their relative importance and acceptance as model of choice for developmental activity and processes within organisations (Fraser *et al.,* 2002). Capability maturity models (CMMs) and the remodelled variants in Capability Maturity Model Integration (CMMI) have been used in various sectors and organisational activity, such as in Construction, procurement management, software engineering, Education and training improvement, risk management and numerous other functions and undertakings (Cooke-Davies and Arzymanow, 2003; Eadie *et al.*, 2011; Mahamadu, 2017). Over the past four decades, CMMs/ CMMIs have been deployed or integrated into variable models and modifications: popular among these, are such as used in construction management, project management, supply chain management etc., for examples: (i) Standardized Process Improvement for Construction Enterprise (SPICE) (Sarshar *et al.,* 2000). PRINCE2 project maturity model (Kwak and Ibbs, 2002), the Verify End-user E-readiness using a Diagnostic Tool (VERDICT) (Khalfan *et al.,* 2001), among others.

According to Chan and Qi (2003), MMs are quite similar to the management concepts of Business Process Reengineering (BPR). Studies undertaken on MMs show that, organizations that attain higher maturity status, achieve greater efficiency and effectiveness, and gain competitive edge over peers within the sector (Backlund *et al.,* 2014). Research carried out by the SEI, showed considerable improvement in returns on investment portfolio, within organizations that adopted the MM concept and process. The Office of Government Commerce (OGC, 2010) susggest, more organizations that have attained maturity levels, are known to have experienced 75% cost reduction, and 85% reduction in rate of defects. Capability maturity models (CMMs) have gained increased importance in recent years, as they have been found instrumental for enhancing business development processes. Though MMs were originally designed for business process improvement in the information Technology sector, its applicability for guiding developmental processes in a wide range of business and organizational sectors, keeps gaining popularity and relevance. It is acknowledged that MMs facilitate a three-pronged utility, which are instrumental as tools for capacity assessment, development/ improvement and benchmarking.

For examples, Adeninyi *et al.,* (2018) developed a maturity model which aimed at providing not only a capability assessment tool, but also an improvement and benchmarking mechanism for built environment flood resilience capacity. Jones (2003), designed an assessment framework for gauging the maturity and developmental processes of emergency management functions in the hazardous industry sector of the UK, using the five-level structure of the capability maturity model. The model and interventions from this PhD research work, engendered improvement in emergency management systems, and heightened efficiency in disaster preparedness/ response. The application of maturity models in designs for developing capacity in national public institutions and non-business organizations, is a more recent and uncommon feature in research undertaking (Bhagarva and Boswell, 2014). Studies undertaken recently indicate, there is considerable potential for application of MMs in developing capacity of public institutions in developing economies and democracies as well as "Conflict Nations" (2014).

Evidently, all the process improvement mechanisms reviewed above, hold some pivotal strength towards performance enhancement and capacity development to varying degrees or desired levels (Asah-Kissiedu, 2020). It can be realised however that the CMMI system is a relatively integrated and evolved process that encompasses key aspects of the contemporary process improvement models. Like the balance scorecards, CMMI benchmarks the highest industry standards, and details clear-cut guidelines within a system of continuous improvement akin to LEAN, and TQM processes, towards attaining the highest targeted standards. As highlighted beforehand (4.3.2), CMMI and some ISO standards, such as the 9000 series share some common targets, relating to quality and process management (Garzas *et al.,* 2013). It is realised however, while ISO 9001 for instance, provides guidelines towards meeting the least acceptable standards, the CMMI transcends the prescriptive requirements and maps out stage by stage procedures towards surpassing or achieving the highest set standards of performance (Jones, 2003). It is realisable also, while some process improvement strategies are deployed largely towards improvement of organisational capability, and to some extent gauging of performance levels within internal systems; the CMMI, is relatively adaptable and can be deployed for industry benchmarked assessment of performance, within analogous institutional settings, as well as inducing optimal performance (Eadie *et al.,* 2012; Adeninyi *et al.,* 2018).

4.9 CHAPTER SUMMARY

Various strategies, and frameworks have been assessed within this chapter, considering frameworks/ models and best practice approaches to attaining capability development for performance improvement. On the basis of the foregoing appraisal and reflections, the CMMI model is considered holistic, and recommended as a pivotal mechanism for development/ assessment of capability improvement interventions, towards EDRM within the petroleum sector of Ghana, due to its relatively robust and versatile utilisation, via a unique 3 pronged function.

CHAPTER 5: METHODOLOGY

5.0 INTRODUCTION

This chapter presents the methodological process adopted, based on a composite research design, as outlined within chapter one (section 1.5; 1.6 and Figure 1.1). The fundamental approach from the philosophical perspective to ethical considerations for the research process, has been comprehensively provided within the chapter. The effective outcome of a research undertaking is hinged on a robust and viable methodological strategy, which can withstand the principles of enquiry as pertains to the standards required for that category of research (Yin, 2003). Methodology in research provides a guide-map of evidence as to how the project has been executed, to establish: (i) compliance to ethical requirements or concerns, as well as (ii) validity of constructs and measures employed as a basis for arriving at acceptable conclusions (Yin, 2003; Fellows and Liu, 2009).

5.1. RESEARCH DESIGN

Research Design represents the comprehensive plan comprising the various components of a research undertaking, and how these integral parts are structured in a phase-by-phase process that is clear, logical and coherent, for the purpose of attaining the aims and objectives of the research (De Vaus, 2001; Creswell and Creswell, 2018). The construction or approach of the Research Design is contingent on the research problem and questions to be addressed; thus, the Research Design serves as the basis for a road map or blueprint that guides the overall process towards achieving the research objectives (Crewell and Creswell, 2018). Collis and Hussey (2009) describe methodological Research Design as the approach taken by the researcher from the conceptualization phase through to the final arrival at conclusions: this encompasses the philosophical basis, theoretical approach, means of data gathering, analysis of data, construction frameworks, and validation. Creswell (2014) identifies three major pillars and sub-components, which encompass the Research Design structure and process, namely: the Research Philosophy, the Research Strategy, and the Research Method to be applied.

Research Philosophy, also termed paradigms, encompass the ontological and epistemological constructs to be employed in the study, such as Positivism, Constructionism and Pragmatism. Research Strategy refers to the applicable methodologies in line with the philosophical viewpoint that best accomplishes the research aim: this determines whether a quantitative, qualitative or mixed approach should be adopted (Creswell and Creswell, 2018). Research Methods, according to Creswell (2014), relate to the techniques or tools employed towards actualizing the research process; they encompass factors such as the design of research questions, means of data collection, methods of analysis, validation, among others.

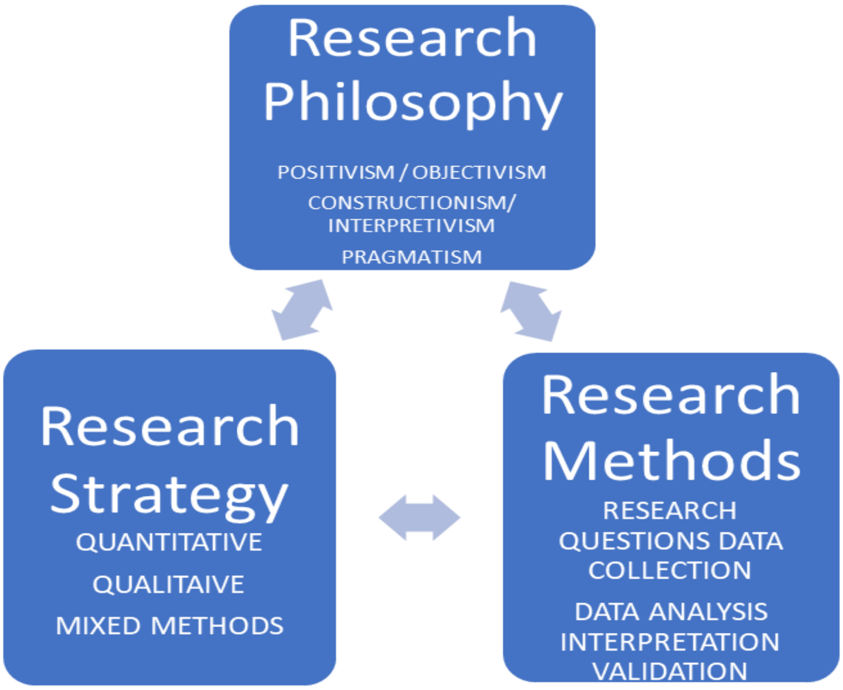


Figure 5. 1 The Three-pronged Model for Research Design

Source: Adapted from Creswell (2014, p.35)

Crotty (1998) advances a somewhat different approach, indicating that the Research Design constitutes the following; epistemology, theoretical perspective, methodology, and methods to be employed. The 'Nested Mode' by Kagioglou *et al.* (1998) provides analogous features that are variants of Crotty (1998) and Creswell (2014); these encompass: Research Philosophy, for example, positivism, interpretivism; Research Approach, for example, case studies, reviews, experiments; Research Techniques, for example, interviews, questionnaire administration, surveys. The 'Research Onion' model by Saunders *et al.*, (2016) identifies six distinct layers underpinning research process (Figure 5.2). While the interpretation of research design concepts appear similar within Crotty (1998) Kagioglou *et al.* (1998), Saunders *et al.* (2016) and Creswell (2014), the procedural structures vary within each model. Saunders *et al.* (2016), for instance, provide 6 distinct layers of 'Research Design' (Figure 5.2), whereas Crotty (1998) identifies four, and both Creswell (2014) and Kagioglou (1998) highlight three stages or dimensions to the research design process. Saunders et al (2016) have within the research 'Onion', six different layers, namely (i) Research Philosophy, (ii) Research Approaches, (iii) Methodological Choices, (iv) Strategies, (v) Time Horizons, and (vi) Techniques and Procedures. The distinct layers provided within the 'Onion' are not meant to signify that the elements are mutually exclusive, but rather to present a clearer guide-map of relatively connected concepts and processes within each layer (Saunders *et al.,* 2016). Having assessed and compared these models of Research Design, Saunders' 'Onion' model has been considered a more comprehensive, explicit and adaptable model for use, as evidenced within research undertaken at various levels and within multiple disciplines. The Saunders *et al.* (2016) Onion model, as the Research Design model employed for this study, will now be further dissected and discussed.

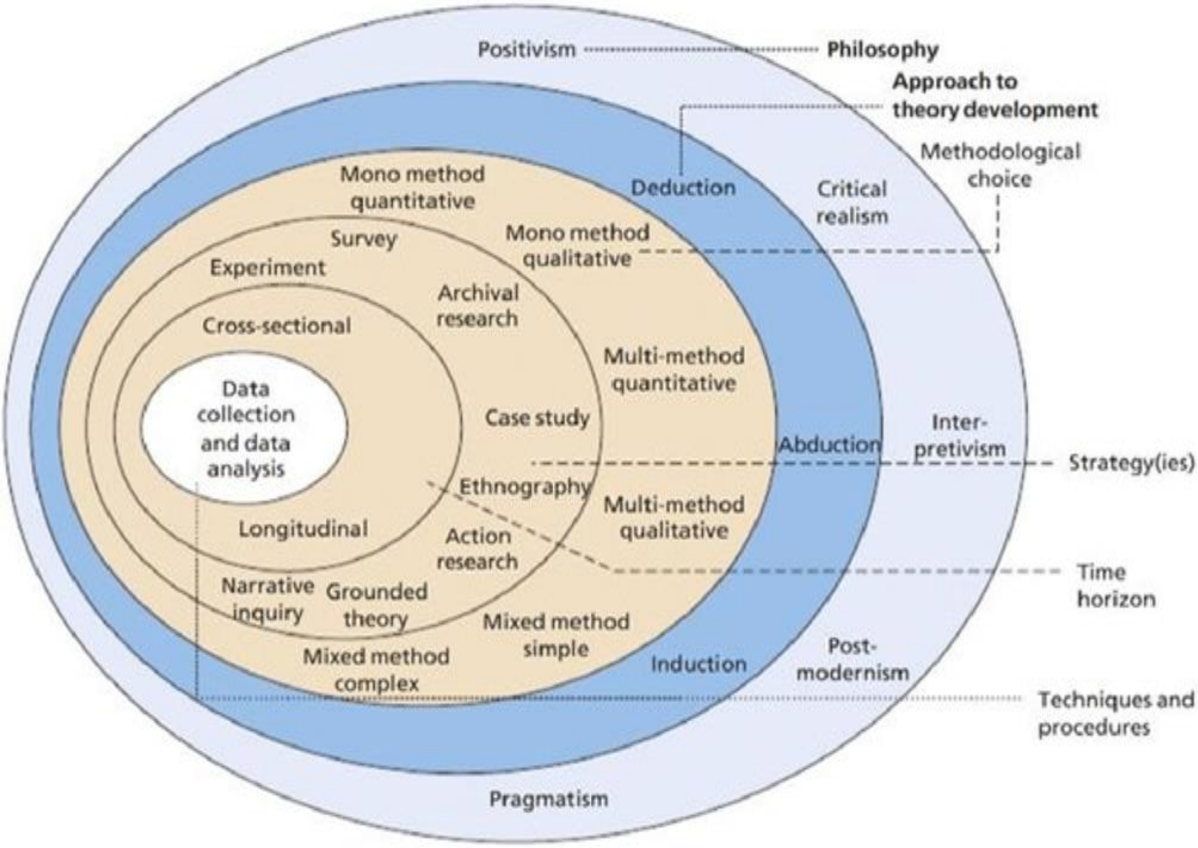


Figure 5. 2 Saunders 'Onion' Representation of Research Design

Source: Saunders et al. (2016)

5.2. RESEARCH PHILOSOPHY

Research Philosophy, also referred to as paradigms or philosophical worldview, is identified as the fundamental set of beliefs that impacts the direction and eventual outcome of research (Guba, 1990). In the view of Saunders et al., the evolvement/processing of knowledge towards attaining set objectives and aims of a researcher is contingent on the philosophical positions taken. Easterby-Smith *et al.* (2012) describe Research Philosophy as the often hidden or unseen parts of a tree trunk and roots respectively.

The identification and deployment of viable methodology is of crucial importance towards attaining impactful and far-reaching aims and goals of research. Easterby-Smith *et al.,* (2012) identify this as being governed by philosophical reasoning, which gives meaning and direction to the research process.

Four major pillars of research are identified as underpinning Research Philosophy: ontology, epistemology, methodology, and methods and techniques (Eaterby-Smith *et al.,* 2012). Creswell (2014) outlines five major philosophical foundations on which academic research is generally undertaken: ontology, epistemology, theoretical standpoint, research strategy, and the methods or techniques to be employed. The principles of scientific research are underpinned by ontology and epistemology. Ontology is conceptualized as the nature of reality and how things exist, and is pivoted on two contrasting principles – realism and relativism – which represents the 'standpoint': this provides credence to theoretical perspectives, and subsequently, the methodology to be employed (Raddon, 2010; Easterby-Smith, *et al.,* 2012). Epistemology, on the other hand, discusses the varying means by which reality can be constructed, based on a congruent ontological approach. The two main contesting epistemological views are positivism and constructionism (Easterby-Smith, *et al.,* 2012). Saunders *et al.* (2016) identify the following as key categories of philosophical positions in research, these are: Positivism, Critical Realism, Interpretivism, Postmodernism, and Pragmatism among other emerging corollary philosophies.

(a) Positivism:

The positivist worldview considers knowledge and reality as evidence-based and measurable phenomena underpinned by static conditions of cause and effect. This position advocates the use of laid down principles, methods and guidelines as the appropriate approach to understanding and addressing existential phenomena. Positivists adopt a more scientific approach to studying reality within social and various other dimensions (Scot and Usher, 2011). In this worldview, the understanding of reality is not subject to interpretations of the observer. Positivism and its sub-variant postpositivism, align towards realism ontology and subscribe to the epistemological position of objectivism (Scotland, 2012; Creswell, 2014). Positivists employ quantitative strategies of data process – based on identifiable sets of relationships within defined sub-cluster or strata of a population – towards establishing generalized definitions of the entire population to clearly stated levels of accuracy, provided with confidence intervals (Charmaz 2011; Creswell, 2014). Methods of data collection are usually through structured questionnaires, surveys, observations and experiments.

(b) Critical Realism

Critical realism philosophy seeks to provide an explanation for existential and experiential phenomena on the basis of underlying occurrences guiding observable events (Saunders *et al.,* 2016). This philosophy embodies some aspects of positivism, particularly with regards to non-dependence on researcher's interpretations, and also occupies a middle ground relatively towards postmodernism (Reed, 2005). The view of critical realists is that reality should be considered beyond what we see on the surface. In a simplistic illustration, the critical realist represented by a fish would consider the 'fisher' behind the sinker, line and hook, rather than just food in the form of a worm floating in the water. The critical realist adapts a reflective path towards understanding reality. Critical realism philosophy argues that, what we see and experience is empirical in nature, and is a manifestation of fundamental structures of reality, therefore reality is not internalized, but should be explained on the basis of all underlying and related functions that may not be necessarily accessible or immediately observable to our senses. Critical realists advocate for applying experiential values through reasoning backwards, a process known as 'retroduction' in order to understand and explain the true cause and manifestation of reality respectively (Reed, 2005). The epistemological position of the critical realist is that of relativism, thus going beyond quantifiable observations and statistical data (2005). Methods usually employed are in-depth historical analysis, reviews/evaluations of pre-existing structures and materials, replication/reproduction of previous events towards understanding, and judging causality.

(c) Interpretivism

Interpretivist philosophy holds the worldview that reality is understood from the viewpoint of the observer; meaning and conclusions can be drawn from positions of individual interpretations. Interpretivists subscribe to the ontology of relativism (Creswell, 2014) which assumes that there is no unitary truth or reality; all meaning and forms of knowledge are subject to the assessment and understanding of the person or parties involved. Reality is therefore dynamic – subject to constant change and revision/redefinition (Sutrisna, 2009). The epistemological position of the interpretivist is that of constructionism or social constructionism. Quite contrary to positivist philosophers, interpretivists argue that reality cannot be taken at face value or considered on the basis of only what is accessible. Interpretivists contend that reality is not independent of the observer, thus a researcher ought to consider various dimensions of viewpoints not limited to their own (Scotland, 2012). In this regard, reflection is made by the researcher on the dynamic conditions and diversity of perspectives from sociological dispositions (Saunders *et al.,* 2016). Qualitative methods are the main strategies adopted by interpretivists for inquiry towards understanding phenomena (Guba and Lincoln, 1994; Scotland, 2012). Typical methods employed in interpretivist research include: focus groups, unstructured interviews and observations. Interpretivist/constructivist philosophies do not usually subscribe to generalizations based on large sampling, and outcomes of research in this domain tend to generate new theories and perspectives (Easterby-Smith, *et al.*, 2012).

(d) Post-Modernism

Post-modernism began to gain prominence from the works of some French philosophers such as Jean-Francois Lyotard, and particularly his book 'The Postmodern Condition' (Easterby-Smith, *et al.,* 2012). Other French scholars whose influence supported the evolvement of this philosophy, are for example, Jacques Derrida, Felix Guattari, and Michael Foucault. This philosophy is geared at employing linguistic processes to provide a balance of philosophical perspectives, especially for marginalized views. Postmodernism has been linked to interpretivism with regard to commonality in critique of objective/positivist philosophy regarding the 'what you see is what you get' dogma (Saunders *et al.*, 2016).

Postmodernists advocate for the evolvement of linguistic values towards understanding reality and discussing diverse phenomena. They believe that order and categorization are transient in nature, and the linguistic basis upon which knowledge is conceptualized is incomprehensive and falls short of integrating marginalized perspectives (Chia, 2003). This philosophy seeks to suggest that the philosophies with greater following tend to favor larger multinational organizations and corporatism generally, at the expense of minority interests (Townley, 1994; Saunders *et al.,* 2016). Postmodernists advocate for critical consideration of the power relations between the researcher and researched; to indicate that the amount/form of knowledge generated is to a large extent a function of, and inextricably connected to, the power relations (Calas and Smircich, 1997; Saunders *et al.,* 2016). Nominalism is the ontological perspective of postmodernists while a deeper version of constructionism is pursued in the epistemological dimension. Methods typically employed by post-modernists include in-depth evaluations and investigations through deconstructive queries, aimed at accessing nuances, subdued voices etc. towards more comprehensive constructs (Cunliffe, 2003; Saunders *et al*., 2016).

(e) Pragmatism

Pragmatist philosophers aim to explore the nexus between objectivism and subjectivism towards achieving greater rigor and inclusiveness in methodological approach and to mitigate the plausible shortcomings in the use of unitary philosophies and methods. This paradigm emanated from the works of philosophers such as Charles Pierce, John Dewey, William James and others (Saunders *et al.,* 2016). Pragmatists argue that concepts and philosophical choices are useful if they drive action to achieve intended outcomes (Kelemen and Rumens, 2008). Within this school of thought, there is a conviction that reality and phenomena in general, cannot be established and discussed from the perspective of only a singular philosophical perspective. Research and inquiry are therefore made in direct relationship to the practicality of the prevailing conditions and not within the abstract context. Though this movement has been criticized as a way of escape from getting entangled in the philosophical debates, pragmatism seeks ultimately to synergize the strengths in various philosophical approaches and minimize weaknesses in the deployment of singular approaches and strategies (Morgan, 2007).

To pragmatists, research philosophy must be driven by the research question and aims fundamentally, and adopt reciprocal methodologies to achieve objectives in the most impactful way (Tashakkori and Teddlie, 1998). In this respect, pragmatists project research philosophy as constructs positioned in a continuum, rather than mutually exclusive phenomena.

5.2.1 Adopted Research Philosophy

Academic research draws a linkage between the ontological and epistemological persuasions of the researcher and the methods to be applied for data collection and interpretation (Creswell, 2014). Since this study is aimed at exploring the relationship between institutional capability improvement and environmental disaster risk minimization within the Ghana petroleum setting; it can be considered that while there is a need to attain generalization of some findings, there is also a need to contextualize outcomes. The underpinnings of the research objectives and aim are linked to positivist and interpretivist philosophies, as described in the foregoing. Therefore, there is a need to consider a more pluralistic approach to answer research questions and attain a custom-made intervention for the problem in context. The various philosophical debates have been considered, and the strengths/validity of each acknowledged within the context of research aims and objectives vis-a-vis the researchers own affinity/authority over the various paradigms.

The shortcomings and limitations of unitary philosophical approaches have, however, been debated at length for decades, and it has become more essential to consider more integral paradigms that facilitate greater triangulation to meet standards of acceptability for diverse dimensions of stakeholders (Venkatesh and Brown, 2013). Furthermore, the categorization/relegation of qualitative or quantitative methods, as belonging exclusively to particular philosophical persuasions, has been extensively debated and could be viewed as practically inconsistent with contemporary research paradigm; as it is considered, the exclusive application of one method may unduly limit or compromise the depth and richness of a research project (Mackenzie and Knipe, 2006; Easterby-Smith, *et al.*, 2012). Pragmatism has therefore been adopted as the more robust, encompassing and impacting philosophical approach for attaining the research objectives and aim.

5.3. RESEARCH APPROACH

All research, particularly in the intellectual domain, is either guided by some theoretical constructs or is directed at establishing novel ones. Until proven valid or otherwise, these underlying constructs remain abstractions (Ketokivi and Mantere, 2010). The process by which researchers generate theoretical/conceptual output is underpinned by three main approaches to reasoning (Saunders *et al.,* 2016):

- **Deduction**: This approach is directed mainly at testing known concepts towards proving or explaining existing theory. The research process typically, begins with a known theory as a fundamental premise, and is developed or evolved through the synthesis of literature and related test of samples to prove or better explain constructs.
- **Induction:** The approach where the research process begins from data gathering towards exploring phenomena, and is aimed at generating novel conceptual designs or theories.
- **Abduction:** Data is collected in synthesis with literature to explore phenomena towards establishing themes and explaining patterns. Additional data is used to test validity aimed at generating novel theories or modifying existing concepts.

5.3.1 Adapted Research Approach

Abduction is the path of reasoning adapted for this research. Given the protracted debates and controversies surrounding existing disaster theories and related models (Shaluf, 2007; Nojavan *et al.,* 2018), it would be quite contentious to seek to explain theories of disaster through deduction, unless one wants to undertake a longitudinal study, which would allow in-depth/broader evaluation of various theories/models and their impacts. However, a longitudinal study, within the timeframe of a PhD research, would not be feasible. Further, as the study goes beyond social and natural science perspectives of disaster theory into dimensions of quantitative strategies/applications within the techno-institutional setting of the petroleum industry, this would require a massive and complex process of data/interdisciplinary knowledge synthesis. Invariably, pursuing an inductive process towards a generation of novel theories, which are encompassing and conclusive enough, would ostensibly require longitudinal approaches towards inclusivity within the range of disaster theories under study, to attain widely acceptable theoretical outcomes. However, cross-sectional representations and inputs from interrelated perspectives of the research aim and questions based on abductive reasoning, could generate plausible themes and patterns which sit well within a broader context of interdisciplinary/theoretical perspectives of modifying or improving upon theory (Laursen, 2018): this can also be accomplished within a reasonable dispensation, as it is less time-consuming.

Laursen (2018) considers interdisciplinary abduction as a concept-synthesizing/ filtering process, and also, as a nexus for interdisciplinary thinking/ argumentation in research. Baral (2000, p.1) views abductive reasoning as "an inference mechanism such that, given a knowledge base and some observations, the reasoned tries to find hypotheses that, together with the knowledge, explain the observations": This abduction is inferenced by 'adding up' elements or cues to generalize a conclusion (Folger and Stein, 2017). Wang and Shu (2016) leveraged the application of abductive reasoning in a fire-cause investigation research.

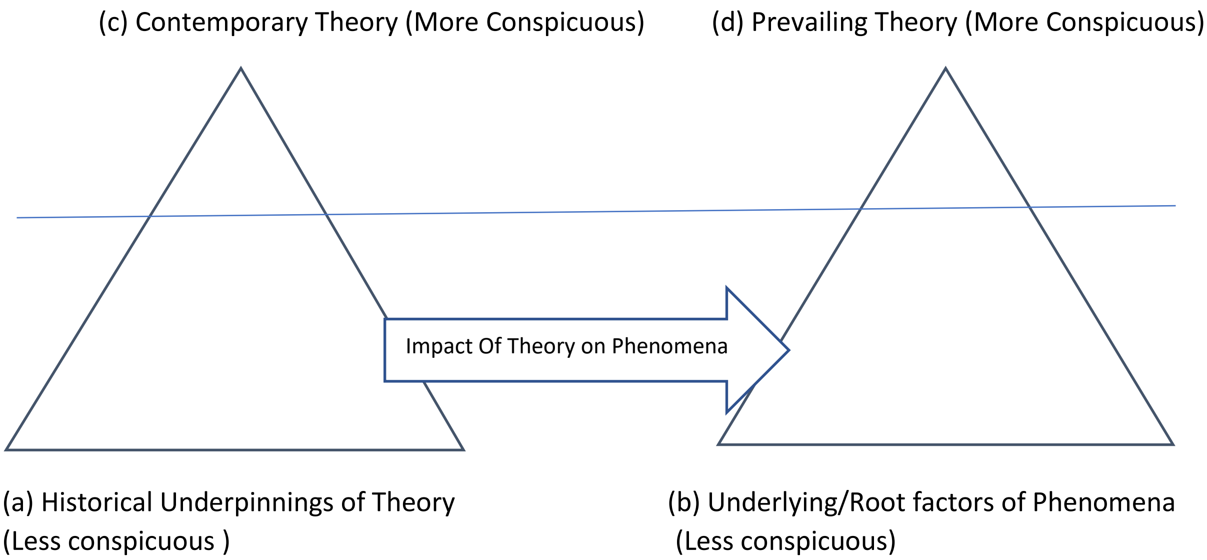
5.3.2 Abductive Approach

A key aspect of this study is a distinct abductive approach in this direction, via instrumentation of the conjectured 'Capsized Iceberg Approach' (CIA) (Figure 5.3). The CIA comprises: (a) investigative analysis of the broader historical underpinnings of theory to establish (x) known and potential adverse impacts on (b) underlying/root factors of phenomena in order to generate (y) a set of interventions that could be deployed/evolved to modify (c) existing knowledge/ theory towards adducing (z) positive impact on (d) prevailing/adverse phenomena.

Primarily, what is quite often apparent/prevalent within deductive and inductive approaches to research enquiry, are the two conspicuous elements of (c) contemporary theory and (d) prevailing phenomena (indicated traditionally as iceberg tips in generic approaches to reasoning: Figure 5.3). However, rather than making overviews of (c) contemporary theory in a deductive sequence to attain broader explanatory outcomes, or exploring (d) prevailing phenomena towards inducing theory, the CIA process overturns both (c) and (d) (i.e. the iceberg 'tips') through an abductive process to critically examine the fundamental evolvement of related concepts (within Chapter 2). This was done to stimulate enquiry into contemporary DRR/DRM concepts and to suggest modifications to knowledge, towards recommendations and improvement/interventions (such as CIF) on these often more conspicuous and largely focal undertakings of petroleum disaster research (i.e. (c) and (d)). This is further developed and elaborated on within Chapters 8 and 10.

It can be noted that, the concept of the iceberg is meant to highlight historical evolvement of relevant theory, which is often under-investigated, and its impact on phenomena within historical as well as contemporary context. This was meant to illustrate, just as the iceberg often has greater mass of hidden material not apparent to the viewer, the integral dimensions of evolvement and development. While Figure 5.3 does not aim to suggest icebergs are exactly conical in shape nor the tips exactly above a lateral line: the aim is to to highlight the concept that, the often under-evaluated historical dimensions of theory could be quite humongous, vaguely understood/ synthesised, where the researcher does not make decisive efforts to address this; whereas contemporary theory could be more refined, clearer tapered, and better defined/ presented within research.

- ICEBERG TIPS



- OVERTURNED ICEBERG

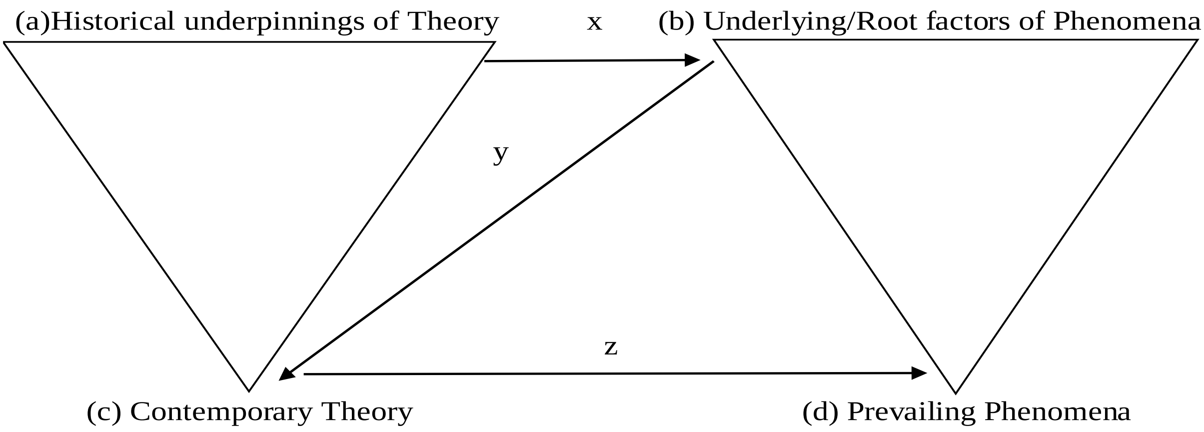


Figure 5. 3 Capsized Iceberg Concept of Research Approach

Source: Author Construct (2020)

5.4. METHODOLOGICAL CHOICE

Crotty (1998) identifies methodology as the action plan underpinning the approach towards attaining the objectives of the research via the facilitation of appropriate techniques and tools. Three key methodological approaches have been identified by Saunders *et al.,* (2016), as follows:

5.4.1 Quantitative Methods of Research

Quantitative research methods involve the use of numerical measures of subsections of a population and the relation of such samples within variables to make generalized observations and conclusions. Analysis and interpretation of data generated via this method are usually standardized statistical measures, inferential patterns, graphs, etc. (Saunders *et al.,* 2016). Application of more scientific and systematic processes are what generally characterize this range of methods, as this approach is underpinned by evidentially quantifiable facts, rather than analogous interpretations. Rigorous controls are observed in order to attain systematic and replicable outcomes. Typical techniques employed include experiments, structured surveys, and experiments (Denscombe, 2010).

(i) Mono method quantitative: quantitative research designs that employ a single data collection technique. Examples are the use of only experiments or surveys, and reciprocal analytical methods (Saunders *et al.,* 2016).

(ii) Multi-method quantitative: quantitative research designs that employ more than one data collection technique, along with singular or multiple quantitative analysis measures (Saunder *et al.,* 2016).

5.4.2 Qualitative Method

Qualitative research methods investigate and explore meanings, perspectives and relationships between subjects and variable factors. Non-standardized variation of data collection techniques is employed towards developing novel constructs and contribution to theory (Saunders *et al.,* 2016). The approach to data gathering is non-structured and sampling techniques are usually of non-probability type. Unlike quantitative methods where the research process is independent of the researcher, with qualitative methods, the influence of the researcher on the research is considered significant (Bansal and Corley, 2011).

(i) Mono method quantitative: qualitative research designs that employ the use of a single qualitative data collection technique and a reciprocal means of analysis.

(ii) Multi-method qualitative: qualitative research designs that employ the use of more than one qualitative data collection technique and variable means of analysis. For example, where unstructured interviews are employed together with case studies.

5.4.3 Mixed Methods

Mixed methods approach is the application of both qualitative and quantitative means of enquiry in a research undertaking (Saunders *et al.,* 2016). Equal or unequal emphasis may be placed on either methods contingent on the nature of the research, the choice of researcher, or the requirements of supervision bodies and standard compliance systems (Creswell and Plano-Clark, 2010). Within such arrangements, where equal weights are not placed on both quantitative and qualitative methodology, one plays a dominant role, while the other is deployed towards a more subsidiary or complementary function (Cresswell and Plano-Clark 2010; Saunders *et al.*, 2016). Mixed methodology gained recognition historically, from the enquiries pursued by Campbell and Fisk (1959) via their use of multiple methods in psychoanalytical research, whereby the overemphasis on biases of the key methods as mutually exclusive and non-integral were challenged and advances made to neutralize these polarizations were achieved in the process (Creswell, 2009). The limitations of a singular methodological approach in research have been highlighted increasingly over time, and propositions made towards more integral and complementary methods aimed at enriching procedural rigor and attaining a deeper understanding of phenomena (Amaratunga *et al.,* 2002; Bryman, 2008).

5.4.4 Mixed Method Approaches

Simpler forms of mixed methods are those that employ qualitative and quantitative strategies in the same phase of research. Examples include concurrent mixed methods and the sequential exploratory model.

- **Concurrent Mixed Methods:** here, both quantitative and qualitative data can be collected separately but at the same stage of the research, and then integrated in order to derive more comprehensive/complementary outcomes which give added weight and validity to findings (Saunders *et al.,* 2016). The concurrent mixed methods approach is deployed ostensibly to achieve shorter data collection time, due to the simultaneous process of data assemblage (Amarantunga *et al.,* 2002; Creswell, 2009)
- **Sequential Exploratory Method:** this starts with qualitative exploratory enquiry, which is followed by a quantitative process at the second phase, such as to derive greater statistical patterns and inferences from the previous qualitative enquiry.

Relatively complex forms of mixed methods are strategies that take a more sequential approach, which are considered more demanding and time-consuming. Examples are the explanatory sequential method and sequential multiphase method.

- **Explanatory Sequential Method:** either quantitative or qualitative is employed during the first phase of the study. Then, the other method is employed at the second phase – usually with the aim of providing further insight and explanations to data gathered within the first stage.
- **Sequential Multiphase Method**: this begins with a more exploratory qualitative phase, followed by a quantitative enquiry, and subsequently another qualitative phase (Saunders *et al.,* 2016).

5.4.5. Adopted Methodological Approach

It is conceptually acknowledged that methodology is the systematic and consistent approach to enquiring into a matter or phenomenon, by the application of tools and techniques which are in consonance with a philosophical and theoretical perspective (Kothari, 2004; Somekh and Lewin, 2005). Methodological pluralism promotes the deployment of multiple philosophical strategies and methods in research; this is strongly advocated by pragmatists towards attaining greater comprehensiveness and triangulation in approach to understanding phenomena. (Amaratunga *et al.,* 2002; Chynoweth, 2006). Though several studies have been undertaken on petroleum disasters and environmental impacts, it can be observed that a considerable amount of these have been conducted within the domains or contexts of more developed economies (Edelstein, 2011; Knol and Arbo, 2014; Obeng-Odoom, 2018; Hovik, *et al.,* 2009). While these studies provide for generalizability of findings and establishment of fundamental constructs, it is crucial to identify and appreciate the contextual variances relating to underlying causation within less developed dispensations, such as Sub-Saharan Africa.

It is therefore considered ideal to reconcile contextual differences between the generalized data, often reflective of relatively developed dispensations, with rather subdued investigations, interpretations and explanations of phenomena which pertain to the divergent perspectives of developing economies – for example, the Ghanaian and Nigerian petroleum industries (Anejionu *et al.,* 2015; Obeng-Odoom, 2017). The adopted philosophy of pragmatism aligns appropriately with the deployment of both quantitative and qualitative methods, which can ostensibly facilitate a deeper understanding of the relationships between the generic global 'quantitized' values and somewhat 'localized' conditionalities pertaining to the context of the study. This study, therefore, aligns with Failing *et al.* (2007) on the need to integrate both local and scientific knowledge in environmental decision-making with the use of a practical structured decision-making process.

This study aims at identifying capability improvement interventions that can be deployed to mitigate disaster risks within the petroleum environment of Ghana, from the perspective of underlying causation. While quantitative mechanisms have been identified to generate objective, assessable and relatively replicable data, qualitative methods have been suggested as being pivotal for causal description and explanation within sets of numerical/quantitized relationships (Grootel *et al.,* 2020). It is therefore seen as essential to employ mixed-method mechanisms to establish findings that aptly link purposeful capability interventions to peculiar underlying causation factors. The sequential multi-phase mixed-method highlighted beforehand is the most appropriate approach for establishing robust triangulation and reliability of findings for this research, and is complemented by the techniques and procedures adopted (section 5.9.0).

5.5 RESEARCH STRATEGY

Research Strategy is basically a plan of action for how the researcher proposes to attain answers to the research question: this encompasses the best possible path or process by which this is achieved. Research Strategy provides a methodological link between the adopted Research Philosophy and selection of methods, as well as an approach towards collecting and analyzing information (Charmaz, 2011; Saunders *et al.,* 2016). Yin (2003) considers strategy as the logical path that best facilitates the gathering of evidence aimed at establishing answers to an enquiry. As indicated the choice of Research Strategy is characteristically connected to Research Philosophy and fundamentally underpinned by the nature of research questions proposed or prevailing (Saunders *et al.*, 2016). Some other considerations which underpin the choice of strategy could be the familiarity and experience of the researcher with particular approaches, available resources, or requirements of supervisory/funding bodies (Robson, 2002; Saunders *et al.,* 2016). Key Research Strategies are hereby reviewed.

5.5.1 Sample Research Strategies

- **Experiment**

Experiments refer to processes that configure variables of samples in controlled tests aimed at understanding the interconnectedness of causal and impact relationships (Fellows and Liu, 2008). Experiments often rely on manipulation of independent variables towards establishing the forms and levels of relationships on predefined dependent variables (Kumar, 2011). Experimental strategies in research are more prevalent within natural science disciplines and domains, particularly medical and biological research (Fellows and Liu, 2008; Kumar, 2011). Rather than employing research questions, hypothesis is applied within experimental strategies primarily aimed at establishing if configuration of independent variables could achieve significant change or impact when applied to dependent variables. The principal objectives of experimental strategies is to attain robustness of findings, objectivity, validity and replicability; and this strategy virtually serves as the litmus test or gold standard by which other strategies are generically assessed (Saunders *et al.*, 2016).

- **Survey**

The survey strategy enables the systematic collection of standardized data within a considerable sample of a population in a relatively efficient manner, and which allows for coordinated comparisons and generalizations. Survey strategies are relatively popular and acceptable, due to their people-centered, economical, and standardized format, which provides wider access for participation based on sampling criteria, verification, and replication - making these more authoritative (Saunders *et al.*, 2016). Surveys employ systematic and numerical formats and are considered more scientifically oriented – they are therefore applied in both natural and social sciences as well as business research (Forza, 2002). Samples from larger populations are accessed statistically and surveyed to establish relationships within dependent variables, towards deriving generalized views and findings applicable to the larger population (Robson, 2002; Knight and Ruddock, 2008). Survey methods are instrumental for exploratory enquiries and also provide explanations for relationships within samples and identifiable perceptions/opinions on variable factors under study (Yin, 2003; Bryman, 2004; Saunders *et al.*, 2016).

- **Archival Research**

Archival research represents documents and records of events – either written, video, audio recordings, or other means of information storage – which are employed for research purposes, usually as secondary data (Saunders *et al.*, 2016). Archival data can provide a rich store of information that facilitates data processing and knowledge synthesis. Archival records may emanate from government, educational, corporate or other globalized institutions etc. (Scott, 1990; Lee, 2012). Discretion and caution are to be exercised by a researcher in the use of archival data to appropriately identify the reliability and validity of the source of information – whether it is an analysis, reappraisal of an original research work, or a primary independent data source not accessed through standard research processes (Hakim, 2000l; Saunders *et al.*, 2016). Archival research is usually employed to complement other forms of research strategies such as case studies, surveys and others, though it can be used unitarily.

- **Case Study**

Case studies are investigations into phenomena employing practical or real-life scenarios (Yin, 2014). The unit of the case being studied could include persons, groups, organizations, past or present events etc. The choice of what constitutes a case worth studying or researching is dependent on the researcher and the objectives, as well as the level of acceptability of findings (Flyyberg, 2011). Case studies have been used widely in business, psychology and other forms of institutional related research – however, this method has received some criticism, as the units of sampling are often considered unrepresentative enough to establish encompassing generalizations (Flyvberg, 2011; Buchanan, 2012). However, the in-depth approach – which usually employs mixed-methods – enables the generation of richly descriptive, exploratory, and explanatory interventions which facilitates greater understanding and knowledge generation within the boundaries of the case unit or similar units (Bansal and Corley, 2011; Charmaz, 2011).

- **Ethnography**

Ethnography is the study of the social and cultural background of a group society or larger unit. It represents an investigation into understanding personalities, groups, and societies from ethnic standpoints (Saunders *et al.*, 2016). This Research Strategy derives its roots from early anthropological studies and was historically guided principally by colonial ideology (Denzin and Lincoln, 2005). Over time, ethnography has evolved and become an integral tool that allows the study of a society, groupings – even nations – from a closer range and perspective, where researchers spend long periods of time within the socio-cultural or environmental context under study in order to generate knowledge that is more experiential and evidential rather than conjectural (LeCompte and Schensul, 1999; Creswell, 2009). Though originally rooted on positivist principles, ethnography has gained popularity in constructivist approaches, with research adherents pursuing varying shades of this strategy such as realist ethnography, interpretive ethnography, and critical ethnography (Delamont, 2007; Denzin and Lincoln, 2011).

- **Action Research**

Closely related to ethnography, action research is a more iterative approach, while ethnography is more longitudinal. Whereas ethnography investigates society and groupings from a close and inclusive proximity, action research similarly studies societal bodies, often organisations and institutions from a practical/action-oriented perspective (Saunders e*t al.*, 2016). Action research has evolved more recently in response to the need to offer more practice-based and actionable solutions, particularly to work-based and organisational challenges. Studies are normally undertaken within organisational or work settings, which facilitate practical on-board involvement (Shani and Pasmore, 1985), while reflecting on theoretical underpinnings. Due to the iterative process this strategy follows, alterations, modifications and restructuring of research questions and objectives may be made in development of the study (Coghlan, 2011; Coghlan and Brannick, 2014). This strategy provides tailored solutions, which are usually limited to the contexts of the organizations, though applicable within analogous industrial settings (Reason and Bradbury, 2008). Much like ethnography, this process may involve an extended length of time.

- **Grounded Theory**

Grounded theory is considered a methodological approach that represents the function of a research strategy adopted by the researcher (Saunders *et al.,* 2016). This strategy involves an intense process of data collection and management, usually longitudinal, and which could involve rigorous concurrent and iterative patterns of knowledge synthesis, leading to the establishment of new dimensions of theories (Charmaz, 2011). Grounded theory may follow either an inductive or abductive approach to conceptualization and theory construction (Strauss and Corbin, 1998; Charmaz, 2011). A key characteristic and criticism of grounded theory is its time-consuming nature; however, the insights from interpretivist data processing/analysis provide complementary comparison of knowledge from objectivist concepts towards the establishment of viable theories (Kenealy, 2012).

- **Narrative Research**

This approach to research records events from the standpoint of a subject matter, and presents outcomes in a narrative or storyline, with some reflection of the researcher's experience on the unfolding events (Cresswell, 2009; Saunders *et al.,* 2016). Recording of events can be derived from live events, audio, visual recordings, and partly written items, which are then reorganized and presented in chronological order to provide as objective and factual a representation of events as possible. The researcher may reflect on existing theories in a deductive pattern to derive inferences for the judgement of the reader (Saunders *et al.,* 2016). Typical examples of narratives are biographies (Clandinin and Connely, 2000).

5.5.2 Adopted Research Strategy

Adhering to the pragmatist philosophy, for the purpose of this study, mixed methodological approaches were adopted in iterative processes of enquiry. This followed a grounded theory path of action, involving the investigation of various dimensions of disaster theory and evolvement of related concepts of disaster risk management. This line of enquiry through assessment of academic literature and global industrial systems was aimed at identifying which ways, and to what extent, theoretical perspectives have impacted global industry practice in the management of EDRs within the petroleum sector, and the implications these hold for Ghana. Sequential review of literature and the global industrial system settings both provided the basic qualitative inputs for the study. This fundamental exploratory approach has been pursued previously by Mahamadu (2017) among others. The main quantitative strategy adopted was the employment of a survey involving experts – this complements the qualitative outputs. The use of surveys is a key strategy employed towards establishing generalizable values that are reflective of the wider population (Fellows and Liu, 2008). The deployment of surveys as a means of prioritising capability elements and related management systems has been adopted within numerous studies in recent times (Yeung *et al.,* 2009; Mahamadu, 2017; Zahoor *et al.,* 2017; Olawumi and Chan, 2018; Assah-Kissiedu, 2020).

5.6. RESEARCH TIME HORIZON

Time Horizon concerns the time range within which a research can be conducted. A choice would have to be made as to whether the study should be situated within a cross-sectional setting, which investigates phenomena over a relatively shorter period, by focusing on a particular frame of time, as a snapshot of events (Saunders *et al.,* 2016). Alternatively, a choice can be made to conduct research over a much longer period of time to assess the evolution of a phenomenon, which is considered as a longitudinal process of research. The decision to pursue a cross sectional or longitudinal process is underpinned chiefly by the (i) objectives and research questions (ii) the resources available towards ensuring acceptable outcomes and (iii) the requirements of institutional settings within which research is being undertaken (Robson, 2002; Saunders *et al.,* 2016). Trypical cross-sectional methods involve surveys, interviews etc., while experiments, grounded theory approaches align with longitudinal studies (Robson, 2002).

5.6.1 Time Horizon Applicable

As with most academic research, time limitations are a constraint that must be considered, and to a large extent dictate the scope of research (Saunders *et al.*, 2016). A cross-sectional approach was pursued in this study, by focusing on the task of soliciting answers to research questions, through instruments such as surveys and interviews, which required relatively shorter periods of time to obtain required data**.** It can also be appreciated that the nature of objectives and research questions for this study did not require highly extensive investigations into the evolution of a phenomenon, thereby further supporting a cross-sectional approach.

5.7. TECHNIQUES AND PROCEDURES

Techniques and procedures refer to the tactical approach towards the data collection and analysis process. These are considered as data collection and analysis activities which are broadly underpinned by the strategy adopted and time horizon considerations (Saunders *et al.,* 2016). Choice of techniques and procedures is inherently linked to accessibility/availability of data, the familiarity and skill of the researcher on their usage, resource base, and time projections pertaining to research (Liu, 2008). Three main techniques have been identified according to Kumar (2011): Interviews, Observations, and

Questionnaires. Surveys have been classified as data collection technique by Naoum (2007), though this has been factored within the category of Research Strategy by Saunders *et al.* (2016).

5.7.1 Interviews

Interviews are instrumental for collecting data that requires more detailed information, and which allows for a wider range of individual opinions and perceptions (Saunders *et al.,* 2009). Interviews allow for more insight and reflection of the interviewee, rather than just the basic questions and answers a researcher would prescribe. This process usually allows for the interviewee to query any areas which are not clear and to offer answers based on a feedback process (Robson, 2002; Denscombe, 2010). Three main types of interviews are used: structured, unstructured, and semi-structured interviews (Robson, 2002). Interviews can be either oral or in written form (Sandelowski, 2000; Cologne-Brookes and Oates, 2006;). It is observed that oral interviews allow for more probing of issues through follow-up questions compared to written interviews: therefore this approach lines up more appropriately with unstructured interview process (Campbell et al., 2013; Hawkins, 2018). Compared to Oral interviews, it is considered, the challenges with transcribing and analogousness of interpretation are mitigated through application of written interviews, since the responses from interviewees are usually presented verbatim: written interviews, due to limitations for follow-up queries, are suggested as relatively supportive to unstructured or semi-structured line of questioning (Kvale, 2007; Campbell *et al.,* 2013; Hawkins, 2018).

Though written interviews, usually through the medium of email or harcopy questionnaires are considered time consuming; however for technology savvy researchers and participants, this technique has proven instrumental where the respondents are committed to the iterative process (Kvale, 2007; Hawkins, 2018). Considering the relatively structured nature of the questions adapted for the validation processess for this study, written interviews, employing semi-structured questions via the medium of Electronic Mail (Email), were deployed towards validation of literature and validation framework. The varying structures of interview options are highlighted as follows:

- **Structured Interviews:** Structured interviews are useful where the research objectives are well defined from the start and not exploratory in nature; therefore, responses to questions are largely in a more pre-defined range. Closed-ended questioning is the form this structured interviews usually follow (Robson, 2002; Thomas, 2006).

- **Unstructured interviews:** Open-ended questions are the usual form for unstructured interviews, which facilitates a more conversational process of seeking further clarifications and provision of further in-depth answers. This approach supports a more exploratory form of data gathering (Thomas, 2006). The flexibility and openness in approach could induce new dimensions of knowledge which could reflect in modifications scope and objectives of research (Denscombe, 2010).
- **Semi-structured interviews**: In this approach, both structured and unstructured questioning are employed. A prescribed format of questioning is applied; however, open-ended questions may be used as a means of seeking clarifications and further feedback, which gives both interviewer and interviewee freedom and control over process (Thomas, 2006; Saunders *et al.*, 2009).

5.7.1.1 Focus Group Exercises

The focus group (F.G) method of data collection has been a vibrant qualitative approach that facilitates broader discussions and deeper insights into subjects under study (Fern, 2001). As an alternative to interviews, it allows for sharing of ideas and wider discussions among selected participants. Participants for F.G discussions – typically 7 to 12 in number – involve selected persons viewed as experts or key stakeholders on the subject under study. Value addition is a key attribute of F.G, as this approach can be pursued to complement knowledge on vital information that could have been missed via the use of other methods (Huston and Hobson, 2008). This method is therefore viewed as a pivotal triangulation method which supports the unearthing of greater scrutinized and peer queried/reviewed knowledge that can be deployed towards policy guidance and improved concepts (Thornton, 1996; Carey and Ashbury, 2016).

This process is usually undertaken face to face – however, online/virtual F.G. processes are increasingly in use (Hollander *et al.*, 2004; Lehoux *et al.*, 2006). F.G.'s are instrumental as a method of accessing expert opinion, as an alternative to other approaches such as the Delphi technique and nominal/consensus group methods (Graefe and Armstrong, 2011). The quality and success of F.G exercises depend on the skills of the facilitator and recruited expertise. A critical demerit of F.G. exercises is the tendency for dominant group members to influence the process; however, the moderation skills of the facilitator is viewed as a key intervention to offset this weakness (Powell, 2003).

5.7.2 Observations

Observation involves the process of studying phenomena within the natural or social setting by watching, listening and following patterns of events as they unfold (Kumar, 2011). Where scope is prescribed for the observation, the observations are categorized as structured; where the process is open to discretion and unbounded by predefined parameters, they are considered unstructured. The researcher monitors and takes records of event occurrences, behaviors, etc., and subjects the collected information to analysis, from which patterns of knowledge can be generated (Bryman, 2004). This approach to information gathering is considered preferable when studying behavioral patterns rather than basic opinions (Kumar, 2011).

5.7.3 Questionnaire

A questionnaire represents a set of questions that respondents are requested to answer (Kumar, 2011). The design of questions offers a common, coordinated platform of investigations, which supports consistency and uniformity in the delivery of questions and the understanding which every respondent is expected to obtain (Robson, 2002). Response formats could be closed-ended or open-ended, while the researcher may also employ a dichotomous or multiple-choice range of questions, or combinations of all the above. The choice of medium of questionnaire delivery and response is dependent on the researcher's skills, resources, and the type of research – there are advantages and disadvantages of employing the various questionnaire formats (Knight and Ruddock, 2008). The use of live interviews can be instrumental, as this enables real-time questioning and instant response, where respondents are within easy range of access. However, with written interviews, and other cases where respondents are geographically dispersed, this may prove expensive and time-consuming (Oppenheim, 1992). Internet-mediated questionnaires, especially those employed in surveys, are fast becoming a valuable means of administering questionnaires, with the rapid and continued growth of information technology and internet access. This process enables a faster and less expensive means of delivering questions and receiving answers in a better-coordinated manner. Also, software packages have evolved over time which aid collation and analyses of all responses more rapidly and efficiently (Dillman, 2007; Saunders *et al.*, 2007).

5.7.4 Use of Experts in Research

Deployment of expert input in research is widely accepted not only in the social sciences, psychology, and education, but also in business research, and to a limited extent the natural sciences (Iriste and Katane, 2018). This approach is considered one of the most appropriate for accessing, analyzing, and evaluating data, as well as for predictions, where: (i) it is essential to make responsible conclusions/decisions with regard to novel phenomena, and (ii) the issues are devoid of certainty or broad-based knowledge. Such methods, which are largely based on the opinions or information verification through experts, are also called ‘methods of expert assessment’, ‘expertise, or ‘expert opinion’ (Iriste and Kante, 2018). Purposive sampling rather than random or probability sampling is often the approach to accessing expertise, as the aim is to derive findings that reflect factual knowledge and accurate understanding of the subject under study (Hallowell and Gambatese, 2009; Iriste and Katane, 2018). There are various data collection and analysis methods which employ the use of experts towards the generation of new ideas, determination of priorities, and solving of complex problems (Delbecq *et al.,* 1975); major types include, focus groups, nominal groups and Delphi techniques (Venon, 2009). Invariably, though, these techniques could also involve interviews, surveys and other means; expert inputs/opinions can be deployed primarily as techniques of data collection, as with the ‘Interview’ and ‘Survey’ methodologies (Libakova and Setakova, 2015).

5.7.5 Means of Data Measurement

There are varying mechanisms of data measurements or assessments which reciprocally support analysis, based on the nature of research. Some data measurement mechanisms include, semantic differential scales, visual analog scales, and summated rating scales (Smith and Albaum, 2005). While some of these data measurement mechanisms, such as semantic differential, have been found useful in some contexts, the more frequently used mechanisms for psychoanalytical and other forms of sociological research are the summated rating scales (Harpe, 2015). Summated rating scales denote the concept that psycho-social phenomena can be measured in an ordered or quantifiable manner; these rating scales include Likert scales, adjectival rating scales, numeric rating scales, etc. (Harpe, 2015). Likert scales have become the dominant tool within psychoanalysis and sociological scholarship, as this basically offers means of attributing both descriptive and quantifiably ordered values (Norman, 2010). The levels of measurement applicable within these summated rating scales, are: ‘nominal’, which is known as the weakest measure; ‘ordinal’; ‘interval’; and ‘ratio’, which is considered the strongest measurement. The typical medium of measurement on Likert scales are by ordinal values which are quantifiably ordered descriptions of measurement choices. Likert scales are described below, along with some debate surrounding their application in quantitative statistics.

- **Likert Scale Principles**

In this study, survey questionnaires were constructed using seven-point Likert scales. Likert scales have been employed increasingly within scientific research – particularly in social sciences – and the fields of business, psychology and psychoanalysis, and within clinical domains, among others (Hodge and

Gillespie, 2007; Leung and Xu, 2013). A vibrant debate has evolved since the middle of the last century over the accuracy and acceptability of treating Likert scales as interval or ratio scales (Knapp, 1990); though in the original measurement tool, Likert proposed a scale of equal distance within assigned numerical values (Harpe, 2015). The 'conservative' school of thought contends that Likert scales, which reflect ordinal values, do not clearly establish units of interval measurements and therefore cannot aptly denote numerical values for statistical measurements (Nanna and Sawilowski, 1998; Michell, 1990); the 'liberal' school of thought conversely argue that this contention on interval measurement is inconsequential, insofar as meaningful measures of equal distance can be attributed to the Likert scales (Labovitz, 1970; Baggaley and Hull, 1983; Uebersax, 2006). Some theorists such as Lord (1953) and Wright (1997) have argued that the choice of employing arithmetic mean and other numerical statistics in the analysis of interval data is principally at the discretion of the researcher, provided selection of an appropriate statistical test could be made in consonance with the distribution pattern of scores. For the purpose of quantitative assessment, numerical values of assumed equal distance are assigned to ordinal scales, usually by adherents of the 'liberal' school of thought, which are reciprocally attributed as interval scales, especially within the analysis of surveys aiming to assess measures of centrality, and descriptive and other statistical inferences (Lord, 1953; Knapp, 1990; Jamieson, 2004).

Another evolving dimension of the debate is the need to establish what is termed 'continuise' (Knapp, 1990; Hodge and Gillespie, 2007), which according to some advocates could be facilitated by an incremental range of ordinal values, which is more reflective of continuous interval scales (Leung and Xu, 2013). In their opinion, the greater the number of scale points employed, for example from a 5 Likert point to 7- or 10-point ordinal scale – the more the parameters needed to establish 'continuise' (Jamieson, 2004).

5.8. DATA ANALYSIS PRINCIPLES

Following secondary and primary data collection, the researcher must demonstrate competence in the art of data analysis, and be adept at presenting and explaining the data without introducing any bias or misrepresentation. Additionally, the researcher must be able to present these in a way that motivates the reviewer/reader to appreciably visualise the process undertaken towards attaining the findings and outcomes. The presenting of copious quantitative values that bear a very minimal relationship to each other and the production of massive data sets should be avoided; unless these induce interest in the reader to associate different pieces of data towards generating other findings and additional insight. Panas and Pantouvakis (2010) advocate the need to thoroughly appraise and re-assess results as well as be sensitive to data processing/analysis principles, in order to attain exhaustive perspectives on implications of the research findings. Furthermore, having appreciable command over statistical analysis methods is a requirement for many researchers who aim to analyse their data employing statistical techniques.

5.8.1 Techniques for Statistical analysis

The first stage of analysis and interpretation of survey data, as applied in this study, involves descriptive statistics, which is a basic process towards identifying patterns and mode of responses as well as variations occurring within the distribution of data across response categories (Denscombe, 2010). Frequency and relative frequencies are applied towards assessing the weighting and direction of choices numerically, chiefly represented by the mode. Mean and median values are indicators of central tendency, whilst measures such as standard deviation and variance indicate the spread and skew of distribution (Denscombe, 2010). After establishing basic descriptive patterns, inferential statistical analysis is conducted for most surveys and similar types of data processing. In this study, basic descriptive analysis was employed towards assessing frequency and modal values within the SR findings to adduce thematic patterns of studies assessed (n=90). The use of descriptive statistics was also employed in analysis of post-survey data, via the application of mean, median, standard deviation and other measures to ascertain data distribution patterns and scoring modes of expert participants. Inferential statistics was deployed via the use of bivariate analysis tools, using SPSS version 27, to assess statistically significant skews, variances and deviations, which may hold implications on the attainment of research aims and objectives – the statistical analysis techniques used are described below.

5.8.2 Reliability and Validity

For research to meet standards of acceptability and dependability, the constructs of reliability and validity – and how these are fulfilled – are critical. Satisfying reliability and validity components of research provide added credence and dependability of methods and processes employed in achieving findings (Golafshani, 2003). Attainment of reliability and validity are considered critical concepts – not only to attaining trustworthiness of results, but also as a means of minimizing the potential for attaining false outcomes (Miles and Huberman, 1994; Cooper and Schindler, 2001; Saunders *et al.*, 2016). Reliability is directed at ensuring the research instruments generate a steady and consistent pattern of outcomes over time when tested (Miles and Huberman). Invariably, validity verifies if constructs and methods deployed towards attaining results are actually adhering to the measures and means through which the desired or required outcomes can be achieved. Validity is achieved chiefly by ‘validation’ processes, which involve referring the findings to relevant stakeholders to evaluate both the conformity of methods and processes to results and findings, and the efficacy for achieving research aims (2004, Silverman, 2001; Hardy and Bryman).

Internal consistency underpins the reliability of constructs employed, which enables levels of reliability to be determined before a test can be employed for the purpose of ensuring research or examination validity. The Cronbach's alpha is one of the more widely used of such tools – others include Cohen's Kappa, Fleiss' Kappa etc. This gives consistency to the data acquired and analyzed. The Cronbach's Alpha indicates the inter-item consistency (Behroozi and Pashakhanlu, 2015). Cronbach's Alpha is a common instrument of data analysis that measures the levels to which all items within a test measure the same construct. This establishes the internal consistency of the test as a measure of agreement of variables within a test or category (Field, 2005; Tavakol and Dennick, 2011). Cronbach's Alpha, which has been used in a wide range of academic research and recently by, Koranteng (2018) and Kayode (2019), was applied to assess reliability and internal consistency within the survey instrument deployed.

5.8.3 Test of Normality

The test of normality is a basic principle in research employed towards identifying the manner of spread or skew within a data set. For a given sample or samples, the test is aimed at establishing whether the data is evenly distributed from the mean, or scattered. Prior to analysis of inferential patterns for survey data, the Kolmogorov-Smirnov test of normality, complemented with the Shapiro-Wilks test was deployed via the instrumentation of SPSS, to ascertain the skew and spread of data (See 7.5.3). Ascertaining of normality and non-normality in distribution would support the determination of application of parametric or non-parametric analysis tools within this study, as outlined below.

5.8.4 Data Analysis Methods Employed

5.8.4.1 One Sample T-test

The one sample T-test was employed to test for a statistically significant difference within the risk factor minimization category (See 7.5.4). The one sample T-test is instrumental for assessing if a sample from a population deviates from a given mean value (taken to be the population mean) (Laerd, 2020). The one-sample t-test was identified as pertinent, as the KS test output for survey data on risk factor minimization was compliant to normally distributed data. Application of the one sample T-test is supported by adherence to some basic assumptions which are integral to the validity of test findings (Jamieson, 2004). Key among these assumptions are:

(i) That the measure of variability within the sample is consistent with the interval or ratio scale. In this regard, the assumption of interval scale measurement was established by the use of numerical values of measurement in incremental order, and was expressly emphasized within the survey by indicating to respondents that the Likert measures represented increasing weight or value on the basis of superior numbering.

(ii) That the samples within the category of variability are independent of each other. In this regard the design of questions or samples within categories of variability were structured uniquely and were independent from each other.

(iii) That the dataset is devoid of considerable numbers of outliers. It is identified in generality that the presence of considerable numbers of outliers within a dataset tends to distort the accuracy of the test and validity of the findings (Laerd, 2020). However, having a larger number of case/respondents mitigates the negative impacts of the test and could lead to increased validity of results (Jamieson, 2004; Fritz and Berger, 2015).

(iv) Closely connected to the avoidance of outliers with deployment of T-test measures is the essentiality of a normal distribution of data. Thus, the distribution of measures must be fairly spread around the centralized mean. Non-normally distributed datasets tend to generate outcomes that could be subject to some distortion in reliability and validity, as in point (iii).

It can be noted, however, that under varying conditions, some data distributions and conditions of variability could generate quite valid tests outcomes even when they fail compliance to some of the assumptions indicated beforehand, generally in a marginal way; however, the broadly tested protocol is the avoidance of non-compliance to the fundamental assumptions outlined above (Laerd, 2020).

5.8.4.2 Kruskal-Walis Test

The Kruskal-Wallis (KW) test – which is sometimes referred to as the 'one-way ANOVA on ranks' – is a non-parametric test that can be used to ascertain if statistically significant differences exist between two or more groups of independent variables measured against a continuous or ordinal dependent variable (Laerd, 2020). The KW test was applied (See 7.5.5) to identify if there are statistically significant differences in data distribution and pattern of scoring within two or more independent categories, e.g. professional groupings of expert respondents on dependent categories. A few basic assumptions lend rationale to the employment of the KW test, including:

(i) There must be a dependent variable, that is measured on an ordinal or continuous scale.

(ii) There must be an independence of relations within the observed categories.

(iii) There must be two or more independent variable categories that can be measured pairwise or listwise.

(iv) The shape of distribution patterns of categories within the independent variable ought to be similar if plotted visually. This premise is vital for the appropriate interpretation of the KW test findings. The KW test is employed discreetly as an alternative to the one-way ANOVA as they generate comparable outcomes; however, the process of finding and interpreting results differs. Brutti and Borenstein (2018) employed the KW test effectively in assessing statistical variance in sampling on risk management mechanisms for portfolio optimization.

5.8.4.3 Mann-Whitney U Test

The Mann-Whitney U-test, sometimes referred to as the Wilcoxon-Mann-Whitney test, is a rank-based nonparametric test that is employed to assess if there are variations in distribution patterns between two groups based on a continuous or ordinal measurement of a dependent variable (Hart, 2001). The Mann-Whitney (MW) test is considered commonly as a nonparametric alternative for tests such as the T-test, which is deployed chiefly towards analysis of relatively normal distributed data. There are basic assumptions that precede consideration for applying the MW test, these include:

(i) There must be one dependent variable within the continuous or ordinal scale of measurement, e.g. the Likert scale (Laerd, 2020).

(ii) An independent variable with two categories of measurement – that is, dichotomous choices, or multiple. However, tests are conducted based on paired selections simultaneously.

(iii) The cases within the independent variables or constructs under observation must be independent of each other, and no two cases can belong to two groups.

(iv) The reporting and interpretation of the MW test is dependent on the shape of the distribution pattern of scores of the cases within the independent variable. The Mann-Whitney U test was deployed as a post-hoc test within the inferential analysis process for this study (See 7.5.6)

5.9. ADOPTED TECHNIQUE/ PROCEDURE

An exploratory approach was taken from the beginning, through the review of literature as advocated by Thomas (2006). This was followed by: (i) a semi-structured written interview process, towards validation of literature findings by experts; (ii) a survey of experts/key stakeholder professionals, and finally (iii) a written interview process to validate the Capability Improvement Framework resulting from findings. These three phases were all directed at optimizing triangulation procedures in consonance with the philosophical underpinnings of the study (as detailed below).

5.9.1 Random/ Systematic Review of Literature and Frameworks

A review of literature in the generic or narrative form was conducted to provide background information to the study and to identify basic underlying concepts, previous investigations, gaps, and projections made towards future research. This was followed by a systematic review of literature, specifically aimed at ascertaining critical environmental risk factors within the petroleum sector and capability improvement mechanisms for addressing identified risk factors. Systematic Literature Reviews are increasingly gaining acceptance as the preferred means of data acquisition from literature (Tranfield *et al.,* 2003; Mallet *et al.*, 2012). Systematic literature reviews not only provide a means of secondary data collection, but also a pivotal process of assembling primary data, through thematic and meta-analysis of eligible documents. Subsequently, a review of previous and contemporary frameworks and strategies of capability/capacity assessment, improvement and development was undertaken. This facilitated the basic synthesis of knowledge and material pivotal to developing research instruments for primary data collection, and also forming a guide for the discussion and ultimate findings.

5.9.2 Literature Verification/ Validation Process

A more complementary process of verifying the acceptability of findings from the systematically reviewed literature was considered essential, and has been employed in recent studies by Mahamadu (2016) and Assah-Kissiedu (2020), through soliciting expert input. According to Iriste and Katane (2018), expert assessment/opinion can be employed to confirm and revise data obtained by means of other methods. The appropriateness and comprehensiveness of the capability improvement attributes and risk minimization factors identified in literature could not be taken as absolutely conclusive or overall reflective of the generality of contexts: it was, therefore, essential to solicit expert opinion on the correctness and relevance of the findings in the literature. In this respect the literature verification/validation process was intended to access opinions and inputs on: (a) the accuracy and comprehensiveness of both the underlying risk factors and the capability improvement measures identified in literature; (b) other risk factors and capability improvement attributes that could have been missed in the systematic literature review process. The semi-structured interview process using the medium of emails was adopted, based on pre-formulated concepts from the literature as a guide to the data collection process (Thomas, 2006).

5.9.3 Selection of Expert Participants (Literature pilot Validation).

The core of experts targeted for the pilot validation process was upper-level personnel of recognized institutions, with acknowledged expertise over the subject matter, particularly in the areas of petroleum engineering, environmental risk management, safety, environment and sustainability management, and disaster management professionals. In all cases, where a potential participant was not specifically an oil and gas professional, such as a petroleum engineer/manager in core petroleum operations, the person was expected to be a functionary within a petroleum-based environment. Dullaimi and Langford (1999) argued that the job environment does have an impact on the behavioral mindset and skills acquired by a worker, and this makes them more likely to have a better conceptualization of the work environment and the critical processes involved. In this regard, it was considered vital to include persons possessing professional/practical exposure to the institutional and industrial context of the study, besides requisite academic/professional qualifications. These participants will have a minimum qualification equivalent to a Postgraduate degree (Master's) and must have functioned in the field under study for no less than five years. Based on the preceding criteria, 16 experts were recruited for the exercise, which was administered by written interviews, sent via customized emails alongside guiding instructions (In Participant Information Sheet).

5.9.3.1 Determination of Expert Panel Size

It was acknowledged that the literature reviewed was chiefly undertaken by qualified academics and subject area experts and therefore the verification process required equally knowledgeable and expert stakeholders for this exercise, towards triangulation of literature findings. In determining the number of participants in data collection methods requiring expert inputs, such as the Delphi technique, Mullen (2003) suggests a number ranging between 7 and 30; while Ameyaw *et al.* (2016) advocates for an optimal range of 8 to 20. In agreement with the analogous number of participants sampled by Mahamadu (2016) and Asah-kissiedu (2020), for comparable pilot validation exercises, a panel of experts from the mid-range of that suggested by Mullen (2003) (n=16) was selected – these were experts from industry and core stakeholder settings.

5.9.4 Main Survey Process

An expert survey was used to access a wider range of expert inputs and views, rather than relying only on the expertise of a limited number of professionals, top experts and decision-makers. It was considered that a wider span of expert inputs and opinions would not only achieve greater representativeness of the population under study, but also mitigate the possibility or conception of respondent bias, thereby increasing reliability (Avison, 1993). The criteria for participation in the survey process was similar to requirements outlined for the expert verification process, except for the inclusion of recognized professionals with comparably lower academic qualifications, i.e. Higher National

Diploma (HND). Additionally, it was considered that potential participants required relevant exposure to the institutional frameworks and industrial work setting pertaining to the Sub-Sahara African petroleum context – particularly experience within the Ghanaian context, since the questions were aimed at identifying specific interventions relevant to Ghana. Adebayo (2002) suggests that to facilitate bridging theory and practice, generalized policies ought to be tailored to suit the African context; in this regard, contemporary research in the African region is now shifting in this direction (Adegbite, 2013). As with the selected experts for the literature review process, experts targeted for the survey process who were not core petroleum engineers were required to have recognizable knowledge/exposure to the petrochemical industry, e.g. focus persons or officially designated officials within the Environmental Protection Authority, Ghana Institute of Engineers, National Disaster Management Organization, etc.

5.9.4.1 Design of Survey Questionnaire

The seven-point Likert scale was deployed to enhance robustness and add depth of expression within this scoring process by expert stakeholders/professionals in the industrial sector. Besides the background information required, four key areas of enquiry formed the crux of survey questionnaire: (i) rating the order of importance for minimizing underlying risk factors of petroleum disaster incidents; (ii) rating the order of importance of the range of capability mechanisms recommended in SR literature for addressing disaster risk factors; (iii) rating the potential or likelihood of attaining impactful results from capability improvement in mechanisms identified; and (iv) rating the level of capability improvement requirements within key institutional structures (identified/pre-validated) designated towards operationalizing the functions of environmental and disaster risk management within Ghana's petroleum sector. Towards this exercise, the 12 underlying risk factors were recategorized as risks which must be minimized, in other words, Risk Minimization Indicators (RMIs). Also, the capability mechanisms were categorized as Capability Improvement Mechanisms (CIMs).

5.9.5 Survey Sample Size Determination

As indicated in this Methodology chapter, purposive sampling was adopted as a means of identifying the sampling frame and sample size. To this end, potential participants were targeted on the basis of their relevant professional expertise, experience and exposure. This was in line with aim of research and the pre-identified professional and institutional domains as indicated previously in 5.9.4 and expatiated in Table 6.2 (Analysis and findings). The following professional domains were considered as the relevant target 'expertise', based on the subject matter and aim of study: (i) petroleum engineers, (ii) environmental, safety and sustainability, or risk professionals, and (iii) disaster management professionals.

As the population for the key sector skills-base relating to the subject area and aim of the survey was not exactly known, a fact-finding search and enquiry via the facilitation/databases of relevant stakeholder institutions and professional bodies had to be undertaken. Email requests/enquiries and searches were made to public institutions, such as Environmental Protection Authority, National Disaster Management Organization, and publicly recognized bodies e.g. Ghana Institute of Engineers, as well as to private based organizations, industrial organizations, and relevant consultancy setups among others. An assessment of LinkedIn profiles to identify potential/qualified participants was also made; and in this regard, the premium membership status of LinkedIn enabled access to more detailed information, and the ability to contact members who were of interest to the project.

Gauging from the key criteria outlined for participation, from responses to exploratory enquiries, 10 public institutions were identified as containing accessible experts of interest – Ministry of Energy; Petroleum Commission of Ghana; Ghana National Petroleum Commission; National Petroleum Authority; Environmental Petroleum Agency; Ghana Maritime Authority and Ghana Ports and Harbours Authority; National Disaster Management Organisation; Ghana Navy; Ghana National Fire Service; Ghana Standards Authority). These institutions contained on average 3 to 5 experts of interest. Additionally, the Ghana Institute of Safety and Environmental Professionals provided access to databases/credentials of members, from which around 60 met the criteria established for participation and had accessible contact information. Table 5.1 provides a breakdown of an estimated (a) basic, and (b) higher margin of population of experts within identified institutions/professional bodies/websites based on sampled responses from enquiries made. It can be considered that the relatively lower number of expertise projected within the public sector institutions is unsurprising, since Ghana's petroleum industry is in early stages of development, and relevant human resources are similarly underdeveloped (Amponsah-Tawiah *et al.*, 2015; Osei-Hwere, 2015).

Table 5. 1 Estimated Survey Population Breakdown

Sector	**(a) Accessible Baseline population**	**(b) Projected Higher margin Population**
Public sector Institutions	≤50	80
Ghana Institute of Safety and Environmental Professionals	≤60	100
Private sector institutions/ Consultancy/NGOs, LinkedIn etc.	≤ 70	120
Total for all sectors	≤ 180	300

5.9.5.1 Sample Size Calculation

The formula for identifying sample size for an unknown population, established by Creative Research systems (Equation 6.1), was adapted for this study. This formula has been employed recently in determining a basic sample size for surveys in parallel studies by Manu (2012) and Mahamadu (2017). This formula was also instrumental, particularly as the standard deviation for the variables of the survey was not yet known, as in formulae which employ standard deviation in place of a 'p' value.

Equation 5. 1: Formula for determining sample size

$$ss = \frac{z^{2} \times p\,(1 - p)}{C^{2}}$$

Where:
ss = sample size;
z = standardized variable;
p = percentage picking a choice, expressed as a decimal; and
C = confidence interval error margin, expressed as a decimal.

Assuming a confidence level of 95%, a Z variable of 1.96 was derived. Secondly, a confidence interval error margin (C) of ±5% was considered rational as applied within post-graduate studies undertaken by Koranteng (2014). Towards attaining a substantial level of accuracy, Czaja and Blair (1996) recommended the use of a p value of 50%. Upon applying these basic parameters, the minimum sample size was derived from the formula above, which resulted in a basic sample size of 384.16, as computed below.

Equation 5. 2: Basic sample size

$$ss = \frac{1.96^{2} \times 0.5\,(1 - 0.5)}{0.05^{2}} = 384.16 \text{ participants}$$

The derived basic sample size, projected to a ±5% confidence interval, was higher than the estimated total population of expert participants for this particular survey, and adjustment was required to derive a workable sample size. According to Saunders *et al.* (2016), where the known or estimated population is less than 10,000 the adjusted sample size can be used towards maintaining sampling accuracy. In this regard, Czaja and Blair (1996) deployed this formula, which facilitated adjusting the basic sample size from an unknown population (384.16 in current research) in accordance with the estimated or known population

Equation 5. 3: Adjusted Sample Size Formula

$$\text{Adjusted ss} = \frac{ss}{1 + (ss - 1)/Pp}$$

Employing the formula above, this resulted in an adjusted sample size (equation 5.5), being revised to 169 participants based on the estimated higher margin population of 300 as outlined in Table 5.1.

Equation 5. 4: Adjusted Sample Size Computation

$$\text{Adjusted ss} = \frac{ss}{1 + ss - 1/Pp} = \frac{384.16}{1 + (384.16-1)/300} = 169$$

Therefore, the adjusted sample size of 169 was employed for the survey as a minimum. This adjusted sample size compares exactly with results derived from the Qualtrics sample size calculator software (Qualtrics, 2020). Takim *et al.*, (2004) suggested a 20-30% adjustment towards potential for non-response – however, considering low response rates of surveys conducted in Ghana previously (Hammond, 2006; Ahadzie, 2007) and also considering prevailing pandemic restrictions in this era, a 50% adjustment to compensate for non-response was viewed as appropriate. Thus, a targeted distribution of 338 survey instruments was prepared initially, based on 50% adjustment for non response; however, owing to challenges experienced during the distribution process, by way of accessibility and cooperation from some institutional settings, only 195 survey questionnaires were accepted or delivered successfully to potential participants (as projected, access was denied to intermediaries/assistants in the process of follow-up and reminders to ensure delivery). See section 7.3.3 and Table 7.2a for survey distribution pattern and response rate.

5.9.6 Relative Weighting and Ranking of Dependent Variables

Having acquired a basic description of data within independent variables from distribution pattern of background information, it is essential to identify the relative importance placed on various items under assessment. This is aimed at identifying the more critical (i) risk minimisation factors and (ii) capability improvement mechanisms required for developing the proposed decision support framework (in order of importance). Relative weighting indices enable identifying most of the important criteria based on participants' responses provided; and it is also an appropriate tool towards prioritising indicators rated on Likert- type scales. The Weighted Average Score (*WASi*) formula below (Equation 6.5) propagated by Shen and Tam (2002) was deployed towards computing the relative weighting indicators and ranking accordingly.

While the WAS_i is considered instrumental for identifying indicators of relative importance, Shen and Tam (2002) recognised the need for a complementary formula to derive an adjusted score ranking, which is more thorough with regard to weighted attributed value to each variable. The adjusted score method has been employed effectively in a recent study, by Owolana and Booth (2016), Bailey et al (2020), and others. This formula (Equation 4.5) which employs the use of coefficient of variation, determined via dividing the WAS_i by the standard deviation as advocated by Naoum (2013), was adopted for this study. The resultant coefficient is then added to the value attained for *WASi* to derive an adjusted score for determining the actual ranking.

Equation 5. 5: Weighted Average Score Formula

$$WAS_i = \frac{\sum_{j=1}^{7}(\alpha \text{j} * nij\ )}{N}$$

Where:

WASi = weighted average score of each factor i

αj = the numerical value given to each of the ranking categories

n_{ij} = denotes the number of respondents for factor i with respect to the ranking category j

N = the total number of respondents

∑ = the total sum

The adjusted Weighted Average Score formula is shown below:

Equation 5. 6: Adjusted Weighted Average Score Formula

$$\text{Adjusted Score} = WAS_i + \frac{WAS_i}{\delta_i}$$

Where:

WASi = same as above

δ_i = Standard deviation for each factor i, calculated using the weighted average score.

5.9.7 Approach to Research Design

As understood generally, research design can be considered as a guide-map through the various layers of methodological choices towards achieving the objectives and aims of the study (Thomas, 2006). It is required that the process and deployment of strategies, techniques, etc. toward achieving objectives and aims should be in congruence with the philosophical underpinnings of the study (Creswell, 2012). Pragmatism, which underpins the philosophy of this study, supports the deployment of both quantitative and qualitative measures through a sequential multi-phase process of triangulation towards better understanding and contextualization of concepts required for deriving the proposed decision support tool.

Table 5. 2 Projected Strategies for Framework Design

<table>
<tr><th rowspan="2"></th><th rowspan="2">Underlying Risk factors</th><th rowspan="2">Key Capability Attributes</th><th colspan="7">Level of Importance
(Risk factors/ Capability Mechanisms)</th><th colspan="7">Institutional Mechanism
(Level of Capability Improvement Needed)</th><th rowspan="2">Performance Improvement Mechanism</th></tr>
<tr><th>Unimportant</th><th>Low important</th><th>Slightly Important</th><th>Moderate Importance</th><th>Important</th><th>Very important</th><th>Extremely Important</th><th>None</th><th>Very Low</th><th>Low</th><th>Average</th><th>High</th><th>Very High</th><th>Extremely High</th></tr>
<tr><td>OBJECTIVES</td><td colspan="2">Identify major Environmental Disaster risk factors and capability improvement measures for addressing EDRs (Objective 3)</td><td colspan="14">Rank the most Important Environmental Disaster Risk factors (as RMIs) and Capability Improvement Mechanisms (CIMs) (Objective 4)</td><td rowspan="2">Review of Capability Improvement Frameworks/ Strategies (Objective 2)</td></tr>
<tr><td>STRATEGY</td><td colspan="2">Systematic Literature Review/
Expert Validation</td><td colspan="14">Expert Survey</td></tr>
<tr><td>PARTICIPANTS</td><td colspan="2">Stage 1: Data Synthesis
Stage 2: Petroleum Engineering/ Risk/ Safety Management Professionals/ (n=12)</td><td colspan="14">Industry Practitioners/ Subject area Professionals in Ghana (n=78)</td><td>Secondary Data</td></tr>
</table>

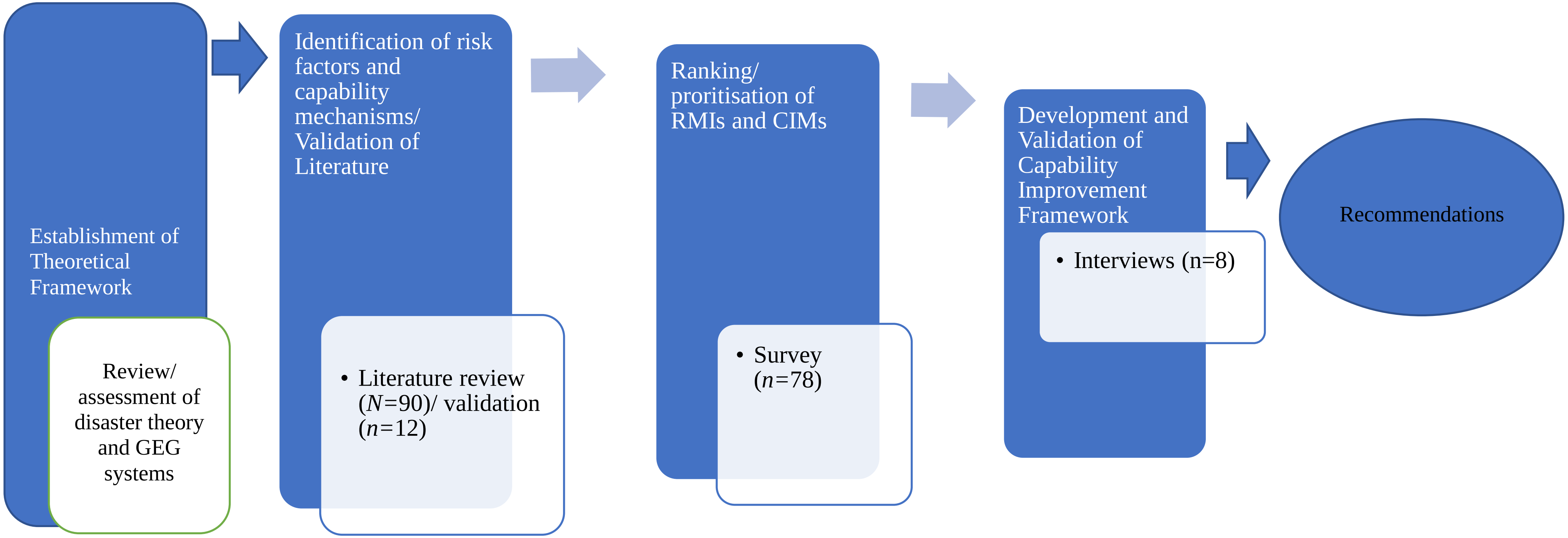


Figure 5. 4 Representation of the Methodological Process

5.10 ETHICAL CONSIDERATIONS

Ethical considerations are vital ingredients in the research process, and meeting required standards of ethics approval, is a sine qua non measure to be addressed by researchers (Robson, 2002; Saunders *et al.,* 2016). The University of the West of England, Bristol subscribes to very high standards of ethics compliance in adherence to national and global policies/ protocols.

In compliance to required standards of the university, ethical approval was sought from the post-graduate research ethics committee and granted via a commitment to follow through in giving due respect and consideration for the privacy, dignity and confidentiality of all participants. A participant information sheet accompanied by a consent form, detailed the aim objectives and requirements of the study, in addition to this, the rights of participants to privacy and abstention or withdrawal from the study was assured. The requirement by the UWE postgraduate research management, to use Qualtrics software as the designated instrument for surveys, further supports, standardization and a more coordinated process of undertakings, which enhances transparency and verifiability. All participants for various stages of data collection process were given letters of invitation requesting their willingness and consent to participate in the various sections of undertaking, this was accompanied by privacy/ confidentiality statements and consent forms, to be duly endorsed by participants. The Faculty Research Ethics Committee (FREC), consistently monitors each stage of data collection process and reciprocal outcomes in evolvement of project/ dissertation at the progression examination stages to ensure that the researcher is consistently adhering to stated and agreed process/ methodology and ethical compliance indicators for the research.

In this regard, compliance to requirements of ethics and propriety in research has been met to globally accepted standards, to the best of researcher’s knowledge and approval of the governing institution.

5.11 CHAPTER SUMMARY

The methodological process, designed for achieving the aim and objectives of this study has been made in this chapter. Critical consideration and assessment of strategies, methods techniques, tools and procedures of the multi-method approach in line with pragmatist philosophy has been employed through a sequential multi-phase process of investigation towards attainment of the research aim and goal.

CHAPTER 6: IDENTIFICATION OF KEY RISK FACTORS AND CAPABILITY IMPROVEMENT MECHANISMS FOR MINIMISING ENVIRONMENTAL DISASTER IN THE PETROLEUM SECTOR

6.0 INTRODUCTION

The basic premise on which this systematic review is being undertaken, is to draw insight from the academic perspective towards knowledge synthesis, having already assessed this subject broadly from a multidimensional and random context in the preceding chapters. This would allow for evaluating the strengths and weaknesses in perspectives, as well as gaps in academic interventions within contemporary literature. This exercise represents a qualitative process of enquiry towards data acquisition for framework design and final recommendations.

6.1. AIM AND OBJECTIVES

The research is directed towards exploring the fundamental relation between improved disaster risk reduction capability within public sector institutions, and environmental disaster pre-emption/ minimization, within the petroleum sector of Ghana. This review process would therefore, investigate the state of the art, regarding environmental disaster concepts from the academic perspective, with the aim to: (a) Evaluate, what generally constitutes environmental disaster risks within the offshore petroleum sector; (b) Appraise the level, form of coverage and tangent of discussion on this topic (i.e. the perspective from which previous investigations have been undertaken, within academic literature); and (c) Identify attributes, or indicators of disaster risk reduction capability, which can be factored into a capability improvement framework towards optimizing institutional capacity for disaster risk reduction, specifically within the petroleum sector of Ghana.

The one fits all approach/ prescription for disaster risk management within the petroleum setup, has been identified as highly problematic, and having potential for avoidable complications when indiscriminately applied within some settings (Tierney, 2012; Obeng-Odoom, 2017). The foregoing position is mirrored in Edelstein's observation (2011), on the "unusual" risks, conditions and occurrences leading to the Gulf of Mexico Macondo incident. Evidently the geographical, socio-environmental, geo-political and economic conditions are diverse, not to mention that, institutional capacity in terms of operational exposure, levels and forms of vulnerability among others, differ across jurisdictional contexts. In the occurrences leading to the Macondo incident, Edelstein identifies incongruent risk management models as highly contributory. There are, however, some universal models and generic mechanisms which are widely applicable for disaster risk management within the petrochemical industry: in this regard, it is pivotal that the literature in this domain be appraised, to ascertain the crucial linkages and relevance of these interventions to the Ghanaian context, as well as the existing gaps.

6.1.1 Definitional Context

To further evolve this discussion, it would be essential to gain an understanding of what the phenomenon of petroleum and environmental disaster is, and how these fit within the broader context of disaster theory. The National Institute of Disaster Management (NIDM, 2014) considers environmental disasters (EDs) as, "the realization of hazards to serious impacts, damages and losses, initiating in some or the other environmental systems or resources". Various forms are identified (2014), to include: (a) Geo-hydrological disasters; (b) Chemical accidents/ disasters; (c) Industrial Environmental Disasters; and (d) Climate Change and Disasters. Apparently, petroleum disasters fall within the context of (b) and (c) and can be classified as forms of E.Ds. The use of the term "petroleum disasters" within this study would from this point, refer to disaster incidents within this sector, which have potential environmental implications, except otherwise indicated.

6.2. THE SYSTEMATIC REVIEW CONCEPT

Increasingly, systematic review of literature has gained wider acceptance and credence as a more consistent and evidence-based means of assessing secondary data (Tranfield *et al.*, 2003). Application of Systematic Literature Reviews (SLRs) have been more prevalent in the clinical research domain; apparently SLRs were first employed and progressively developed for usage within the medical discipline (Clarke and Chalmers, 2018). Grant and Booth (2009) identified and appraised fourteen different types of reviews and found some distinct features within each; however salient similarities and overlaps pertaining to these methodologies do not permit mutual exclusivity in categorizing these protocols. What is apparent from this (Grant and Booth, 2009) and similar studies (Massaro *et al.*, 2016; Harari *et al*, 2020) are key attributes of the degree of emphasis and rigour which characterize the process of the various review types.

Considering the high standards required in postgraduate research and the need to identify critical features and attributes of capability improvement which can support decision making, the SLR method was considered a more robust and conclusive form of review for this study. Mengist *et al.*, (2020) advocate for deployment of systematic literature review protocols, as the more viable method of reviewing literature within environmental science research undertaking. The SLR process has in recent times been used effectively in other fields of industry and general academic undertaking, including reviews in areas such as construction, supply chain management and disaster management, among others (Lettieri *et al.,* 2017; Masi *et al.,* 2017; Ewbank *et al.*, 2019; Novais *et al.,* 2019). There are various protocols for undertaking SLRs; those in popular use include among others: Search, Appraisal, Synthesis, and Analysis (SALSA), Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), Population, Intervention, Comparison, Outcome, and Context (PICOC) etc. The choice of a review protocol and approach to fulfilling aims is contingent on the researcher's familiarity with methods, the levels of rigour desired, or requirement of oversight, stakeholder bodies: for instance the medical professional sector conventionally subscribes to the PRISMA protocol (Haidich, 2010)

6.2.1 Features and Attributes of Systematic Reviews

Contemporary academic research reviews are characterized by rigorous and methodically coordinated processes, towards attaining key criteria and standards of quality, in line with procedures such as the PRISMA (2009) and Cochrane (2019) protocols. The PRISMA study design for example, accompanied by a systematized checklist is available for adaptation, and as a roadmap for navigating the SLR process. Critical requirements or attributes of the SLR process and reporting standards are the following: (i) Inclusiveness of eligible material: (ii) objectivity in search process/ avoidance of bias; and (iii) replicability of research process, underpinned by a transparent study protocol, among others. (Moher *et al.,* 2009).

1. The need for inclusiveness, that is, by way of ensuring all relevant documents or materials are captured and considered for eligibility assessment, is a major feature of the SR process (Cooper *et al.*, 2018; GU, 2019). This requirement makes the SR process demanding and time consuming at the initial stages, however, this pays off at the end, compared to random narrative and analogous searches (Tranfield *et al.,* 2006). Once relevant and eligible materials have been screened and selected at the final stage, this compensates for the time and uncertainty that would have gone into making random narrative searches. A key challenge in this regard is the tendency to derive unnecessarily large volumes of literature at the initial stages, most of which are excluded, sometimes laboriously through the screening process. Smith *et al.* (2011.p3), propose a guideline as; "Furthermore, search terms should be focused so that they are broad enough in scope to capture all the relevant data yet narrow enough to minimize the capture of extraneous literature that may result in unnecessary time and effort being spent assessing irrelevant articles".

While the aim for inclusiveness and comprehensiveness of relevant records are key requirements of SLRs, it has been suggested that exhaustiveness of all relevant material, is in a way not practicable (Massaro *et al.,* 2016); as it has not been a conventional approach to search all existing databases and grey literature. The selection of databases and exclusion of other data sources which may arguably provide additional information is subject to some amount of discretion on the part of the researchers. The ostensible bias or subjectivity presented by the foregoing is compensated for by establishing transparency through a clear statement of aims and objectives, a well-defined search protocol and screening procedure, which ensures effective replicability. To establish inclusiveness of relevant material for this SLR process, the search criteria has been contextualized within a significant time frame and data source domains that are focal and targeted at achieving the key aim of the study. Search terms and search strings have been discretely defined and refined to ensure that all relevant records are identified and included for screening.

2. Objectivity and avoidance of bias is another critical requirement of the SR process, which according to Mallet *et al.* (2012) is achievable through outlining clearly and concisely, an inclusion and exclusion protocol. This is usually peer reviewed or verified by research supervisors, to ensure the protocol towards attaining inclusion, is clear, comprehensible and unambiguous. The inclusion and exclusion criteria for this study has been clearly contextualized to apprehend relevant records and data from the academic domain, and also tailored to reflect a more contemporary span of time; which provides precision and narrowing of the research scope.

3. Replicability is a key feature of SR, which further enhances the rigour and transparency of the process (Massaro *et al.,* 2016; Harari *et al.,* 2020). Replicability underpins the evidence based approach which adds to the robustness of the SR process and makes this less likely to be considered arbitrary or subjective. In the event of disagreement or doubt over the search, analysis and findings, the SLR process can be repeated, using the exact and prescribed process as originally undertaken by researcher (Mallet *et al.,* 2012). The search words, configuration of terms and limiters, where applicable within this study, have been outlined below in 6.2.3.

6.2.2 Study Strategy

Towards attaining the aims of this review, a series of actions were undertaken as shown below: (i) Determining of research questions; (ii) Identifying of search terms and search strings; (iii) Identifying appropriate databases; (iv) determining inclusion and exclusion criteria; (v) Identification and screening for eligible material; (vi) Processing and analysis of data; and (vii) Findings and conclusions. This approach is in adaptation of the five-point proposal by Tranfield *et al.,* (2003) on ideal procedural patterns for conducting systematic reviews in social science and management research. These steps include: 1. Definition of research questions; 2. Locating of studies in databases; 3. Selection and eligibility assessment; 4. Analysis and synthesis of selected material; and 5. Reporting, presenting and application of findings

6.2.3 Systematic Review Search Process

Having identified the aims and research questions for this review process, a search protocol was designed, and search terms were assessed by researcher under review of the supervisory team as shown below. Key Search Terms: “Offshore petroleum oil gas environment disaster risk capability”. Combinations of these search words were assessed and refined in pilot searches within relevant databases, such as ScienceDirect, Google Scholar, Scopus, Emerald, Wiley online, amongst others. SCOPUS, Emerald Insight and Wiley online Library were identified databases with substantial range of material relating to the search aims, after pilot searches. Search strings employing Boolean operators ‘AND’ ‘OR’ and * where applied in search words as follows: (offshore AND petroleum AND environment* AND disaster AND risk*) (offshore AND oil OR gas AND environment* AND disaster AND risk*) (offshore AND petroleum AND disaster AND capability). Search terms and strings where made broad and inclusive as possible in order to maintain contextual connectivity (Smith *et al.,* 2011).

Search through the three main databases was made from the 17th, terminating on 23rd July, 2019. Advanced search through all fields of the databases, defined within the specified dates; 2005 to 2019 and scholarly peer reviewed journals initially yielded a total 4,057 records. The inclusion and exclusion criteria are shown in Table 6.1; and the selection of records from databases, through screening process to eligibility of material for final inclusion is presented hereby in Figure 6.1.

Table 6. 1: Inclusion and Exclusion criteria for SR Process

Inclusion Criteria was based on the following	Exclusion criteria was based on the following
1. Studies that clearly indicate disaster incidents and or related risks, which have environmental implications from the focal setting of the upstream petroleum industry (Objective “a”) 2. Consideration has been given to studies conducted within the range of years, 2005 to 2019. It can be considered that disaster risk reduction/ management concepts are more recent and of an evolving complexion, both in theory and practice, compared to disaster management (Manu *et al.*, 2019). The contemporary discussion from a post Hyogo era is directed at attaining objectives “b”. This is also meant to provide focus and precision within the scope of review. 3. Research findings that meet the following: (i) clearly indicated research methodology/ methods (ii) explored the dimensions of underlying risks or root factors, and (iii) identified or proposed interventions or mechanisms for institutional capacity/ capability improvement (Objective “c”).	1. Studies that are widely remote and disconnected from environmental implications, or of a nature that has inconsequential impacts on surrounding biological life and ecosystem; such as internal leakage of asphyxiating chemicals, or offshore related carcinogenic radiation incidence, etc. 2. Studies on petroleum vessels operating remotely, and where accidents or disasters occurred not as a direct result of operations within the environment of the offshore petroleum exploration and production (E and P) context. Also excluded are extreme natural events, not caused as a direct result of Exploration and Production activities. 3. Studies which do not meet the criteria of environmentally related incidents, e.g., petroleum industrial crisis, commercial or politico-economical adversities such as recession, oil glut, etc., and downstream petrochemical operations etc.

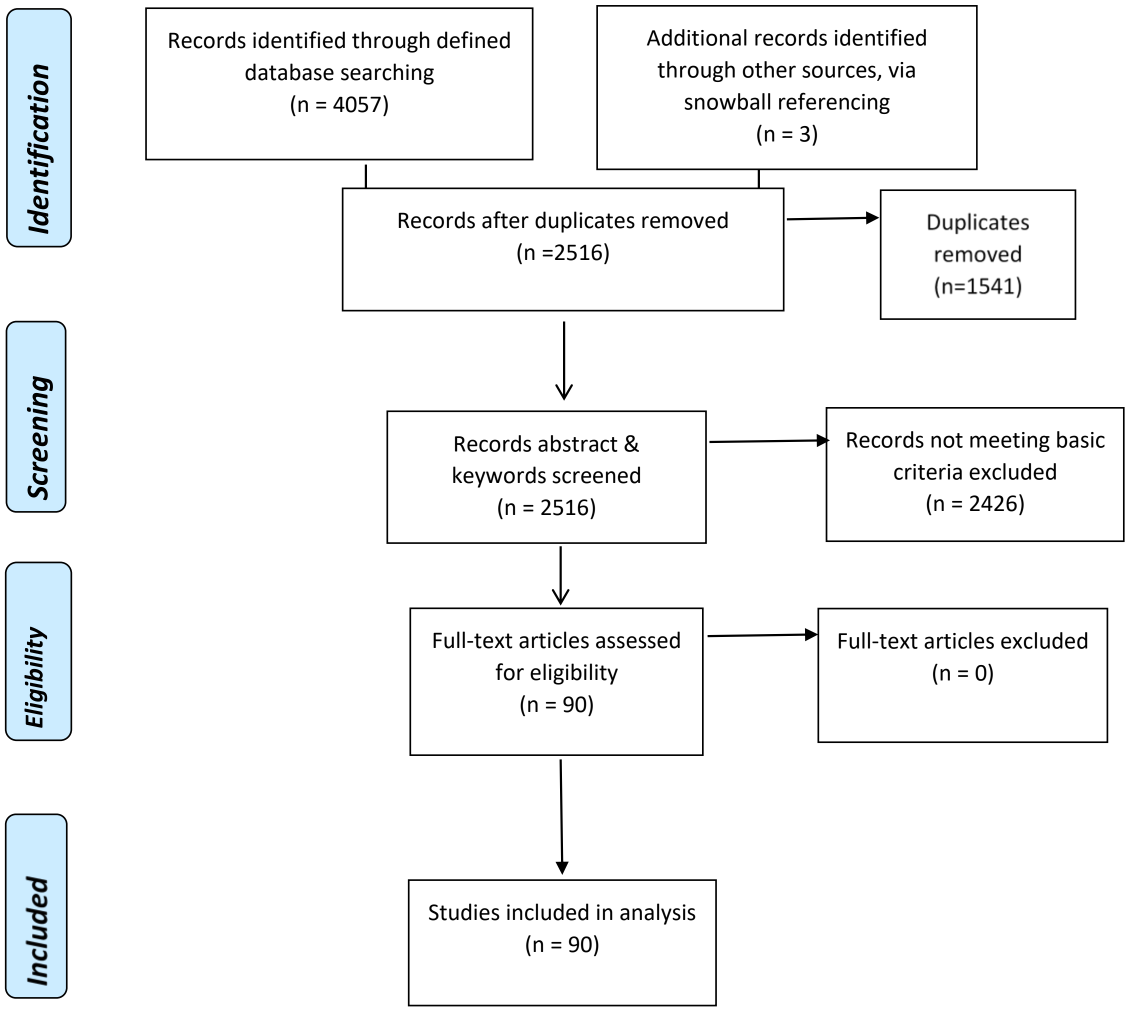


Figure 6. 1 PRISMA 2009 Flowchart for Study

A summary breakdown of general outline and key components of the findings from assessment of documents within n=90 are hereby presented in Table 6.2 below

Table 6. 2: Breakdown of General Findings of SR Search (n=90)

No.	Year	Research Country	Incident Type	Study Type	Environmental Impact	Authors
1	2019	Iran	HCR	Conceptual	Pollution/ Habitat damage	Amir-Heidari et al
2	2019	Norway	HCR	Experiment	Habitat damage/ Effect on marine life	Arnberg et al
3	2019	France	HCR	Mixed	Pollution/ Habitat damage	Chiri et al
4	2019	Denmark	HCR	Mixed	Pollution/ Habitat damage	Goerlandt et al
5	2019	Canada	Pipeline damage	Mixed	GEI	Iqbal et al
6	2019	Arctic	HCR	Review	GEI	Johannsdottir et al
7	2019	China	HCR	Mixed	Pollution/ Habitat damage	Li et al
8	2019	Greece, Norway,	HCR	Review	GEI	Liaropoulos
9	2019	USA	Blowout	Case study	Habitat damage/ Effect on marine life	Meng et al
10	2019	UAE	Blowout	Mixed	Pollution/ Habitat damage/ Loss of human life	Muhammad
11	2019	USA	HCR	Review	Pollution/ Habitat damage	Nelson et al
12	2019	NI	NS	Case study	Habitat damage/ Loss of human life	Paltrinieri
13	2019	Arctic	HCR	Interviews	Pollution/ Habitat damage	Parviainen et al
14	2019	USA	Blowout	Survey	Habitat damage/ Effect on marine life	Raza et al
15	2019	Italy	HCR	Conceptual	Pollution/ Habitat damage	Ribotti et al
16	2019	Russia	HCR	Mixed	Pollution/ Habitat damage	Shavykin et al
17	2019	NI	HCR	Mixed	Pollution/ Habitat damage	Shi et al
18	2019	Russia	HCR	Case study	Pollution/ Habitat damage	Sidortsov
19	2019	China	Structural collapse	Case study	GEI	Tang et al
20	2019	USA	Blowout	Mixed	Pollution/ Habitat damage	Verwijen et al
21	2019	China	Chemical discharge	Mixed	Pollution/ Loss of human life	Wu et al
22	2019	China	HCR	Review	Pollution/ Habitat damage	Yang et al
23	2019	NI	HCR	Mixed	GEI	Zhaou et al
24	2018	Arctic	Fire/ explosion	Mixed	Pollution/ Loss of human life	Bucelli et al
25	2018	NI	Blowout	Mixed	Pollution/ Habitat damage	Cala et al
26	2018	China	Fire/ explosion	Experiment	Pollution/ Effect on marine life	Chen et al
27	2018	Australia	Blowout	Review	Habitat damage/ effect on marine life	Daszuta et al
28	2018	NI	Explosions	Content analysis	Pollution/ Loss of human life	Halim et al
29	2017	Nigeria	HCR	Interviews	Habitat damage/ Drinking water pollution	Adekola et al
30	2017	Portugal	HCR	Mixed	Habitat damage/ Effect on marine life	Azevedo
31	2017	USA	Pipeline damage	Survey	Habitat damage/ Effect on marine life	Brogan
32	2017	Denmark, Swede	HCR	Mixed	Pollution/ Loss of human life	De Padova et al
33	2017	Arctic	HCR	Review	GEI	Gulas et al
34	2017	Norway-UK	HCR/ Explosion & fire	Experiment	Habitat damage/ Effect on marine life	Heo et al
35	2017	NI	NS	Mixed	GEI	Kim
36	2017	NI	HCR	Review	Pollution/ Loss of human life	Nelson et al
37	2017	USA	Blowout	Case study	Pollution/ Loss of human life	Pranesh et al
38	2017	Brazil	NS	Case study	GEI	Silvestre et al
39	2016	Iran	HCR	Survey	Pollution/ Habitat damage	Atighechian
40	2016	NI	Pipeline damage	Conceptual	Pollution/ loss of human life	Bariha
41	2016	NI	Blowout	Case study	Pollution/ Habitat damage	Lazarus
42	2016	UAE	NS	Mixed	GEI	Pathirage et al
43	2016	Norway	Structural collapse	Fuzzy logic	GEI	Ratnayake
44	2015	NI	NS	Conceptual	GEI	Alkazimi
45	2015	Nigeria	NS	Review	GEI	Anejiounu
46	2015	NI	NS	Case study	GEI	Argenti et al
47	2015	Arctic	HCR	Review	GEI	Arruda
48	2015	Norway	HCR	Interviews	Pollution/ Habitat damage	Belkina
49	2015	Canada	Helicopter Crash	Review	GEI	Hart
50	2015	China	HCR	Case study	Pollution/ Habitat damage	Lan
51	2015	China	HCR	Case study	Pollution/ Habitat damage	Liu
52	2015	USA	Blowout	Case study	Pollution/ Habitat damage	Mills et al
53	2015	USA	HCR	Case study	Pollution/ Loss of human life	Nelson et al
54	2015	NI	HCR	Mixed	Pollution/ Habitat damage	Ong
55	2015	NI	Structural collapse	Review	GEI	Ratnayake
56	2015	Norway	HCR	Case study	Pollution/ Habitat damage	Vinnem et al
57	2015	NI	HCR	Review	Pollution/ Habitat damage	Walker
58	2014	Greece	HCR	Mixed	Pollution/ Habitat damage	Alves et al
59	2014	Nigeria	Pipeline damage	Mixed	Habitat damage/ Effect on marine life	Anifawose et al
60	2014	NI	Composite	Review	GEI	Arruda
61	2014	NI	NS	Conceptual	GEI	Griffin et al
62	2014	NI	HCR	Experiment	Pollution/ Habitat damage	Li et al
63	2014	USA	HCR	Case study	GEI	McNamara
64	2014	Brazil	NS	Mixed	GEI	Mendes et al
65	2013	Canada	Blowout	Case study	Habitat damage/ Effect on marine life	Doelle et al
66	2013	USA	HCR	Experiment	Pollution/ Habitat damage	Kurtz
67	2013	Iran	HCR	Case study	Pollution/ Habitat damage	Mansoureh
68	2013	Norway	NS	Interviews	GEI	Markeset et al
69	2013	NI	HCR	Review	Pollution/ Habitat damage	Vinogradov
70	2013	Norway	HCR	Content analysis	GEI	Vinnem
71	2012	Canada	HCR	Mixed	Pollution/ Habitat damage/ Effect on marine life	Burke et al
72	2012	USA	HCR	Mixed	Pollution/ Habitat damage	Eckle et al
73	2012	Australia	Blowout	Review	Pollution/ loss of human life	Hayes
74	2012	USA	HCR	Mixed	Pollution/ Habitat damage/ Effect on marine life	Lord et al
75	2012	USA	Blowout	Case Study	Pollution/ Habitat damage	Neill et al
76	2012	Nigeria	NS	Mixed	GEI	Ruffin
77	2011	Bangladesh	Blowout	Review	Habitat damage/ Loss of human life	Islam et al
78	2011	Russia	HCR	Interview	GEI	Ivanova
79	2011	USA	Blowout	Case study	Pollution/ Habitat damage	Lin-Hi et al
80	2011	USA	Blowout	Case study	Habitat damage/ Effect on marine life	McCrae-Strub et al
81	2011	USA	Blowout	Review	Habitat damage/ Effect on marine life	Richardson et al
82	2011	Norway	HCR	Interview	Pollution/ Habitat damage/ Effect on marine life	Sydnes et al
83	2010	Nigeria	Pipeline damage	Survey	Habitat damage/ Effect on marine life	Aroh et al
84	2010	Norway	NS	AHP	GEI	Ratnayake et al
85	2010	UAE	Fire/ explosion	Mixed	Pollution/ Loss of human life/ Habitat damage	Shaluf et al
86	2009	Nigeria	Pipeline damage	Review	Habitat damage/ Effect on marine life	Obanijesu et al
87	2009	Nigeria	Pipeline damage	Case study	Habitat damage/ Effect on marine life	Onuoah
88	2008	USA	NS	Mixed	GEI	Harrison
89	2006	NI	Structural damage	Fuzzy logic	GEI	Oke et al
90	2005	USA	NS	Case study	GEI	Chrichton et al

LEGEND

Abbreviation	
HCR	Hydro-Carbon Release
GEI	Generalized Environmental Impacts
NS	Not stated
AHP	Analytical Hierarchical Process

6.2.4. Key Findings

Upon a thorough search and review of the selected documents *n=90*, identification was made of some (a) 12 key concepts relating to underlying or root factors of disaster risks within the petroleum sector; and (b) 16 key capability/ capacity improvement interventions recommended/ proposed towards addressing these risks. The underlying risk factors and essesntial capability attributes where identified largely, from the discussion of findings, recommendations and conclusion section of the selected studies *(n=90).* These factors and attributes where grouped into four functional or related categories by researcher to facilitate thematic assessment and design of CIF, which underpins the aim of the main research. The categorisation of identified root factors and critical capability attributes are presented in Tables 6.3 and 6.4; and the breakdown of the frequencies of the findings in each document is shown in Tables 6.5 and 6.6.

Table 6. 3 Identified Root Causes/ Underlying Factors of Petroleum Environmental Disasters

Categories	**Risk Factors**
TECHNICAL	(i) Equipment failure
	(ii) Technical capability gaps
	(iii) Human error
GOVERNANCE	(i) Governance system gaps
	(ii)) Sabotage/ terrorism, vandalism
	(iii) Socio-environmental accountability
MANAGERIAL	(i) Managerial and leadership shortcomings
	(ii) Material resource management shortcomings
	(iii) Risk management shortcomings
OPERATIONAL	(i) Emergency preparedness flaws
	(ii) Delayed action/ response
	(iii) Operational risk taking

Table 6. 4 Key Capability Mechanisms for Addressing EDRs

Categories	**Key Capability Attributes**
TECHNICAL	(a) Early detection and warning systems
	(b) Technology adoption/ improvement
	(c) Decision support systems/ frameworks
	(d) Material resource management
GOVERNANCE	(a) Legal and regulatory mechanisms
	(b) Standards monitoring and auditing
	(c) Governance institution development
	(d) Inter-organizational cooperation
MANAGERIAL	(a) Research
	(b) Human resource development
	(c) Risk management
	(d) Stakeholder management
OPERATIONAL	(a) Emergency preparedness strategy
	(b) Public involvement and education
	(c) Pre-emptive, early, and rapid action (PERA);
	(d) Training and simulation

Table 6. 5 Cumulative Breakdown of Underlying Factors of Petroleum Disaster

	Root or Underlying Risk Factors of Petroleum Disaster											
Author	**Equipment failure**	**Technical Capability gaps**	**Governance System Gaps**	**Managerial/ Leadership shortcomings**	**Risk Management Shortcomings**	**Human error**	**Sabotage Terrorism and Vandalism**	**Operational Risk Taking**	**Material Resource Management Challenges**	**Socio–Environmental accountability**	**Emergency Preparedness flaws**	**Delayed Action and Response**
1					√							√
2					√					√		
3		√				√						
4					√							
5	√				√							
6			√					√		√		
7	√											√
8			√									
9	√							√				
10	√	√		√		√						
11		√										
12			√		√							
13			√		√							
14		√				√						
15					√							
16					√							
17					√		√					
18			√					√		√		
19	√				√							
20		√						√				
21					√							
22			√	√								
23	√											
24	√							√		√		

25				√								
26	√					√						
27		√	√			√						
28				√		√		√				
29			√							√		
30					√							
31	√					√						
32	√					√						
33			√							√		
34	√											
35					√							
36					√							
37				√		√						
38			√									
39					√						√	
40	√											
41					√					√		
42			√				√					
43	√					√						
44		√			√							
45			√									
46							√					
47				√						√		
48				√								
49			√	√								
50					√							
51				√								
52			√									
53		√			√							
54			√									
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61		√				√						
62									√			
63				√	√							
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66			√					√				
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81			√					√				
82		√	√					√				
83			√				√			√		
84		√						√				
85	√											
86	√	√				√						
87			√							√		
88							√			√		
89						√		√				
90		√		√				√			√	
	16	**15**	**34**	**13**	**25**	**16**	**6**	**15**	**1**	**15**	**3**	**2**

Table 6. 6 Cumulative breakdown of Capability Improvement Mechanisms

	DRR Capability Improvement Mechanisms																
Author	**Standards Monitoring / Audit**	**Material Resource Management**	**Stakeholder Management**	**Early Detection and Warning Systems**	**Technology Adoption**	**DSF/ DSS**	**Governance institutional Development**	**Early action (PERA)**	**Training and Simulation**	**Emergency Preparedness strategy**	**Research**	**HR Development**	**Public Involvement and Education**	**Risk Management**	**Legal/ Regulatory**	**Inter-organizational cooperation**
1		√				√			√							
2						√					√					
3								√			√					
4						√					√			√		
5	√					√								√		
6			√													√
7						√		√	√							
8				√	√			√								√
9					√					√						
10					√									√		
11		√		√	√											
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15				√	√									√		
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22					√								√		√	
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25					√	√										
26	√								√		√	√				
27	√								√							
28									√		√	√				
29				√		√							√			
30													√			
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40					√	√				√						
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43							√									
44	√				√										√	
45					√	√									√	
46						√				√	√			√		
47										√					√	√
48											√				√	√
49	√														√	
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52	√						√					√				

53				√	√				√	√						
54															√	
55	√												√			
56	√				√											
57			√										√			
58				√	√											
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61	√					√						√			√	
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66											√					
67							√							√		
68	√															
69															√	
70									√		√				√	
71	√						√				√					
72				√			√							√		
73	√														√	
74												√		√		
75							√									
76			√									√			√	
77	√											√	√			
78							√			√	√				√	
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81	√									√					√	
82								√								√
83								√			√					
84					√							√				
85											√					
86				√	√			√				√				√

87				√										√		
88			√								√		√	√		
89					√											
90					√				√			√				
	15	**3**	**6**	**14**	**20**	**16**	**10**	**8**	**10**	**12**	**21**	**13**	**8**	**22**	**19**	**10**

6.3. QUALITATIVE APPRAISAL OF SR PROCESS

A descriptive and thematic analysis process was employed as a means of assessing the findings derived from the systematic review of literature (*n=90*). Drawing on the following: "Meta-analysis needs the use of statistical methods that can be descriptive and/ or inferential towards summarizing data from several studies on the specific topic of interest. The techniques help to generate knowledge from multiple studies both in qualitative and quantitative ways" (Menggist *et al.*, 2019, p.2). It is considered however, the most widely used method for phenomenological based studies is thematic analysis, as suggested by Thomas and Harden (2008). According to Creswell (2007), this approach (thematic analysis) allows systematic data structuring in order to adduce patterns relevant to answering the research question. A descriptive meta-analysis procedure was deployed to adduce thematic patterns.

6.3.1 Thematic Assessment Process

Articles (*n =90*) where derived from the search process within the three main databases and external sources. This represents a massive volume of critical data considering these where sourced from a wide range of publication bodies, regional groupings, and sectors etc. These are hereby assessed under the various themes and indicators outlined in Tables 6.2, 6.5 and 6.6.

(a) Assessment by year of publications

Research undertaken, ranged from the years 2005 to 2019, according to the selection/ eligibility criteria, in line with the aims of study. From the representative documents reviewed, 23, that is 25 % of eligible publications where produced in 2019, while 2015 accumulated 14, which is 15% of the total documents reviewed. Out of a 14-year range, about 30% of the systematically reviewed documents, were produced in just 2 years, that is 2015 and 2019. The number of publications when considered in cross-sectional proportion, could indicate increasing research and interventions towards environmental concerns and petroleum disaster mitigation, broadly. A massive surge of publications identified in 2015, could also ostensibly be attributed to activities surrounding the Sendai 2015 - 2030 round of conferences in Japan. It can be suggested that a great amount of research undertakings, trail epochal events such as the Hyogo/ Sendai conferences; as well as momentous calamities, such as the 2010 Gulf of Mexico blowout. Ostensibly, the periodic increase of disaster reports, within the post 2010 dispensation, bear reflection on studies/ investigations rather motivated by or targeted at post calamitous event, conference papers and journals etc. The foregoing could be interpreted as a skew of research activity and attention towards post incident or epochal event inclination (Tierney, 2012; Lee, 2017). (Figure 6.2)

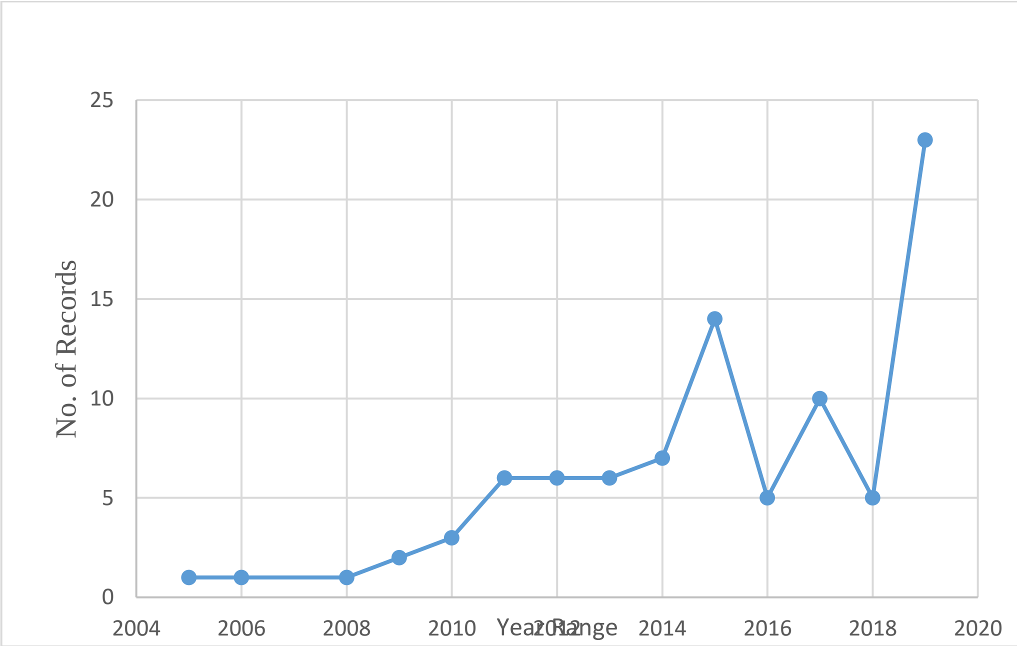

Figure 6. 2 Annual Breakdown/ Trend of Records

(b) Assessment by country of incident/ focus

Countries of incidence under study, cut across all continents and Regions of the world. The USA was most referenced with 18 i.e. 24% out of 75 references to specific countries. Norway follows at a distant margin with 10 references, that is close to 50% less than incidents referenced to the USA. China and Nigeria follow in line of frequency/ volume recorded; with 7 for each (representing 8%). Though it may appear that Africa is massively represented within the investigations at face value, however, when considered cumulatively within a continental/ Regional context, the sub-region (Africa) is grossly underrepresented as viewed in charts (6.3 and 6.4)

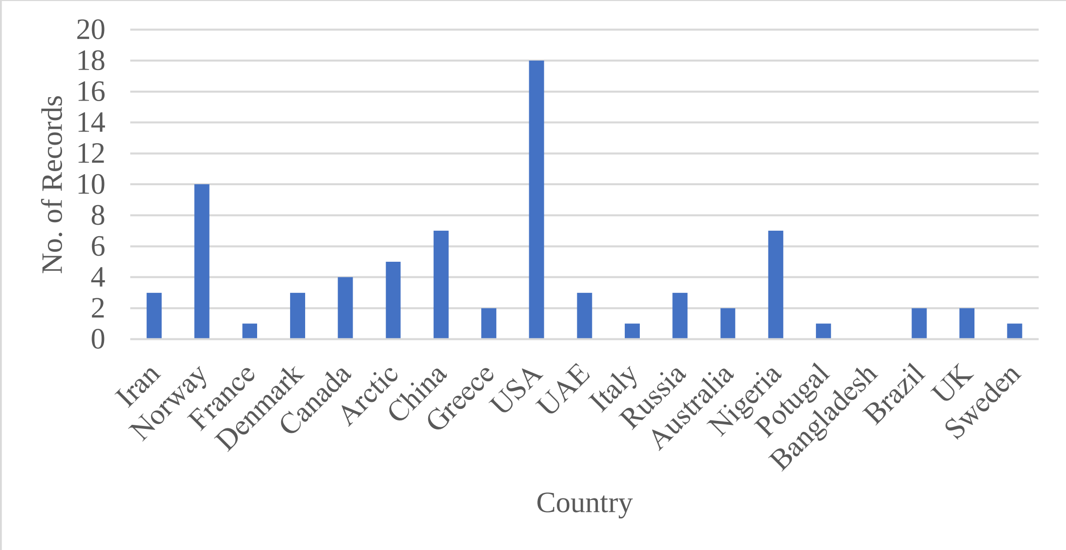

Figure 6. 3: Countries Record Breakdown

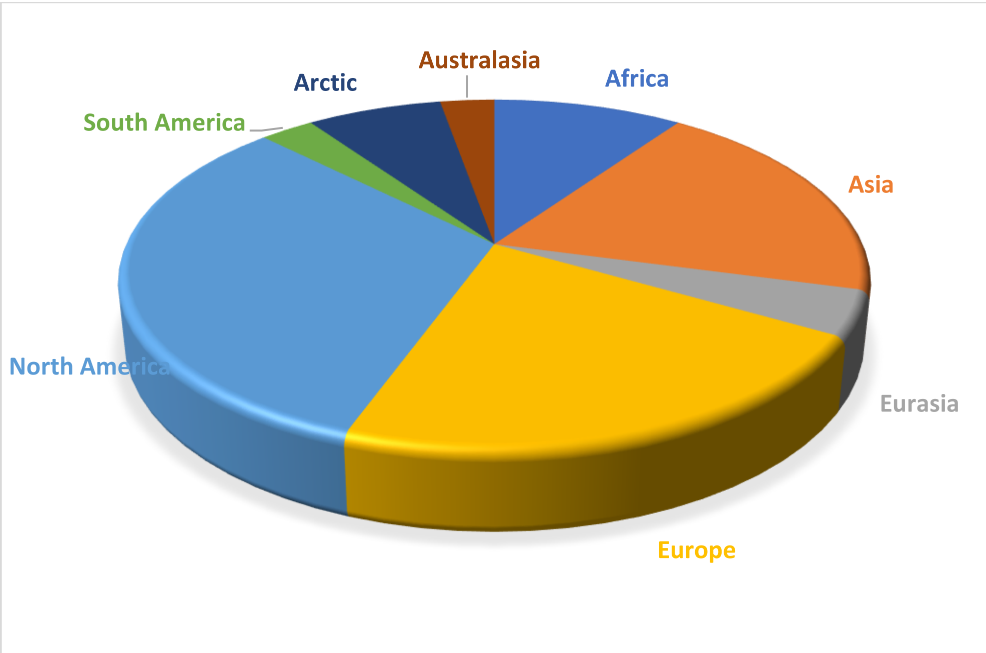

Figure 6. 4 Continental Record Breakdown

A considerable chunk of studies within the cross-sectional studies are chiefly from the Americas, Europe and Asia, and this debatably could constitute skewed perspectives of research focus, interests, views, and concepts that are reflective of particular regions, i.e. the more developed economies.

(c) Assessment by Incident Type (Trigger or Medium of Incident)

Hydro-carbon releases (HCRs) were the most recurrent incident types: this was investigated focally within 41 studies, which is 54% of all incidents. It may be argued that almost every environmental disaster within the petrochemical sector result in some level and form of HCRs; however, what distinguishes these specific offshore incidents/ investigations (See Figure 6.5) within, is the focus of research undertaking on HCRs. Where research focus was on blowouts, or pipeline incidents per examples, these have been aptly represented. Records within indicate, the focus of reportage is more on HCR, which could depict a more posterior dimension or perspective of investigations on PDs relative to the precursor/ triggering events (e.g. pipeline damage/ vandalism or structural collapse).

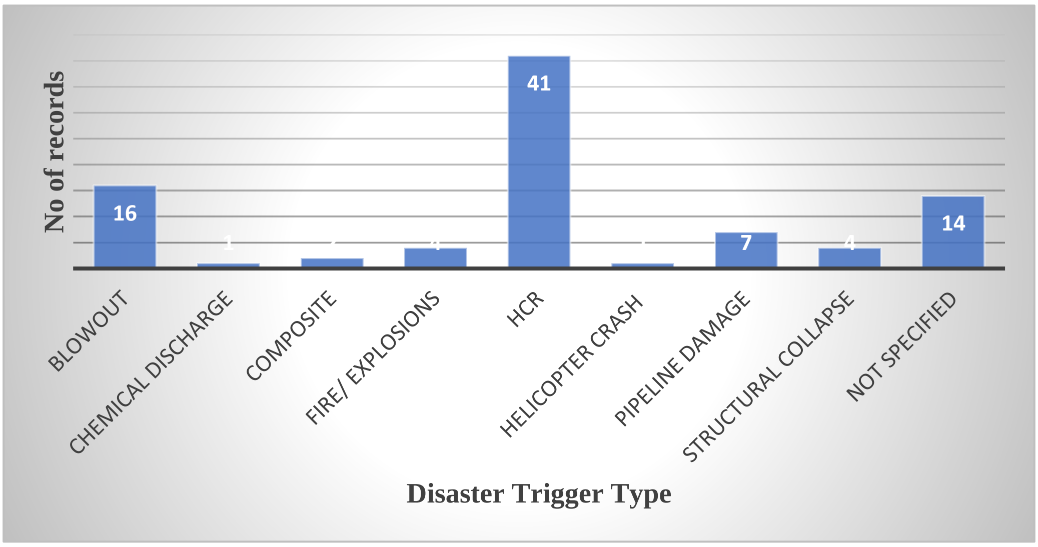

Figure 6. 5: Records on Disaster Triggers

1 Assessment on methods deployed

Mixed methods were predominantly the means by which records were investigated. This methodology was used 26 times, representing nearly a third of all documents under review. Case studies quite characteristically was likewise massively applied, i.e. 21 times (Figure 6.6).

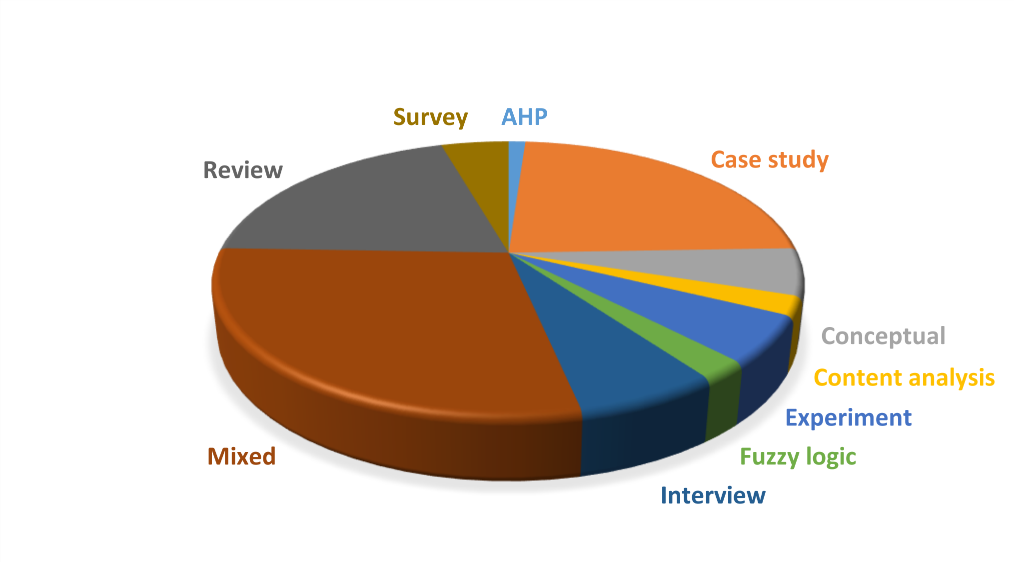

Figure 6. 6: Research Methods Employed

(e) Assessment by Environmental Impacts

Environmental impacts were largely reflective of marine habitat damage, and or preceding pollution as reflected in chart. This further identifies with the selection criteria for n=90, regarding eligibility for document inclusion (criteria 1, objective ‘a’), that is, records that reflect environmental impacts.

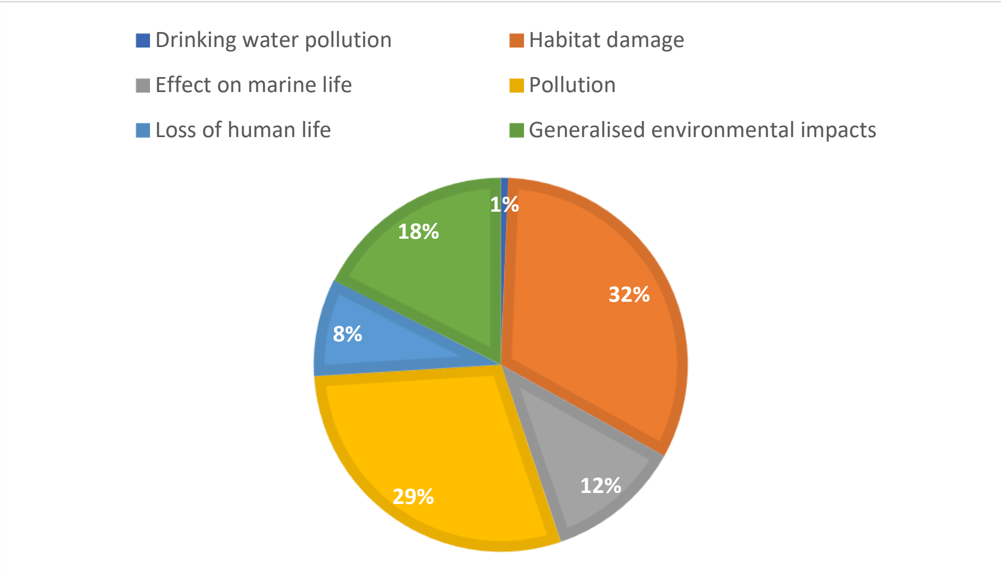

Figure 6. 7: Environmental Disaster Impacts

(f) Assessment of underlying causation/ root factors

Underlying sources and risk factors leading to incidents under investigation within were identified and classified within 12 main sub-headings or groupings. Key among root factors underlying disaster causation within the petroleum sector are shortcomings within the ‘Governance Systems’. This factor compasses internal organizational governance systems and related stakeholder governance mechanisms. Governance systems within this study/analysis has been considered as the broad, intricate, and interconnected function of laws, regulations, guideline, standards industrial policies, codes as well as self/ peer control mechanisms.

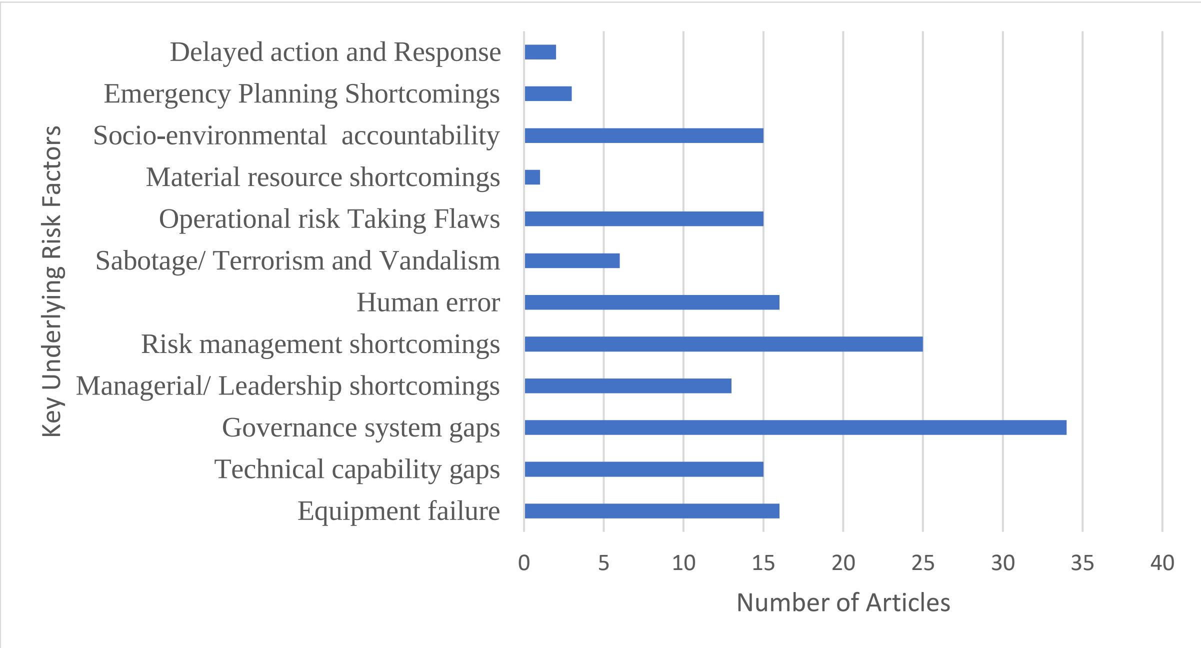

Figure 6. 8: Underlying Disaster Risk Factors Identified

It can be contended that internal safety and environmental governance lapses and violations could invariably be directed at the culpability/ responsibility of institutional oversight and or third-party governance/ control failures. Closely connected in prevalence, is ‘Risk Management Shortcomings’, underpinned by environmental impact and vulnerability assessment errors or incongruencies (e.g. Edelstein, 2011). The risk of terrorism and vandalism, which has been a thorny challenge within certain jurisdiction within Sub-Saharan Africa, such as Nigeria, Cameroun etc. was covered in 6 out of 90 investigations, representing 6.66%. Summarizing findings on studies within the Barents Sea and Arctic, Hovik indicated, “Nobody talked about security. This may reflect the fact that workers in Norway feel safe at work and do not consider their personal safety, such as kidnapping and terrorism, to be a problem” (Hovik, *et al.*, 2009).

This quote is in sharp contrast to the state of affairs within the West African sub-region and some other developing nations, where terrorism and social upheaval underpins endemic environmental devastation (Kadafa, 2012; Barkin, 2016; Sam *et al.,* 2017; Obeng-Odoom, 2018).

Interestingly, less than 4.4% of studies identified 'Emergency Preparedness Shortcomings', equipment and material resourcing deficiencies as underlying disaster causation factors. Implicitly, it could be conceived that operators/ stakeholders within offshore petroleum exploration ostensibly, possess the economic muscle to muster the sophisticated machinery and mechanisms required. The question that arises hereto, is effectiveness or congruence of these facilities, as to whether they are best fit, within a given context. It may well be, as can be seen per projections in the capability improvement measures (Table 6.5), that investment may relatively be essential towards improved monitoring techniques and early warning systems/ technologies, decision support and analogous systems, juxtaposed to the "fire-fighting"/ damage control mechanisms (Edelstein, 2011; Tierney, 2012).

(g) Assessment of DRM Capability Improvement Interventions

Capability improvement towards disaster risk management within the petroleum sector, has been identified from the breakdown into 16 main classes (Figures 6.9. and 6.10). The dominantly identified interventions aside 'Risk Management' (10.6%) and 'Research' (10.1%) towards capability improvement within petroleum sector, are 'Technology Adoption (9.7%). Following in close relation to the foregoing attributes are the interconnected mechanisms of 'Legal and Regulatory', 'Standards Monitoring and compliance' and 'Early Detection/ Warning'. It does appear quite comprehensibly that, early detection/ warning and response systemss are configured to an appreciable extent within some techno-environmental setup. The foregoing bears reflection towards a greater volume of advocacy and recommendations on the use of technological and interrelated regulatory mechanisms, as means of achieving DRR within the petroleum sector globally.

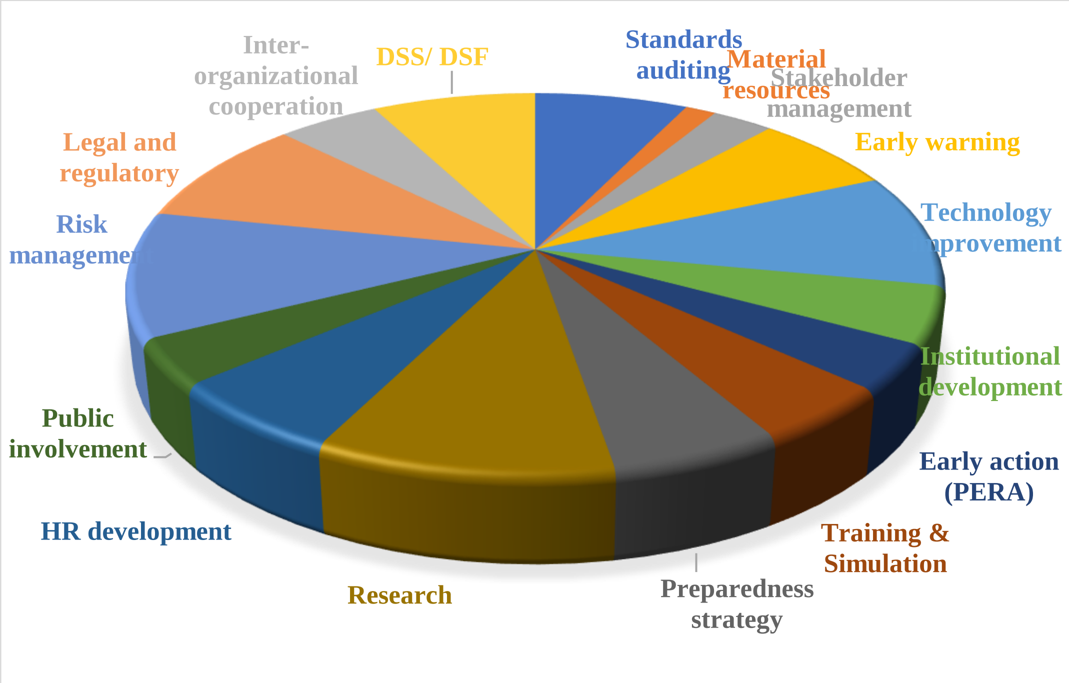

Figure 6. 9: Numerical Comparison of Capability Improvement Methods

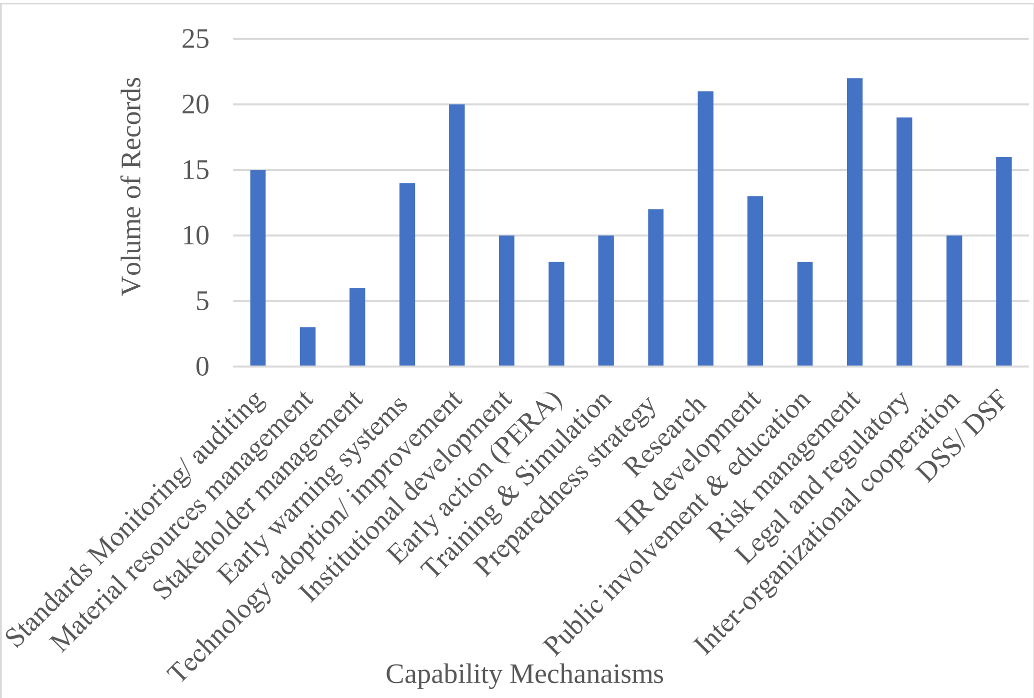

Figure 6. 10: Records on Capability Improvement Methods

6.4 SUMMARY OBSERVATION OF SYSTEMATIC REVIEW PROCESS

The skew of attention towards post incident interventions/ research as means of addressing disaster risk management is evident in practice and the literature (Alexander, 2012; Goldstein *et al.,* 2011). It could be comprehended from the foregoing appraisal (SR process) and identified outcomes that, disaster identification and typology may have been investigated dominantly from the perspective of massive force incident as well as trajectory of impacts, more so, than from root factor/ underlying events. These findings from the petroleum sector, are mirrored largely in the observation by Tierney (2012), "Disaster governance policies and programs tend to be reactive, concentrating on solving problems that were revealed by recent events, rather than being based on comprehensive risk and vulnerability assessments".

Conceptually, Environmental disasters are realized or realizable from the impacts on the environment. However environmental disasters are rooted on or triggered from seemingly non-environmental calamities such as well blowouts, pipeline raptures, etc. The discussion can be further extended to the effect that, environmental impacts of incidents such as well-blowouts, are largely determined or rather predetermined by pre-existing conditions of vulnerability, and or susceptibility. Therefore, though it can be acknowledged that environmental disasters are impact related, it can well be realized that such disasters and disaster risks have stronger bearing on pre-incident phenomena than on post incident effects; and this condition rather appears quite prevalent within the petroleum sector of Sub-Saharan Africa and other under-developed and developing nations of the global south (Obeng-Odoom, 2018)

It stands to reason with respect to the foregoing inquest/ outcomes that governance mechanisms and institutional capability for DRR would invariably evolve more from a post incident tangent as reflected (Tierney, 2012). It can be viewed however, that disaster risk reduction capability that draws dominantly from the perspective of post incident and post epochal event epistemology, could be deprived of the opportunities that lie within mechanisms for unpacking disaster causation and interventions from the root and underlying/ outlying context.

6.5 CHAPTER SUMMARY

The systematic review of literature has yielded a set of underlying risk indicators (12 major factors) that are at the core of petroleum disaster incidents. Also identified are 16 critical capability constructs or mechanisms that can be deployed to address the identified risk factors. While the literature reviewed points to a greater level of attention and interventions (within disaster literature and industry practice) towards post incident phenomena; there appears to be indications of growing advocacy and exponential drive towards contextualising disaster risk management constructs and functions within a more pre-incident domain

CHAPTER 7: ANALYSIS AND FINDINGS

7.0 INTRODUCTION

This section provides details on the various phases/ stages of secondary and primary data collection undertaken towards accessing complementary information for further discussion and exploration, and to establish critical components for the formulation of the proposed capability improvement framework.

7.1 SYSTEMATIC LITERATURE REVIEW FINDINGS

As highlighted in chapter 6, the systematic review of literature led to the identification of '12' underlying risk factors at the root of disaster incidence within the petroleum sector: these were recategorized as risk factors which must be minimized: or Risk Minimization Indices (RMIs). Likewise identified from the SLR process were '16' capability measures recommended towards addressing/ mitigating the risk factors (See Table 7.1): these were also redesignated, Capability Improvement Mechanisms (CIMs) or capability measures which must be improved (this was prior to expert survey process).

Table 7. 1: Identified RMIs and CIMs

Risk Minimization Indices (RMIs) **(Risk factors which must be minimized)**	**Capability Improvement Mechanisms (CIMs)** **(Capability interventions which must be improved)**
(1) Equipment failure	(1) Early detection and warning systems
(2) Technical capability gaps	(2) Technology adoption and improvement
(3) (ii) Human error	(3) Decision support systems/ frameworks
(4) Governance system gaps	(4) Material resource management
(5)) Sabotage/ terrorism and vanadalism	(5) Legal and regulatory mechanisms
(6) Socio-environmental accountability	(6) Standards monitoring and auditing
(7) Managerial and leadership shortcomings	(7) Governance institutional development
(8) Material resource provision	(8) Inter-organizational cooperation
(9) Risk management shortcomings	(9) Research
(10) Emergency Preparedness flaws	(10) Human resource development

(11) Delayed action/ response	(11) Risk management
(12) Operational risk taking flaws	(12) Stakeholder management
	(13) Emergency preparedness strategy
	(14) Public involvement and education
	(15) Pre-emptive, early, and rapid action (PERA);
	(16) Training and Simulation

7.2 LITERATURE VALIDATION PROCESS

A quasi-qualitative approach was made in the initial phase of primary data collection, that is via a literature finding verification and validation process, through the instrumentation of semi-structured written interviews. Predefined categories and fields where not provided within the 'participant background' section of the questionnaire (Appendix A1: Literature validation questionnaire). Respondents were required to fill in answers on basic background information such as profession, area of expertise, years of professional experience etc., based on their individual circumstances. The semi-structured approach to the questions allowed for expression of precise professional backgrounds, qualifications among others, rather than having to fit indiscriminately into some nominal/ ordinal category. The professional credentials and associations/ professional bodies to which the expert participants belonged to (from responses), provided further insight to the professional domains, associations etc. to be considered when designing categories for selection within the expert participant survey that would follow this more exploratory phase. Breakdown of participants' background information is provided in Table 7.2.

The literature validation participants were viewed as very representative of the range of expertise and professions that have a bearing or significant relation within the area under study, and the aim of the research. The experiential credentials of participants were based on the professional qualification and area of expertise stated; therefore though participants may have attained some experience in some other occupational settings, the number of years' experience indicated, reflected work within the professions specifically stated (as pre-requisite from the interview form).

Table 7. 2: Background Information on Expert Participants for Literature Verification Process

Expert ID	Profession / (Area of expertise)	Qualification	Professional Membership	Experience (Years)
LV001	Petroleum contracts manager (Energy Management)	PhD Energy Magt.	SPE, OSHA,	12
LV002	Petroleum consultant (Petroleum Engineering)	PhD Mech Eng	IOSH, SPE, IPIECA	9
LV003	Petroleum Economist (Economics, Resource Governance)	PhD Pet. Econs.	AIPN, IAEE	10
LV004	Risk Analyst (Security, Sustainability, Risk management)	MSc Risk Magt.	IIRSM, GhISEP, IFE	22
LV005	Safety and Environmental Practitioner (HSE Management)	PhD Safety Magt.	NEBOSH, GhiE	20
LV006	Consultant (Petroleum and Renewable Resources)	PhD Energy Magt.	IAEE, IPIECA, IOSH	15
LV007	Safety and Environmental Practitioner (HSE Management)	MSc Safety and Risk Magt.	GhISEP, IEMA	17
LV008	Chemical Engineer (Petrochemical Engineering)	PhD Chem Eng.	SPE, NEBOSH	7
LV009	Petroleum contracts Engineer (Petroleum Management)	PhD Pet. Eng	PMI, OSHA	13
LV010	Sustainability manager (Safety security, Risk magt.)	PhD Project/sust.	NEBOSH, GhiE	25
LV011	Emergency/ Incident Responder (Emergency/ disaster)	MSc Safety science	IFE, NEBOSH	12
LV012	Chemical Engineer (Energy and mining)	MSc Energy	GhIE	10

CODE:

SPE =Society of Petroleum Engineers; OSHA= Occupational Safety and Health Administration; IPIECA=International Petroleum Industry Environmental Conservation Association; IOSH=Institution of Occupational Safety and Health; AIPN=Association of International Petroleum Negotiators; IAEE=International Association for Energy Economics; PMI=Project Management Institute; GhISEP=Ghana Institute of Safety and Environmental Professionals; NEBOSH=National Examination Board for Safety and Health; IFE=Institute of Fire Engineers; HSE=Health safety and Environment; Magt.=Management; Mech.Eng.=Mechanical Engineering; Chem.Eng=Chemical Engineering; Pet.Eng=Petroleum; Engineering ; Sust.=Sustainability; Pet. Econs =Petroleum Economics; GhIE=Ghana Institute of Engineers

7.2.1 Literature Validation Findings

In all 16 interview forms were distributed, out of which 12 were successfully returned, which represented 75% of all the experts consulted. For Section 1 of the interviews, 10 out of 12 respondents indicated an outright acceptance of the findings in literature as valid and did not add further comments, corrections or additions. Within this section, two participants made comments or suggestions on the following: (a) what was not too clear within the factors outlined; and (b) areas that could improve on the findings identified. For Section 2 of literature validation written interviews, 3 out of 12 respondents, made additional inputs/ recommendations, as itemized below.

- **Section 1: Responses to Unstructured Questions.**

1. Participant LV005 indicated within the remarks column as follows: 'inclusion of extreme natural events could make the underlying risk factors more comprehensive'. A mail was sent to appraise participant (LV005) to the effect that, this suggestion would have been ideal, however the research aim was geared towards a more focal socio-technical aspect of underlying risks, and designed to avoid broader ramifications of risks such as posed by climate change and other related debates, which could be considered in other studies of a broaderr scope. Participant LV005 was reminded that the reviewed literature being validated, did exclude extreme natural phenomena, as indicated in questionnaire. Upon this appraisal, participant LV005 agreed with the findings in literature as complete and valid.

2. Participant LV008 agreed with all findings in the literature, however, expressed uncertainty as to whether 'Operational risk taking flaws' was an exclusive underlying risk factor, and suggested this could have been assigned within 'human error' or invariably as a reflection of risk management shortcomings. While in some peripheral way participant LV008's observation could be considered relevant, it was identified within the literature reviewed, particularly regarding the 2010 Gulf of Mexico incident and other analogous occurrences (e.g. hydraulic fracturing within geologically sensitive areas), that 'Operational risk flaws' where discussed as key underlying factors, distinct from just issues of human error or 'risk management shortcomings'. This underpinned the need to include 'Operational risk flaws' as a separate underlying or root factor of some petroleum disaster incidence, therefore was maintained within the 12 underlying risk factors. Participant LV008 had already established agreement with all findings of the systematic literature review, besides this query made in the supplementary remarks section. In sum, all 12 expert participants agreed in principle with the findings of the literature as comprehensive and acceptable within the context of the objectives of the study and validation exercise.

- **Section 2: Responses to Unstructured Questions**

Within this section, participants were asked to indicate their agreement or otherwise with findings from literature, on mapping of institutional structures against relevant areas of responsibility identified, based on their constitutional charters, institutional regulations and mandates etc., towards minimizing underlying risks of petroleum disaster. All 12 participants agreed in sum with the mapping of institutions onto critical functions/ responsibilities towards addressing key underlying risk factors of petroleum disaster. Three participants basically agreed with the institutional mapping, however, made recommendations as follows:

(i) LV002 Suggested the inclusion of relevant 'Ministries' in Ghana for tackling the 'Governance system gaps' function. This recommendation was seen as reasonable; however the structure and functions of Ministries can be wide ranging and not particularly focussed on the core issues being addressed in this study (Petroleum environmental disaster). Furthermore, the related ministries were duly represented by institutional bodies having focal responsibilities, e.g. Ministry of Energy, by Petroleum Regulatory Institution, Ministry of Local Government, by Local Government Institution etc. Consequently the 'Ministries' where excluded.

(ii) LV009 Recommended that 'petroleum companies' could be included in the institutional mechanisms for addressing 'Human Error'. This suggestion was seen as quite insightful and rational: the suggestion would be addressed within research recommendations and delimitation, however petroleum companies were excluded at this stage, because the study focusses on capability improvement of public sector institutions only.

(iii) LV005 Proffered that Research and academic Institutions could be added to institutions meant to address 'Human Error'. This input was considered quite interesting as academic/ research institutions play critical roles in generating research interventions which could help mitigate human error. However, academic/ research institutions in Ghana have wide ranging scope of undertaking, and there appears to be no public sector academic institution particularly designated for petroleum operations in Ghana. Also, it was considered academically prudent within this postgraduate research, to limit institutional mechanisms to the most critical structures with direct functions within the scope of study. The participant further recommended that Local Government institution be included within bodies for addressing 'Emergency Preparedness Planning Gaps'. This was previously not included, but the suggestion was seen as relevant, therefore was added in that sector.

7.3 ANALYSIS OF SURVEY DATA

7.3.1 Survey Process: Analysis Findings

The main survey, following the initial validation of (a) 12 underlying risk factors and (b)16 capability improvement measures, was employed to: (i) identify the relative importance and weighted contribution of the pre-validated items ('a' and 'b'), towards risk minimization in Ghana's petroleum sector (ii) to solicit expert opinion on the potential impact of capability improvement mechanisms on underlying risk minimization and the principal mediums/ immediate causes of disaster, and (iii) assess the capability/ capacity improvement needs base of key institutions designated for undertaking functions related to minimizing environmental disaster risks in Ghana's petroleum sector.

The survey was administered by means of a questionnaire in structured format: questionnaires which are clearly and concisely structured, comprehensible and user friendly, tend to generate a greater rate of response (Xiao, 2002; Walonick, 2004). The survey was designed with clear guidelines by way of Participant Information Sheets (PIS) preceding (In most cases emailed to participants prior to sending questionnaire), to enable participants apprehend the basic requirements and facilitate progressive/ less time-consuming flow of the response process. One survey coordinating assistant was recruited in Ghana, in the person of a senior public servant (with MSc in Risk Management), to follow up on mails and survey questionnaires sent out. In most cases also, institutional representatives, mainly human resource officials, administrative secretaries etc. complemented in coordinating activities towards ensuring that survey links and questionnaires were pertinently distributed and returned appropriately. It is noteworthy to indicate that experts involved in the literature verification process, were not included as participants in the general survey.

A pilot test of the survey instrument was made to trial the effectiveness and ascertain how comprehensible and applicable the various constructs within the questionnaire were. Five resource persons, two from the academic setting and three from industry, were recruited for this exercise. Responses from these participants indicated that the constructs, wording and objectives were fairly well understood, user friendly, and self-explanatory (given additional resource in the PIS). The option that allowed participants to save previous answers and continue at a later time allowed for ease and flexibility, as one could make reflections or take breaks and return to complete unanswered sections. The average timespan for completing of the pilot surveys from responses received, was 12 minutes.

7.3.2 Screening of response data

The instructions on mode of responses was clearly spelt out to participants, and categorically itemized therefore all sections of questionnaire were correctly filled, principally. The electronic version of the survey (Qualtrics) featured forced responses in an automatic flip and fade mode, ensuring questions left unanswered were tackled before progressing; accordingly, questions tackled by 64 respondents were automatically filled without missing or misplaced data. There were a few misplaced data with regards to 3 of 14 responses made, paper-based, prior to entry into the Qualtrics survey software. To ensure that all sections were completed appropriately, the 3 data responses were returned to participants respectively to ensure missing data were added in the right places, prior to inclusion in the Qualtrics software.

7.3.3 Survey Response

The successfully returned responses of 78 out of 195, formed 40% of all distributed instruments, and this number of responses was employed towards analysis and developing the framework identified in chapter 8. While it was observed that the initial minimum adjusted sample size for the survey should be 169; however, though this was not achieved entirely, the rate of 78 responses attained represents over 46% of the initially required sample size (169); and this figure compared to surveys undertaken under parallel conditions, measures adequately in line with, or over response rates achieved within related doctoral research carried out in Ghana and UK previously (Ahadzie, 2007; Ankrah, 2007; Mahamadu, 2017). The response rate was therefore considered fairly reliable for rational analysis of findings and discussion, aimed at acceptable outcomes.

Table 7.2 a: Survey Questionnaire Distribution and Response Rate

Descriptions	Paper-Based Distributions	Online Email Distributions	Total
	GhiseP/ Linkedin/ Public sector/ Consultancy/ NGOs (Target sampling frame: *n =300*)		
Questionnaires Distributed	21	174	195
Questionnaire Returned	14	64	78
Valid Returns deployed for Analysis	78		
Computed Minimum Survey ss	169		
Response Rate	46.15% per minimum survey ss		40% per total distribution

7.4 DESCRIPTIVE STATISTICAL BREAKDOWN OF RESPONDENTS BACKGROUND

- **Key Professions**: The various responses of participant groupings where compositely assessed as well as within demographic categories. Responses received from 78 participants indicate, a greater number of respondents held professional titles/ responsibilities such as Health, Safety and Environmental Manager, representing 18.10%; this is followed by respondents who function within professional category of Petroleum Engineers/ Managers, which represents 13.79% of responses. Two main categories or professional groupings were identified as the prime target expert stakeholders: i.e. (a) 'Health Safety and Environmental professionals', and (b) 'Petroleum engineering professionals': these representing 31.89% of all respondents from the results derived. As participants in various professional sectors could belong to multiple categories, a comparatively higher number of respondents (10.34%) were also identified as risk analysts.

- **Professional Bodies/ Associations**: Invariably a significant number of respondents belonged to multiplicity of professional bodies and associations which hold integral stakes within the field of this research; such as GhIE, SPE, IEMA, OSHA, among others, were observed. Respondents belonging to NEBOSH/IOSH that is 23.30% were the highest single category of professional associations within varying combination of associations. Also significant are the cumulative representation of 22.16% by respondents belonging to IEMA/ SPE, which have integral bearing on attaining the aims of the survey, as these professional body groupings were considered highly relevant to the study (These professional bodies have been established primarily for environmental and petroleum professionals, respectively). Table 7.3 below gives a breakdown of the professional background of respondents.

Table 7. 3: Breakdown of Responses by Professional Categories/ Associations

	Professions/ Associations	**Number of Participants**	**% Score**	**Cummulative Frequency**
Professional Status of Respondents	Environmental Officer	9	7.76	7.76
	Sustainability Manager	8	6.90	14.66
	Risk Analyst	12	10.34	25.00
	Health Safety and Environmental Manager	21	18.10	43.10
	Petroleum Engineer/ Manager	16	13.79	56.89
	Emergency Response and Disaster Management	8	6.90	63.79
	Oil and gas contractor	10	8.62	72.41

	Consultant (Petroleum/ Safety and environment)	10	8.62	81.03
	Project Manager	10	8.62	89.65
	Other	12	10.34	100
Association/Professional Body	GhIE	14	7.95	7.95
	GhISEP	24	13.64	21.59
	NEBOSH/IOSH	41	23.30	44.89
	SPE	15	8.52	53.41
	IPIECA	9	5.11	58.52
	OSHA	17	9.66	68.18
	IIRSM	12	6.82	75.00
	IEMA	24	13.64	88.64
	IFE	6	3.41	92.05
	IAEE	7	3.98	96.03
	Others	7	3.98	100
CODE	GhIE=Ghana Institute of Engineers; Nebosh= Examination Board for Safety and Health; IOSH= Institute of Occupational Safety and Health; SPE=Society of Petroleum Professionals; IPIECA IPIECA=International Petroleum Industry Environmental Conservation Association; OSHA= Occupational Safety and Health Administration; IAEE=International Association for Energy Economics; International Institute of Risk and Safety Management; IEMA= Institute of Environmental Management and Assessment; IFE=Institute of Fire Engineers			

Holders of master's degrees were the predominant participants, forming 60.26% of all respondents; Bachelor's/ first degree holders also generated a fair share of responses, which is 20.51%, with HND holders providing the minimum number of responses, of 3.85%. Doctoral degree holders forming 15.38% of respondents together with Masters holders, form over 75% out of all responses, which provides a critical mass of expertise; given that the Ghanaian petroleum industry is in the infant stage, and the human resource base within this sector, as well as professional categories sampled within the national context, is an evolving and mainly nascent one (Sakyi *et al.*, 2012, Oseiwusu-Kumi, 2020). Overall, the academic credentials of participants were considered significant and integral towards achieving the aim of the survey. Table 7.4 is a breakdown of academic and complementary institutional/ demographic details.

Table 7. 4: Descriptive breakdown for Qualifications/ Resource base of Respondents

Category	Sub-Category	Number of scorers	% Score	Cummulative Frequency
Academic	HND	3	3.85	3.85
	Bachelor's	16	20.51	24.36
	Master's	47	60.26	84.62
	Doctorate	12	15.38	100
Experience in professional practice	3 – 5 Years	9	11.54	11.54
	6 – 10 Years	19	24.36	35.9
	11 – 15	21	26.92	62.82
	16 – 20	14	17.95	80.77
	Over 20 years	15	19.23	100
Size of organization	1 – 10	4	5.13	5.13
	11 – 49	12	15.38	20.51
	50 – 249	24	30.77	51.28
	250 – 500	9	11.54	62.82
	Over 500	29	37.18	100

The occupational settings or industry domains within which participants operate is considered impactful to their behavioral responses and professional outlook (Dulaimi and Langford, 1997; Ahadzie, 2007), and this was duly factored into the survey design as a crucial categorical variable. Respondents were therefore required to state the institutional domain or setting within which they operate, based on, and also as principally, reflected by their professions identified in Table 7.5. The breakdown of selected responses within institutional domains by respondents is presented in Table 6.4 below. Upstream suppliers and contractors were the dominant respondent grouping, i.e. 13, forming 16.67% of all valid responses, with Exploration and Production companies/ Consultants providing 11 each, making 28.20%. It is unsurprising that these non-governmental institutions formed the core resource base for responses received: as highlighted beforehand, the public sector manpower base in the petroleum sector of Ghana is embryonic in terms of population, whereas the multinational corporate bodies, consultancies, NGOs have a relatively richer human resource base in this respect, having been in operation for a longer period of time.

Table 7. 5: Statistical Breakdown of Responses based on Institutional Settings

Instititions Settings	Number of Scorers	% Score	Cummulative Frequency
Regulatory institution (Environment and Safety)	10	12.82	12.82
Regulatory Institution (Petroleum specific)	3	3.85	16.67
Exploration and production company	11	14.10	30.77
Upstream suppliers and contractors	13	16.67	47.44
Emergency or incident management institution	5	6.41	53.85
Enforcement or security institution	2	2.56	56.41
Non-governmental Organisation (Petroleum/ Safety and environment)	3	3.85	60.26
Ports and harbours authority	3	2.56	62.82
Standards/ inspectorate Authority	2	2.56	65.38
Consultancy (Petroleum/ Safety and environment)	11	14.10	79.48
Energy and Extractive Industry	6	7.69	87.17
Government	2	2.56	89.73
Others	7	10.26	100

A breakdown of descriptive analysis outputs for the '12' Risk Minimization Indices and '16'; Institutional Capability Needs; and Capability mechanisms have been presented in Tables 7.6, 7.7 and 7.8 respectively.

Table 7. 6: Descriptive Statistical Breakdown for Risk Minimization Components

No.	Risk Minimization Indices	Descriptive Statistics						
		Mean	**Median**	**Standard Deviation**	**Variance**	**Minimum**	**Maximum**	**Number of Participants**
1	Minimization of Human Error	6.12	6.00	0.78	0.61	5.00	7.00	78
2	Addressing Governance System Gaps	6.23	6.00	0.64	0.41	5.00	7.00	78
3	Pre-emption of Sabotage Terrorism and Vandalism	5.87	6.00	1.18	1.39	2.00	7.00	78

4	Improving Socio-environmental Accountability	6.28	6.00	0.71	0.51	3.00	7.00	78
5	Ensuring Emergency Preparedness Planning	6.38	6.00	0.74	0.54	3.00	7.00	78
6	Minimizing of Operational risk Flaws	5.79	6.00	1.02	1.03	1.00	7.00	78
7	Minimizing Delayed Action and Response to Threats	6.13	6.00	0.84	0.70	3.00	7.00	78
8	Addressing Risk Management Shortcomings	6.44	7.00	0.69	0.48	4.00	7.00	78
9	Addressing Material Resource Management Shortcomings	5.99	6.00	0.76	0.58	4.00	7.00	78
10	Addressing Management and Leadership Shortcomings	6.05	6.00	099	0.97	3.00	7.00	78
11	Minimization of Equipment Failures	5.87	6.00	0.92	0.86	3.00	7.00	78
12	Addressing Technical Capability Gaps	5.96	6.00	0.85	0.73	3.00	7.00	78

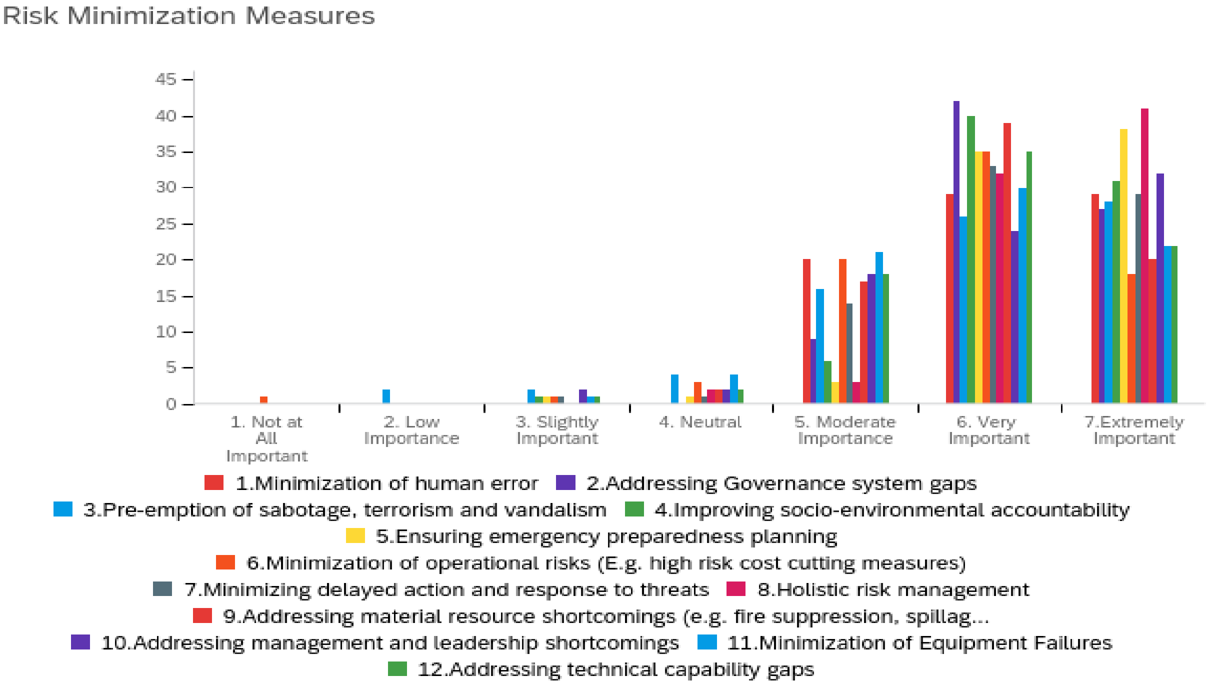

Figure 7. 1 Representation of responses on Risk Minimization Measures

Table 7.7: Descriptive Statistics Breakdown for Institutional Capability Improvement Needs

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
INSTITUTIONAL SECTORS - 7. Standards compliance and Inspectorate organizations	78	8	2	10	570	7.31	1.700	2.891
INSTITUTIONAL SECTORS - 1.Regulatory Institutions (Environment and Safety)	78	8	2	10	565	7.24	1.860	3.459
INSTITUTIONAL SECTORS - 2.Regulatory institutions (Legal and Governance)	78	8	2	10	561	7.19	1.859	3.456
INSTITUTIONAL SECTORS - 3. Response and incident management institutions	78	8	2	10	537	6.88	1.459	2.129
INSTITUTIONAL SECTORS - 4. Security and enforcement institutions	78	8	2	10	512	6.56	1.410	1.989
INSTITUTIONAL SECTORS - 5. Maritime, Ports and Harbours management	78	8	2	10	485	6.22	1.158	1.341
INSTITUTIONAL SECTORS - 6. Local Government	78	5	2	7	435	5.58	.974	.949
Valid N (listwise)	78							

Table 7.8: Descriptive statistics breakdown for Capability Improvement Mechanisms

Category/	Capability Indices	Descriptive Statistics						
		Mean	Med	SD	Var	Min	Max	N
Governance	1. Legal and regulatory Mechanisms	6.33	6.00	0.69	0.48	3.00	7.00	78
	2.Standards compliance monitoring/ auditing	6.42	7.00	0.78	0.60	3.00	7.00	78
	3. Governance Institution Development	6.15	6.00	0.75	0.57	4.00	7.00	78
	4. Inter-organizational Cooperation	5.86	6.00	0.75	0.56	3.00	7.00	78
Technical	1. Early detection and Warning Systems	6.54	7.00	0.71	0.50	3.00	7.00	78
	2. Technology Adoption/ improvement	6.09	6.00	0.85	0.72	3.00	7.00	78
	3. Decision Support Systems & Frameworks	5.94	6.00	0.74	0.55	3.00	7.00	78
	4. Material resource management	5.76	6.00	0.68	0.47	4.00	7.00	78
Managerial	1. Research	6.17	6.00	0.71	0.50	5.00	7.00	78
	2. Human Resource Development	6.35	6.00	0.77	0.59	3.00	7.00	78
	3. Risk Management	6.62	7.00	0.58	0.34	5.00	7.00	78
	4. Stakeholder Management	5.99	6.00	0.71	0.50	4.00	7.00	78
Operational	1. Emergency Preparedness Strategy	6.37	6.00	0.66	0.44	4.00	7.00	78
	2. Public Involvement and Education	5.97	6.00	0.77	0.59	4.00	7.00	78
	3. Pre-emptive, Early and Rapid Action (PERA)	6.15	6.00	0.77	0.59	3.00	7.00	78
	4. Training and Simulation	6.49	7.00	0.57	0.33	5.00	7.00	78
CODE	Min=Minimum	SD=Standard Deviation						
	Max=Maximum	Var=Variance						
	Med=Median	N=Number of Participants						

Figures 7.2 up to 7.5 present radar chartsalso known as spider maps of the four categorical capability functions as configured within the range of mean measures.

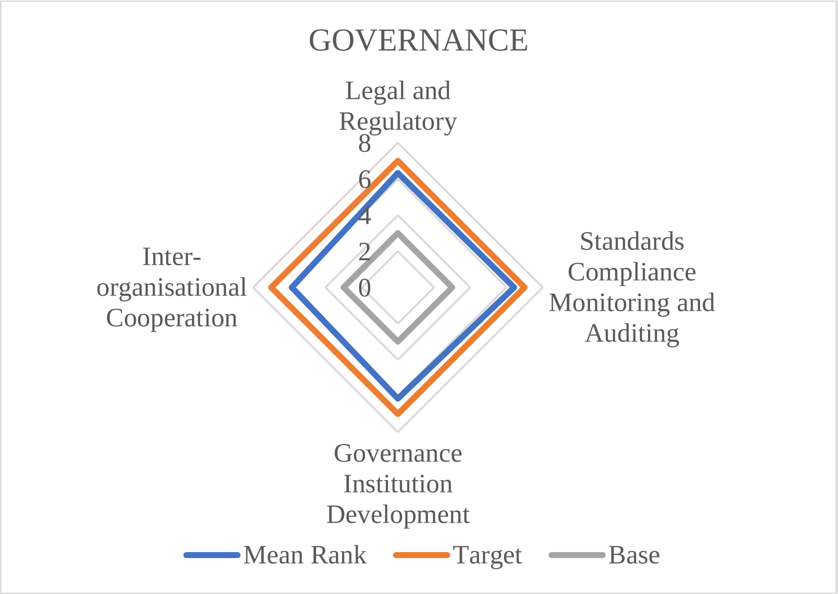

Figure 7. 2 Radar Chart of Mean Ranks of importance for the Governance Functions

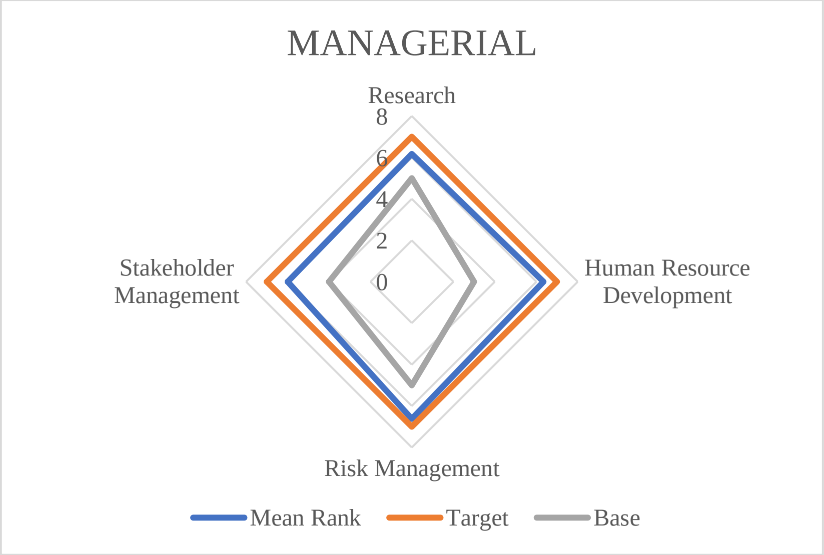

Figure 7. 3: Radar Chart of Mean Ranks of Importance for the Managerial Functions

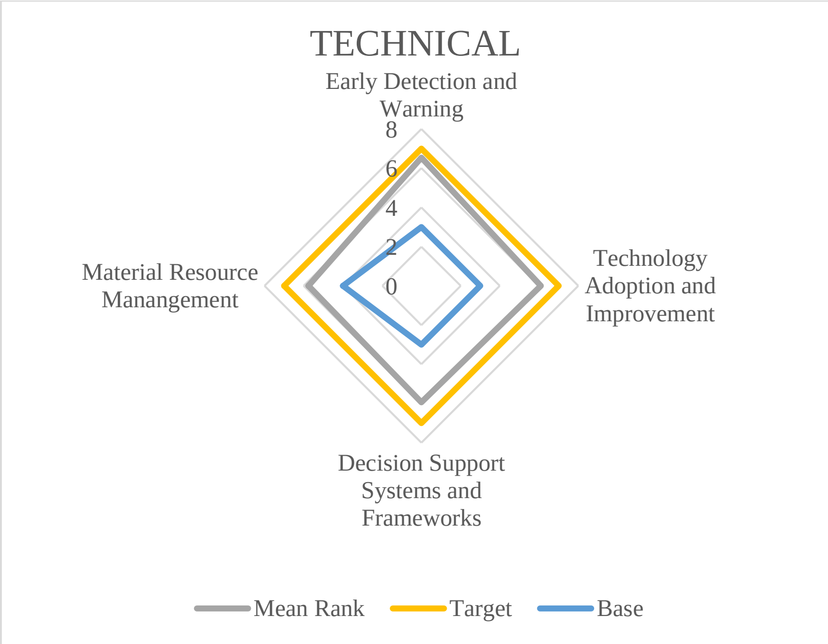

Figure 7. 4 Radar Chart of Mean Ranks of importance for the Technical Functions

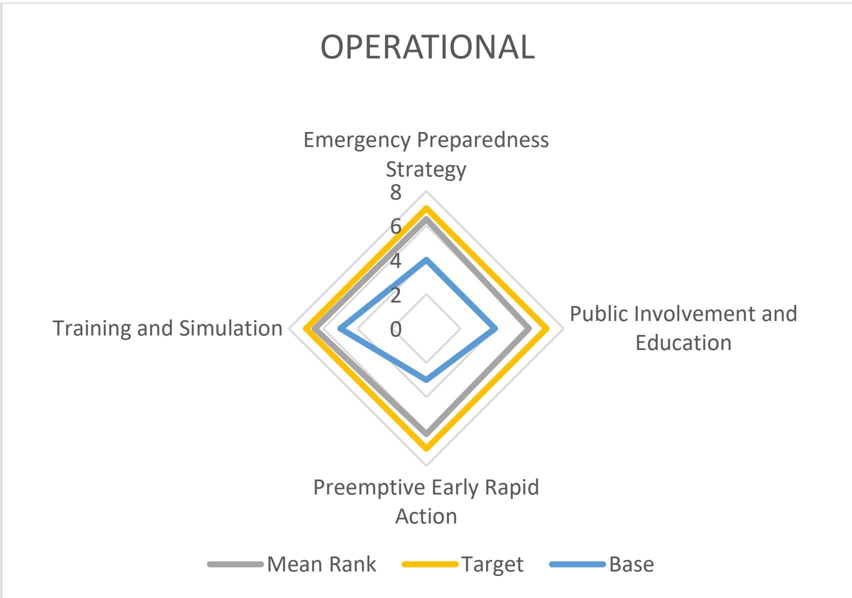

Figure 7. 5: Radar Chart of Mean Ranks of importance for the Operational Functions

7.5 INFERENTIAL ANALYSIS: RELIABILITY, NORMALITY AND TESTS OF SIGNIFICANCE

7.5.1 Inferential Analysis

Beside tests of reliability and normality, other inferential analysis tests were carried out to identify the possibility of linkages, correlations and implications based on patterns of data distribution within the study (Flemming, 1998). These analyses are directed at gaining insight into predictors over phenomena based on testing of hypothesis which are assigned occasionally prior to data collection or, usually after undertaking data collection (Bettany-Saltikov and Whittaker, 2014; Trafimow and MacDonald, 2017). Hypothesis tests are assumptions, based on what one expects to find from a set of data. The choice of tests to be carried out, are contingent on certain factors, such as the normality or otherwise of data distribution, the population of samples being tested, and the level of confidence or accuracy required among others (Lindstromberg, 2016; Trafimow and MacDonald, 2017).

7.5.2 Reliability Analysis

Reliability Test ensures that the variables and factors considered for the testing of constructs deployed towards data collection and for further analysis, are reliable. In simple terms, reliability adheres to the fact that if a study is conducted using similar constructs and analogous variables for a multiple numbers of times, it has the ability to fetch the similar results each time the test is conducted (Refer 5.8.2). In this respect, the Cronbach's Alpha test was conducted, employing SPSS software (version 27): the results of the test conducted is shown in Table 7.9. Cronbach's Alpha based on non-standardized items ranged from 0.662 to 0.921. Since the overall alpha values were principally above 0.700 rounded up, it is therefore deemed good and acceptable. Hence all the items within the range of categorical and dependent variable constructs were considered relevant for further analysis.

Table 7. 9: Reliability Statistics on Survey Constructs

Variables	Cronbach's Alpha (A)
Risk Minimization Measures	0.800
Governance Functions	0.774
Technical Functions	0.691
Managerial Functions	0.662

Process Functions	0.743
Disaster Incident Triggers	0.921
Institutional Sectors	0.900

7.5.3 Results on Test of Normality

The two sample Kolmogorov-Smirnov test is a nonparametric test that is employed in comparing the cumulative distributions of two data sets (a,b). A Kolmogorov – Smirnov test was applied in order to test the normality of data distribution within dependent variables. A preview of the likely distribution pattern of data can be accessed through a Kurtosis test, to ascertain if data distribution is evenly aligned from a central point, or skewed towards the lower or higher boundaries (Laerd, 2020). Normality tests assess the extent to which the data is normally distributed or *vice-versa*. Testing for normality of distribution would indicate whether the data is closely aligned or far scattered. The 2 sample Kolmogorov-Smirnov (KS) statistics is employed to detect departures from the underlying distribution. The smaller the KS statistical value, the closer to the underlying distribution, and *vice versa.*

Table 7. 10 Tests of Normality

Variable Dependent Factors	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Risk Minimization Measures	.078	78	.200*	.957	78	.010
Governance Functions	.177	78	.000	.854	78	.000
Technical Functions	.172	78	.000	.922	78	.000
Managerial Functions	.132	78	.002	.934	78	.001
Operational Functions	.146	78	.000	.889	78	.000
Disaster Incident Triggers	.145	78	.000	.886	78	.000
Institutional Sectors	.157	78	.000	.884	78	.000

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The Kolmogorov – Smirnov test indicated that the p-value for the dependent variables in the overall dataset was valued as p=0.002 (P<0.05), except for the variable for 'Risk Minimization Indices' (RMIs) which was assigned as p= 0.200 (P>0.05) (See Table 7.10). Shapiro – Wilk test likewise, shows that, the p value of all the dependent variables was generally less than 0.05: p= 0.010 (p <0.05). From this finding one can conclude that the general data-set was not evenly distributed except for the risk minimisation measures. Based on this outcome it was determined relevant to employ parametric tests for the RMIs and non-parametric tests for the other non-normally distributed variables.

7.5.4 Test of Significance on the Risk Minimisation Indices: One-sample T-test

Test of significance in brief, configures data into categories, checking to ascertain if categories align with, or represent different populations (Balkan, 1966; Gerhan, 2001). In order to test whether there was statistically significant difference within the rating patterns for risk minimization measures, a one sample T test was employed by using SPSS (version 27). One sample T test was employed, as the assumption of homogeneity of variance was accomplished (Fagerland and Sandvik, 2009). Homogeneity of variance outlines that the mean value of the sample is appropriate for the entire sample. As indicated in 7.5.3 (Table 7.10), the RMIs where indicated as normally distributed data, and the independence of the data-points requirement were met, therefore application of parametric tests was considered relevant (Gaddis and Gaddis, 1990). As there were less than 3 groupings for this category, the one sample T-test, instead of the ANOVA was applicable (Refer 5.8.4.1).

- **Hypothesis**

H_{01}: There is no statistical difference in Risk Minimization Measures.
H_{11}: There is a statistical difference in Risk Minimization Measures

Table 7. 11 One-Sample Test Results for Risk Minimisation Measures

	Test Value = 4					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Risk Minimization Measures	38.305	77	.000	2.09295	1.9841	2.2017

The T value corresponding to the mean difference between the risk minimization measures and a fixed mean value of 2.09295 was 38.305 and its corresponding p value was, p= 0.000($P<0.01$). Since the p value was less than 0.01 (Table 7.11), the study can conclude that there was a 99.9% statistically significant difference in risk minimization measures. Thus, the study rejects the null hypothesis and accepts the alternative one. This implies that the mean value gained is scattered. Scattering of the mean value implies that there are majority responses from the populations, agreeing to similar terms with other groupings bearing divergent views or perspectives. On the basis of representation of expert participants from diverse occupational backgrounds on the survey panel (ranging from petroleum engineering consultants, incident responders, environmentalists etc.), projections of some subjective consideration over which risk factor was viewed as relatively important, could be envisaged, therefore variances identified in RMI scoring process, is not unusual (See chapter 8, for further implications).

7.5.5 Test of Significance Phase 2: Kruskal-Wallis Test on Non-parametric Elements

Within this succeeding phase, the Kruskal Wallis (KW) test was applied to check whether Institutional Domain and the non-normally distributed dependent variable factors of the study share a statistically significant relationship. The Kruskal-Wallis test which is sometimes referred to as the 'one-way ANOVA on ranks', is a non-parametric test that can be used to ascertain if statistically significant differences exist between two or more groups of independent variables measured against a continuous or ordinal dependent variable (Wilcox, 1990; Aly and BuHamra, 1996). (Refer 5.8.4.2 for introduction on KW test). Moreno *et al.,* (2017) deployed the Kruskal Wallis test to ascertain significant differences in population in relation to wastewater treatment plants on energy efficiency and environmental management performance. The test (KW) was applied in this study using the SPSS version 27 software. Since the variables of Governance Functions, Technical Functions, Managerial Functions, Process Functions, Disaster Incident Triggers, and Institutional Sectors are separately distributed for scoring within the Likert scale; and the variable population of 'Institutional domain' is also distributed into other categories, thus satisfied the basic requirements for deployment of this test. On the basis of the foregoing and non-assumption of homogeneity of variance (Fagerland and Sandvik, 2009), the Kruskal Wallis Test was applied.

Table 7.12 Results for Kruskal Wallis H Test on Overall Data Categories

Measures	Governance Functions	Technical Functions	Managerial Functions	Operational Functions	Disaster Incident Triggers	Institutional Sectors
Chi-Square	10.917	10.723	9.733	15.064	22.646	10.619
Df	12	12	12	12	12	12
Asymp. Sig.	.536	.553	.639	.238	.031	.562

a. Kruskal Wallis Test

b. Grouping Variable: 1d. Institutional Domain (Major occupational setting) - Selected Choice

Based on the breakdown of inferential results (Table 7.12), the variable of 'Governance Functions' had gained a p-value = 0.536 (P>0.05), therefore it can be concluded that no statistically significant relationship existed between Institutional Domain and the construct of 'Governance Functions'. The p-value attained for 'Technical Functions' was p-= 0.553 (P>0.05), therefore, there is no significant relationship between Institutional Domain and 'Technical Functions'. The construct of 'Managerial Functions' had gained a p-value = 0.639 (P>0.05), hence, there is no significant correlation between Institutional Domain and 'Managerial Functions'. 'Operational Functions' had gained a p-value = 0.238 (P> 0.05), Hence, there is no statistically significant relationship between 'Operational Functions' and Institutional Domain. The construct of 'Disaster Triggers/ mediums' had gained a p-value = 0.031 (P<0.05), hence, the study concludes that there exists a statistically significant correlation between 'Disaster Trigger/ mediums' and Institutional Domain. Lastly, the 'Institutional Sectors' assessment gained a p-value = 0.562 (P> 0.05) Thus, there is no statistically significant relationship between Institutional Domain and 'Institutional Sectors', regarding capability improvement needs. As a result, it can be delineated that only 'Disaster Trigger/ Mediums' share a statistically significant relationship with Institutional Domain. The explanations for statistically significant difference identified within the 'Disaster Trigger' section could be identified from some indicators within the Mann-Whitney 'U' test, which is employed as a pot-hoc test (see 7.5.8). However, the focal constructs for attaining the aims of the study, which are the Capability Improvement Indices, have no statistically significant difference per the output of the KW test, which result is considered pivotal.

7.5.6 Test of Significance Phase 3: Mann-Whitney U Test on Key Dependent Variables

The Mann-Whitney U (MWU) test was used as a post hoc test after the Kruskal-Wallis Test to identify specific institutional/ demographic domains or groupings that could have made divergent scoring, resulting in variance with respect to the various constructs. The use of Mann-Whitney U test has been deployed recently by Ekpobomene (2012), as a pot-hoc test. The Mann-Whitney U test in this regard provides a complementary and somewhat greater depth of indicators, with the comparison and contrasting of institutional categories as in relation to dependent variables. For example, though the KW test did not delineate statistically significant difference with the 'Technical Functions'; within the sub-categories of this capability improvement measure (such as, 'material resource management'), some statistically significant difference manifests within the MWU test, e.g. as highlighted below in: (i) column 4 of Table 7.13, 7.15; and marginally within Table 7.14; (ii) columns 1 and 4 of Table 7.16 (the relatively significant variances within institutional relations from the survey scoring process is highlighted below).

Table 7. 13 Pairwise Comparison of Environmental Institution with Exploration and Production Companies

Statistical Measures	C2 - TECHNICAL FUNCTIONS - 1. Early detection and Warning Systems	C2 - TECHNICAL FUNCTIONS - 2. Technology Adoption/ improvement	C2 - TECHNICAL FUNCTIONS - 3. Decision Support Systems	C2 - TECHNICAL FUNCTIONS - 4. Material resource management
Mann-Whitney U	48.000	38.500	42.500	21.500
Wilcoxon W	103.000	104.500	108.500	87.500
Z	-.603	-1.269	-1.066	-2.634
Asymp. Sig. (2-tailed)	.546	.204	.286	.008
Exact Sig. [2*(1-tailed Sig.)]	.654[b]	.251[b]	.387[b]	.016[b]

a. Grouping Variable: 1d. Institutional Domain (Major occupational setting) - Selected Choice

b. Not corrected for ties.

Table 7. 14 Pairwise Comparison of Exploration and Production Companies with Emergency and Incident Response Institutions

Statistical Measures	C2 - TECHNICAL FUNCTIONS 1. Early detection and Warning Systems	C2 - TECHNICAL FUNCTIONS - 2. Technology Adoption/ improvement	C2 - TECHNICAL FUNCTIONS - 3. Decision Support Systems	C2 - TECHNICAL FUNCTIONS - 4. Material resource management
Mann-Whitney U	24.000	26.500	19.500	10.000
Wilcoxon W	39.000	92.500	85.500	76.000
Z	-.493	-.126	-1.062	-2.303
Asymp. Sig. (2-tailed)	.622	.900	.288	.021
Exact Sig. [2*(1-tailed Sig.)]	.743[b]	.913[b]	.377[b]	.052[b]

a. Grouping Variable: 1d. Institutional Domain (Major occupational setting) - Selected Choice**b. not corrected for ties

Table 7. 15 Pairwise Comparison Bachelor's Degree with Doctorate Degree Scoring

	C2 - TECHNICAL FUNCTIONS - 1. Early detection and Warning Systems	C2 - TECHNICAL FUNCTIONS - 2. Technology Adoption/ improvement	C2 - TECHNICAL FUNCTIONS - 3. Decision Support Systems	C2 - TECHNICAL FUNCTIONS - 4. Material resource management
Mann-Whitney U	74.000	87.500	84.000	27.000
Wilcoxon W	152.000	165.500	220.000	105.000
Z	-1.182	-.426	-.702	-3.654
Asymp. Sig. (2-tailed)	.237	.670	.483	.000
Exact Sig. [2*(1-tailed Sig.)]	.324[b]	.698[b]	.599[b]	.001[b]

a. Grouping Variable: 1b. Highest Qualification - Selected Choice

b. Not corrected for ties.

Table 7.16 Pairwise Comparison of Master's Degree with Doctorate Degree Scoring

Statistical Measures	C2 - TECHNICAL FUNCTIONS - 1. Early detection and Warning Systems	C2 - TECHNICAL FUNCTIONS - 2. Technology Adoption/ improvement	C2 - TECHNICAL FUNCTIONS - 3. Decision Support Systems	C2 - TECHNICAL FUNCTIONS - 4. Material resource management
Mann-Whitney U	190.000	255.500	257.000	166.500
Wilcoxon W	268.000	1383.500	1385.000	244.500
Z	-2.041	-.539	-.533	-2.383
Asymp. Sig. (2-tailed)	.041	.590	.594	.017

a. Grouping Variable: 1b. Highest Qualification - Selected Choice

Table 7. 6 Sample Pairwise Comparison of Master's Degree and Doctorate Holders on Disaster Incident Triggers

	DISASTER INCIDENT TRIGGERS - 1. Well Blow-out	DISASTER INCIDENT TRIGGERS - 2. Chemical discharges	DISASTER INCIDENT TRIGGERS- 3. Fire/ Explosions	DISASTER INCIDENT TRIGGERS- 4. Hydro-carbon releases	DISASTER INCIDENT TRIGGERS- 5. Marine Vessel/ Helicopter accidents (on oil rig)	DISASTER INCIDENT TRIGGERS- 6. Pipeline rapture/ Vandalism	DISASTER INCIDENT TRIGGERS- 7. Oil rig structural failure
Mann-Whitney U	170.000	227.000	231.000	155.500	204.000	267.500	222.000
Wilcoxon W	248.000	305.000	309.000	233.500	282.000	1395.500	300.000
Z	-2.175	-1.080	-1.051	-2.522	-1.527	-.291	-1.192
Asymp. Sig. (2-tailed)	.030	.280	.293	.012	.127	.771	.233

a. Grouping Variable: 1b. Highest Qualification - Selected Choice

7.6 FINDINGS ON INDICATORS FOR CAPABILITY IMPROVEMENT CONSTRUCTS

- **Comparison within institutional domains:**

The key areas of statistical difference were mainly on ‘Material Resource Management’ under technical functions, and also ‘Early Detection/ Warning mechanisms’, to a marginal level. This divergence in survey participant scoring, is identified e.g. within environmental regulatory institutions and petroleum exploration companies, as in Table 7.13. However, Environmental regulatory institutions had a comparatively lower level of variance with consultancy groupings with ‘p’ value =0.152 (P>0.05), on the comparative level of statistically significant difference relating to same item (‘Material resource management’) when compared to the level of difference with other professional groupings. Further, there appeared to be greater agreement between ‘petroleum regulations institution’ and ‘maritime port and harbours institution’ particularly with regard to technical issues, where the lowest comparative p value was 0.400 for ‘material resource management’ and all other technical functions approximately 0.700

- **Comparison Within Educational Domains:**

There was a greater degree of agreement between (i) Bachelors and Masters compared to (ii) Bachelors and doctorate degree holders on the ‘Technical functions’, this agreement (i) was apparent except marginally on ‘Material resource management. This further emphasises the indication that, ‘Material resource management’ was the sub-construct, which elicited some degree of divergence in scoring. Also, there was a significant difference between persons with Masters compared to doctorates, on ‘Early warning systems’; and to a slightly higher degree on ‘Material resource Management’ (Table 7.16). Aside ‘material resource management’, there was no critical identification of statistical difference, within the various risk minimisation measure variables and capability improvement measures, except with ‘Early detection and warning systems’, which deviation was identified between the ‘Masters’ and ‘Doctorate degree’ respondents (That is, overall, with regard to educational backgrounds).

- **Indicators for Disaster Incident Triggers**

(i) **Statistical Significance based on Educational Background Indices:** On disaster incident triggers, Bachelors and Doctoral respondents had significantly divergent scoring on incident triggers: this provides reflection on the ‘p’-value deviation/ variances highlighted in Tables 7.12 (KW test), and 7.17 (MW test).

(ii) **Statistical Significance based on ‘Institutional Domain’ Indices**: There was also statistically significant difference between scoring by ‘environmental regulators’ and ‘exploration and production companies’ on incident triggers/ mediums. It could be observed also that, ‘Petroleum Regulation Institutions’ elicited less statistically significant difference with ‘Exploration and Production Companies’, on disaster incident triggers, as also with other constructs of the dependent variables, showing relatively greater tendency to agree, within the scoring process. As highlighted beforehand, the incident trigger constructs did not form the focal component for the aim and goal of the study, therefore, though some statistical difference was generated in that sector of the survey process, this would be expatiated on briefly under discussions and in the conclusion chapter (under recommendations) and not discussed exhaustively here.

7.7 PROCEDURE TOWARDS ATTAINING KEY ITEM PRIORITIZATION

7.7.1 Determination of Ranked Risk factor Minimisation Measures

In order to determine the highest and lowest ranked components of Risk Minimization Indices (RMIs), the weighted average of each factor was calculated using the formula in Equation 5.6 (methodology), beginning with the relative weighting process based on expert scoring for levels of importance indicated in Table 7.18 However, the *WASi* alone as noted above, gives a somewhat imprecise representation of the highest and lowest ranked measures, as it does not take account of the levels of variance in scoring of dependent variables among respondents (Shen and Tam, 2000; Naoum, 2013). Therefore, the adjusted score was calculated using the complementary formula as shown in equation 5.7 of the methodology. The adjusted score value for RMIs have been labelled Risk Minimisation Index Value (RMIV) in Table 7.19 and the final rank derived from this calculation is indicated under the column $RMIV^R$, respectively.

Table 7. 7 Relative Weight Scoring Chart for RMMs

Scores RMI	Extremely Important	Very Important	Important	Moderate Importance	Slightly Important	Low Importance	Not at all Important
	7	6	5	4	3	2	1
Rm-1	29	29	20	0	0	0	0
Rm-2	27	42	9	0	0	0	0
Rm-3	28	26	16	4	2	2	0
Rm-4	31	40	6	0	1	0	0
Rm-5	38	35	3	1	1	0	0
Rm-6	18	35	20	3	1	0	1

Rm-7	29	33	14	1	1	0	0
Rm-8	41	32	3	2	0	0	0
Rm-9	20	39	17	2	0	0	0
Rm-10	32	24	18	2	2	0	0
Rm-11	22	30	21	4	1	0	0
Rm-12	22	35	18	2	1	0	0

Table 7. 8 Weighted Score and Adjusted Rankings: RMIs

Risk Minimisation Index	$\sum(\alpha_j * n_{ij})$	**ASS**	δ	**RMIV**	**RMIV^R**
Rm-1	477	6.12	1.20	11.21	7
Rm-2	486	6.23	0.90	13.16	4
Rm-3	458	5.87	1.60	9.54	12
Rm-4	490	6.28	0.89	13.38	3
Rm-5	498	6.38	0.83	14.07	2
Rm-6	452	5.79	1.18	10.69	10
Rm-7	478	6.13	1.13	11.53	5
Rm-8	502	6.44	0.79	14.57	1
Rm-9	467	5.99	1.11	11.40	6
Rm-10	472	6.05	1.30	10.71	9
Rm-11	458	5.87	1.26	10.52	11
Rm-12	465	5.96	1.18	10.99	8

The sequential outcome of the weighted average scoring process is the generation of the Average Significant Score (ASS) which provides the weighted ranking of the various risk minimisation measure items (RMIV), and final adjusted rank RMIV^R. The breakdown of the final ranking derived is as indicated (Table 7.20).

Table 7. 9 Final Ranking of Risk Minimisation Indices (RMIs)

1	Rm-8	Addressing Risk Management Shortcomings
2	Rm-5	Ensuring Emergency Preparedness Planning
3	Rm-4	Improving Socio-Environmental Accountability
4	Rm-2	Addressing Governance System Gaps
5	Rm-7	Minimisation of Delayed Action and Response to Threats
6	Rm-9	Addressing Material Resource Shortcomings
7	Rm-1	Minimisation of Human Error
8	Rm-12	Addressing Technical Capability Gaps
9	Rm-10	Addressing Management and Leadership Shortcomings
10	Rm-6	Minimisation of Operational Risks
11	Rm-11	Minimisation of Equipment Failures
12	Rm-3	Pre-emption of Sabotage Terrorism and Vandalism

Based on the adjusted $RMIV^R$ score as outlined in Table 7.20, it can be identified that: Rm-8 (Addressing risk management Shortcomings); Rm-5 (Ensuring Emergency Preparedness Planning) and Rm-4 (Improving socio-environmental accountability emerged as the top risk minimisation measures, that were advocated by respondents towards environmental disaster pre-emption within the petroleum sector of Ghana. The lower ranking measures, by way of importance on the scale of disaster risk minimisation measures in that context were: Rm-6 (Minimization of operational risk taking); Rm-11(Minimisation of equipment failure) and Rm-3 (Pre-emption of sabotage terrorism and vandalism). A graphical representation on the distribution of RMIV scores is presented in Figure 7.6.

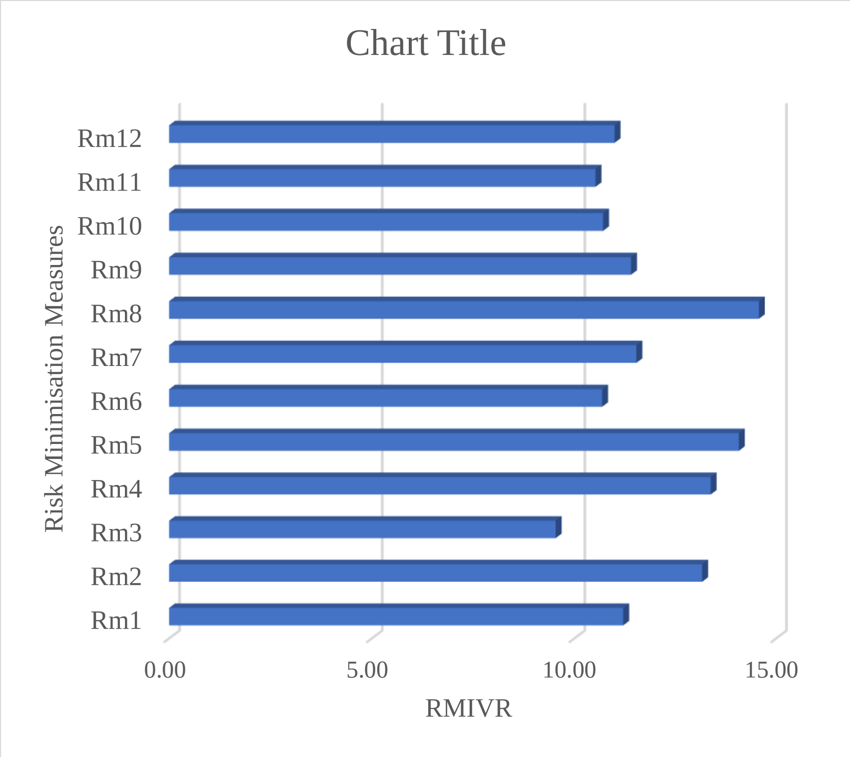

Figure 7. 6 Representation of RMM Rankings

7.7.2 Determination of Prioritized Capability Improvement Mechanisms

Invariably, the Capability Improvement Measures (16), proposed for addressing the risk minimising measures were presented to respondents for appropriate ranking, in order of importance. Towards determining the highest and lowest ranked capability improvement mechanisms (CIMs), the *WASi* formula (equation 5.) was deployed, and the adjusted score was calculated via the coefficient of variation. The adjusted score for the capability improvement mechanisms (CIMs) were labelled CMIV, and the adjusted ranking as $CMIV^R$. The process of scoring and final results as via employment of the adjusted *WASi* score is outlined in tables 7.21 and 7.22 respectively.

Table 7. 10 Expert Participant Scoring Chart for CIMs

Scores / CIM	Extremely Important	Very Important	Important	Moderate Importance	Slightly Important	Low Importance	Not at all Important
	7	6	5	4	3	2	1
Cm-1	33	40	4	0	1	0	0
Cm-2	41	33	2	0	2	0	0

Cm-3	26	41	8	3	0	0	0
Cm-4	13	44	19	1	1	0	0
Cm-5	48	27	1	1	1	0	0
Cm-6	26	37	13	0	2	0	0
Cm-7	14	49	12	2	1	0	0
Cm-8	9	43	24	2	0	0	0
Cm-9	27	37	14	0	0	0	0
Cm-10	37	34	5	1	1	0	0
Cm-11	52	22	4	0	0	0	0
Cm-12	15	51	8	4	0	0	0
Cm-13	35	39	2	2	0	0	0
Cm-14	19	41	15	3	0	0	0
Cm-15	24	46	6	0	2	0	0
Cm-16	41	34	3	0	0	0	0

Table 7. 11 Weighted Score and Adjusted Ranks for CIMs

Capability Improvement Mechanisms	$\sum (\alpha_j * n_{ij})$	**ASS**	δ	**CMIV**	**CMIV^R**
Cm-2	501	6.42	0.84	14.09	3
Cm-3	480	6.15	0.95	12.62	6
Cm-4	457	5.86	1.10	11.17	10
Cm-5	510	6.54	0.75	15.30	2
Cm-6	475	6.09	1.12	11.53	9
Cm-7	463	5.94	0.99	11.90	8
Cm-8	449	5.76	1.11	10.93	11
Cm-9	481	6.17	1.05	12.06	7
Cm-10	495	6.35	0.91	13.35	5

Cm-11	516	6.62	0.75	15.49	1
Cm-12	467	5.99	6.50	6.91	15
Cm-13	497	6.37	6.49	7.35	13*
Cm-14	466	5.97	6.43	6.90	16*
Cm-15	480	6.15	6.01	7.18	14*
Cm-16	506	6.49	6.61	7.47	12*

The final sequential breakdown of prioritised Capability Improvement Mechanisms, are outlined in Table 7.23.

Table 7. 12 Final Breakdown of CIM Rankings

1	Cm-11:	Risk Management
2	Cm-5:	Early Detection and Warning
3	Cm-1:	Legal and Regulatory
4	Cm-2:	Standards Compliance Audit
5	Cm-10:	Human Resource Management
6	Cm-3:	Development of Governance Institution
7	Cm-9:	Research
8	Cm-7:	Decision Support Systems
9	Cm-6:	Technology Adoption
10	Cm-4:	Interorganizational Cooperation
11	Cm-8:	Material Resource Management
12	Cm-16:	Training and Simulation
13	Cm-13:	Emergency Preparedness Strategy
14	Cm-15:	Pre-emptive, Early and Rapid Action (PERA)
15	Cm-12:	Stakeholder Management
16	Cm-14:	Public Involvement

Based on results as outlined in Table 7.23, Cm-11 (Risk management); Cm-5 (Early Detection and warning), Cm-1 (Legal and Regulatory mechanisms) are the topmost 3 capability mechanisms indicated as critical for addressing risk minimisation factors identified beforehand, towards pre-empting environmental disaster risks within the petroleum sector of Ghana. Conversely, Cm-15 (PERA); Cm-12 (Stakeholder management) and Cm-14 (Public involvement) were selected among the lower scored capability improvement mechanisms. A graphical representation of the distribution of ranking is presented in Figure 7.7.

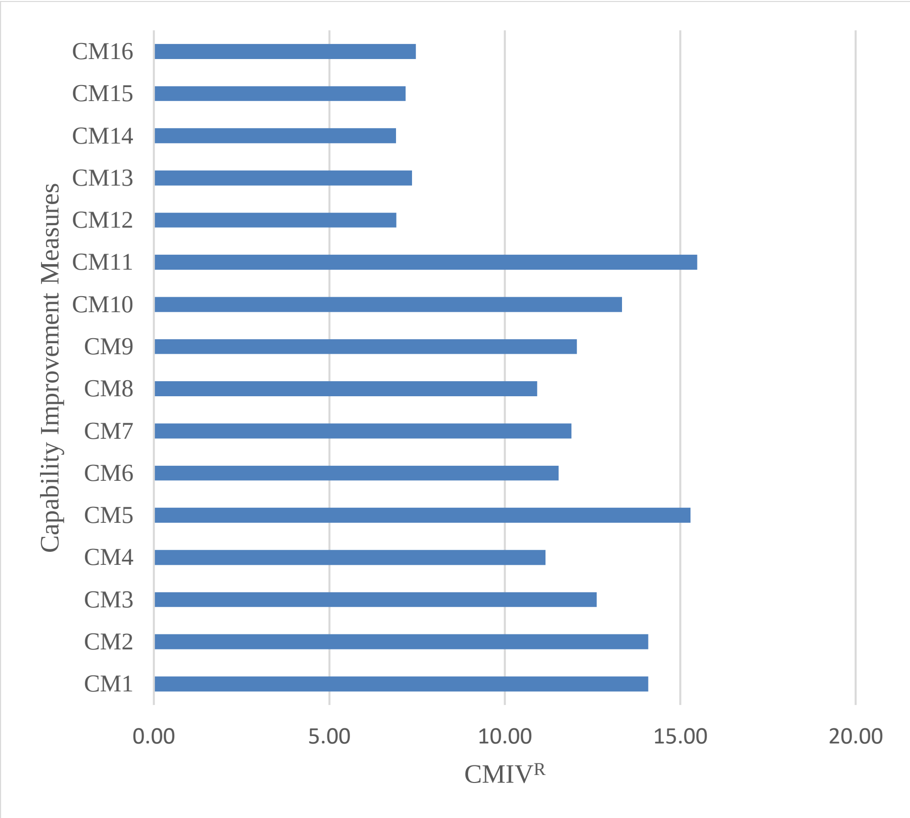

Figure 7. 7: Representation of CMIV Rankings

7.8 CHAPTER SUMMARY

Presentation of findings and appreciable analysis has been made on the data and information derived from: (i) the systematic review of literature (ii) Verification/ validation of literature, and (iii) Expert survey process: with fundamental indicators of themes, patterns and inferences emerging from the processes. This section (chapter 7), is pivotal to synthesis of knowledge for discussion and evaluation towards attainment of the CIF and recommendations.

CHAPTER 8: DISCUSSION OF FINDINGS AND FRAMEWORK DESIGN

8.0 INTRODUCTION

This chapter discusses findings made within this study from three (3) categorical perspectives. These are: (1) The Critical Relationship between Theoretical Constructs and Institutional Capability/ Performance. (2) Global Environmental Governance systems and Implications for Ghana Petroleum Sector, and finally, (3) Implications of findings from Identification and prioritisation of the EDRM Mechanisms. This chapter also discusses, and highlights processes and considerations made towards designing of the Capability Improvement Framework (CIF) for this study.

8.1 RELATIONSHIP BETWEEN THEORETICAL CONSTRUCTS AND INSTITUTIONAL PERFORMANCE

Drawing from reviews and assessments of literature, the findings within this study affirms that, theoretical considerations, pivoted on definitional constructs, have significant relationship to organizational systems, work approach and performance. This study identifies that theory and evolvement of interlinked concepts, play pivotal roles towards deriving solutions to challenging phenomena. This underscores the concepts and observations in studies by Von Clausewitz (1976), Fischer (2002), Rautela, (2006), Phillips (2015) and others, that, theoretical and definitional constructs do have significant impact on institutional capability and performance. Research findings within this study indicate, theories guide concepts of acceptable behaviour, strategy and operational approach (Rautela, 2006; Zeb-Obipi and Harcourt, 2007; Wang *et al.*, 2017): rationally, if theories are defective in some respects, the impacts on ancillary conceptual frameworks and operationalizing of concepts could invariably be susceptible to shortcomings (Fischer, 2002; Tierney, 2012).

An abductive evaluation of the evolvement of disaster theory and related management concepts employing the proposed ‘Capsized Iceberg Approach’ (Researcher’s construct), have further provided insight in the following key areas:

(A) That, disaster theorization, attribution, conceptualisation and management has evolved immensely over time from diverging dimensions of historical dispensations. Findings from evaluation of literature (chapter 2), have revealed, disaster theorization/ conceptualisation from historical perspectives is by far disparate from contemporary concepts and models such as subscribed to by the IFRC (2020) and United Nations (2019). Disaster theory and attribution was in the past conceptualized as spiritual phenomena and consequently management approach was situated reciprocally in this dimension (Furedi, 2007). Remarkably, disaster conceptualisation and attribution has in the past not rather been associated with capacity and capability, just as vulnerability and resilience were implicitly delinked from management of these phenomena. Findings from synthesis of knowledge within this study, has highlighted the exponential infusion of the concepts of 'Vulnerability' and 'Resilience' within disaster conceptualization (Hewitt, 1983; Vatsa, 2011), and more recently capability (Aven, 2011), as these constructs have formed the core concern of disaster management literature and global governance systems in contemporary times. Drawing on concepts and findings within research work (Aven, 2011; Wilson and McCreight, 2012; Shavell, 2014; Wang and Kuo, 2014; Lee, 2017), it can be postulated, based on trajectory of disaster theory, related concepts and management systems, supported by findings from this study that; capacity, or capability enhancement would serve as the pivotal element and nexus from which disaster conceptualisation and management processes are addressed, within contemporary and future dispensations.

(B) The theoretical frame and disaster management model categorization within which this CIF falls is, the 'Other Models' category, bearing reflections on the Gonzales, Herrero and Pratt models (1996, cited in Norjavan et al, 2018: Table 2.3). It is recognisable that the 'Other Models' disaster management frameworks and mechanisms are largely hybrid forms of the more common constructs and theoretical approaches (Nojavan *et al.,* 2018). The uniqueness of approach to the research process, and outcomes for this study (CIF); is a mechanism, which addresses/ apprehends disaster impacts from a more anterior perspective, inherently linking disaster ('consequence') with integral risk ('probabilities') and threat reduction prioritisation, towards achieving EDRM goals.

8.1.1 Situating This Study Within a Framework of Evolving Theory

Having established that theoretical constructs do have vital impact on performance, it is crucial to place within the right perspective, some evolving arguments and counter-arguments emerging from the process of this research. As indicated (Chapter 2), disaster attribution concept has been contextualised within varying domains historically, and evolved through time, to more dynamic and interdisciplinary considerations than what used to be (Furedi, 2007; Aven 2011). Whereas it has been acknowledged from the constructs of disaster attribution (Carr, 1934, Kemp, 2003, Quarantelli, 2001) that, this is an impact related phenomenon, with respect to severity of impact on biological and socio-economic setups; it has emerged from the evolvement of findings within this study that, disaster can be much broader than the projected impact related constructs prevalently pronounced within disaster literature (Fischer, 2002; Rautela, 2006; Lee, 2017).

Based on knowledge synthesis within this study (Chapter 2); it can be suggested from findings that:

1. Disaster is neither a massive force event nor mainly impacts related phenomena delineated from pre-incident ‘probabilistic’ risks: rather, disaster occurs, or is situated within a ‘continuum’; since for instance, the end-point of a ‘disaster’ could imply the inception of a ‘disaster risk’, vice versa.

2. Disasters are not just massive force events (disaster incident trigger), or cascading impacts (consequences), but also configurations and interplay of vulnerability and shortcomings within socio-infrastructural resilience modes, most of which were pre-incident, underlying factors (risks or probabilities).

8.2. GLOBAL ENVIRONMENTAL GOVERNANCE SYSTEMS AND IMPLICATIONS FOR GHANA PETROLEUM SECTOR

Global environmental governance systems and mechanisms have been identified as pertinent and largely applicable within the petroleum sector, in a universal context. For examples the ‘Polluter Pays Principle’, ‘Precautionary Principle’ among other institutional instruments, statutes and conventions, among others, are applicable within this sector (Birnie *et al.,* 2009). Appraisal of some global best practice and national governance institutions for the petroleum sector, shows some debate over preference for hybrid performance-based system pursued by the US, and the ‘Safety Case’ approach practiced in Norway, Uk, etc. (Barua *et al.,* 2016, DNV, 2014). Evaluation of the merits and demerits of these governance systems indicate, there is wider acceptance towards the safety case regime, as more petroleum producing nations, such as e.g. Australia, Nigeria and Ghana have adapted this system (Abudu and Rockson, 2020; Adegbite *et al.,* 2020). Consideration however, can be made by user nations, on the identifiable inadequacies of the safety case (3.1.4) in order to proffer interventions towards addressing/ mitigating the gaps and deficiencies, on the basis of dynamic jurisdictional contexts.

It is particularly apparent petroleum environmental management systems have been designed to ensure the minimal interference and intrusion as possible from public sector institutions. This is underpinned by the administration of the safety case objectives, aimed at motivating operators and industry partners to maintain the highest level of acceptable/ best practice of environmental (SHE) governance. With the exponential shift towards more performance-based approach to governance within the petroleum industry however, comes potential arbitrariness, randomness and premises for abusing systemic weaknesses (as addressed below).

8.2.1 Caveat on Contemporary Governance Systems

Circumspection must be employed therefore, towards the recommendation by DNV (a major institutional entity in petroleum governance systems) (3.1.4), and the caution from Nilsen and Storkersen (2018, p.38), as hereby underscored: “Our findings send an important message to governments that are striving toward ensuring the safety of industries: If regulation is to be efficient, it must be supported in terms of resources and political will, especially in industries with challenging conditions, and the authorities should be aware and prepared for possible changes in the industry´s context”.

8.3 IMPLICATIONS OF FINDINGS FROM IDENTIFICATION AND PRIORITISATION OF EDRM MECHANISMS

This section discusses indicators from emerging themes/ patterns of knowledge synthesis and opinions from the expert survey process, which are identified as pivotal to development of the CIF, and also guidelines for key stakeholder bodies, as well as for future research.

8.3.1 Discussion on General Findings from SR of Literature and Expert Survey

The study sought to establish the root causes or underlying factors in disaster incident causation within the petroleum sector, and key capability mechanisms that can be deployed towards addressing the identified risk factors. The aim ultimately, is to rank and prioritize these identified factors, thereby summarize findings to support policy and decision making, towards minimising environmental disaster risks within the upstream petroleum sector of Ghana. The indicators from the systematic review of literature show that the generality of risk factors and capability interventions identified, are of universal applicability, though some risk factors and capability mechanisms may be relatively pertinent to some geographical and economic contexts/ jurisdictions (Onuaha, 2008; Hovik *et al.*, 2009; Aroh *et al.*, 2010; Edelstein, 2011; Mills, *et al.*, 2015). For instance, there were some underlying risk factors, which were distinctively pertinent to the Arctic and surrounding regions (Hovik *et al.*, 2009; Tynkkynen *et al.*, 2018); whereas others were prevalently identified with developing nations particularly within the sub-Saharan region and global south (Okpanachi and Andrews, 2012; Obeng-Odoom, 2018).

This notwithstanding, the capability interventions identified within this study, are largely applicable across jurisdictions, with subjective considerations to requirements for capability improvement, according to the state of national/regional institutional capability status and criticality of risk factors involved (Mills, *et al.*, 2015). However, contrary to indicators from literature, that sub-Saharan Africa has relatively higher levels of petroleum related vandalism, terrorism, sabotage etc. (Okpanachi and

Andrews, 2012; Aroh *et al.,* 2010), findings from the survey analysis (table 7.20) show, these risks/ threats though important, are not among the topmost ranked risk factors demanding prioritised attention, within Ghana's oil sector, despite Ghana being at the heart of this region. This contrasting finding is discussed in section 10.6.2 (recommendation and conclusion), chapter 10.

8.3.2 Discussion on Survey Inferential Analysis

The general outlay of data distribution within the survey rankings indicate a mean score of 5.7 on the seven-point Likert scale for the items of variability measured (for both RMIs and CIMs). This gives indication that the items rated towards EDRM within the petroleum sector of Ghana, were largely considered essential, though with varying degrees of importance. Within the key dependent variables of risk factors to be minimised (RMIs), there were noticeable statistical difference in scoring, as highlighted within seven constructs, and which draws ostensibly from perspectives of subjective judgement of participants. It has been suggested beforehand (Section 7.5.4) that, the variance and statistically significant difference highlighted could be from some subjective considerations based on the diversity of survey participant grouping, rather than from sampling error. Interestingly with the interventions assigned for addressing RMIs, that is, Capability Improvement Mechanisms (CIMs), there is evidence of a general convergence on scoring patterns for all items, except for items under the sub-construct of 'Technical Functions', particularly 'material resource management', and an isolated case of divergence (statistical difference) in scoring for 'early detection and warning' mechanisms. Giving consideration for statistically significant indicators on 'material resource management', it is prudent to reflect on the components this item and the plausible implications in this respect. Material resource management, as highlighted within the survey process and expatiated within framework, constitute the administration/ operation of early intervention mechanisms such as: ignition cut-off systems, fire suppression systems, well sealing/ capping systems to avert blow-out, oil spill booms for confining and collecting oil/ chemical spills, among similar or auxiliary items.

It could have been considered, e.g. as generated from the MWU test, significant difference on scoring pattern of e.g. petroleum companies and environmental regulatory respondents that, management of such highly mechanized and industry centred infrastructure/ machinery, was more pertinent or operable within the responsibility domain of petroleum companies, than public sector organisations. Globally management of such 'technicalized' custom designed mechanisms appear to be largely managed and operated by industry players and private sector organisations internally (Edelstein, 2011; Mills *et al.,* 2015). Whereas it is acknowledged that specialist industry operations such as petroleum/ mining are managed chiefly, by highly competent professionals within a 'closed-up' industry environment, it can also be appreciated that oversight monitoring/ supervision of related operational systems, cannot be the exclusive concern and responsibility of petroleum companies, if incidents such as the Bp Gulf of Mexico well-blowout are to be averted or mitigated (Edelstein, 2011, Mills, *et al.,* 2015). It is further acknowledged for instance that, the Ghana Navy e.g., is acquiring oil spill booms, for use under emergencies (GIWACAF, 2020), and arrangements are in place for public private partnership/ collaborative effort (including the use of fire-boats etc.) towards arresting and containing threats of varying forms that could lead to disaster with environmental impacts.

While petroleum companies, oil consultancy firms etc., (based on the representation of survey scoring), may have considered the specialist activity of 'Material resource Management' as a responsibility aligned chiefly to private companies, such as Haliburton/ Schlumberger etc., the connected risk of lapse in oversight responsibility e.g. as evidenced in the Bp 2010 well-blowout related to operational risk taking/ management and technological lapses; necessitates a greater participatory/ supervisory role by public sector institutions (Edelstein , 2011; Tierney 2012). It is also not too complex to appreciate possible reasons for the isolated item of significant statistical difference within 'Early warning systems', emanating from the MW test, since the specialist/ technical mechanisms are closely inter-related. The Implication for these unitary indicators of variance on the 'Technical functions' together with variance identified on 'Disaster incident triggers' are further addressed in the conclusion and recommendations chapter.

8.3.3 Discussion on Outcome of Survey Analysis: Deploying the *WASi* Method

It can be considered pertinent and aptly reflective of practical institutional activity that, Rm-8; Rm-5; Rm-4 (i.e. 'Addressing Risk Management Shortcomings'; 'Ensuring Emergency Preparedness Planning'; 'Improving Socio-Environmental Accountability'), were ranked in the top quartile of risk minimisation indices by respondents, in relation to public sector institutions responsible for environmental risk governance of the Ghana petroleum sector: as these traditional functions are considered inherent or largely identifiable to the roles and responsibilities of oversight institutions, per the statutes regulating this industry in Ghana (Sakyi *et al*., 2012; Platform, 2012; Osei-Hwere, 2015; Acheampong and Akumperigya, 2018).

Its noteworthy that all items that ranked closer to the lower half of the Risk minimisation Indices (except the lowest: Rm-3) largely reflect underlying technical conditions or 'technically' connected activity: i.e., linked more directly to actual operational functions within the upstream exploration and production setup. By way of explanation, it can be suggested that, though all risk minimisation indices were considered important (scored above a mean of 5.9 on the 7-point Likert scale), the relatively technical risk factors of actual offshore exploration and production operations, may have been viewed as less critical within the prioritized hierarchy of public sector oversight responsibilities. This outcome in a way, reflects the more posterior/ traditional approach to tackling disaster risks as fore-indicated (Platform, 2012; Glover, 2017; GIWACAF, 2018; Obeng-Odoom). In sum, there is indication of a broad agreement by respondents on what may constitute the critical mandate of public sector institutions, and which areas ought to be prioritized by way of risk factor minimisation, towards pre-empting environmental disaster within Ghana's petroleum sector.

The exception within the lower ranking 'technical' related risk minimizing indices is, Rm-3 (Pre-emption of Sabotage Terrorism and Vandalism), which ostensibly cannot be categorized as a technical challenge. On the foregoing, it could be argued, as has been associated with some other developed countries, that, Ghana has a relatively peaceful and stable system of socio-economic governance and there is therefore a lower potential for the sector experiencing any significant level of related threats (Sakyi *et al.,* 2012). It may also be argued, Ghana's petroleum infrastructure is remotely situated offshore and out of the range of other socio-economic activity/ external human interference, unlike e.g., conditions evident within the Niger delta and Bakassi area of the sub-region (land-based/ socio-economically connected) which makes that region relatively susceptible to vandalism, terrorist attacks and related social unrest (Onuaha, 2008; Okpanachi and Andrews, 2012).

The foregoing epistemology, however, is debatable, and could form the basis of a latent risk by itself in some contexts (Amponsah-Tawiah *et al.,* 2015; Obeng-Odoom, 2018); for instance, with regards to the intricate interconnectedness of Ghana's offshore and onshore facilities such as oil pipelines, which are interlinked and un-detached from regional socio- political activity, as well as socio-economic impacts, e.g., from fishing etc. (Sakyi *et al.,* 2012; Badgeley, 2012). However, this contention could form the basis of enquiry within another study towards appraising the ramifications; on the basis of research findings which indicate, sub-Saharan Africa has some of the highest occurrences of petroleum related terrorism, vandalism, sabotage, etc. (Onuaha, 2008; Aroh *et al.,* 2010).

Conversely, as was the pattern with scores for the RMIs, whereby 'Technical' oriented factors where ranked lower; the capability improvement (CIM) scores ranked the 'Technical' connected and 'governance' functions relatively higher, than the more operational and socially linked interventions. Furthermore, the scoring pattern of expert participants were reflective of/ consistent with the questions of the survey and aim of study: which was the prioritisation of capability improvement needs (see 3.3), rather than which capability mechanisms were particularly more superior. Therefore, it could be relevant that, public sector capability measures which required greater improvement would ostensibly be scored higher than capability areas already relatively developed. For example, evidence can be adduced from the lowest ranked CIMs, 'Stakeholder management' and 'Public involvement', which have been interventions traditionally tackled and pursued by institutions in Ghana over the past decade (Glover, 2017; GIWACAF, 2018). It can be suggested from the foregoing and scoring of experts that, the areas of capability requiring greater improvement, were the relatively 'technical' functions which are comparatively non-traditional to public sector institutions. This finding agrees with the growing advocacy on the need to nurture and improve in-house capacity pertaining to technical competence, and related governance mechanisms for managing underlying disaster risks (Edelstein, 2011; Tierney, 2012; Mills *et al*., 2015).

Further, it can be identified that the lower ranked Capability measures (CMIVs), belonged relatively closer to: (i) emergency management (ii) incident and post incident operational functions and (iii) issues of vulnerability; thus, reflecting the impact aspect of risks. Invariably, the higher scored capability mechanisms (CMIVs), were not the emergency/ post-incident response factors, but the more technical, governance-based interventions, critical and pivotal towards pre-emptive action, and addressing underlying causation. This corresponds consistently with the higher ranking RMIV factors, which reflected concerns of underlying causation and pre-incident conditions, relating to the probability aspect of risk (Edelstein, 2011; Obeng-Odoom, 2018). Additionally, it is instructive to note, the themes and patterns of knowledge or opinion emerging from the expert survey process, broadly agree with the concepts and indicators established within the systematic review of literature.

8.4. CONSIDERATIONS TOWARDS DESIGN OF FRAMEWORK

Framework refers to a set of interlinking ideas, concepts, basic measures etc.; a pattern or accepted process which supports an identifiable structure, or desired results. Frameworks can be tested or modified by adding to, or removal from, to meet required end objectives (Guba, 1981; Goldschmidt, and Matthews, 2021). A framework can serve as a tool, guide-map or set of instructions on how goals, desired aims and objectives can be achieved. Frameworks can be simple in form, procedure and operation, etc. such as the Fink (2003) learning outcome framework; whereas other forms of frameworks can be relatively complex in outlook and process of comprehension, based on the disciplinary status, requirements and perspective of the observer or user (Mahamadu, 2017).

The capability improvement framework as proposed and established within this study, was designed with reflection on a broader range of mechanism such as decision support frameworks/ systems (Jones, 2003; Morley *et al.*, 2012; Mahamadu, 2017); decision guidance frameworks (Prasad and Chakraborty, 2018) Governance frameworks (Loorbach, 2010; Gilman, 2010). The evolvement and design of the capability improvement framework for this study, can be considered a hybrid mechanism, based on composite attributes of the aforementioned interventions. As indicated in preceding chapters, the study is aimed at public sector regulators and key stakeholders within the context of environmental risk reduction within the petroleum sector of Ghana: therefore though the various constructs, risk factors, capability measures and institutional structures derived from the various stages of data collection bear universal extraction and applicability, there was a need to maintain the final ranking/ prioritisation of the various constructs and interventions, as uniquely tailored to the perspective of the operational and jurisdictional context of the Ghana upstream petroleum environment (see 8.4.3).

The framework has been designed to provide key information that can help in enhancing policy and strategy/ planning for prioritising public sector capability improvement needs within Ghana's petroleum sector, for achieving environmental disaster risk minimisation. This (CIF) provides indicators to the critical areas of risks within the petroleum sector and the key capability mechanisms, ranked in order of priority, which public sector institutional bodies would need to consider and give crucial attention to (Table 8.1). In the final design stage of the CIF, the findings from the literature validation process and survey rankings have been synthesised to attain a conceptual pattern upon which the framework would be developed. Decision support and governance frameworks, take varying shapes and patterns; however they are designed to be as comprehensive as possible, yet simple within the perspective of relevant stakeholders, framework developers/adaptors, and finally end users (Mansourian, 2017). In designing the framework, a tabular structure which itemises the various identified risk factors and capability mechanisms in prioritised order, as deployed by Mahpour (2018), and reflective of CMMs (Jones, 2003; Mahamadu, 2017; Asah-Kissiedu, 2020), was pursued. This facilitated the presentation of prioritised mechanisms and their key descriptors, as well as institutional structures which were mapped onto the areas of risk management best suited or applicable to their constitutional mandates/ functional responsibilities (refer literature validation questionnaire, in appendix).

8.4.1 Preconceptual Design

Towards designing of the framework, the prioritised capability mechanisms (CIMs) were mapped onto the risk measures which required minimisation (RMIs), based on the number of times used within the systematic review of literature and how these capability measures were recommended as interventions for addressing the risk factors. In addition, the rated institutional sectors (according to their capability improvement needs), where mapped together onto the foregoing risk factor minimization indicators (RMIs), as proposed and validated in the literature validation process (Appendix A2, section C). The preconceptual design at this conceptual stage constituted the various risk factors and capability mechanisms aforementioned, howbeit, not arranged in any particular order.

A representation of the preconceptual design is indicated in Table 8.1. The prefix numbers (in box brackets) in column A and B show the ranked order of importance as scored by expert participants; while the suffixes in column B only, show the number of times the capability interventions were recommended within literature (*n=90*) towards addressing the underlying risk factors of petroleum disaster. The suffixes with (p) indicated in column 'B' represent the proposed capability mechanisms considered by researcher as apposite within the context of applicability and relevance for inclusion. The preconceptual design (Table 8.1), formed the outline for the formulation of the final validated Capability Improvement Framework, as expatiated below (8.4.2) and presented in Table 9.3

8.4.2 Formulation and Guide to Framework Design

The framework was segregated into 4 basic Columns, that is: A, B, C, D, as conceptualised in 8.4.1 (8.1), organised within Table 9.3 and validated in Table 9.2.

A) Column 'A' Components: Ranked Underlying Risk Factors that must be Minimised

This constitutes the underlying risk factors at the root of environmental disasters within the petroleum sector: which have been identified from a systematic review of literature (*n=90)* and validated by top industry experts (*n=12*). These have been ranked and prioritised by industry experts and key stakeholder professionals (*n=78*), from 1 - 12, in the main research survey. The prefixed numbers in box brackets placed before each risk factor, represents the ranked position; with the foremost number indicating the 'higher' order of importance or level of criticality scored by industry experts. E.g., the item 'Risk management shortcomings' has a prefix [1], representing the highest in importance (This ranking protocol is similar for the capability interventions (CIMs) in column B.

B) Column 'B' Components: Capability Improvement Mechanisms which must be Improved

This section represents the prioritized capability measures (16) that must be improved in order to minimise the risk factors in column A. The capability interventions (B) are to be deployed to address (A), as proposed or recommended from systematic review of literature. As in 'A' above, the prefixed numbers in box brackets, indicate the level of importance and priority to be attached, in order to address/ mitigate the risk factors itemised in 'A'. The 4 major categories under column B have been assigned from left to right, indicating the mechanisms rated higher in relative importance. It was identified from application of relative importance indices, employing SPSS version 27, that 'Governance' mechanisms formed the relatively higher rated interventions, followed by 'Managerial', 'Technical' and 'Operational' in descending order. These indicators align strongly with findings within the systematic review of literature (Chapter 6), with indicators on prevalence of 'Governance' mechanisms as key capability elements for addressing EDRs (*n=90).* The critical capability elements within Column B have therefore been arranged under the four major categorical functions, starting from ‘Governance’, ‘Managerial’, ‘Technical’, and ‘Operational’.

C) Column ‘C’ Components: Prioritised Institutional Sectors According to Levels of Improvement Requirement

This section represents the institutional structures envisaged as key bodies or agencies designated for oversight and operational implementation of required actions, based on the relevant constitutional charters and institutional mandates; as well as the nature of functions and capability attributes and mechanisms required. These institutional structures (not organisations) have been mapped onto functions/ roles (in column A and B) respectively, best suited to the institutional mandates and functions, and validated by expert participants. The institutions have been arranged according to the order of capability improvement needs (conducted by expert survey process), with the foremost institutions requiring greater levels of capability enhancement towards achieving the specific goal of environmental disaster risk minimisation (EDRM) For breakdown on mean values on descriptive statistics for each institutional sector capability improvement needs, see Table 7.7.

D) Column ‘D’ Components: Recommended Process/ Capability Improvement Tool

This column represents the reviewed/ proposed process for improvement and assessment of capability mechanisms. The Capability Maturity Model Integration (CMMI), a model for optimising capability development is proposed as a tested and robust means of institutional capability development (based on a critical review of various analogous mechanisms (chapter 4) highlighted in column D).

8.4.3 Operationalising of Framework

Operationalization of the framework can be undertaken in the following ways: For example; to address ‘Socio-environmental accountability gaps’ under column ‘A’ (ranked 3rd most important risk factor); the capability mechanisms of ‘Risk management’ (ranked 1st) followed by ‘Early Detection/Warning’ (ranked 2nd), then ‘Standards Monitoring/ Auditing’ (ranked 4th) and others in that prioritised format, would have to be considered pivotal for improvement and development within policy, strategy/ planning and evaluation, and deployed in prioritised manner within implementation processes to achieve goals of EDRM within Ghana’s petroleum sector. Consequently, governance institutions can be equipped to assess and and gauge capability levels based on the performance of institutions on these key elements of criticality as ranked and prioritised through expert stakeholders, within the CIF. The designated institutions under ‘C’ have the key roles of employing the proposed capability improvement mechanism under ‘D’ to attain the aim and ultimate goals (As indicated in Appendix A, beneath framework). Critical attention would be needed towards designing policies, strategies and related mechanisms, giving relative focus to institutions requiring greater capability improvement in descending order, of structures listed under column ‘C’ (from institutions requiring greater levels of improvement, to institutions with relatively lower levels of improvement requirement), as ordered/ ranked through expert stakeholder participants in the survey (*n=78*).

Table 8. 1: Preconceptual Design of Proposed CIF

A) GOALS **Underlying Risk Factors** **(to be minimised)**	B) **ACTIONS** **Capability Improvement Mechanisms**				**C) RESPONSIBILITY** **Institutional Bodies Identified**	**D) PROPOSED CAPABILTY DEVELOPMENT MODEL (CMMI)**
	GOVERNANCE	MANAGERIAL	TECHNICAL	OPERATIONAL		
[3] Socio-Environmental Accountability Gaps	**[3]** Legal and regulatory (2)	**[15]** Stakeholder management (4)	**[2]** Early Detection and Warning (2)	**[16]** Public involvement and education (5)	1. Petroleum Regulation Institutions 2. Environmental Regulatory Institutions 3. Maritime, Ports and Harbours Institutions 4 Local Government Institutions	
	[6] Governance institution development (3)	**[7]** Research (5)	**[8]** Decision support systems/ frameworks (1)			
	[10] Inter-organisational Cooperation (p)	**[1]** Risk management (4)				
[4] Governance System Gaps	**[4]** Standards monitoring and auditing (3)	**[15]** Stakeholder management (2)	**[2]** Early detection and warning (2)	**[13]** E. Preparedness Strategy (2)	1.Petroleum Regulation Institutions 2. Environmental Regulatory Institutions 3. Maritime, Ports and Harbours Institutions 4. Local Government Institutions	
	[3] Legal and regulatory (14)	**[7]** Research (6)	Technology adoption (8)			
	[6] Governance institution development (7)	**[5]** Human resource development (3)	**[8]** Decision support Systems/ frameworks (2)			

	[10] Inter-organizational cooperation (6)	**[1]** Risk management (3)			Standards Inspectorate Institutions	
[12] Sabotage, Vandalism and Terrorism	**[10]** Inter-organisational cooperation (p)	**[15]** Stakeholder management (3) [7] Research (2) [5] Human resource development (1) **[1]** Risk management (3)	**[2]** Early detection and warning (4) **[8]** Decision support systems/ frameworks (2)	**[13]** E. Preparedness Strategy (2) **[14]** Pre-emptive, Early and Rapid Action (PERA) (p)	1. Petroleum Regulation Institutions 2. Security and Enforcement Institutions 3. Maritime Ports and Harbours Institutions. 4. Local Government Institutions	
[1] Risk Management Shortcomings	**[4]** Standards monitoring and auditing (p)	**[7]** Research (4) **[1]** Risk management (14)	**[9]** Technology Adoption (3) [8] Decision support systems/ frameworks (10) **[2]** Early detection and warning (4) **[11]** Material resource management (1)	**[16]** Public Involvement and Education (2) **[14]** PERA (1)	1. Petroleum Regulation Institutions 2. Environmental Regulatory Institutions 3. Security and Enforcement Instutions. 4. Maritime, Ports and Harbours Institutions	
[6] Material Resource Management Shortcomings	**[10]** Inter-organisational cooperation (p)	**[5]** Human resource development (p)	**[9]** Technology adoption (3) [8] Decision Support systems/ frameworks (1)		1.Petroleum Regulation Institutions	

			(11) Material resource management (3) **[2]** Early detection and warning (2)		2. Emergency and Incident Response Institutions 3. Security and Enforcement Institutions	
[9] Management and Leadership Shortcomings	**[6]** Governance institution development (2)	[5] HR Development (6)	[8] DSS/ DSF(3)	[12] Training and Simulation (p)	1. Standards Inspectorate Institutions 2. Petroleum Regulation Institutions	
[7] Human Error	**[6]** Governance institution development (p)	**[7]** Research (4) **[5]** HR Development (6)	**[9]** Technology adoption (5) [8] DSS/ DSF (3) [2] Early detection and Warning (p)		1. Petroleum Regulation Institutions.	
[8] Technical Capability Gaps	**[6]** Governance institution development (1) **[4]** Standards monitoring and audit (4) **[10]** Inter-organisational cooperation (p)	**[7]** Research (2) **[5]** HR Development (3)	**[9]** Technology adoption (5) **[8]** DSS/ DSF (2)		1. Standards Inspectorate Institutions 2. Petroleum Regulation Institutions.	
[11] Equipment Failure	**[4]** Standards monitoring and auditing (5)	[7] Research (2)	**[9]** Technology adoption (5)	**[16]** Public involvement and education (1)	1. Standards Inspectorate Institutions	

	[10] Inter-organisational cooperation (p)	**[6]** HR Development (2)	[8] DSS/ DSF (4)	[**13**] Emergency preparedness strategy (1)	2. Petroleum Regulation Institutions 3. Security and Enforcement Institutions	
			[2] Early Detection and Warning (2)	[**14**] PERA (2)		
[2] Preparedness Planning Shortcomings	**[10]** Inter-organizational Cooperation (2)	**[6]** HR development (p)	**[8]** DSS/ DSF (2)	**[13]** E. Preparedness Strategy (5)	1. Petroleum Regulation Institutions. 2. Environmental Regulatory Institutions 3. Emergency and Incident Management Institutions. 4. Security and Enforcement Institutions .5. Local Government Inst.	
			[2] Early detection and warning (p)	[14] PERA (3)		
				[12] Training and Simulation (4)		
[5] Delayed Action and Response to Threats	**[10]** Inter-organisational cooperation (p)		**[2]** Early detection and warning (3)	**[14]** PERA (2)	1. Petroleum Regulation Institutions 2. Environmental Regulatory Institutions 3. Emergency and Incident Management Institutions 4. Security and Enforcement Institutions	
			[8] DSS/ DSF (2)	**[12]** Training and simulation (2)		

					5. Local Government Institutions	
[10] Operational Risk Taking Flaws	**[6]** Governance institution development (2)	**[15]** Stakeholder management (1)	**[8]** DSF/ DSS (1)		1. Standards Inspectorate Institutions. 2. Petroleum Regulation Institutions 3. Environmental Regulatory Institutions	
	[10] Inter-organizational cooperation (1)	**[7]** Research (1)				
	[3] Legal and regulatory (1)	**[1]** Risk management (2)	**[9]** Technology adoption (2)			
	[4] Standards monitoring and auditing (3)					

8.5 CHAPTER SUMMARY

Findings from knowledge synthesis within this study, have been discussed and evaluated in the light of evolving knowledge from academic and industrial domains; upon which the Capability Improvement Framework has been proposed. Considering the methodological richness deployed and clear, scientific process of investigation towards arriving at findings for establishing the CIF, it is therefore viewed as having fulfilled the basic criteria and requirements for attaining internal validity. The CIF (See Table 9.3) is therefore presented for external validation to complement the research requirement process.

CHAPTER 9 VALIDATION PROCESSES

9.0 INTRODUCTION

This section provides the fundamental principles and processes culminating to the valdation of the proposed Capability Improvement Framework (CIF). Varying approaches to validation of research undertakings have been critically considered, towards ensuring validity, reliability and acceptability of findings from this study.

9.1 VALIDATION PRINCIPLES

The concept of validation has been defined differently by researchers and academic writers in varying ways; however, the generality of definitions identify with, a process of measuring the objectives/ aims of the research against the outcomes. While acknowledged that there is no unitary way to define validation, the concept considers critically, the methodologies employed by the researcher in attaining the aims and outcomes of the research (Winter, 2000). Validation has been defined by Kennedy *et al.* (2005) as a process by which the confidence in and reliability of research findings, frameworks or models are enhanced, thus making them more acceptable and useable. Validity ascertains whether the research measures what it actually intends to measure or how realisable the research results are within the context of the aim of study (Golafshani, 2003). The quality of a qualitative research is measured by the validity of the findings of the research (Egbu, 2007). In validating a research project, some major areas which ought to be critically assessed are value, correspondence and robustness. Value deals with the worthiness or usefulness of the research, while correspondence is the degree to which the features and patterns of relations in the various stages of the research process fit together. Whereas robustness, considers the strenghth, validity and philosophical principles, as congruent and impactful.

There are different kinds of validity ranging from internal validity, external validity, construct validity, content validity and some other types of validity (Winter, 2000; Golafshani, 2003). The two major ones that are commonly used in research are the external and internal techniques (Ahadzie, 2007; Ankrah, 2007; Al-Zahrani, 2013). External validity is done through the consistency of the empirical findings through replication and convergence. Internal consistency, Effectiveness, testability and adaptability could be ascertained within the conceptual framework and process of establishing validity of outcomes; whereas for the methodological phase it would be expected that explicitness and effectiveness would manifest in synthesis of theory, knowledge and clear linkages of objectives to findings/ outcomes. Within the empirical domain, it can be expected that, the research would be useful or relevant in terms of any potential practical application (Kennedy *et al.*, 2005).

9.1.1 Internal and External Validity

- **Internal Validity**: This represents the process for determining the extent of bias in research, through the aim and objectives and the relevance of methods employed, in attaining goals (Fellows and Liu, 2008). Assessment of internal validity was pursued through evaluation existing knowledge and comparison of findings within the process of this study, towards attaining the eventual findings and design of framework. Synthesis of knowledge was via a systematic literature review within the cross-sectional body of petroleum disaster and related literature (Chapters 2,3,4, and 6). Through cross-referencing and citing of analogous findings from existing body of knowledge/ published academic works, demonstration of convergence was established (Silverman, 2006). According to De Vaus (2002) discussions which evaluate and draw insights from previously published work is considered a pivotal process towards demonstrating internal validity. In this regard, it can be evidenced that discussions (Chapter 8) show appreciable levels of convergence of study design/ outcomes regarding the tangent of evolving disaster theory, as well as petroleum disaster literature, within the context of environmental governance. Additionally, the establishment of the CIF and outcomes towards recommendations, are in synthesis with the entire preceding phases of the research.

- **External Validity**: External validity represents the level to which findings from a study corresponds with the outlined aim and objectives; and their applicability can be justified within generalised settings, considering some variations in settings, to attain fairly replicable or predictable outcomes (Silverman, 2006; Hu *et al.,* 2016). External validation serves to establish and enhance reliability and acceptability of the research, thus broadening the user interface. Replication, boundary search and convergence analysis are the 3 main criteria for validation processes. Boundary search and replication involves time consuming challenges as well as heavy financial considerations (Rosenthal and and Rosnow, 1991): given the limited amount of time and funding available within postgraduate research activities, these methods are less recommended and rarely employed within PhD studies (Bashir, 2013; Mahamadu, 2017; Asah-Kissiedu, 2020). Convergence analyses however constitutes the employment of varying forms of techniques and procedures, that could involve experiments, case studies, consensus group activities among others (Denzin, 2009). A valuable means of validation via convergence analysis, used widely in research, is by deployment of 'respondent validation' which involves employment of stakeholder participants within the research process (Silverman, 2006, Cresswell, 2014). Respondent validation is deemed characteristic of sound and effective research procedure, therefore, has been adopted for undertaking of some built environment studies (Manu, 2012; Mahamadu, 2017; Osei-Kyei, 2017; Asah-Kissiedu, 2020). This approach was therefore employed for validation processes of this study, through the use of expert stakeholder professionals, and end user officials operating within the petroleum and disaster management sectors of Ghana. The validation process was conducted to access views on, and ascertain the usefulness of the CIF developed from findings within this study. Additionally, validation was undertaken to ascertain the clarity/ understandability, as well as ease of use, and adaptability of the CIF, within the domain of end user institutions and agencies. This process constituted a critical component of the research, towards establishing the relevance and impact of the CIF, as projected in objective 5 and Table 5.2.

9.1.2 Methodological Pluralism and Impact on Validity

Methodological pluralism underpinned by the pragmatism philosophy has been contended as means of consolidating methodological validity and boosting potential for reliability and acceptability (Venkatesh and Brown, 2013). The pursuit of a sequential multiphase exploratory approach towards attaining research objectives and findings, has served to strengthen the methodological constructs employed in this study and to enrich a triangulation process for broader reliability and acceptability. The employment of mixed and multi-methods in research methodology though not emphatically contended as superior to other singular strategies, is considered a pivotal approach to enhancing robustness, reliability and validity of research outcomes; as the shortcomings with employment of unitary strategies are mitigated through deployment of complementary methods of triangulation (Mackenzie and Knipe, 2006; Easterby-Smith *et al.,* 2012).

9.1.3 Deployment of Seven-point Likert Scale Towards Robustness/ Validity

The seven-point Likert scale has supported and injected methodological richness and depth via widening the scope of expression for assessment of constructs, juxtaposed to studies undertaken by employing the five-point Likert scale or dichotomous measures (Asah-Kissiedu, 2020; Cheng *et al.,* 2021). Furthermore, the employment of higher numerical value Likert scales, e.g. 7 – 12 points, have been advocated as means of establishing ‘continuise’, which reciprocally bears reflection of interval scales within arguably ‘ordinal’ measures of Likert scales (Knapp, 1990; Hodge and Gillespie, 2007). The greater ‘quantitized’ values attained through the deployment of seven-point scale can be considered appreciably representative of a more valid bearing on a wider range of choices, made by the expert participants.

9.1.4 Approach/ Technique for Validation

Some generic standard research validation methods were considered, including congruent types as:

(a) Focus group: focus group means of data collection (as expatiated in methodology), was considered as a pivotal tool, enabling rigorous but rewarding generation of rich information, especially, where participants are able to arrive at converging conclusions. The target participant category, was top executive i.e. CEOs and or key experts and recognised officials of the major stakeholder/user institutions highlighted within the CIF. Such top-level officials, especially within Government institutions can be quite difficult to gain access to, let alone get them to agree to meet in a live or virtual focus group forum, though that feasibility could have been pivotal to validation the process. A live forum was rather impractible, considering 'covid 19' protocols, and the heavy/ conflicting work schedules of entities targeted did not likewise facilitate a timeous online forum. Though a virtual meeting would have served in this direction, allowing for exhaustive discussion of the CIF: however, for key reasons highlighted beforehand, this consideration was shelved considering time limitations .

(b) Interviews (face to face/ online), were considered as alternatively impactful means, as they were likewise relatively less time consuming, provided the professional calibre and status of targeted resource persons could be accessed and agree to participate. Live Interviews enable a faster turn-around of communication and optimises the capacity for greater dimension of expression as well as heighten value of qualitative inputs (Cresswell, 2014; Saunders *et al*., 2016). Some pilot procedures to such targeted institutional officials (with the study background and sample validation questions) to test their preparedness/ availability to grant interviews were made within relevant stakeholder institutions. As reflected in the case of focus group, it proved quite challenging to gain access to relevant officials/ resource persons, though 3 of these (out of 15), who were finally accessed, showed some interest in supporting the process. The wider affirmation on agreeing to an interview appeared rather futile. It was however forthcoming that, some responses through email (from target participants) within the convenient timing of these persons, appeared to be their preferred way of interacting.

(c) Since the preceding data collection method via survey, was thorough and authoritative (considering the status of participants: *n=78*; and having yielded robust findings upon which the CIF was constructed), it was rational to provide for a fairly qualitative means of validation, that would enable some amount of qualitative choices through complementary unstructured information exchange and also, ability to make liberal inputs without having to fit necessarily into predefined/ digitized choices, e.g. Likert scale scores, etc. Additionally, considering the preference of officials for email correspondence within a liberal time frame during the pilot validation interview exercise, Written Interviews were projected as the more viable and impactful means of a validation process for the CIF from this study.

9.2 SELECTION OF VALIDATION PARTICIPANTS

Towards recruitment of validation participants, consideration was given to the major end user institutional sectors/ organisations, and key stakeholders. The targeted institutional sectors already projected and deployed within the survey process (Refer to the 7 key institutional sectors assessed for capability improvement requirements: column C of framework). These were complemented with inputs from relevant stakeholder bodies such as deployed in the literature validation process (5.9.3); these include petroleum companies, petroleum consultancy bodies and expert academics in the subject area. A similar range, in terms of quantum of validators (10) has been deployed impactfully by Olusola (2019) in a recent doctoral thesis. The qualifying criteria for participation was similar to the process deployed within the pilot literature verification/ validation process (5.9.3). Steps were taken to ensure participants involved in the expert survey process were not involved in the validation of framework, in order to maintain neutrality, and avoid bias towards findings/ framework. In all 10 invitations via email in the form of written interviews were sent to participating organisations, primarily through the heads of institutions, such as chief executive officer (CEO), Human Resource Manager, Administrative officer, among others (See breakdown of invitations and responses: Table 9.2).

9.2.1 Validation Findings

From the 10 written interview forms sent out to participating bodies, 8 were returned with completed answers/ inputs. (See participants background and returned responses in Table 9.1). The written interview process provided means of seeking clarifications on areas not clear in terms of questions asked by researcher, and also responses made by participants. For some participants, responses were provided outright with minimal or no enquiries for clarifications and or follow up questioning. For 2 participants, some suggestions or queries were made, and clarifications, explanations as well as revision of inputs were provided, where needed (see 9.2.2 for the qualitative responses and inputs from participants). In totality, all 8 expert validators agreed in principle with, and endorsed the usefulness, clarity as well as the adaptability of the CIF largely.

Table 9. 1 Validation Process Responses

ID NO.	VALIDATION RESPONSES					
	Institution	**Profession/ Area of Expertise**	**Position in Organisation**	**Experience**	**Qualification/ Professional Qualification**	**Answers/ Comments**
FV001	Ghana Petroleum Commission	Health, Safety and Environment/Petroleum Engineering	Seniour Officer	8 Years	MSc. Engineering in Coastal Environment	Ques. 1 Yes Ques. 2 (a)Yes; Ques. 2 (b) Yes Ques.3 Yes Ques. 4 Recommended Supplementary institutions inset Ques. 5. N/A
FV002	Ghana Standards Authority	Petroleum Engineer	Assistant Petroleum Engineer	13 Years	MSc Petroleum Engineering	Ques. 1 Yes Ques. 2 (a) Yes; Ques. 2 (b) Yes Ques. 3 Yes Ques. 4 N/A Ques. 5 N/A
FV003	PENAf (Ports Environmental Network-Africa)	Consultant/ Port Environmental Sustainability Politics	Executive Coordinator	32 Years	PhD Port Environment	Ques. 1 Yes Ques. 2 (a) Yes; Ques 2 (b) Needs testing first Ques. 3 When proven adaptable Q4 N/A Q5 Comments as indicated below
FV004	Environmental Protection Authority	Engineer/ Geoscience and Environment	Assistant Director	15 Years		Q1 Yes Q2 (a) Yes; Q2 (b) Yes Q3 Yes Q4 Q5
FV005	Ghana National Fire and Rescue Service	Safety Officer/ Environmental, Health and Safety	Divisional Officer	21 Years	MSc. Environmental Health and Safety	Q1 Yes Q2 (a) Yes; Q2 (b) Yes Q3 Yes Q4 N/A Q5 N/A
FV006	Trident Energy company	Engineer/ Mining and Energy	Executive Director	19 Years	PhD Extractive Resource Management	Q1 Yes Q2 (a) Yes; Q2 (b) Yes Q3 Yes Q4 N/A Q5N/A
FV007	Local Government Service	Administrative Manager/ Local Government	Deputy Director	15 Years	Master Of Business Administration – Oil and Gas	Q1 Yes Q2 (a) Yes; Q2 (b) Yes Q3 Yes Q4 N/A Q5 N/A
FV008	University of Ghana	Lecturer and Research Fellow/ Renewable Energy	Senior Lecturer	25	PhD Renewable Energy and Sustainability	Q1 Yes Q2 (a) Yes; Q2 (b) Yes Q3 Yes Q4 Recommended Supplementary Institutions inset Q5 N/A

Table 9. 2: Breakdown of Validation Responses

Validation Response Metrics			
Response Rate	8 /10 = 80%		
Usefulness and Effectiveness of CIF	8 /8 = 100%		
Clarity and Ease of understanding CIF	8 /8 = 100%		
Adaptability	7 /8 = 88%		
Recommendability	7 /8 = 88%		
Academic Background	PHD (3/8)	38%	
	Masters	62%	
	Others	NIL	
Mean Work Experience	148 / 8	19 Years Average	

9.2.2 Responses to Validation Unstructured Questions

Regarding responses made for unstructured questions, which provided access for participants to make any queries, objections or recommendations towards improving the framework (CIF), the following comments and inputs were derived:

(i) Response from FV001: Respondent FV001 recommended the inclusion of (i) 'academic institutions' and also (ii) 'petroleum companies' within the institutional structures assigned for addressing 'Governance System Gaps' and 'Human Error' and 'Technical Capability Gaps' respectively, under column C. Considering the key roles that such institutions play and the potential for enhanced impact on operationalising of the framework, the recommended institutions have been inserted as supplementary bodies within the framework in non-ranked order (as these were not scored in the survey for capability improvement requirements). Consideration was further given to the suggestions made within the literature validation process for inclusion of academic institutions towards addressing 'Human Error'. Also, it is viewed petroleum companies, as major stakeholders, can play strategic/ complementary roles in the area of peer monitoring/ best practice standardisation, technology transfer and development of regulatory systems. With regard to the foregoing, though petroleum companies do not fall within the structure of public sector institutions (Ghana Government), they have been inserted as a supplementary institutional body together with educational institutions in the appropriate column (C) of the framework, due to complementary roles assumed.

(ii) Response from FV003: Respondent FV003 in responding to Question 1 and 2a indicated approval/ usefulness of the framework: however, for question 2b ('Is the framework Simple and easy to adapt?') , participant indicated that 'framework needs testing'. Follow up communication was made to validator (FV003) acknowledging the idealness of his remark, with additional remarks that, 'like most frameworks, there may be need to adapt or modify within a requisite context; therefore, though testing of frameworks before attaining broader acceptance may be ideal, this wasn't always practicable'. The participant was reminded, frameworks were not absolute finished work, as already known to him and therefore the need to accept for adaptation was crucial. This follow-up appraisal was likewise made in relation to Question 3, as it follows in the same spirit and was subsequent to question 2b. The participant FV003 was unavailable to provide further comments: therefore, the comment made on the need to test framework is subsequently considered as pivotal for consideration within the recommendations section.

Respondent FV003, also queried, why organisations under column C were not 'identified by name specifically, E.g. Security and Enforcement Institutions could have been specified with direct names, such as Police, etc., rather than generic structures'. It was explained in follow-up communication that, specific organisations were not named, during the expert survey, to avoid plausible/ potential biases; therefore, institutional sectors or systems rather than specific organisations where sampled. Whereas specifying organisations for needs based ranking by name, could have made the bodies under column C, more distinct, specific and somewhat simpler, this could also have widened the range of unitary organisational bodies expected to be scored/ ranked for capability improvement needs. It was re-iterated, the study sought to sample and rank capability needs base of 'Over-arching institutional structures and sectors; and as representative as these were ranked within the survey, it was deemed prudent to present them in the framework as indicated by expert participant ranking, rather than the sub-organisations. It was considered also, just as in the USA, and Norwegian context, the EPA was just one among several agencies, responsible for petroleum environmental governance (Maiteland, 2020): it would invariably be imprudent to consider for example, that Ghana's EPA is the sole environmental management body for this sector. When adapting the model, the developer or user could specify e.g., Security institutions as 'Navy' 'Police' etc. and Emergency/ incident response as NADMO, Fire Service etc.

Table 9. 3: Framework for Environmental Disaster Risk Minimisation: Ghana Petroleum Sector

<table>
<tr>
<th rowspan="2">A) GOAL
Ranked Underlying Disaster Risk Factors to be Minimised</th>
<th colspan="4">B) ACTION
Prioritised Capability Mechanisms to be Improved</th>
<th rowspan="2">C) RESPONSIBILITY
Institutional Sectors, Indicated According to Levels of Capability Improvement needs</th>
<th rowspan="2" colspan="2">D) PROCESS
Proposed Capability Development Process- (*CMMI*)</th>
</tr>
<tr>
<th>GOVERNANCE Mechanisms</th>
<th>MANAGERIAL Mechanisms</th>
<th>TECHNICAL Mechanisms</th>
<th>OPERATIONAL Mechanisms</th>
</tr>
<tr>
<td rowspan="3">**[1] Risk Management Shortcomings**
(Deficiencies, gaps, errors/ incongruence in risk assessment and management systems etc.)</td>
<td rowspan="3">**[4] Standards Monitoring and Auditing**.
(Monitoring, inspection, auditing and certification of industry infrastructure, operational and management statutory standard systems: including third party auditing mechanisms)</td>
<td rowspan="2">**[1] Risk Management**
(Involves environmental and disaster risk assessment; vulnerability assessment; internal and external risk governance capacity/ capability assessment, insurance planning and related management measures; put in place to preempt or minimize risks)</td>
<td rowspan="2">**[2] Early Detection and Warning Mechanisms**
(Provision and management of early detection, early information/ warning mechanisms: including such as, Geographic Information Systems (GIS), whistle blowing/ cyber threat detection among other such measures.)</td>
<td rowspan="3">**[14] Pre-emptive, Early and Rapid Action *(PERA)***
(Measures in place for pre-empting risks: including disincentive towards risk taking and non- compliance; measures deterrent towards sabotage/ terrorism and vandalism; early action to repel or contain high probability hazards; rapid coordinated action to ensure occurring or threatening incidents do not escalate into disaster)</td>
<td>1. Standards Inspectorate Institutions</td>
<td rowspan="3">1) The Capability Maturity Model Integration, (CMMI) is proposed as a relatively robust/ versatile performance assessment and improvement tool for</td>
<td rowspan="3">2) Other models of capability performance improvement methods assessed include: LEAN, SIX-IGMA, TQM, ISO Models.</td>
</tr>
<tr>
<td>2. Petroleum Regulation Institutions</td>
</tr>
<tr>
<td>**[5] Human Resource (HR) Development**
(Includes efficient and effective management and</td>
<td>**[8] Decision Support Systems and Frameworks**
(Provision and application of</td>
<td>3. Environmental Regulatory Institutions</td>
</tr>
</table>

		development of human resource base/ capacity in DRM, particularly in the aspect of petroleum risk management)	*decision/ management support mechanisms, such as expert systems, decision support frameworks etc.)*		4. Security and Enforcement Institutions		
		[7] Research *(Research and documentation on environmental disaster and risk reduction, particularly in the field and context of petroleum related disaster)*	**[9] Technology Adoption** *(Capacity and ability to evolve, adopt or adjust to improved/ best practice technology, industry technique and practice)*	**[16] Public Involvement and Education** *(Inclusion/ integrating/ involving stakeholder public, especially local communities/ authority in industry strategies and operations which have environmental risks; and undertaking periodic educational/ sensitization fora etc.)*	5. Maritime, Ports and Harbours Institutions		
			[11] Material Resource Management *(Provision and management of physical resources towards pre-empting incidents or containing/ controlling incidents from escalating into a disaster, including protection equipment e.g., auto fire suppressors, spill booms, etc.)*				
[2] Emergency Preparedness Planning Gaps *(Deficiencies in emergency/ preparedness*	**[10] Inter-organizational Cooperation** *(Capacity/ ability to cooperate, coordinate etc. with allied governance agencies to complement*	**[5] HR development** *(Includes efficient and effective management and development of human resource base and capacity in DRM,*	**[2] Early detection and warning Mechanisms.** *(Provision and operation of early*	**[12] Training and Simulation** *(Developing and undertaking relevant/ regulated training and simulation modules; periodically revising*	1. Petroleum Regulation Institutions	*(Same As above)*	*(Same As above)*

strategy towards threatening incidents)	*capability or build synergies locally and internationally, in the area of risk minimization)*	*particularly in the aspect of petroleum)*	*detection, early information/ warning mechanisms: including such as, Geographic Information Systems (GIS), whistle blowing/ cyber threat detection among other such measures)*	*and updating statutory training in line with emergency preparedness planning and evolving risk conditions)*	2. Environmental Regulatory Institutions		
			[8] Decision Support Systems and Frameworks (*Provision and application of decision and management support mechanisms, such as expert systems, decision support frameworks etc.*)	**[13] Emergency Preparedness Strategy** *(Ensuring preparedness strategies, plans and programs are in place, and periodically reviewing, revising/ developing these strategies)*	3. Emergency and Incident Management Institutions		
					4. Security and Enforcement Institutions		
				[14] PERA *(Same As above)*	5. Local Government Institutions		
[3] Socio-environmental Accountability Gaps *(Neglect, insensitivity, noncooperation towards socio-environmental concerns)*	**[3] Legal and regulatory Systems** *(Provision and administration of laws, regulations, guidelines, enforcement, etc. governing the industry and operators)*	**[1] Risk Management** *(Environmental and disaster risk assessment; vulnerability assessment; internal and external risk governance capacity/ capability assessment, insurance planning and related management measures)*	**[2] Early Detection and Warning Mechanisms** *(Same As above)*	**[16] Public Involvement and Education** *(Same As above)*	1. Petroleum Regulation Institutions	(Same as Above)	(Same as Above)
					2. Environmental Regulatory Institutions		

	[6] Governance Institution Development *(Capacity/ ability i.e. mechanaisms in place towards evolvement, improvement, restructuring governance institution and systems)*	**[7] Research** *(Same As above)*	**[8] Decision support Systems and Frameworks** *(Same As above)*		3. Maritime, Ports and Harbours Institutions		
	[10] Inter-organisational Cooperation *(Same As above)*	**[15] Stakeholder Management** *(Identification and management of various stakeholders complementary to interorganizational cooperation/ coordination mechanisms)*			4 Local Government Institutions		
[4] Governance System Gaps *(Including shortcomings and gaps in laws, regulations, enforcement etc.)*	**[3] Legal and Regulatory Systems** *(Same as above)*	**[1] Risk management** *(Same as above)*	**[2] Early Detection and Warning Mechanisms** *(Same as above)*	**[13] Emergency Preparedness Strategy** *(Same as above)*	1.Petroleum Regulation Institutions		
	[4] Standards Monitoring and Auditing *(Same as above)*	**[5] Human resource Development** *(Same as above)*	**[8] Decision support Systems and Frameworks** *(Same as above)*		2. Environmental Regulatory Institutions		
	[6] Governance Institution development *(Same as above)*	**[7] Research** *(Same as above)*	**[9] Technology Adoption** *(Same as above)*		3. Maritime, Ports and Harbours Institutions		
					4. Local Government Institutions		

	[10] Inter-organizational cooperation *(Same as above)*	**[15] Stakeholder Management** *(Same as above)*			5. Academic Institutions (S)		
[5] Delayed Action and Response to Threats *(Negligence, inattention, delay towards threatening conditions, risks, triggering incidents etc.)*	**[10] Inter-organisational cooperation** *(Same As above)*		**[2] Early Detection and Warning Mechanisms.** *(Same as above)* **[8] Decision Support Systems and Frameworks** *(Same as above)*	**[12] Training and Simulation** *(Same as above)* **[14] PERA** *(Same as above)*	1. Petroleum Regulation Institutions 2. Environmental Regulatory Institutions 3. Emergency and Incident Management Institutions 4. Security and Enforcement Institutions 5. Local Government Institutions		
[6] Material Resource Management Shortcomings *(Deficiencies in provision of basic safety, protective, early detection/ suppression, and emergency response equipment etc.)*	**[10] Inter-organisational cooperation** *(Same as above)*	**[5] Human resource development** *(Same as above)*	**[2] Early Detection and Warning Mechanisms** *(Same as above)* **[8] Decision Support Systems and Frameworks** *(Same as above)* **[9] Technology Adoption** *(Same as above)*		1. Standards Inspectorate Institutions 2.Petroleum Regulion Institutions 3. Emergency and Incident Management Institutions		

			(11) Material Resource Management *(Same as above)*		4. Security and Enforcement Institutions		
[7] Human Error *(e.g., negligence, uncalculated risk taking, misjudgment of risk conditions etc.)*	**[6] Governance institution development** *(Same as above)*	**[5] HR Development** *(Same as above)*	**[2] Early Detection and Warning Mechanisms.** *(Same as above)*		1. Petroleum Regulation Institutions.		
			[8] Decision Support Systems and Frameworks *(Same as above)*		2. Petroleum Companies (S)		
		[7] Research *(Same as above)*	**[9] Technology Adoption** *(Same as above)*		3. Educational Institutions (S)		
[8] Technical Capability Gaps *(E.g., Defective, outmoded, incongruent technology/ technique, skills etc.)*	**[4] Standards Monitoring and Auditing** *(Same as above)*	**[5] HR Development** *(Same as above)*	**[8] Decision Support Systems and Frameworks** *(Same as above)*		1. Standards Inspectorate Institutions		
	[6] Governance Institution Development *(Same as above)*	**[7] Research** *(Same as above)*	**[9] Technology Adoption** *(Same as above)*		2. Petroleum Regulatory Institutions		
	[10] Inter-organisational cooperation *(Same as above)*				3. Educational Institutions (S)		
[9] Management and Leadership Shortcomings	**[6] Governance Institution Development** *(Same as above)*	**[5] HR Development** *(Same as above)*	**[8] Decision Support Systems and Frameworks** *(Same as above)*	**[12] Training and Simulation** *(Same as above)*	1. Standards Inspectorate Institutions.		

(General weaknesses, incompetence, and shortcomings of managerial/ leadership capability etc.)					2. Petroleum Regulation Institutions		
[10] Operational Risk Taking Flaws (*E.g. Risky cost cutting measures; hydraulic fracturing in geologically sensitive locations etc.*)	**[3] Legal and Regulatory Systems** *(Same as above)*	**[1] Risk management** *(Same as above)*	**[8] Decision Support Systems and Frameworks** *(Same as above)*		1. Standards Inspectorate Inspections.		
	[4] Standards Monitoring and Auditing *(Same as above)*	**[7] Research** *(Same as above)*	**[9] Technology Adoption** *(Same as above)*		2. Petroleum Regulation Institutions		
	[6] Governance Institution Development *(Same as above)*	**[15] Stakeholder Management** *(Same as above)*			3. Environmental Regulatory Institutions		
	[10] Inter-organizational Cooperation *(Same as above)*				Petroleum Companies (S)		
[11] Structural/ Equipment Failure *(Machinery breakdown, systems failures, equipment/ structural collapse etc. leading to loss of containment, spillage, explosions & related hazards)*	**[4] Standards Monitoring and Auditing** *(Same as above)*	**[6] HR Development** *(Same as above)*	**[2] Early Detection and Warning Mechanisms** *(Same as above)*	**[13] Emergency Preparedness Strategy** *(Same as above)*	1. Standards Inspectorate Institutions		
			[8] Decision Support Systems and Frameworks *(Same as above)*	**[14] PERA** *(Same as above)*	2. Petroleum Regulation Institutions		
	[10] Inter-organisational Cooperation *(Same as above)*	**[7] Research** *(Same as above)*	**[9] Technology Adoption** *(Same as above)*	**[16] Public Involvement and Education** *(Same as above)*	3. Security and Enforcement Institutions		

[12] Sabotage Vandalism and Terrorism *(Adverse, hostile actions of aggrieved/ opposing parties on infrastructure, operations etc.)*	**[10] Inter-organisational Cooperation** *(Same as above)*	**[1] Risk management** *(Same as above)*	**[2] Early Detection and Warning Mechanisms.** *(Same as above)*	**[13] Emergency Preparedness Strategy** *(Same as above)*	1. Petroleum Regulation Institutions		
		[5] HR Development *(Same as above)*			2. Emergency and Incident management Institutions		
		[7] Research *(Same as above)*	**[8] Decision support systems and Frameworks** *(Same as above)*	**[14] Pre-emptive, Early & Rapid** Action *(PERA)* *(Same as above)*	3. Security and Enforcement Institutions		
		[15] Stakeholder Management *(Same as above)*			4. Maritime, Ports and Harbours Institutions.		
					4. Local Government Institutions		

INTEGRAL GOAL OF THE CAPABILITY IMPROVEMENT FRAMEWORK (CIF)

MINIMISATION OF DISASTER MEDIUMS/ TRIGGERS *(Expert survey rated in sequential order of attainability)*	1. Fire and Explosions; 2. Pipeline Rapture/ Vandalism; 3. Hydrocarbon Releases; 4. Chemical Discharges; 5. Rig Structural Failure; 6. Well-blowout; 7. Helicopter/ Marine Vessel Accidents
GOAL: PRE-EMPTION/ MINIMISATION OF ENVIRONMENTAL IMPACTS	*Damage to Marine Ecology; Habitat Damage; Effect on Surrounding Vegetation and Drinking Water; Loss of Human Life; General Environmental Impacts; Pollution, Etc.*

9.3 CHAPTER SUMMARY

Based on the foregoing written interview process, responses, queries, clarifications and reviewed inputs etc., the CIF (Table 9.3) is concluded as validated, from the broad acceptance of the usefulness, adaptability and potential impact of this research outcome.

CHAPTER 10 CONCLUSIONS AND RECOMMENDATIONS

10.0 INTRODUCTION

In this final chapter, the conclusions that integrate findings from the study is incorporated and presented hereby. Conclusions drawn and presented herein, have been made with regard to the aim and objectives of the study, as outlined beforehand, to establish convergence, reliability and validity. Also, in this chapter, the contribution to knowledge from the research findings; applicability and impact of the CIF, as well as recommendations for governance policy development is presented. Some ramifications on findings from this study, together with limitations of the research have been presented as recommendations, to guide future related research.

10.1 REVIEW OF THE RESEARCH OBJECTIVES

The limitedness of adaptable and tailor-made frameworks for achievement and assessment of disaster risk reduction objectives as envisaged within the SFDRR, has been a critical challenge for many countries, particularly within the socio-technological domains, such as mining and energy production (Al-Qahtani, 2015; Juanzon and Oreta, 2018). It is identified that public sector institutions within the developing world, such as Ghana are confronted with current and potential challenges with respect to managing environmental disaster from the root factor perspective, as evidenced for instance within the nation's mining sector (Mayorga-Alba, 2010; Obeng-Odoom, 2018). The establishment of this framework (CIF) is therefore seen as pivotal towards addressing such challenges within Ghana's petroleum sector, based on the outcomes of having accomplished the following objectives.

The study is aimed at establishing a framework for prioritizing mechanisms towards improving public sector institutional capability/ capacity for minimizing environmental disaster risks within the petroleum sector of Ghana. This has been accomplished through meeting the following objectives:

- ***Objective 1.*** *Evaluating the theories, and concepts that underpin DRR, towards identifying existing models and concepts that bear impactful relationship to achieving the aim of the study.*

  The linkage and synthesis of existing knowledge and theory with research methodological processess, discussions and findings, is seen as a vital ingredient in attaining robust more widely acceptable outcomes (Winter, 2000; DeVaus, 2001). Chapter 1 has projected the key gaps and challenges to be addressed; while Chapter 2 (generic review of literature), Chapter 3 (review of existing governance frameworks/ mechanisms), and sections of the methodology chapter of this study, has fulfilled this objective, and brought to the fore, vital constructs which guided and informed the basic design of methods and approaches, as well as guided the discussion of varying perspectives/ arguments within the study, towards attaining the projected capability improvement framework (CIF) and recommendations (See 10.5: Contribution to knowledge for added impact and expatiation).

- **Objective 2**. *Reviewing of existing frameworks, approaches, and strategies for capacity/ capability improvement.*

  While forming an integral part of the random review of literature, this undertaking, is seen as pivotal, as this section brought into discussion crucial perspective on existing global best practice systems and adaptable frameworks/ strategies which have been considered and factored where appropriate within the CIF; and further, towards recommendations outlined. Similar approaches have been pursued effectively within studies on the natural and built environment by Mahamadu (2016), Assah-Kissiedu (2020), Jones (2003), among others. This objective has been pursued and attained within chapters 3 and 4 respectively. In this regard, the Capability Maturity Model Integration (CMMI) has been identified and proposed as the more viable means of evolving the capabity improvement mechanisms, identified and prioritized within this study. Suggestions and recommendations have been outlined for the petroleum sector of Ghana, based on the reviews (Chapter 2, 3, and 4), by way of a more custom made and impactful system of governance for environmental sustainability

- **Objective 3**. *Reviewing the literature to identify (i) key underlying disaster risk factors (that is, the root cause of incidents that engender environmental disaster), and (ii) Capability Improvement Mechanisms (CIM) for addressing EDRs within the petroleum sector.*

  This undertaking, represented a major component of the methodological process of data collection for the study, which led to findings on key components of the CIF conducted within this study. It was identified within the review processs that, a considerable number of disaster literature within the petroleum industry exists within the academic domain, however relatively lower quantum of attention was directed at researching root factors underlying disaster incident causation, such as undertaken by Agyekum-Mensah *et al.,* (2017). Furthermore, relatively lower number of studies reflected prevalent risk factors/ threatening conditions which are commonplace within Sub-Saharan Africa (Oke *et al.,* 2006; Hovik, *et al.,* 2009; Aroh *et al.,* 2010; Obeng-Odoom, 2018), based on the cross-section of research reviewed (*n=90*). Invariably it could be identified that, far less a margin of studies reflected or focused on perspectives, challenges and institutional development needs of Sub-Saharan Africa nations, such as Nigeria, Gabon, Ghana, etc. (see breakdown: Chapter 6).

  Also, though a limited volume of studies have been conducted on Ghana's nascent petroleum sector, very few have been undertaken within the area of underlying risks/ root factors of disaster incidents which culminate in environmental catastrophe and devastation. The identified studies tended to focus on building local content, oil spill response preparedness and social responsibility (Glover, 2017). No known study was available within the scope of identifying from a systematic review of literature: (i) itemized/ validated set of factors at the root of environmental disaster incidents within the Ghanaian petroleum sector (ii) Additionally, no available study has itemized through the systematic review process, a verified/ validated range of capability mechanisms that can be deployed towards addressing the itemized risk factors within the Ghana context, in an appreciably comprehensive format, as conducted in this study. The identified underlying risk factors (12) and capability improvement mechanisms (16) from the systematic review of literature, has local as well as global applicability, based on the broad scope of the objectives and search process. The foregoing (Objective 3) has generally been achieved within chapters 6 and 7 of this study.

- **Objective 4**. *Rank and prioritize in order of importance the critical underlying risk factors, and Capability Improvement Mechanisms requisite for attaining environmental disaster risk reduction, within Ghana's petroleum sector, employing expert opinion*.

  As indicated, the study pursued methodological pluralism as a philosophical choice, therefore 'multi methods' was the strategy deployed. Following the qualitative systematic review of literature, the next phase was the validation of literature process, which was in a semi-structured format. The subsequent phase was a quantitative process of a survey (n=78) of experts/ key stakeholders. As mentioned beforehand, some research interventions on petroleum environmental governance have been undertaken in Ghana, especially with regards to social responsibility, local content and community involvement etc. However no definitively itemized indicators of root factor risks and capability interventions have been documented at this level of study; neither has a ranking/ prioritization of these mechanisms been generated through expert stakeholder process of a scientific format as undertaken within this study. The ranking and prioritization process via the survey process (*n=78*) constituted the main quantitative sector of the mixed methods process and this formed the key composition of the CIF as well as recommendations for this study. The deployment of experienced and relevant professionals, considered critical stakeholders and industry experts, have contributed largely to a rich and robust framework of prioritsed mechanisms and processes, for EDRM within the petroleum sector of Ghana.

- **Objective 5**. *Develop and validate a framework for improving public sector institutional capability, towards minimizing environmental disaster risks within the petroleum sector of Ghana*.

  The establishment of the CIF has been subsequently facilitated through the previous undertakings and synthesis of knowledge from existing literature and frameworks reviewed. The recommendation of the CMMI pathway to developing capability for EDRM, integrally with institutions ranked in order of capability improvement needs, have been configured within a tabular format framework, as employed by Mahpour (2018), in a prioritization framework for construction waste management and also by Jones (2003) in an Emergency Management framework, adapting the CMMI model. Recognised/ high ranking professionals from key stakeholder authorities and end user institutions were deployed within a process of written interviews to assess and validate the CIF, as presented in chapter 9.

  Objective 6. *Provide recommendations for policy planning and practice, with the aim of improving institutional capacity pertaining to environmental disaster risk minimisation, for the petroleum sector of Ghana.*

  Through an integrative random and systematic review of literature, and subsequently, synthesis of knowledge from the foregoing, as well as complementary information and inputs via data collection/ analysis methods employed in this study; a collection of recommendations have been made, complementary to the CIF, in this concluding chapter (10). Findings/ suggestions, based on fulfilling the foregoing objectives and synthesis of knowledge have recommended redirections towards a critical focus on underlying/ root causes of environmental disaster, and enhancing capacity within the more 'Thechnical' and 'Governance' oriented mechanisms for addressing safety critical risks and capability gaps within Ghana's petroleum sector.

10.2 SIGNIFICANCE OF THE FRAMEWORK AND STUDY FINDINGS

The framework is the first of its kind which constitutes a comprehensive set of factors and institutional mechanisms that could be deployed towards governance strategy and policy improvement direction for minimizing root factors of environmental disaster risks within Ghana's petroleum sector. Based on knowledge synthesis from the integral sequence of the research, recommendations have been generated and outlined from findings and emerging themes/ implications. Unresolved concepts/ gaps, and unclear knowledge patterns emerging from the qualitative and quantitative process of enquiry have been outlined and presented within a set of recommendations (10.6), in addition to indicators on limitations to this study. This framework may be considered a hybrid form of decision support frameworks and governance frameworks, considering the interrelationships/ classification of such mechanisms (Morley *et al.,* 2012). However, this intervention (CIF) goes beyond a unitary institutional system bearing a specific set of guidelines and procedures, towards considerations required within a broader interface of key stakeholder national and multi-national bodies. The framework provides insight and perspectives, which reflect on current institutional capacity/ capability conditions and directions or recommendations on key sector agencies which would need improvement or restructuring in order to achieve the aim of EDRM within Ghana's petroleum sector.

10.2.1 Usefulness of the Framework

1. The CIF could serve as a guidance tool for stakeholder decision makers, to provide direction on what is considered relatively important within current conditions in Ghana, and the critical action required by way of prioritising these factors within policy and decision making towards achieving environmental disaster risk minimisation within the petroleum sector. Conditions may change in the future as industry, society and systems evolve, but for the current dispensation, the framework and accompanying findings/ recommendations provide a pivotal resource base and guide-map; which not only provides the key indices by which risk factors can be itemized and prioritised, but also the most critical of institutional interventions, which have been ranked in order of importance.

2. The framework established from this study can also be employed as a vital tool within further research towards evolving/ developing interventions or models aimed at assessing institutional performance levels and critical path processes for improving performance on the prioritized capability mechanisms for EDRM in Ghana's petroleum sector.

3. Examples of ways in which the CIF can be useful are e.g.

(i) The CIF can be deployed to develop a maturity model by adapting the constructs/ mechanisms herein towards identifying the gradual maturity stages of the identified capability measures.

(ii) Within a capability index grid; where institutions/ organisations are scored and assessed, attributing greater weighted value to the higher ranked capability mechanisms (assigned in CIF) measured against a denominator value of the ranked risk factors (assigned in CIF) in descending order, to gauge aggregate performance levels within relevant parameters.

4.The systematically reviewed literature summarises a set of underlying/ root factors of petroleum disaster and critical capability mechanisms, which are representative and reflective of universal conditions and not only for Ghana. As interventions itemized within the framework (CIF) are largely reflective of conditions pertaining within developing countries or global south, these can be considered and deployed within similar countries as well as, within the policy strategies and development programmes of global institutions (towards developing countries), such as, the UN, International Maritime Organisation, and World Safety Council, among others.

10.3 SUMMARY OF THE FINDINGS

10.3.1 Conclusion on Findings

(A) It can be suggested, from evaluating the expert participant ranking that, the areas of focus considered more critical for addressing underlying factors towards achieving EDRM are, the core Governance, Technical and Managerial functions, rather than the incident management and simulation activities, which have traditionally been the areas of focus, for public sector institutions. It could also be suggested from the foregoing, that these operational functions and tactical procedures have arguably gained some amount of developmental attention and improvement within Ghanaian institutions, therefore, to tackle root factor pre-emption, and underlying risk minimisation; these 'Operational' functions, in the view of expert respondents, ought to be strategically subsequent to the more technical and governance mechanisms.

(B) Furthermore, it can be suggested that factors of risk minimisation (RMIs) and capability mechanisms (CIMs) that reflect pre-emptive or proactive approach to addressing environmental disaster risks within Ghana's petroleum sector, were rated higher in weighted scoring by expert respondents. This underscores the exigency and growing advocacy towards contextualising disaster risk management constructs and functions, within a more pre-incident (probabilistic) domain. Additionally, the areas of capability improvement considered relatively critical to achieving the risk minimisation aims within public sector institutions in Ghana, were the ‘governance’ and more ‘technical’ oriented mechanisms as compared to emergency and incident management functions.

10.4 RESEARCH LIMITATIONS

As is quite common with research generally, there can be identifiable limitations to the scope and applicability of study and findings respectively. The following are highlighted hereby, as limitations of this study:

(i) This study was directed specifically at socio-technical factors within the petroleum operational domain, which engender environmental disaster. In this respect, extreme naturally occurring events such as tsunami, hurricanes, climate change impacts etc., which could effect some bearing on petroleum infrastructure/operations, have not been included among risk factors for reasons as per foregoing, and as expatiated on in literature validation process (7.2.1). Future studies in that tangent, bearing a wider scope, could be directional to investigating the interplay of such factors on EDRM, within the petroleum sector.

(ii) The study has not critically discussed the socio-political ramifications of the impact of human/ socio-economic activity on the petroleum industry and vice-versa. This is invariably underpinned by the emphasis of the study on socio-technical factors emanating from within the internal and interconnected environment of the industry operational area. It can be realised that a study of a wider scope could critically consider a broader range of conditions of socio-economic/ political ramifications on the interplay of factors identified beforehand, and integral impacts on the environment.

(iii) The study and findings though largely applicable within international jurisdictions, have an orientation to the Ghana Petroleum sector, with regard to the prioritised elements, based on the survey of experts. Therefore, some modifications or adaptations may be needed to attain prioritised mechanisms (of broadly applicable constructs from the validated elements of the SR literature), tailored towards other geographic jurisdictions.

10.5 CONTRIBUTION TO KNOWLEDGE

- Through an abductive and integrative analysis of the literature and evolving theory, findings from this study lend support to a suggestion that: Capability mechanism, and or resilience of institutional capability, are exponentially the critical considerations for Disaster Risk Management (DRM) objectives; just as in previous dispensations, (a) hazards, (b) vulnerability and (c) resilience, have been considered the critical considerations for DRM.

- This study has highlighted and discussed incongruence between some generic disaster concepts within literature/ industry practice on one hand, and on another hand, the contemporary concepts of disaster definition advocated by the UN: as also supported within findings from this study (Chapter 2 and 6), by way of the following:

  (i) Disaster risks and disasters are not mutually exclusive phenomena, but integrated and evolving processes, within an interconvertible interface of progressive risks actuated or catalysed by societal vulnerability, socio-technical and capacity shortcomings.

  (ii) Disaster and disaster impacts can exponentially be conceptualised, addressed or managed from more pre-incident/ probabilistic domains and not just from incident/ impact dimensions: since disasters are progressive phenomena, rather than just massive or residual impact events.

  (iii) Disaster occurs within a continuum and not just a sudden force or massive impact event. Invariably, disaster is sequential and not precisely a consequential phenomenon, as classical definitional constructs may suggest.

- Conjectural presentation has been made with regard to the deployment of the 'Capsized Iceberg Approach' (CIA) of abduction, within this study (5.3.2)

- A methodologically rich and robust sequential multi-phase process has been deployed to access a unique (not previously undertaken) guide-map of prioritized capability interventions, critical to realization of EDRM goals within the petroleum sector of Ghana, which protocol could be a model methodological approach and pivotal tool in future research.

- The concept of considering internal safety critical breaches, hazards and threats emanating from industry operations/ management shortcomings, as intermediate safety management concerns, somewhat remotely detached from environmental disaster conceptualisation, is contested as potentially counterproductive; a significant source of risk and a conceptual gap which is avoidable, and could be bridged via instrumentation of interventions, such as the CIF, established within this study.

10.6 RECOMMENDATIONS

10.6.1 Recommendation on Research Findings and CIF

Based on the findings and interventions established from this study, the following recommendations are proposed:

1. It is recommended that policy and decision making pertaining to capability improvement within relevant public sector institutions in Ghana be undertaken with pivotal consideration to the prioritised mechanisms identified within this study (both RMIs and CIMs) towards attaining EDRM goals.

2. That a relevant capability/ performance improvement and assessment model/ framework such as the CMMI be adopted or developed (considering the CIF mechanism) within key sector organisations in this respect; towards achieving the goal of environmental disaster risk minimisation in the petroleum sector of Ghana.

3. Reflecting on the guidelines/ recommendation by Nilsen and Storkersen (2018): that national regulators may need to be more agile and adept in terms of industry dynamism and evolving global governance systems, rather than relying on unitary mechanisms such as the 'safety case' as a 'fool-proof' governance panacea, the following is recommended

(a) That consideration within governance policy and implementation, apportion critical attention to some shortcomings within the 'safety case regime' (adopted by Ghana) which holds potential for circumvention/ abuse and regulatory inertia. In this regard, complementary and evolving frameworks/ systems such as the CIF established from this research for bridging such governance gaps and limitations can be pursued consistently within policy and strategy.

(b) That, tailor-made mechanisms such as the CIF established in this study be considered a critical complementary tool within policy design, with potential to address remote, underlying/ under-regulated challenges and phenomena, often inadequately addressed within generic systems and frameworks such as the 'Safety Case' and other prescriptive mechanisms of governance.

4. Towards improvement in institutional performance, it can be noted from the expert scoring process that, institutional bodies requiring higher levels of capability improvement, are the 'Standards and Inspectorate', 'Environmental Regulatory', and 'Petroleum Regulations' institutions respectively (Table 7.7). While it can be considered rational e.g. that, the 'Local Government' institution requires the minimal level of improvement, due to their non-direct involvement in petroleum management operations: it is critical that the aforementioned institutions, particularly the 'Standards and Inspectorate' institutions be given critical attention within policy planning, backed by requisite resources, and performance appraisal systems to facilitate the crucial role of attaining their mandate for EDRM within this sector.

10.6.2 Recommendations for Future Research

1. That, future research takes into consideration, implications of the view from expert survey rankings that, ‘Sabotage, terrorism, and vandalism’ though important, are relatively less critical threats within Ghana’s petroleum sector, in contrast to what pertains within some countries in the sub-region. This (potential research undertakings) would ascertain underlying reasons, and support consolidation of the prevailing mechanisms, governance systems and environmental integrity in this tangent.

2. With respect to the ranking indicators from expert survey on disaster incident triggers and mediums; it could be suggested that capability conditions for addressing incidents such as structural collapse, well-blowouts, marine vessel/ helicopter accidents were considered areas of relative challenge for public sector institutional capability. Consequently, future research could consider underlying reasons for this, to ascertain if interventions can be marshalled for capability development or improvement in this respect.

3. The consideration of disasters as impact determined/ related phenomena massively projected within classical disaster theory, could be subjected to consistent debate to stimulate re-appraisal and or modification, in the light of evolving knowledge on disaster conceptualisation.

10.7 CHAPTER SUMMARY

This chapter incorporates the processes and findings for the entire thesis, assessed against the aim and objectives outlined within chapter one of study. This chapter also embodies the impact of this study and contribution to knowledge as well as practice. Findings from this research provide direction toward a need to consistently re-evaluate conceptualisation of disaster in relation to integral concerns of safety and environmental risk management. It is envisaged that complementary strategies, models and frameworks, such as the CIF established from this study would be deployed within the relevant national institutions, towards attaining minimised risks of petroleum related environmental disaster.

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APPENDICES:

Appendix A1: Expert Verification/ Validation Process

Participant Information Sheet For: Literature Validation Exercises

A FRAMEWORK FOR PRIORITIZATION OF CAPABILITY MECHANISMS FOR ENVIRONMENTAL DISASTER RISK MINIMISATION WITHIN THE PETROLEUM SECTOR OF GHANA

Invitation

You are invited to take part in a research project being undertaken at the University of the West of England, Bristol. This research is in partial fulfilment of a PhD study. Before you decide whether to take part, it is important for you to understand why the study is being done and what it will involve. Please read the following information carefully and if you have any queries or would like more information, please be free to contact the researcher Gerald Nana Acheampong, at the Faculty of Environment and Technology, University of the West of England, Bristol.

PhD Researcher: Gerald Nana Acheampong
Email: gerald2.acheampong@live.uwe.ac.uk
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Second Supervisor: Dr Abdul-Majeed Mahamadu -
Department: Faculty of Environment and Technology

Aim of the study

The research is directed towards exploring the pivotal relation between improved disaster risk reduction capability in public institutions, and environmental disaster risk pre-emption/ minimisation within the petroleum sector of Ghana. This is aimed at establishing a capability improvement framework for improvement of public sector institutional capability towards minimising environmental disaster risks within the petroleum sector of Ghana. Research questions: The research questions are: (a) What are the key institutional capability mechanisms requisite for minimising environmental disaster risks within the petroleum sector of Ghana? (b) How can the identified capability attributes be assessed and improved. The aim for your participation in this exercise is outlined in letter of invitation attached. The results of the study will be analysed and used to produce a doctoral thesis that could be made available to students through the University of the West of England's online library system. The anonymised results may also be used in conference papers and peer-reviewed academic papers.

Reason for invitation

As a seasoned professional, expert and or academic, the researcher is interested in gaining information about your opinion on the questions and aim outlined; therefore, the survey will ask you about your opinions, on the identified root factors and key capability attributes needed for reducing disaster risks in the petroleum sector. Questions would focus on the aim of study only and not on personal information.

Do I have to take part?

You are not obliged to take part in this research. It is up to you to decide whether or not you want to be involved. If you do decide to take part, you can download a copy of this participant information sheet to keep, together with the Privacy Notice and Consent Form. Please note, if you do decide to take part, you are able to withdraw from the research before, during or after, without giving a reason until 14 days after completion of process, at which point the anonymised data will be incorporated within the analysis.

What will happen to me if I take part and what do I have to do?

If you agree to take part you will be asked to provide your expert/ professional view on the institutional capability attributes identified within literature, required for mitigating environmental disaster risks within the petroleum sector, which should take approximately 10 minutes. The subject and focus of the questions will be whether you agree with the comprehensiveness/ relevance of the list of capability attributes identified or not, and if not to provide any missing attributes. Your answers will be fully anonymised. Please note your identity may be known only to the researcher and his supervisors however your personal details will never be shown anywhere in the research or in any reports or outputs. Where data from your survey is to be used it will be represented by a pseudonym.

Your views and answers will be provided via email and integrated with other participant inputs using a unique identifier code, which will be used to re-identify you if you choose to withdraw from the study, up 14 days on completing the survey, after which date your data will be anonymised and be analysed with survey data from other anonymised participants.

What are the benefits of taking part?

The capability improvement framework to be developed through this process, will be instrumental towards assessing and improving essential capability and enhance capacity for reducing environmental disaster risks in the petroleum sector of Ghana

What are the possible risks of taking part?

There are no particular risks identified or anticipated. However, if at any point a participant feels uncomfortable about the process, he/ she can ask to withdraw without providing explanation

What will happen to your information?

All the information received from you will be treated in the strictest confidence. All the information that you give will be kept confidential and anonymised in soft copy in a secured UWE-Bristol allocated computer and allocated one drive, to which only the researcher will have access in accordance with the University's regulations on the Data Protection Act 2018 and General Data Protection Regulation requirements. Your anonymised data will be analysed together with other survey data and will ensure that there is no possibility of identification or re-identification from this point. Please note your identity may be known only to the researcher and his supervisors however your personal details will never be shown anywhere in the research or in any reports or outputs. Where data from your survey is to be used it will be represented by a pseudonym.

Where will the results of the research study be published?

A doctoral thesis will be written containing the research findings. This Report will be available on the University of the West of England's open-access Research Repository. A hard copy of the dissertation will be made available to all research participants if you would like to see it. Key findings will also be shared both within and outside the University of the West of England. Anonymous and non-identifying direct quotes may be used for publication and presentation purposes.

Who has ethically approved this research?

This research project has been reviewed and approved by the Faculty Research Ethics Committee (FREC). Any comments, questions or complaints about the ethical conduct of this study can be addressed to the supervisor or UWE's Research Ethics Committee (researchethics@uwe.ac.uk)

What if something goes wrong?

Should you have any concerns or complaints about this research project please contact the supervisor named at the top of this form, Coilin Boot: colin.booth@uwe.ac.uk.

Context and Definition

For the purpose of this study, you may rely on the following references or definitions:

Environmental Disaster Risks:

Refers to events, interlinked factors or conditions which can develop into extensive environmental damage (This research excludes naturally occurring events, e.g. Tsunami, etc).

Critical Capability Mechanisms:

Refers to the key resource base and ability pertaining to an institution towards achieving assigned job functions; and is synonymous/ reflective of terms such as capacity, competence, ability, preparedness etc.

Disaster Risk Minimisation:

Adopts the UN definition of Disaster risk reduction (DRR), which is: policies/ measures in place, aimed at preventing new and reducing existing disaster risks. This includes mitigating vulnerability of people and property, prudent management of land and the environment, and improving early warning/ preparedness towards adverse events.

What if I have more questions or do not understand something?

If you would like any further information about the research, please contact the researcher or supervisor on emails above

Thank you for agreeing to take part in this study.

You will have a copy of this Participant Information Sheet and your signed Consent Form to keep.

Consent Form

Research Project: A Framework for Prioritisation of Capability Mechanisms For Environmental Disaster Risk Minimisation Within Ghana's Petroleu Sector.

This consent form will have been given to you with the Participant Information Sheet. Please ensure that you have read and understood the information contained in the Participant Information Sheet and asked any questions before you sign this form. If you have any questions please contact a member of the research team, whose details are set out on the Participant Information Sheet

If you are happy to take part in the survey, please sign and date the form. You will be given a copy to keep for your records.

Name (Printed)……………………………………………………………………………

Signature…………………………………………………… Date……………………

SAMPLE INVITATION LETTER: FOR LITERATURE VALIDATION (To be emailed to participants)

Faculty of Environmental Technology

University of the West of England-Bristol

BS16 1QY

United Kingdom

Date…/…/ …...

Dear Sir/Madame,

REQUEST FOR PARTICIPATION IN RESEARCH ON: A FRAMEWORK FOR PRIORITISING CAPABILITY MECHANISMS FOR ENVIRONMENTAL DISASTER RISK MINIMISATION, WITHIN GHANA'S PETROLEUM SECTOR.

You are respectfully invited to participate in a PhD research taking place at the University of the West of England-Bristol, on the above subject. The research is directed towards exploring the fundamental relation between improved disaster risk reduction capability in public institutions, and environmental disaster pre-emption/ mitigation within the upstream petroleum sector of Ghana. This is aimed at establishing a Capability Improvement Framework for assessment and improvement of institutional capability for mitigating environmental disaster risks, within the petroleum sector of Ghana.

Toward this aim, you will be asked to indicate your agreement or otherwise with a set of underlying causes of Petroleum Disasters (PDs), and capability improvement mechanisms for tackling the PDs, sourced from a systematic review of literature. Your invitation to participate is based on your acknowledged expertise on the topic under study. With improved capability from interventions such as envisaged in this project, it is hoped Ghana's infant offshore oil infrastructure would be better positioned to avoid some of the pitfalls, such as avoidable disasters that have bedevilled other oil producing countries.

Thank you for the kind attention and anticipation of a favourable consideration of this invitation.

Sincerely,

Gerald Nana Acheampong

(PhD researcher

Appendix A2: Sample Literature Verification/ Validation Interview Question Form

A FRAMEWORK FOR PRIORITIZATION OF CAPABILITY MECHANISMS FOR ENVIRONMENTAL DISASTER RISK MINIMISATION WITHIN THE PETROLEUM SECTOR OF GHANA

(Please note* this research is focused on socio-technical disaster risks, and excludes risks emanating from natural incidents, such as Tsunami, hurricanes, etc.)

Please tick (click) appropriate box (example X) or type responses where appropriate.

SECTION A: PERSONAL DETAILS

Profession / area of expertise	................................./..................................
Qualification	HNC/HND ☐ Bachelor's Degree ☐ Master's Degree☐ Doctorate Degree ☐; Other…………………………………………….
Membership of professional body if any	....
No. of Years' Experience in the profession/ Occupation (e.g. *risk management/ safety, sustainability, environmental management/ petroleum management, etc.*)	…………………………………………………………………
Survey Participant ID/ Code	LV000

SECTION B: VALIDATION OF PRE -IDENTIFIED LIST OF UNDERYLING CAUSES (RISKS) OF PETROLEUM ENVIRONMENTAL DISASTER AND CRITICAL CAPABILITY ATTRIBUTES

B1. Below is a list of major types of triggers/ mediums of upstream petroleum related disaster risk incidents *(A)*, and their root causes in *(B)*, identified from literature. Please answer the associated questions beneath the list.

(A) MAJOR TYPES OF TRIGGERS/ MEDIUMS OF PEROLEUM DISASTER INCIDENTS	
1.	Well blowout
2.	Associated chemical discharges
3.	Fire/ explosions
4.	Hydrocarbon release
5.	Helicopter/ marine vessel crash
6.	Pipeline damage
7.	Structural collapse (*e.g. Oil rig, Tanker, etc*.)
(B) ROOT CAUSES OR UNDERLYING FACTORS ATTRIBUTED TO THE INCIDENTS ABOVE	
1.	Equipment failure
2.	Human error
3.	Governance system gaps (*Including laws, regulations etc*.)
4.	Sabotage, terrorism and vandalism
5.	Technical capability shortcomings
6.	Socio-environmental accountability shortcomings
7.	Managerial and leadership shortcomings
8.	Material resource management challenges
9.	Operational risk taking flaws (e.*g. Risky cost cutting measures; fracking in geologically sensi* *location etc.*)
10.	Emergency preparedness planning gaps
11.	Risk management shortcomings
12.	Delayed action and response

Does the list above in (B) adequately reflect known root causes of (A)? (Please tick Yes or No)

Yes □ **No** □

If no, please list missing factors *(B)*

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

B2. Below is a list of 16 critical mechanisms of institutional capability identified as essential for reducing environmental disaster risks within the petroleum sector *(accessed from systematic review of literature),* Through addressing undelying factors in 'B' above. Please assess and answer the questions beneath the list.

C1	***GOVERNANCE FUNCTIONS***
1	Legal and regulatory system *(Provision and administration of laws, regulations, guidelines and enforcement etc. governing the industry and operators)*
2	Standards monitoring and auditing (*Monitoring, inspection, auditing and certification of management/ operational statutory standard systems: including third party auditing mechanisms)*
3	Governance institution development *(Capacity/ ability i.e. mechanaisms in place towards evolvement, improvement, restructuring governance institution and systems)*
4	Inter-organizational cooperation *(Capacity/ ability to cooperate, coordinate etc. with allied governance agencies to complement capability or build synergies locally and internationally in the area of risk minimization)*
C2	***TECHNICAL FUNCTIONS***
5	Early detection and warning systems *(Provision and operation of early detection, early information/ warning mechanisms: including such as, Geographic Information Systems (GIS), whistle blowing/ cyber threat detection etc.)*
6	Technology adoption *(Capacity and ability to evolve, adopt or adjust to improved/ best practice technology, industry technique and practice)*
7	Decision support systems and frameworks *(Provision and application of decision/ management support mechanisms, such as expert systems, decision support frameworks etc.)*
8	Material resources management *(Provision and management of physical resources towards pre-empting incidents or containing/ controlling incidents from escalating into a disaster, including protection equipment e.g. auto fire suppressors, spill booms etc*.)
C3	***MANAGERIAL FUNCTIONS***
9	Research *(Research and documentation on environmental disaster and risk reduction, particularly in the field and context of petroleum related disaster)*
10	Human resource development *(Includes appropriate management and development of human resource base/ capacity in DRM)*
11	Risk management *(Involves environmental and disaster risk assessment; vulnerability assessment; internal and external risk governance capacity/ capability assessment, insurance planning and related management measures; put in place to preempt or minimize risks)*

12	Stakeholder management (*Appropriate identification and management of various stakeholders and building on interorganizational cooperation/ coordination mechanisms*)
C4	***OPERATIONAL FUNCTIONS***
13	Emergency preparedness strategy (*Ensuring preparedness strategies, plans and programs are in place, and periodically reviewing, revising/ developing these strategies*)
14	Public involvement and education *(Inclusion/ integrating/ involving stakeholder public, especially local communities/ authority in industry strategies and operations which have environmental risks; and undertaking periodic educational/ sensitization fora etc.)*
15	Pre-emptive, early and rapid action (PERA) *(Measures in place for pre-empting risks: including disincentive towards risk taking and non- compliance; measures deterrent towards sabotage/ terrorism and vandalism; early action to repel or contain high probability hazards; rapid coordinated action to ensure occurring or threatening incidents do not escalate into disaster)*
16	Training and simulation *(Developing and undertaking relevant/ regulated training and simulation modules; periodically revising and updating statutory training in line with preparedness planning and evolving conditions)*

Is the list above exhaustive and representative of the critical capability improvement attributes/ mechanisms required for public institutions to achieve environmental disaster risk reduction, in the petroleum sector? (Please tick Yes or No)

Yes ☐ **No** ☐

If NO, please list any additional capability attributes or factors:

1 ………………………………………………………………………………………

2 ………………………………………………………………………………………

3 ………………………………………………………………………………………
.

SECTION C

Please indicate if you agree or not with the mapping of institutions *(accessed from literature, institutional charters/ governance regulations, statute documents, observation)* indicated against the underlying risk factors fore-identified in SLR

A) ROOT CAUSES OR FACTORS ATTRIBUTED TO THE INCIDENTS ABOVE		***B) IDENTIFIED/ PROPOSED INSTITUTIONAL SECTORS (*Not Organizations) DESIGNATED TOWARDS ADDRESSING INDICATED RISK FACTORS IN (A)***
1.	Equipment failure	1. Petroleum Regulation Institutions 2. Standards Inspectorate Institutions. 3. Security and Enforcement Institutions
2.	Human error	1. Petroleum Regulation Institutions
3.	Governance system gaps	1. Environmental Regulatory Institutions 2. Petroleum Regulation Institutions 3. Local Government Institutions 4. Maritime, Ports and Harbours Institutions 5. Standards Inspectorate Institutions
4.	Sabotage, terrorism and vandalism	2. Security and Enforcement Institutions 2. Petroleum Regulation Institutions 3. Emergency and Incident Response Institutions 4. Maritime Ports and Harbours Institutions 5. Local Government Institutions
5.	Technical capability gaps	1. Standards Inspectorate Institutions 2. Petroleum Regulation Institutions
6.	Socio-environmental accountability shortcomings	1. Petroleum Regulation Institutions 2. Local Government Institutions 3. Environnemental Regulatory Institutions 4. Maritime, Ports and Harbours Institution.
7.	Managerial and leadership shortcomings	1. Petroleum Regulation Institutions 2. Standards Inspectorate Institutions
8.	Material resource management Shortcomings	1. Standards Inspectorate Institutions 2. Emergency and Incident Response Institutions 2.Petroleum Regulation Institutions 3. Security and Enforcement Institutions

9.	Operational risk flaws	1. Environmental Regulation Institutions 2. Petroleum Regulation Institutions 3. Standards Inspectorate Institutions
10.	Emergency preparedness planning gaps	1.Emergency and Incident Response Institutions 2. Security and Enforcement Institutions 3. Petroleum Regulation Institutions. 2. Environmental Regulatory Institutions 5. Local Government Institutions*
11.	Risk management shortcomings	1.Petroleum Regulation Institutions 2. Environmental Regulatory Institution 3. Standards Inspectorate Institutions 4. Security and Enforcement Institution 5. Maritime, Ports and Harbours Institution
12.	Delayed action and response	Emergency and Incident Response Institutions Petroleum Regulation Institutions Security and Enforcement Institutions Environmental Regulatory Institutions Local Government Institutions

Answer:
1. I agree with all institutional mapping indicators:…………………………………………

2. I do not agree with mapping indicators: (Please state your reasons)…………………………………………….

3. I agree with some sections of institutional arrangements above, but recommend inclusion or exclusion of the following: (Please Indicate with reasons: Required) ………………………………………………………

Please provide any relevant comments *(Optional):* Use additional pages if necessary, for providing answers

Please return: Thank you very much for your participation. Please kindly return the answers by Email. If you have any queries, please contact Gerald Acheampong *(E-mail: gerald2.acheampong@live.uwe.ac.uk).*

Appendix B1: Participant Information Sheet For Expert Survey

FRAMEWORK FOR PRIORITIZATION OF CAPABILITY MECHANISMS FOR ENVIRONMENTAL DISASTER RISK MINIMISATION WITHIN THE PETROLEUM SECTOR OF GHANA

Invitation

You are invited to take part in a research project being undertaken at the University of the West of England, Bristol. This research is in partial fulfilment of a PhD study. Before you decide whether to take part, it is important for you to understand why the study is being done and what it will involve. Please read the following information carefully and if you have any queries or would like more information please be free to contact the researcher Gerald Nana Acheampong, at the Faculty of Environment & Technology, University of the West of England, Bristol.

PhD Researcher: Gerald Nana Acheampong
Email: gerald2.acheampong@live.uwe.ac.uk
Project Supervisor: Prof. Colin Booth - Email: colin.booth@uwe.ac.uk
Second Supervisor: Dr Abdul-Majeed Mahamadu -
Department: Faculty of Environment and Technology

Aim of the study

The research is directed towards exploring the pivotal relation between improved disaster risk reduction capability in public institutions, and environmental disaster risk pre-emption/ minimisation within the petroleum sector of Ghana. This is aimed at establishing capability improvement framework for assessment and improvement of public sector institutional capability towards minimising environmental disaster risks within the petroleum sector of Ghana.

Research questions: The research questions are: (a) What are the critical institutional capability measures/ mechanisms requisite for minimising environmental disaster risks within the petroleum sector of Ghana? (b) How can the identified capability attributes be assessed and improved. To help answer these questions, the researcher is conducting a survey on underlying/ root factors of environmental disaster risks and capability attributes/ factors identified from literature (validated by key experts), which are required for attaining the aim (a and b). The participants in this process will be made anonymized.

The results of the study will be analysed and used to produce a doctoral thesis that could be made available to students through the University of the West of England's online library system. The anonymised results may also be used in conference papers and peer-reviewed academic papers.

Reason for invitation

As a seasoned professional, expert and or academic, the researcher is interested in gaining information about your opinion on the questions and aim outlined; therefore, the survey will ask you about your opinions, on the identified root factors and key capability attributes needed for reducing disaster risks in the petroleum sector. Questions would focus on the aim of study only and not on personal information.

Do I have to take part?

You are not obliged to take part in this research. It is up to you to decide whether or not you want to be involved. If you do decide to take part, you can download a copy of this participant information sheet to keep, together with the Privacy Notice and Consent Form. Please note, if you do decide to take part, you are able to withdraw from the research before, during or after, without giving a reason until 14 days after completion of process, at which point the anonymised data will be incorporated within the analysis.

What will happen to me if I take part and what do I have to do?

If you agree to take part you will be asked to provide your expert/ professional view on the institutional capability attributes identified within literature, required for mitigating environmental disaster risks within the petroleum sector, which should take approximately 10 minutes. The subject and focus of the survey is as embodied in letter of invitation, and PIS. Your answers will be fully anonymised. Please note your identity may be known only to the researcher and his supervisors however your personal details will never be shown anywhere in the research or in any reports or outputs. Where data from your survey is to be used it will be represented by a pseudonym.

Your views and answers will be provided via online survey or email and integrated with other participant inputs using a unique identifier code, which will be used to re-identify you if you choose to withdraw from the study, up 14 days on completing the survey, after which date your data will be anonymised and be analysed with survey data from other anonymised participants.

What are the benefits of taking part?

The capability improvement framework to be developed through this process, will be instrumental towards assessing and improving essential capability and enhance capacity for reducing environmental disaster risks in the petroleum sector of Ghana

What are the possible risks of taking part?

There are no particular risks identified or anticipated. However, if at any point a participant feels uncomfortable about the process, he/ she can ask to withdraw without providing explanation

What will happen to your information?

All the information received from you will be treated in the strictest confidence. All the information that you give will be kept confidential and anonymised in soft copy in a secured UWE-Bristol allocated computer and allocated one drive, to which only the researcher will have access in accordance with the University's regulations on the Data Protection Act 2018 and General Data Protection Regulation requirements. Your anonymised data will be analysed together with other survey data and will ensure that there is no possibility of identification or re-identification from this point. Please note your identity may be known only to the researcher and his supervisors however your personal details will never be shown anywhere in the research or in any reports or outputs. Where data from your survey is to be used it will be represented by a pseudonym.

Where will the results of the research study be published?

A doctoral thesis will be written containing the research findings. This Report will be available on the University of the West of England's open-access Research Repository. A hard copy of the dissertation will be made available to all research participants if you would like to see it. Key findings will also be shared both within and outside the University of the West of England. Anonymous and non-identifying direct quotes may be used for publication and presentation purposes.

Who has ethically approved this research?

This research project has been reviewed and approved by the Faculty Research Ethics Committee (FREC). Any comments, questions or complaints about the ethical conduct of this study can be addressed to the supervisor or UWE's Research Ethics Committee (researchethics@uwe.ac.uk)

What if something goes wrong?

Should you have any concerns or complaints about this research project please contact the supervisor named at the top of this form, Coilin Boot: colin.booth@uwe.ac.uk.

Context and Definition

For the purpose of this study, you may rely on the following references or definitions

Environmental Disaster Risks:

Refers to events, interlinked factors or conditions which can develop into extensive environmental damage (This research excludes naturally occurring events, e.g. Tsunami, etc).

Critical Capability Mechanisms:

Refers to the key resource base and ability pertaining to an institution towards achieving assigned job functions; and is synonymous/ reflective of terms such as capacity, competence, ability, preparedness etc.

Disaster Risk Minimisation:

Adopts the UN definition of Disaster risk reduction (DRR), which is: policies/ measures in place, aimed at preventing new and reducing existing disaster risks. This includes mitigating vulnerability of people and property, prudent management of land and the environment, and improving early warning/ preparedness towards adverse events.

What if I have more questions or do not understand something?

If you would like any further information about the research, please contact the researcher or supervisor on emails above

Thank you for agreeing to take part in this study.

You will have a copy of this Participant Information Sheet and your signed Consent Form to keep.

Thank you for agreeing to take part in this study.

You will have a copy of this Participant Information Sheet and your signed Consent Form to keep.

Consent Form

Research Project: A Framework for Prioritisation of Capability Mechanisms For Environmental Disaster Risk Minimisation Within Ghana's Petroleu Sector.

This consent form will have been given to you with the Participant Information Sheet. Please ensure that you have read and understood the information contained in the Participant Information Sheet and asked any questions before you sign this form. If you have any questions please contact a member of the research team, whose details are set out on the Participant Information Sheet

If you are happy to take part in the survey, please sign and date the form. You will be given a copy to keep for your records.

Name (Printed)……………………………………………………………………….

Signature…………………………………………………. Date…………………….

OR

For online surveys…

By clicking on the link to participate in this online survey you are agreeing to the following:

- I have read and understood the information in the Participant Information Sheet which I have been given to read before asked to sign this form;
- I have been given the opportunity to ask questions about the study;
- I have had my questions answered satisfactorily by the research team;
- I agree that anonymised quotes may be used in the final Report of this study;
- I understand that my participation is voluntary and that I am free to withdraw at any time until the data has been anonymised, without giving a reason;
- I agree to take part in the research

Sample Invitation Letter for Expert Survey Process (To be emailed)

Faculty of Environmental Technology
University of the West of England-B
BS16 1QY
United Kingdom
Date…/…/ 2019

Dear Sir/Madame,

REQUEST FOR PARTICIPATION IN A POSTGRADUATE RESEARCH

You are respectfully invited to participate in a PhD research taking place at the University of the West of England-Bristol titled: **A Framework for Prioritisation of Capability Mechanisms For Environmental Disaster Risk Minimisation Within Ghana's Petroleum Sector.** The research is directed towards exploring the fundamental relation between improved disaster risk reduction capability in public institutions, and environmental disaster pre-emption/ mitigation within the upstream petroleum sector of Ghana. This is aimed at establishing a decision support framework for assessment and improvement of institutional capability for mitigating environmental disaster risks, within the petroleum sector of Ghana.

Toward this aim, you will be asked to provide your expert/ professional view in a survey on the institutional capability attributes identified within literature, required for minimising environmental disaster risks within the petroleum sector, which should take approximately 10 minutes. The subject and focus of the questions will be mainly on your views, pertaining to underlying/ root factors of environmental disaster risks, and capability attributes/ factors identified from literature (validated by stakeholder professionals/ experts), which are required for attaining the aim.

With improved capability from interventions such as envisaged in this project, it is hoped Ghana's infant offshore oil infrastructure would be better positioned to avoid some of the pitfalls, such as avoidable disasters that have bedevilled other oil producing countries.

Thank you for the kind attention and anticipation of a favourable consideration of this invitation.

Sincerely,

Gerald Nana Acheampong

(PhD researcher):

APPENDIX B2: SAMPLE OF SURVEY QUESTIONNAIRE

1.1 INVITATION/ INTRODUCTION TO PhD SURVEY

You are respectfully invited to participate in this doctoral research being conducted at the University of the West of England, titled: . This is aimed at establishing a decision support framework for developing public sector institutional capacity, titled: FRAMEWORK FOR PRIORITIZATION OF CAPABILITY MECHANISMS TOWARDS ENVIRONMENTAL DISASTER RISK MINIMISATION WITHIN THE PETROLEUM SECTOR OF GHANA. Comprehensive information on this study is contained in Participant information sheet (PIS) in link above, including explanation on some terms and concepts used in this survey (Where needed). If you have any further questions about this survey or the research, please do not hesitate to contact researcher addressed below.
Please return or direct any inquiries to: Gerald Acheampong |University of the West of England | Bristol, UK | BS16 1QY| Email:gerald2.acheampong@live.uwe.ac.uk

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Q1.2
CONSENT Before we begin I will like to emphasize that: 1. Your participation is entirely voluntary 2. You are free to withdraw at any time (within the limits specified on the information sheet) In order to participate it is essential that you agree with all of the following statements and consent to take part: (a) I have read and understood the information sheet(b) I am participating in this research on a voluntary basis(c) I consent to anonymised data from my responses being used in the dissertation report, conference presentations and journal articles(d) I qualify within the criteria set out for participant inclusion.

○ By ticking this choice I confirm that I agree with the above statements and consent to participate in survey

---

Q1.3
SECTION 1

BACKGROUND INFORMATION
Please indicate as appropriate

Q1.4
1a. Profession or Occupation (Select all that applies)

- ☐ Environmental Officer
- ☐ Sustainability Manager
- ☐ Risk Analyst
- ☐ Health Safety and Environmental Manager
- ☐ Petroleum Engineer/ Manager
- ☐ Emergency Response and Disaster Management
- ☐ Oil and gas contractor
- ☐ Consultant (Petroleum/ Safety and environment)
- ☐ Project Manager
- ☐ Other (Please indicate below) ____

Q1.5 1b. Highest Qualification

- ○ HND
- ○ Bachelors/ First Degree
- ○ Masters
- ○ Doctorate
- ○ Other (Please state) ____

Q1.6 1c. Professional Body/ Association (Select all that applies)

- ☐ GhiE
- ☐ GhISEP
- ☐ NEBOSH/ IOSH
- ☐ SPE
- ☐ IPIECA
- ☐ OSHA
- ☐ IIRSM
- ☐ IEMA
- ☐ IFE
- ☐ IAEE
- ☐ Other (please state) ____

Q1.7 1d. Institutional Domain (Major occupational setting)

- ◯ Regulatory institution (Environment and Safety)
- ◯ Regulatory Institution (Petroleum specific)
- ◯ Exploration and production company
- ◯ Upstream suppliers and contractors
- ◯ Emergency or incident management institution
- ◯ Enforcement or security institution
- ◯ Non-governmental Organisation (Petroleum/ Safety and environment)
- ◯ Ports and harbours authority
- ◯ Standards/ Inspectorate Authority
- ◯ Consultancy (Petroleum/ Safety and environment)
- ◯ Energy and Extractive Industry
- ◯ Government
- ◯ Other (please state) ____

Q1.8 1e. Size of Your Organization

- ◯ 1 to 10 employees
- ◯ 11 to 49 employees
- ◯ 50 to 249 employees
- ◯ 250 to 500 employees
- ◯ Over 500 employees

Q1.9 1f. Professional work experience (As in 1a)

- 3 - 5 years
- 6 -10 years
- 11 -15 years
- 16 -20 years
- 20 + years

Q1.10
***GUIDANCE NOTES**

1. The underlying factors (risks) of petroleum sector disasters being addressed in Section 2 & 4, were pre-identified from literature and validated by stakeholder experts in a previous questionnaire (see PIS). *These are*: *1.Human Error 2.Governance System Gaps 3. Sabotage, Terrorism, Vandalism 4. Lack of Socio-environmental accountability 5. Emergency Preparedness Shortcomings 6. Operational Risk Taking 7. Delayed Action & Response 8. Risk Management Shortcomings 9. Material Resource Shortcomings 10. Management & Leadership Shortcomings 11. Equipment failure 12. Technical capability gaps*

2. The capability improvement interventions being addressed in this study are: public sector oversight capacity to supervise or manage petroleum industry incidents and environmental safety risks, from the direction of underlying causes.

3. Note: Numerical values assigned in the Likert scale points, denote relative weighting.

** Please continue with the 3 remaining Questions (Thank you)*

Q1.11
SECTION 2: MEASURES FOR MINIMIZING UNDERLYING RISK FACTORS OF PETROLEUM DISASTER INCIDENTS.

QUESTION 2. The underlisted measures have been identified as instrumental for pre-empting or minimizing 12 root factors of incidents associated with potentially severe environmental consequences in the petroleum industry. To what extent are the underlisted measures important towards reducing such factors within Ghana's petroleum sector?

Q1.12 Risk Factors to be Minimized (Risk Minimization Measures)

	1. Not at All Important	2. Low Importance	3. Slightly Important	4. Moderate Importance	5. Important	6. Very Important	7.Extremely Important
1. Minimization of human error	○	○	○	○	○	○	○
2. Addressing Governance system gaps	○	○	○	○	○	○	○
3. Pre-emption of sabotage, terrorism and vandalism	○	○	○	○	○	○	○
4. Improving socio-environmental accountability	○	○	○	○	○	○	○
5. Ensuring emergency preparedness planning	○	○	○	○	○	○	○
6. Minimization of operational risk taking	○	○	○	○	○	○	○
7. Minimizing delayed action and response to threats	○	○	○	○	○	○	○
8. Ensuring risk management	○	○	○	○	○	○	○
9. Addressing material resource management shortcomings	○	○	○	○	○	○	○
10. Addressing management and leadership shortcomings	○	○	○	○	○	○	○
11. Minimization of Equipment Failures	○	○	○	○	○	○	○
12. Addressing technical capability gaps	○	○	○	○	○	○	○

Q1.13
SECTION 3: KEY CAPABILITY ATTRIBUTES FOR ADDRESSING ENVIRONMENTAL DISASTER RISKS

QUESTION 3A. Underlisted are 16 key capability attributes, integral to minimizing environmental disaster risks in the petroleum sector (indicated above). Please rate the importance of each attribute, within the context of relevant public sector institutions in Ghana?

Q1.14 C1 - GOVERNANCE FUNCTIONS

	1. Not at All Important	2. Low Importance	3. Slightly Importance	4. Moderate Importance	5. Important	6. Very Important	7. Extremely Important
1. Legal and regulatory Mechanisms	○	○	○	○	○	○	○
2. Standards compliance monitoring/ auditing	○	○	○	○	○	○	○
3. Development of Governance Institutions	○	○	○	○	○	○	○
4. Inter-organizational Cooperation	○	○	○	○	○	○	○

Q1.15 C2 - TECHNICAL FUNCTIONS

	1. Not at All Important	2. Low Importance	3. Slightly Important	4. Moderate Importance	5. Important	6. Very Important	7. Extremely Important
1. Early detection and Warning Systems	○	○	○	○	○	○	○
2. Technology Adoption/ improvement	○	○	○	○	○	○	○
3. Decision Support Systems	○	○	○	○	○	○	○
4. Material resource management	○	○	○	○	○	○	○

Q1.16 C3 - MANAGERIAL FUNCTIONS

	1. Not at All Important	2. Low Importance	3. Slightly Important	4. Moderate Importance	5. Important	6. Very Important	7. Extremely Important
1. Research	○	○	○	○	○	○	○
2. Human Resource Development	○	○	○	○	○	○	○
3. Risk Management	○	○	○	○	○	○	○
4. Stakeholder Management	○	○	○	○	○	○	○

Q1.17 C4 - PROCESS FUNCTIONS

	1. Not at All Important	2. Low Importance	3. Slightly Important	4. Moderate Importance	5. Important	6. Very Important	7. Extremely Important
1. Emergency Preparedness Strategy	○	○	○	○	○	○	○
2. Public Involvement and Education	○	○	○	○	○	○	○
3. Preemptive, Early and Rapid Action (PERA)	○	○	○	○	○	○	○
4. Training and Simulation	○	○	○	○	○	○	○

Q1.18 QUESTION 3B. The underlisted disaster triggering incidents in the petroleum industry have been associated with extensive environmental damage, loss of life/ biodiversity, marine/ water pollution among others. What is the likelihood, these incidents could be prevented or minimized if public sector capability is developed in the 16 interventions identified above (3A)

Q1.19 Disaster incident triggers

	1. Extremely Unlikely	2. Very Unlikely	3. Unlikely	4. Moderately likely	5. Likely	6. Very Likely	7. Extremely Likely
1. Well Blow-out	○	○	○	○	○	○	○
2. Chemical discharges	○	○	○	○	○	○	○
3. Fire/ Explosions	○	○	○	○	○	○	○
4. Hydro-carbon releases	○	○	○	○	○	○	○
5. Marine Vessel/ Helicopter accidents (on oil rig)	○	○	○	○	○	○	○
6. Pipeline rapture/ Vandalism	○	○	○	○	○	○	○
7. Oil rig structural failure	○	○	○	○	○	○	○

Q1.20

SECTION 4: ASSESSMENT OF INSTITUTIONAL CAPACITY NEEDS QUESTION 4. The underlisted public sector institutions have been identified as critical to the prevention and management of environmental disaster risks in the petroleum sector. In your opinion, to what level do these institutions require capability Improvement in order to pre-empt and minimize environmental disaster risks within the Ghana context.

X→

Q1.21 INSTITUTIONAL SECTORS

	1. No Capability Improvement Required	2. Very Low Capability Improvement Required	3. Low Capability Improvement Required	4. Average Capability Improvement Required	5. High Level Capability Improvement Required	6. Very High Capability Improvement Required	7. Extremely High Capabilty Improvement Required
1. Environmental Regulatory Institutions	○	○	○	○	○	○	○
2. Petroleum Regulations Institutions	○	○	○	○	○	○	○
3. Response and incident management institutions	○	○	○	○	○	○	○
4. Security and enforcement institutions	○	○	○	○	○	○	○
5. Maritime Ports and Harbours Institutions	○	○	○	○	○	○	○
6. Local Government	○	○	○	○	○	○	○
7. Standards and Inspectorate Institutions	○	○	○	○	○	○	○

Q1.22
END OF SURVEY:
Please click the yellow arrowed button below to submit inputs. Where the submission fails, this could mean some questions have not been addressed. Uncompleted questions would show red; you can click on the draw up or drop down (^ v) arrows to open and complete unfinished questions. THANK YOU

Appendix B3: Institutional Map onto Underlying Root Factors: Attached to PIS

A) ROOT CAUSES OR FACTORS ATTRIBUTED TO THE INCIDENTS ABOVE		***B) IDENTIFIED/ PROPOSED INSTITUTIONAL SECTORS (*Not Organizations) DESIGNATED TOWARDS ADDRESSING INDICATED RISK FACTORS IN (A)***
1.	Equipment failure	1.Petroleum Regulation Institutions 2. Standards Inspectorate Institutions. 3. Security and Enforcement Institutions
2.	Human error	1. Petroleum Regulation Institutions
3.	Governance system gaps	1.Environmental Regulatory Institutions 2. Petroleum Regulation Institutions 3. Local Government Institutions 4. Maritime Ports and Harbours Institutions 5. Standards Inspectorate Institutions
4.	Sabotage, terrorism and vandalism	2. Security and Enforcement Institutions 2. Petroleum Regulation Institutions 3. Emergency and Incident Response Institutions 4. Maritime Ports and Harbours Institutions 5. Local Government Institutions
5.	Technical capability gaps	1. Standards Inspectorate Institutions 2. Petroleum Regulation Institutions
6.	Socio-environmental accountability shortcomings	1.Petroleum Regulation Institutions 2. Local Government Institutions 3. Environnemental Regulatory Institutions 4. Maritime, Ports and Harbours Institution.
7.	Managerial and leadership shortcomings	1. Petroleum Regulation Institutions 2. Standards Inspectorate Institutions
8.	Material management resource Shortcomings	1. Standards Inspectorate Institutions 2. Emergency and Incident Response Institutions 2.Petroleum Regulation Institutions 3. Security and Enforcement Institutions
9.	Operational risk taking flaws	1. Environmental Regulation Institutions 2. Petroleum Regulation Institutions 3. Standards Inspectorate Institutions

10.	Emergency preparedness planning gaps	1.Emergency and Incident Response Institutions 2. Security and Enforcement Institutions 3. Petroleum Regulation Institutions. 2. Environmental Regulatory Institutions 5. Local Government Institutions*
11.	Risk management shortcomings	1.Petroleum Regulation Institutions 2. Environmental Regulatory Institution 3. Standards Inspectorate Institutions 4. Security and Enforcement Institution 5. Maritime, Ports and Harbours Institution
12.	Delayed action and response	Emergency and Incident Response Institutions Petroleum Regulation Institutions Security and Enforcement Institutions Environmental Regulatory Institutions Local Government Institutions

Appendix C1: Participant Information Sheet For: Framework Validation Exercise

A FRAMEWORK FOR PRIORITIZATION OF CAPABILITY MECHANISMS FOR ENVIRONMENTAL DISASTER RISK MINIMISATION WITHIN THE PETROLEUM SECTOR OF GHANA

Invitation

You are invited to take part in a research project being undertaken at the University of the West of England, Bristol. This research is in partial fulfilment of a PhD study. Before you decide whether to take part, it is important for you to understand why the study is being done and what it will involve. Please read the following information carefully and if you have any queries or would like more information, please be free to contact the researcher Gerald Nana Acheampong, at the Faculty of Environment & Technology, University of the West of England, Bristol.

PhD Researcher: Gerald Nana Acheampong

Email: gerald2.acheampong@live.uwe.ac.uk

Project Supervisor: Prof. Colin Booth - Email: colin.booth@uwe.ac.uk

Second Supervisor: Dr Abdul-Majeed Mahamadu -

Department: Faculty of Environment and Technology

Aim of the study

The research is directed towards exploring the pivotal relation between improved disaster risk reduction capability within public sector institutions, and environmental disaster risk pre-emption/

minimisation within the petroleum sector of Ghana. This is aimed at establishing a capability improvement framework for improvement of public sector institutional capability towards minimising environmental disaster risks within the petroleum sector of Ghana.

Research questions: The research questions are: (a) What are the key institutional capability mechanisms requisite for minimising environmental disaster risks within the petroleum sector of Ghana? (b) How can the identified capability attributes be assessed and improved. The aim for your participation in this exercise is outlined in letter of invitation attached. The results of the study will be analysed and used to produce a doctoral thesis that could be made available to students through the University of the West of England's online library system. The anonymised results may also be used in conference papers and peer-reviewed academic papers.

Reason for invitation

As a seasoned professional, expert and or academic, the researcher is interested in gaining information about your views on the questions and aim outlined; therefore, the interview will seek to access informationa about your expert opinions, on the suitability and applicability of the framework established from findings within this study towards achieving the aim and goal.

Do I have to take part?

You are not obliged to take part in this research. It is up to you to decide whether or not you want to be involved. If you do decide to take part, you can download a copy of this participant information sheet to keep, together with the Privacy Notice and Consent Form. Please note, if you do decide to take part, you are able to withdraw from the research before, during or after, without giving a reason until 14 days after completion of process, at which point the anonymised data will be incorporated within the analysis.

What will happen to me if I take part and what do I have to do?

If you agree to take part you will be asked to provide your expert/ professional view on the institutional capability attributes identified within literature, required for mitigating environmental disaster risks within the petroleum sector, which should take approximately 10 minutes. The subject and focus of the questions will be whether you agree with the comprehensiveness/ relevance of the list of capability attributes identified or not, and if not to provide any missing attributes. Your answers will be fully anonymised. Please note your identity may be known only to the researcher and his supervisors however your personal details will never be shown anywhere in the research or in any reports or outputs. Where data from your survey is to be used it will be represented by a pseudonym.

Your views and answers will be provided via email and integrated with other participant inputs using a unique identifier code, which will be used to re-identify you if you choose to withdraw from the study, up 14 days on completing the survey, after which date your data will be anonymised and be analysed with survey data from other anonymised participants.

What are the benefits of taking part?

The decision support framework to be developed through this process, will be instrumental towards assessing and improving essential capability and enhance capacity for reducing environmental disaster risks in the petroleum sector of Ghana

What are the possible risks of taking part?

There are no particular risks identified or anticipated. However, if at any point a participant feels uncomfortable about the process, he/ she can ask to withdraw without providing explanation

What will happen to your information?

All the information received from you will be treated in the strictest confidence. All the information that you give will be kept confidential and anonymised in soft copy in a secured UWE-Bristol allocated computer and allocated one drive, to which only the researcher will have access in accordance with the University's regulations on the Data Protection Act 2018 and General Data Protection Regulation requirements. Your anonymised data will be analysed together with other survey data and will ensure that there is no possibility of identification or re-identification from this point. Please note your identity may be known only to the researcher and his supervisors however your personal details will never be shown anywhere in the research or in any reports or outputs. Where data from your survey is to be used it will be represented by a pseudonym.

Where will the results of the research study be published?

A doctoral thesis will be written containing the research findings. This Report will be available on the University of the West of England's open-access Research Repository. A hard copy of the dissertation will be made available to all research participants if you would like to see it. Key findings will also be shared both within and outside the University of the West of England. Anonymous and non-identifying direct quotes may be used for publication and presentation purposes.

Who has ethically approved this research?

This research project has been reviewed and approved by the Faculty Research Ethics Committee (FREC). Any comments, questions or complaints about the ethical conduct of this study can be addressed to the supervisor or UWE's Research Ethics Committee (researchethics@uwe.ac.uk)

What if something goes wrong?

Should you have any concerns or complaints about this research project please contact the supervisor named at the top of this form, Coilin Boot: colin.booth@uwe.ac.uk.

Context and Definition

For the purpose of this study, you may rely on the following references or definitions

Environmental Disaster Risks:

Refers to events, interlinked factors or conditions which can develop into extensive environmental damage (This research excludes naturally occurring events, e.g. Tsunami, etc).

Critical Capability Mechanisms:

Refers to the key resource base and ability pertaining to an institution towards achieving assigned job functions; and is synonymous/ reflective of terms such as capacity, competence, ability, preparedness etc.

Disaster Risk Minimisation:

Adopts the UN definition of Disaster risk reduction (DRR), which is: policies/ measures in place, aimed at preventing new and reducing existing disaster risks. This includes mitigating vulnerability of people and property, prudent management of land and the environment, and improving early warning/ preparedness towards adverse events.

What if I have more questions or do not understand something?

If you would like any further information about the research, please contact the researcher or supervisor on emails above

Thank you for agreeing to take part in this study.

You will have a copy of this Participant Information Sheet and your signed Consent Form to keep.

Consent Form

Research Project: A Framework for Prioritisation of Capability Mechanisms For Environmental Disaster Risk Minimisation Within Ghana's Petroleum Sector.

This consent form will have been given to you with the Participant Information Sheet. Please ensure that you have read and understood the information contained in the Participant Information Sheet and asked any questions before you sign this form. If you have any questions please contact a member of the research team, whose details are set out on the Participant Information Sheet

If you are happy to take part in the survey, please sign and date the form. You will be given a copy to keep for your records.

Name (Printed)…………………………………………………………………………….

Signature……………………………………………………. Date…………………….

SAMPLE INVITATION LETTER: FOR VALIDATION OF FRAMEWORK (To be emailed to participants)

Faculty of Environmental Technology

University of the West of England-B

BS16 1QY

United Kingdom

Date…/…/ …..

Dear Sir/Madame,

<u>REQUEST FOR PARTICIPATION IN RESEARCH ON: A FRAMEWORK FOR PRIORITISING CAPABILITY MECHANISMS FOR ENVIRONMENTAL DISASTER RISK MINIMISATION, WITHIN GHANA'S PETROLEUM SECTOR</u>

You are respectfully invited to participate in a PhD research validation exercise, undertaken at the University of the West of England-Bristol on the above subject. The research is directed towards exploring the fundamental relation between improved disaster risk reduction capability in public institutions, and environmental disaster pre-emption/ mitigation within the upstream petroleum sector of Ghana. This is aimed at establishing a Capability Improvement Framework (CIF) for assessment and improvement of institutional capability for mitigating environmental disaster risks, within the petroleum sector of Ghana.

Toward this aim, you will be asked to validate the suitability and effectiveness of the framework established from findings within this study. Your invitation to participate is based on your established expertise on the topic under study. With improved capability from interventions such as envisaged in this project, it is hoped Ghana's infant offshore oil infrastructure would be better positioned to avoid some of the pitfalls, such as avoidable disasters that have bedevilled other oil producing countries.

Thank you for the kind attention and anticipation of a favourable consideration of this invitation.

Sincerely,

Gerald Nana Acheampong

(PhD researcher)

Appendix C2: Framework Validation Interview Form

Section (a) FRAMEWORK VALIDATION QUESTIONS: Please note*; respondents can seek clarification or make queries on any aspect of the framework/ questions which are not clear to understand: likewise, the researcher may make further enquiries on responses which are not clear or seek further information where required (*Researcher Contact Information is shown below**).

Semi-structured Questions: Answer: Yes or No (If 'No', please provide reason)

1. Is this framework useful for the intended purpose of pre-empting underlying risk factors that lead to environmental disaster conditions (such as shown in appendix A of framework attached)? Answer:…………………………………..

2. Is the framework:

(a) Clear and easy to understand? Answer:………………………………

(b) Simple and easy to adapt? Answer:……………………………………

3. Would you recommend this framework for use by the relevant state institution(s)? Answer:……………….

4. (i) Under column 'C', you may suggest additional institutions you believe are key stakeholders which ought to be added within particular rows. For example, under row 7 (for minimizing 'Human error') you may suggest relevant/ additional institutions. Answer:… …………………………………….

5. Any other suggestions/ inputs that could enhance and strengthen the framework, can be included here (below). >>>>

……………………………………………………………………………………………………… …………………………………..

Section (b) VALIDATORS BACKGROUND INFORMATION

Required Information	Response
a) PROFESSION / AREA OF EXPERTISE	*(e.g., System Analyst/ Petroleum or Marine Engineering, HSSE etc.)*
b) POSITION HELD IN ORGANISATION	*(e.g., Assistant Director, Auditor etc)*
c) NAME OF INSTITUTION/ ORGANISATION/ COMPANY etc.	
d) NUMBER OF YEARS IN OCCUPATION	
e) ACADEMIC STATUS (highest qualification only/ subject area)	*(e.g., MSc/in Safety Engineering etc.)*
f) PROFESSIONAL QUALIFICATION (if different from academic qualification)	
YOUR UNIQUE IDENTIFICATION NUMBER	FV000

Researcher Contact: email- gerald2.acheampong@live.uwe.ac.uk /Tel. No. +447405959378

Appendix D: Authors Publications

Acheampong, G., N., Booth, C.A., and Mahamadu, A. (2021) Minimisation of environmental disaster risks within the upstream petroleum sector of Ghana. The 7th International conference on Sustainable Ecological and Enginneering Design for Society (SEEDS). 1 – 3 September 2021, Leeds Becckett University, Leeds, United Kingdom.