



A Blockchain-enabled Framework for the Humanitarian Supply Chain in Kenya

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A Blockchain-enabled Framework
for
the Humanitarian Supply Chain in Kenya

Jemimah Muthoni Maina

A thesis submitted in partial fulfilment of the requirements of
Sheffield Hallam University
for the degree of Doctor of Philosophy

February 2025

Candidate Declaration

I hereby declare that:

1. I have not been enrolled for another award of the University, or other academic or professional organisation, whilst undertaking my research degree.
2. None of the material contained in the thesis has been used in any other submission for an academic award.
3. I certify that this thesis is my own work. The use of all published or other sources of material consulted have been properly and fully acknowledged.
4. The work undertaken towards the thesis has been conducted in accordance with the SHU Principles of Integrity in Research and the SHU Research Ethics Policy, and ethics approval has been granted for all research studies in the thesis.
5. The word count of the thesis is 73800 words.

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Date of Submission	February 2025
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Director(s) of Studies	Professor Sameh Saad

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Dedication

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Abstract

As the frequency and intensity of disasters continue to rise globally, there is a growing need for efficient humanitarian supply chains, which are crucial for delivering lifesaving resources during emergencies. (HSCs), particularly in resource-constrained environments like Kenya, face critical challenges of aid diversion and fraud, logistical delays, and a lack of trust amongst humanitarian partners, which makes information sharing and coordination difficult. Solving these multi-faceted challenges calls for innovative approaches. Blockchain technology (BCT), known for its decentralised and immutable features, guarantees data privacy and security, and provides benefits of enhanced transparency and trust, which are critical in addressing operational challenges within HSCs.

Numerous authors have recommended the integration of blockchain solutions in HSCs. To date, there remain few blockchain use-cases that provide evidence on the benefits and limitation of its implementation. Furthermore, humanitarian organisations (HOs) still face the challenge of how to implement the blockchain as there is a lack of a framework to guide them on the implementation process. This thesis aimed at filling this gap, by designing and developing a blockchain-enabled framework tailored for the HSC in Kenya. The framework shows a clear roadmap for blockchain implementation stages with distinct phases from initial planning to full-scale deployment and optimisation of the blockchain.

The research adopted a mixed-method approach, specifically the explanatory sequential design, which starts with a quantitative phase, followed by a qualitative phase. For the quantitative phase, a feasibility study was conducted through a questionnaire survey involving key Kenyan humanitarian stakeholders, to identify the sectoral needs that BCT could address. Further to the feasibility study, the survey explored stakeholder's awareness about the blockchain. Statistical analysis for hypothesis testing was conducted using SPSS statistical software. Insights from the analysis, supplemented by secondary literature, guided the development of the blockchain-enabled framework. The qualitative phase involved the validation of the framework, and deeper exploration, and explanation of the quantitative results, which was done through in-depth interviews, with Kenya humanitarian experts. The interviews were coded and analysed thematically, using Nvivo software.

The finetuned blockchain-enabled framework consisted of nine stages. Findings indicate that the awareness stage was the most critical for the wide-scale adoption of BCT. BCT promises to significantly reduce most operational challenges within the Kenya HSC, ultimately strengthening disaster resilience of the country. To achieve these benefits, blockchain design should consider users experience, and interoperability with existing systems and HOs' values. Leaders must also support BCT implementation to ensure strategic buy-in. Respondents were worried about BCT's privacy and security due to association with fraudulent activities like the Silk Road, and therefore, stronger regulations and compliance to ethical standards in BCT usage is required to mitigate system risks. Future studies should focus on validating the blockchain-enabled framework in other countries to enhance the generalisation of results in HSCs. Further exploration of the benefits and drawbacks of using BCT in third-party and cloud computing infrastructure such as Microsoft Azure in HSCs is required.

Published Papers from my Ph.D.

SAAD, Sameh, MAINA, Jemimah, PERERA, Terrence and BAHADORI, Ramin (2022). Blockchain technology - understanding its application in humanitarian supply chains. In: SHAFIK, Mahmoud and CASE, Keith, (eds.) *Advances in Manufacturing Technology XXXV*. Advances in Transdisciplinary Engineering, 25. IOS, 385-391.

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List of Abbreviations

Abbreviations	Meaning
3D	Three dimensions
ACAPS	Assessment Capacities Project
AI	Artificial Intelligence
APV	Adjusted P-Value
ASAL	Arid and semi-arid lands
BCT	Blockchain Technology
BEH & IFHV	Bündnis Entwicklung Hilft and Institute for International Law of Peace and Armed Conflict
CBO	Community Based Organisations
CE	Coordinating Entity
CFA	Confirmatory Factor Analysis
CO	Collaboration
COMESA	Common Market for Eastern and Southern Africa
CRBV	Contingent Resource Based View Theory
CRED	Centre for Research on the Epidemiology of Disasters
CSF	Critical Success Factor
CSG	County Steering Group
DIMS	Disaster Information Management Systems
DLT	Distributed Ledger Technology
DOI	Diffusion of Innovations
DM	Disaster Management
DRM	Disaster Risk Management
DRO	Disaster Relief Operations
DRPs	Disaster Response Plans
DRR	Disaster Risk Reduction

EWS	Early Warning Systems
FBO	Faith Based Organisations
HL	Humanitarian Logistics
HO (s)	Humanitarian Organisation (s)
HoA	Horn of Africa
HQ	Headquarter
HR	Human resources
HSC	Humanitarian Supply Chain
HSCM	Humanitarian Supply Chain Management
HSNP	Hunger Safety Net Programme
ICRC	International Committee of the Red Cross
ID	Identification
IFRC & KRC	International Federation of Red Cross Societies and Kenya Red Cross
IoT	Internet of Things
IPRs	Intellectual Property Rights
LSP	Logistics Service Provider
M&E	Monitoring and Evaluation
MPESA	Mobile Money
NDMA	National Drought Management Authority
NDOC	National Disaster Operations Centre
NGO	Non-Governmental Organisation
NIMS	National Incident Management System
OCHA	Centre for Research on the Epidemiology of Disasters
OIPT	Organizational information processing theory
OSCT	Operational Supply Chain Transparency
PBFT	Practical Byzantine Fault Tolerance
PM	Project Management

PoA	Proof of Authority
PoC	Proof of Concept
PoS	Proof of Stake
PoW	Proof of Work
R&D	Research and Development
RBV	Resource Based View Theory
ROI	Return On Investment
RQ	Research Question
RVT	Relation View Theory
SAGAs	Semi-Autonomous Government Agencies
SC	Supply Chain
SCM	Supply Chain Management
SCR	Supply Chain Resilience
SET	Social Exchange Theory
SLR	Systematic Literature Review
SME	Small and Medium Enterprises
SOPs	Standard Operating Procedures
ST	Swift Trust
TAM	Technology Acceptance Model
TMST	Transactive Memory System Theory
TOE	Technological, Organisational and Environmental
UN	United Nations
USA	United States of America
UTUAT	Unified Theory of Acceptance and Use of Technology
WASH	Water, Sanitary and Hygiene
WFP	World Food Program
WHO	World Health Organisation

CHAPTER ONE

INTRODUCTION AND BACKGROUND OF STUDY

1.0 Introduction

This chapter provides an overview of humanitarian supply chains, with a background of disasters and the challenges encountered in managing them. A focus on blockchain technology in solving some specific challenges of trust and coordination is given. Additionally, the research purpose with objectives and research questions are provided, following a research problem that is grounded in a local context, in Kenya. A significance of the study and the structure of the thesis is provided at the end of this chapter.

1.1 Background of the Study

The increased number of recent disruptions and crises are affecting more people globally while lasting longer on average than ever before. This calls for adequate emergency preparedness systems such as the development of knowledge and capacities by governments, recovery organisations, communities, and individuals to plan, prepare, respond to, and recover from hazards or emergency situations (Leung et al., 2024) as threats like climate change, food insecurity and urbanisation continue to grow globally, thus driving the need for humanitarian action (Donatti et al., 2024). Global disruptions such as the Covid-19 pandemic; the on-going Ukraine and Middle-East war; The 2023 Turkey Earthquake; Locusts invasion in East Africa (2020); Hurricane Dorian in Bahamas (2019); Severe drought in Ethiopia (2015-2017); the 2014–2016 Ebola outbreak in West Africa; Hurricane Katrina in the USA in 2005; and the South-East Asia tsunami in 2004 have all served a reinforcement for better understanding of the need for humanitarian action.

Damoah (2022) maintains that a disaster is a severe disruption, which develops from a hazard, and it affects the normal functionality of a society. Disasters are mainly classified into two;

natural disasters such as earthquakes, and man made disasters such as terrorist attacks (Van Wassenhove, 2006). Damoah (2022) adds that a third category of disasters can be formed by a combination of both the man-made and natural disasters, and these are the most common and complex. Disasters are projected to continue rising (Behl & Dutta, 2019), and their impacts will raise more economic and human losses (Dubey et al., 2019), due to increased levels of vulnerabilities and exposure by populations that lack coping and adaptive mechanisms to deal with the disaster risks (Samaraweera, 2024). In 2023 alone, over ninety-three million people were affected by natural disasters globally with a total of 86,473 deaths and \$202.7 billion economic losses (CRED, 2024). The high deaths were attributed to the Türkiye earthquake that caused at least fifty-six thousand deaths (CRED, 2024). The number of people affected in that same year, is however below the last two decades (2003-2022) annual average of 175.5 million (CRED, 2024), and this phenomenal illustrate that the world has become more resilient to disasters because of improved early warning systems and reduction in poverty levels globally (Ritchie, 2024).

Despite this global trend of increased resilience, there remains a significant difference in how different countries are affected, with more people in developing and emerging economies facing significant disaster impacts (Samaraweera, 2024). African countries are hit more than European countries due to the differences in human development across these continents (Donatti et al., 2024). The Horn of Africa (HoA) in particular, is categorised as one of the most disaster-prone parts of the world with a distinguishing aspect of a ‘very high alert’ classification as compared to other countries that are classified as either ‘alert’ or ‘high alert’ (Kuol, 2019). Kenya, which is a country in the HoA, is extremely vulnerable to disaster risks like drought and floods that heighten other risks like food insecurity and malnutrition (BEH and IFHV, 2022). These risks are recurrent due to poor planning and delayed response from the government and other humanitarian stakeholders (Baudoin & Wolde-Georgis, 2015).

When a disaster occurs, humanitarian organisations (HOs) and host governments need to make a quick response to evacuate victims, provide food, medicines and other critical goods and services to those affected to save lives (Mangla & Luthra, 2022). Contemporary research advocates for these stakeholders to lay more emphasis on the Prevention and Mitigation phase which aims at reducing disaster risks rather than the response phase (Bang et al., 2019). According to Van Wassenhove (2006); Cozzolino et al. (2012) the disaster risk management (DRM) cycle is made up of four phases of mitigation, preparedness, response and recovery. More efforts are however geared towards the response stage, and the lack of or minimal efforts in other phases, minimises an effective DRM operation (Kovács & Spens, 2009). There's thus a global recognition that focusing on disaster risk reduction (DRR) efforts will promote disaster resilience (Bang et al., 2019). These efforts include making environmental developments through carbon emissions reduction (Caparros-Midwood et al., 2019), developing infrastructural projects (Sivakumar et al., 2024), strengthening the governance and political systems to seek for greater accountability (Almoradie et al., 2020), investing in technological advancements (Firdhous & Karuratane, 2018; Zhao et al., 2024), and increasing international co-operation to support DRR initiatives (Swaris et al., 2024).

The HOs, government, and donors are directly involved in disaster relief operations (DROs) and these stakeholders or actors must coordinate with all other stakeholders involved directly or indirectly with disaster activities, at all disaster phases, for improved disaster relief performance (Kovács & Spens, 2007). When these actors are coordinating, they form a supply (SC), which is a network of suppliers and buyers involved in upstream and downstream activities (Gurtu & Johny, 2019), only that in this case, a humanitarian supply chain (HSC) network is formed and the disaster-affected people replaces the buyers or consumers in a commercial SC and the donors form part of the suppliers who offer humanitarian support (Kabra & Ramesh, 2016).

Humanitarian Supply Chain Management (HSCM) offers an understanding of sourcing, procuring, moving, storing, and delivering relief materials to the disaster victims in ways that save lives, resources, and assets (Dubey et al., 2019; Burkart et al., 2017). For any SC, the three essential flows are finances, logistics and information (Wang et al., 2020) and therefore the operational excellence of supply and logistics is crucial to a successful DRO. Additionally, due to the impact of disasters on humanity (Sahebi, Arab, & Moghadam, 2017), the need to manage them is critical and it involves a series of SC activities (Damoah, 2022) such as assessing needs, planning, procurement, warehousing and transportation and these activities are undertaken before, during and after a disruption occurs.

A distinguishing feature between humanitarian and commercial SCs is the need to uphold humanitarian principles of humanity, neutrality, impartiality and independence during DRO (Coppi et al., 2021; Baharmanda, et al., 2021a). HSCs have a guiding belief that disaster victims have a right to life with dignity and a right to assistance and HSC actors must make measures to alleviate human suffering and save lives (Haavisto & Goentzel, 2015). HSCs are faced by unique challenges as compared to commercial SCs. Coordination of HSC actors is difficult due to their divergent and conflicting goals, lack of trust and inefficient information sharing which may lead to inefficient disaster response (Kova'cs & Spens, 2007; Prasanna & Haavisto, 2018; Dubey et al., 2020). HSCs face increased donor-pressure - to be transparent and accountable, often refereed to as 'donor preoccupation', where donors fails to invest in logistical preparations but funds the aftermath of a disaster, which inhibits DRO efficiency (Sandwell, 2011), and as HOs are pushed upwards to meet the donor expectation, they neglect the needs of the affected populations (Bealt & Mansouri, 2018).

Fraud and corruption in HSCs impede the humanitarian goal of allevating suffering of those in need (Saad et al., 2023; Dubey et al., 2024); which as a result pushes the affected persons to poverty. Based on these challenges, the researcher argues that there is an urgent need to

overcome these barriers to improve HSCM performance. Technological innovations could help in better management of emergencies and HSCs (Kabra & Ramesh, 2015; Mangla & Luthra, 2020). Particularly, disruptive technologies such as Blockchain Technology (BCT) have received great attention recently, to solve challenges of transparency, traceability and accountability in numerous industries like finance and banking, law and supply chain management (Kshetri, 2017; Mubarik et al., 2020; Sansone et al., 2023; Ghaffari et al., 2023). Blockchain is a distributed ledger that records transactions in blocks and links current transactions of an asset to previous transactions of the same asset to form a chain containing a history of all transactions of an asset, and ensure that the data is immutable and accurate (Mahmood & Jusas, 2021).

Integrating BCT in HSCM has been reported and recommended by various authors to solve specific challenges of trust, transparency and accountability, fraud and corruption and coordination (Rodriguez-Espindola et al., 2020; Hunt et al., 2022; Negi, 2024; Saad et al., 2023; Dubey et al., 2024). Despite these recommendations and the widely recognised benefits of the blockchain in HSCs, BCT practical implementation are few. Similarly, BCT remains at it's infancy stage with minimal explorations in HSCs (Saad et al., 2023), and this little empirical evidence limits its scalability (Dubey et al., 2024), as without numerous real-world evidences, its difficult to validate BCT impacts on HSCs (Baharmand et al., 2021). Additionally, the big question of how BCT can be implemented in HSC still remains (Ozdemir et al., 2021).

This thesis aimed to fill this gap by designing and developing a Blockchain-enabled Framework for the HSC, with a particular focus on the Kenya HSC. Mangla and Luthra (2020) note that creating awareness about technology advancements in emerging economies is paramount in creating an efficient and responsive HSC, and exploring Kenya's views on BCT applications, and the empirical validation of the blockchain-enabled framework add value in providing evidence-based studies for BCT and HSCM studies.

1.2 Research Problem

Kenya is highly vulnerable to natural disasters, especially drought and floods in the arid and semi-arid lands (ASALs), whose approximation is around 70% of the country's ground (Drummond & Crawford, 2014). The severe climate-induced risks have caused El Niño rains that have instigated severe floods in Kenya. Most of the times, the floods follows a prolonged drought, thus heightening food insecurity (Health Cluster & WHO, 2024). Currently, an approximate of 1.9 million people, which is 12% of the total population face food insecurity in Kenya (Relief Web, 2024a). Other crises facing the country include human disease like polio and mpox outbreaks, animal disease outbreaks, intercommunity conflicts, Al-Shabaab attacks, pests, landslides, urban and forest fires, infrastructure collapse, Tsunami and road accidents affecting an approximate of 3 to 4 million people per year (ACAPS, 2017; Government of Kenya, 2019). All these crises require humanitarian intervention.

These crises continue to recur, and, in some cases, the government declares some of them like droughts and floods a national emergency and appeals for help. Despite the efforts by the decision-makers to manage the disasters, the response to humanitarian predicaments is not timely and needs improvement to save lives and reduce human suffering to the victims. This research identified the current structure of HSCM in Kenya by exploring the existing operational policies and legislation structures and the actors involved to find out gaps and develop a framework for improvement. Kenya's preparedness to disasters is faced by challenges of low political will, weak coordination of stakeholders, competing national priorities in the parliament, political interference with DRR, and fraud and corruption that leads to diversion of relief aid items (Development Initiatives, 2017; Nyandiko, 2020; The Star, 2024; Mbiyozo and Owino, 2024). The analysis of Kenya DRM policy also reveals that the country lacks a structured mechanism for mobilising humanitarian aid items like medicines, blood banks, water, sanitary and hygiene products (WASH) and other non-food items. The

country also lacks a structured resource register or database for funding or registering trained volunteers as well as DRM technical and specialised human resource (Republic of Kenya, 2017).

Based on these multifaceted challenges, immense pressure has been created on the Kenya HSC. This research argues that BCT could improve Kenya's HSC performance by addressing specific challenges of coordination, transparency of information and financial flows, and accountability of relief aid and funds and the development of the Blockchain-enabled Framework will function as a useful guide to HSC stakeholders for BCT adoption. Baudoin and Wolde-Georgis (2015) notes that disaster research in the Horn of Africa (HoA) has received extraordinarily little attention, yet the lessons learnt from these countries that are classified as the world most vulnerable, could largely contribute to global knowledge on DRM. Additionally, much of the research done in the HoA has been led by external scholars who predominantly focus on studying regional cross-cutting topics. This calls for context-specific studies that are locally relevant and can influence policy directions (Kuol, 2019).

This research aims to make a notable contribution to the scant research on BCT in HSCs, specifically within the Kenya context, where at the time of writing this thesis there was no research on BCT in the country, despite Kenya being recognised worldwide as the pioneer of a blockchain pilot project in the HSC, conducted by IFRC and KRC. This research is thus timely and relevant, as the absence of similar work, underscores its originality and novelty, which means that this research is pioneering a new approach of creating a Blockchain-enabled framework grounded in local contexts, which could be adapted or scaled to other countries experiencing similar humanitarian challenges, and adapted to other industries too, thus making a notable theoretical and practical contribution to both the blockchain and humanitarian fields.

1.3 Research Purpose

1.3.1 Aim of the Research

The aim of the thesis was to design and develop a Blockchain-enabled Framework for the Kenya HSC. This framework will act as a road map for adopting a Blockchain-based HSC in Kenya.

1.3.2 Research Questions

The main overarching research questions (RQs) for this research were: -

1. What are the challenges, opportunities and gaps for blockchain technology applications in humanitarian supply chains?
2. What is the current structure of humanitarian disaster risk management in Kenya? What challenges exist? What inefficiencies can be reduced by blockchain technology?
3. What stages should humanitarian organisations go through to adopt the blockchain? What are the requirements for a successful blockchain implementation by humanitarian organisations in Kenya?

1.3.3 Research Objectives

To fulfil the aim and RQs, this research followed the following **specific objectives**:

1. To conduct a comprehensive literature review to assess the research landscape, challenges and opportunities for blockchain technology applications in humanitarian supply chains. (Links to RQ1)
2. To assess the current structure of the humanitarian disaster risk management in Kenya and evaluate its effectiveness in reducing disaster risks. (Links to RQ2)

3. To determine the feasibility of blockchain technology in the Kenya humanitarian supply chain and evaluate differences in how stakeholders perceive the factors influencing their readiness to adopt it. (Links to RQ2 & RQ3)
4. To formulate the Blockchain-enabled humanitarian supply chain framework using the findings from the above stages. (Links to RQ3)
5. To validate the framework through an interview and refine the framework based on the feedback. (Links to RQ3)

1.4 Significance of the Study

It is expected that the results of this work will be used by the humanitarian communities both locally and globally whose goal is to reach every vulnerable individual and offer timely assistance. This work will specifically help the government of Kenya in addressing its humanitarian crises and disasters. According to the Government of Kenya (2019) one of the biggest challenges in addressing disasters in Kenya is the lack of effective policies, legal structures, and institutional frameworks for coordinated disaster risk reduction. The hope is that this research could influence policy formulation to integrate BCT in addressing the persistent HSC challenges in Kenya. If Kenya is to be responsible in managing its humanitarian crises, it will be crucial to foster more coordination of HSC actors in relief operations and using innovative mechanisms and tools like BCT will improve coordination, due to the improved trust among the actors. Information sharing will improve as a result, which is critical in DRM and strengthening the country's resilience to disasters.

Referrals to this work could be beneficial in the establishment of the Disaster Risk Management Centre of Excellence which will help in achieving Kenya's Vision 2030. The scarcity of BCT studies addressing specific challenges from a local context like Kenya, highlights a critical literature gap that this research will contribute to. Besides, there is also scarcity in practical frameworks for BCT implementation in HSCs and the empirical evidence

provided in this work contribute to evidence based cases. Academic scholars can use the findings of this research to advance their studies. HSC practitioners from other regions and global contexts could use this framework and test it in their own SCs and share the lessons learned.

1.5 Structure of the Thesis

The thesis is structured in nine chapters as follows.

- a) Chapter One – Introduction and Background of the Study
- b) Chapter Two – Literature Review
- c) Chapter Three – Research Methodology
- d) Chapter Four – Blockchain Technology Feasibility in Kenya - Questionnaire Survey
Quantitative Data Analysis
- e) Chapter Five – Development of the Proposed Blockchain-enabled Framework
- f) Chapter Six – NVivo-Based Thematic Analysis of Expert Opinions on Kenya's HSC
- g) Chapter Seven – Validation of the Proposed Blockchain-enabled Framework
- h) Chapter Eight – Summary and Discussions on the Findings
- i) Chapter Nine - Conclusions, Recommendations, Contributions to Knowledge, Limitations, and Further Areas of Study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter provides a literature discussion of disasters and how to manage them, the features and challenges of humanitarian supply chains and a critical evaluation of blockchain technology. A systematic literature review of blockchain technology's use in humanitarian supply chains is provided, which reveals gaps that require further exploration. A theoretical framework based on the Technology- Organisation- Environment (TOE) model, which was utilised in this research, is presented at the end of this chapter.

2.1 Disasters

A disaster is a major disturbance that disrupts the functionality of a society due to the human, material, or environmental losses it causes, and these losses surpasses the affected community's capacity to manage with its own resources (Damoah, 2022).

Disasters are categorised into two types; natural and man-made disasters (Van Wassenhove, 2006) as shown in **Table 2.1**. Natural disasters can be sudden-onset like earthquakes, hurricanes, tornadoes or slow-onset disasters that include famine, drought and poverty.

Table 2. 1: Classification of disasters. Source: Authors; Adapted from (Van Wassenhove, 2006)

	Natural	Man-made
Sudden-onset	Earthquake	Terrorist attack
	Hurricane	Coup d'etat
	Tornadoes	Chemical leak
Slow-onset	Famine	Political crisis
	Drought	Refugee crisis
	Poverty	

Man-made disasters, have similar categorisation like natural disasters. The sudden-onset

disasters include terrorist attacks, coup d'etat, and chemical leak while the slow-onset disasters include political and refugee crisis (Van Wassenhove, 2006; Jabbour, et al., 2019).

For disaster risks to occur, they have to be determined by hazards, exposure and vulnerability (BEH and IFHV, 2022), as shown in **Figure 2.1**. A lack of exposure and vulnerability doesn't make the hazard dangerous, and therefore these two factors explain why some hazards like floods can lead to extreme impacts and losses, while others do not (Choo et al., 2024). The intersection of the causes of disaster risks is illustrated in **Figure 2.1**.

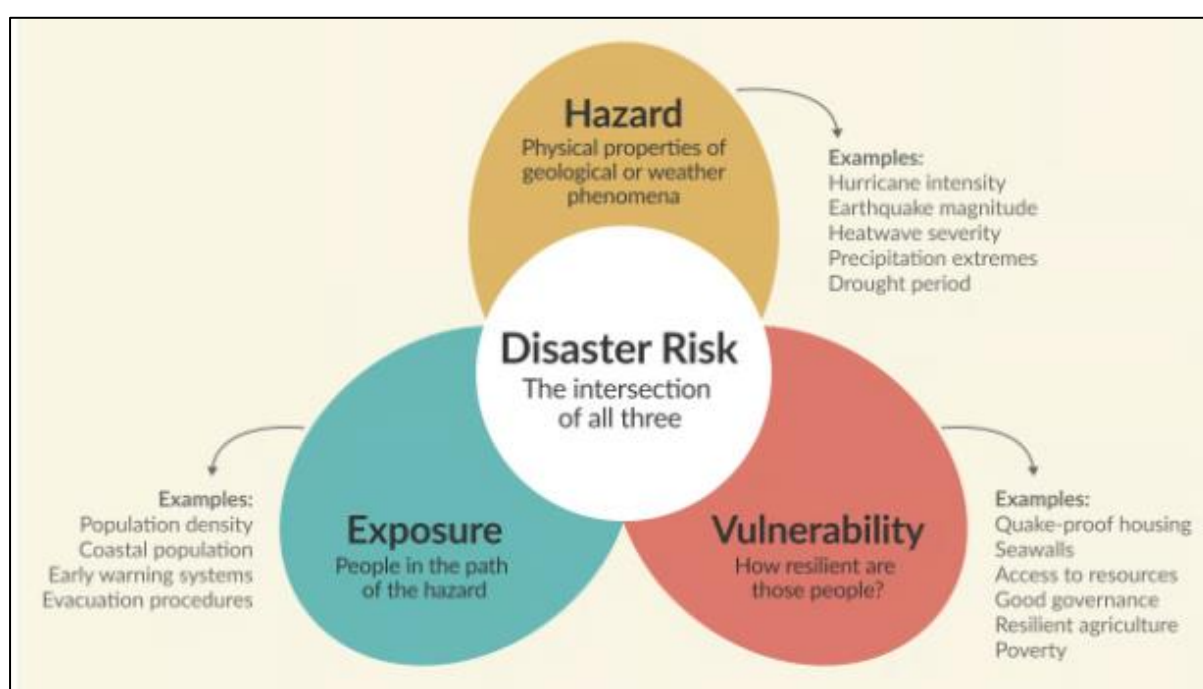


Figure 2. 1: Causes of disaster risks (Ritchie, 2024)

The World Risk Report 2024 mentions that disaster vulnerability is caused by susceptibility to disasters, lack of coping, and adaptive capacities (Relief Web, 2024b) as explained below.

- susceptibility to disasters – depends on social-economic developments and a weakened population, as a result of diseases, violence and disasters
- lack of coping capacities – caused by social disruptions, political instability, inadequate infrastructure and material security

- lack of adaptive capacities – caused by inadequate development in research and education and a lack of disaster preparedness

2.2 Disaster Risk Management (DRM)

DRM is the process of managing disaster risks that occurs in four phases of mitigation, preparedness, response and recovery (Bao et al., 2022). Disaster management (DM) also involve managing and responding to disasters across the four phases of mitigation, preparedness, response and recovery (Bealt & Mansouri, 2018). DRM, however, differs from DM in that DRM is more comprehensive and reactive, because it focuses on preventing and mitigating risks. DM on the other hand focuses on reaction and recovery, which is proactive (Rajabi et al., 2022). Therefore, DRM involve disaster risk reduction (DRR) and DM (Rajabi et al., 2022). The four disaster phases occur in a cycle as illustrated in [Figure 2.2](#). The first two stages are aimed at taking precautions to prevent and minimise the occurrence of disasters and the negative impacts thereof and there has been an increased shift to DRR, which is proactive and focus on reducing disaster risks rather than the reactive means of responding to disasters (Baudoin & Wolde-Georgis, 2015; Mysiak et al., 2016; Bang et al., 2019). The mitigation stage is crucial in setting up collaborative networks and IT systems that helps to shorten the response times (Kova'cs & Spens, 2007), but it is difficult as it receives very little funding (Sandwell, 2011).

Van Wassenhove (2006), argument that the preparedness phase consists of five key elements: human resources, knowledge management, process management, resources, and community. Selecting and training people is key in planning, coordinating, and making intervening mechanisms, which should be done at a local level to enhance better response to disasters. Knowledge management enables learning from past disasters and making knowledge transfers regarding logistics operations. Operation and process management involve making plans about supplies and transport of resources needed to quickly respond to crises. Financial resources

ensure that there is enough money to plan and initiate operations from start to finish of DRO. The community ensures effective collaboration with other key players.

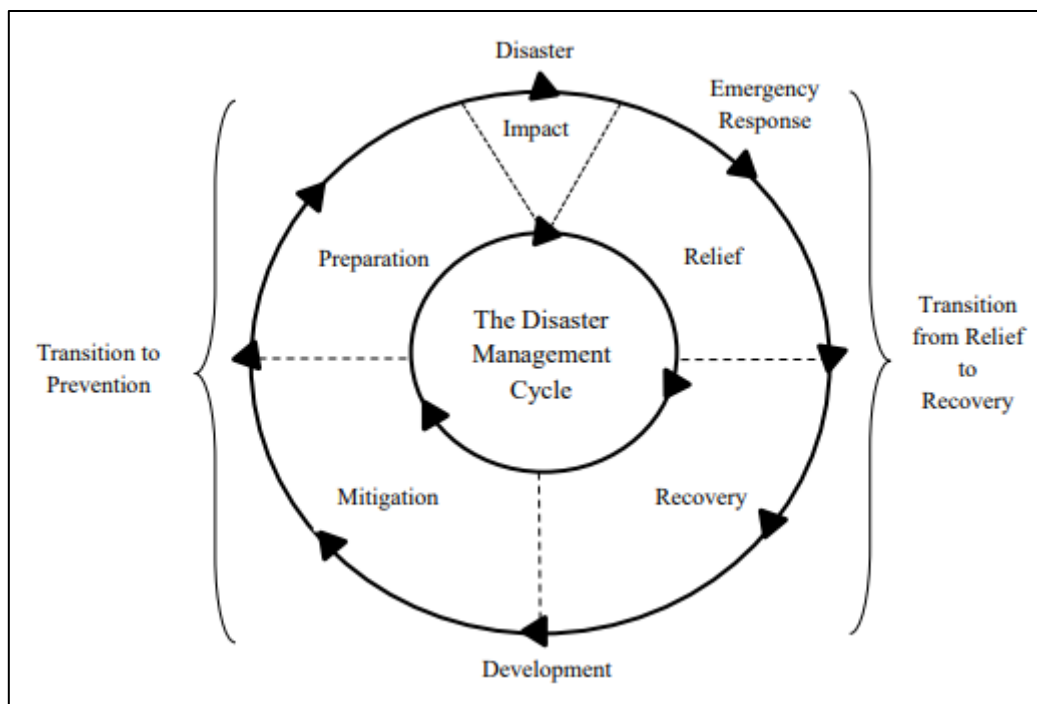


Figure 2. 2: *The disaster management cycle* (Bealt & Mansouri, 2018)

The response stage deal with short term response after the disaster has occurred and the objective is to link demand with supply and manage fulfilment (Cozzolino et al., 2012). This stage also requires effective coordination of all humanitarian players and hence agility and swift trust is crucial (Dubey et al., 2019). The last stage ensures long-term reconstruction to enhance resilience to the affected populations. Unfortunately, this stage has severe consequences to the victims and is often neglected due to minimal funding (Kova'cs & Spens, 2007). **Table 2.2** illustrates the challenges involved in DRM at each phase.

Table 2. 2: DRM Phases. Source: (Researcher)

Disaster Response Phase	Main Objectives	Challenges
Mitigation	Analysis of potential hazards in a specific area and implementing risk reduction programs	Shortage of funds due to low donors' interest
Preparedness	Cost and need forecasting for various disaster scenarios	Future needs uncertainty

	Capacity planning through preparedness plans and trainings	Poor coordination amongst humanitarian players
	Resource allocation for disaster responses and future disasters	Shortage of funds due to low donors' interest
Response	Secure an adequate amount of funds quickly for immediate response to save lives	Slow disbursement of government funds Too little or too many funds depending on media response Too much or too less information sources Lack of trained personnel Damaged transport and communication infrastructure
Reconstruction	Fund allocation to long-term recovery considering efficiency of finances, impacts and needs to reduce vulnerability	Shortage of funds due to low donors' interests Re-allocation of funds to arising emergencies Poor coordination amongst stakeholders Dependency on aid by communities Lack of performance metrics

2.3 Humanitarian Supply Chain Management

Based on an article by International Committee of the Red Cross (ICRC) (1998), humanitarianism has been traced back in 1859 during the Battle of Solferino, when Henri Dunant, a business tourist was shocked by the aftermath of the war and made efforts to gather overwhelming relief assistance to help the wounded soldiers without discrimination. He then wrote a book, "A memory of Solferino" that eventually led to the creation of International Committee for Relief to the wounded, the ICRC. HSCM studies have continued to receive attention due to the increased crises requiring humanitarian intervention. Moreover, Logistics and Supply Chain Management (SCM) are critical success factors for an effective DRO as around 80% of all relief operations are SC activities (Saad, et.al, 2022).

HSCM is used interchangeably with humanitarian logistics (HL). Peretti, et.al, (2015) argued that HL covers the whole supply network from purchasing to last mile distribution while managing other duties like facilities management and security. This makes it more significant and challenging than the commercial logistics that involve general oversight of products, services and information flow through the supply network. Multiple objectives are involved in HL with costs constraints. HL has received significant attention after the Asian tsunami in 2004 due to its vital role of material distribution and rescue in DRO (Kovacs & Spens, 2011; Mangla & Luthra, 2022).

Importantly, in 2005, the UN introduced clusters in HSC and one of the clusters is logistics. The other clusters are "agriculture, camp coordination and management, early recovery, education, emergency shelter, emergency telecommunication, health, nutrition, protection and WASH " to make a total of 11 clusters (Jahre & Jensen, 2010). UN-OCHA (2007) illustrate that these clusters were aimed at coordinating humanitarian efforts between the UN and non-UN humanitarian actors to improve efficiency and response by ensuring increased capacity, predicability in leadership, accountability and partnerships among humanitarian actors. These clusters currently operate in 25 countries (Jahre & Jensen, 2010) and have been deployed in several disasters since their formation and successful results have been achieved but in other disasters like the 2005 Pakistan earthquake, intercluster coordination was observed to be a challenge (Jahre & Jensen, 2010). HL has grown over the years and rapid research has accelerated after 2011, after the birth of the Journal of HL and SCM in 2010, with its first issue being in 2011 (Kovacs & Spens, 2011).

2.4 Principles of Humanitarian Operations

HSCs must uphold the principles are humanity, neutrality, impartiality and independence (Coppi et al., 2021; Baharmanda, et al., 2021b). These principles are illustrated in [Table 2.3](#). The principle of humanity means to 'do no harm' in an effort to alleviate human suffering by

protecting life and health and respecting humans. Neutrality principle states that humanitarians should not engage in controversial topics that involve taking sides in hostilities and situations such as politics, religion, and race. The principle of impartiality stipulate that humanitarian actors should conduct relief operations on the basis of need alone and the most urgent cases of distress should be given priority without making any distinctions in places and population.

The principle of independence mandates that humanitarian efforts remain distinct from political, military, economic or any other objective an actor may have regarding the affected area (UN OCHA, 2012). According to (ICRC, 1986), the fundamental principles that were declared by the 20th International Conference of the Red Cross at Vienna in 1965 were the principle of “humanity, impartiality, neutrality, independence, voluntary service, unity and universality.” HSCs have since applied the first four principles. The other three principles are still adopted by the IFRC.

Table 2. 3: Principles of Humanitarian Operations

Major HSCs Principles	Meaning
Humanity	Relieve human suffering by protecting life and respecting humans
Neutrality	Humanitarians shouldn't take sides in controversial situations
Impartiality	Prioritise the urgent cases with no discrimination
Independence	Separate humanitarianism from other goals in the target area

2.5 Features of HSCs

HSCs, unlike commercial SCs, lack a predetermined set of suppliers and manufacturers (Kovács & Spens, 2007), and material flows in one direction to the recipients unlike in a commercial SC where materials could flow in both directions (Olaogbebikan & Oloruntoba, 2019). HSCs are characterised by unpredictable demand due to the unpredictable nature of disasters (Olaogbebikan & Oloruntoba, 2019). HSCs are dynamic and great uncertainty exists in places of the disaster, that most often characterised by damaged infrastructure (Charles et

al., 2016). In HSCs, supply just like the demand, is highly uncertain and constrained by budgets, as more people continue to suffer as the disaster continues (Comes et al., 2020).

There is a short lead time between the occurrence and fulfilment of demand, and any delays in fulfilment could mean suffering and death of lives (Kovács & Spens, 2007). Additionally, there are many and diverse objectives to pursue in a HSC, with many converging stakeholders, but these objectives are constrained by severe time pressures to respond swiftly to meet the humanitarian goals (Kovacs & Moshtari, 2019). There's also a huge reliance on government and donors to fund HSC activities which causes donor fatigue (Toyasaki & Wakolbinger, 2014).

2.6 Challenges of HSC

Wagner & Weigold (2018) articulates that finding the right human resource to manage HSCs is difficult due to high staff turnover or lack of qualified DRM personnel which makes it difficult to assess needs and respond to them effectively (Baharmanda et al., 2021). Besides, HSC training courses focuses more on collaboration and organisations issues thus causing a deficiency in technical knowledge and skills (Wagner & Weigold, 2018). Comes et al, (2020) argues that HSCs suffers from unreliable information and information overload. Traditionally, information was uncertain due to data gaps and many efforts to collect data have been made and currently due to technology driven innovations, the simplicity of generating and distributing data has led to an increase in subjective and localised information, some of which is of unknown origin and hence may not be reliable (Monaghan & Lycett, 2013).

Other challenges inherent in HSCs include weak monitoring and inadequate performance measures (Balcik et al., 2010; Hashemi Petrudi et al., 2020); Poor strategic planning that limits countries or regions affected to learn from past disasters (Yadav & Barve, 2016); Poor management of donations, both in-kind donations and funds, coupled by a lack of proper

disaster waste management (Yadav & Barve, 2016); Social cultural and political instability of the affected regions and these factors could affect HOs in providing swift assistance (Hashemi Petrudi et al., 2020); The high dependency on donors and food aid leads to lack of sustainable efforts (Kovács & Spens, 2009); Poor inventory management system due to a high variation in demand during the disaster period (Karuppiyah et al., 2021) and lack of trust, transparency, accountability and visibility that hinders coordination of HSC stakeholders (Saad et al., 2023; Dubey, Rameshwar et al., 2024).

There has been an attempt to provide solutions to these problems through studies that aim at solving coordination challenges through clusters, options contract and spot market procurement (Jahre & Jensen, 2010; John et al., 2022), logistics and inventory management challenges through prepositioning of relief items (Abazari et al., 2021) and an increased attention to use technology innovation to solve HSC challenges has risen. Despite these efforts, technological adoption in HSCs is not well understood and more explorations on its implementation are required (Dubey, Rameshwar, 2022; Shayganmehr et al., 2024). Specifically, blockchain technology which has a capability to solve numerous of this issues such as coordination, trust, information transparency and visibility, and accountability, needs further exploration with empirical evidence (Baharmand et al., 2021b).

2.7 Technology Innovation in HSCs

Kabra et al., (2017) notes that the use of IT in HSCs is limited as compared to commercial SCs, because HSCs lack technical expertise to operate sophisticated IT tools, most disaster-prone regions face infrastructural challenges of hardware and internet connectivity, cultural resistance challenges are prominent due to lack of awareness and familiarity with new technologies, and lack of budget allocations for IT programs. HOs should consider beneficiaries in their innovation goals, as the most vulnerable persons within the communities in disaster-prone areas suffers the most from digital divide challenges (Haavisto et al., 2015). According to Iqbal et

al., (2022), digitisation which involves integrating digital technologies like the blockchain in HSCs to enhance transparency in humanitarian operations, has received a lot of attention in recent years from HOs, to efficiently manage their operations. The authors note that despite the benefits brought by digitisation, challenges like infrastructure and resource constraints, and knowledge and skills gaps, should be managed for a successful digital integration in HOs.

Sakurai and Murayama (2019) discussed the major technologies used by HOs across the disaster phases, like remote sensing, drones, data analytics, social media and mobile applications etc. The authors claimed that HOs should have a clear IT strategy for effective use of technologies, across the four disaster phases, which integrates critical aspects of data privacy and data security concerns. Further to this, the authors argued that IT resources, which will cater for infrastructure acquisition, are required for an effective IT adoption, and collaborations with external institutions and IT experts, is essential for effective IT implementations in DRM.

Adu-Gyamfi et al., (2024) examined how technology and innovation could support the goals of the Sendai Framework for DRR (UNDRR, 2015), and they argued that technologies such as GIS, remote sensing, EWS, social media platforms, mobile apps, AI, drones and robotics, etc, could help in DRR decision making while engaging communities, to enable an effective recovery and reconstruction to disasters. They however note that strong collaborations with external stakeholders to mobilise resources, and investment in local capacity building, is required to bridge the challenges of disparities in technology access, and data privacy and security concerns. Izadi et al., (2023) created a system dynamics model for blockchain use in HSCs, integrating feedback loops, where areas like transparency, led to cascading effects in other areas like enhanced coordination. Their study however found out that implementing blockchain is faced by technical and infrastructural issues, especially in remote areas, and collective adoption of the blockchain by HSC stakeholders, required finding the right

blockchain partners, stakeholders buy-in, and training. Their study recommended testing BCT, in specific use areas, before full-scale implementation.

Other technologies discussed in the literature include IoT that help in real-time monitoring of assets and environmental conditions, to ensure effectiveness in DRR (Singh, 2024); Cloud computing that ensures flexibility in data storage, and ensure real-time information sharing amongst diverse stakeholders, in geographically dispersed locations (Schniederjans et al., 2016); and ERP systems that helps in achieving agility, alignment and adaptability of shared data in HSCs (Sigala et al., 2020). **Table 2.4** illustrates the summary of the main technologies used across 4 disaster management (DM) phases, and the main challenges and benefits of their integration.

Table 2. 4: Summary of Technologies used in the DM Phases

	Mitigation	Preparedness	Response	Recovery
Technology	GIS	EWS	GPS	Data analytics
providing most	Remote sensing	Mobile application	Drones	PM software
value across each	Big data analytics	Social media	Mobile application	Social media
DRM phase	IoT	Simulation	Blockchain	Drones
		AI	Cloud computing	Robotics
				ERP
Application of	Hazard mapping to	Disseminate alerts	Locating survivors	Tracking recovery
the technology	analyse risk patterns	to the public	Effective resource	progress
		Conduct simulation	Distribution	Resource
		Create DRPs		management
Benefits from	Improved early-risk	Broad information	Faster coordination	Efficient resource
technology	identification	dissemination	Efficient resource	allocation
adoption		Better response	distribution	Tracking rebuilding
		preparations		efforts
Challenges of	Limited data	Disaster	Information	Data accuracy
adopting the	sharing &	vulnerabilities if	overload	issues
technology	integration issues	systems fail	Infrastructure	System
			damage limit IT	maintenance
				struggles

Most technologies like AI, IoT, mobile applications, blockchain and social media applications can be used across all disaster phases, even if they have been indicated at only one phase in [Table 2.4](#), for simplicity, and analysis on where they could provide more value.

2.8 Blockchain Technology

BCT is a disruptive technology that is a type of distributed ledger technology (DLT) (Coppi & Fast, 2019; Queiroz et al., 2021). DLT is a distributed database, as illustrated in [Figure 2.3](#). A DLT maintains the growing lists of order transactions continuously (Mercy Corps, 2017). A similar copy of the transaction is retained by all participants in the network and any changes to the transaction is captured and updated to all nodes (computers) across the network in real time (Wang, Q. & Su, 2020), while maintaining security using encryption, and digital signatures called hash, throughout the process (Baharmand et al., 2021b).

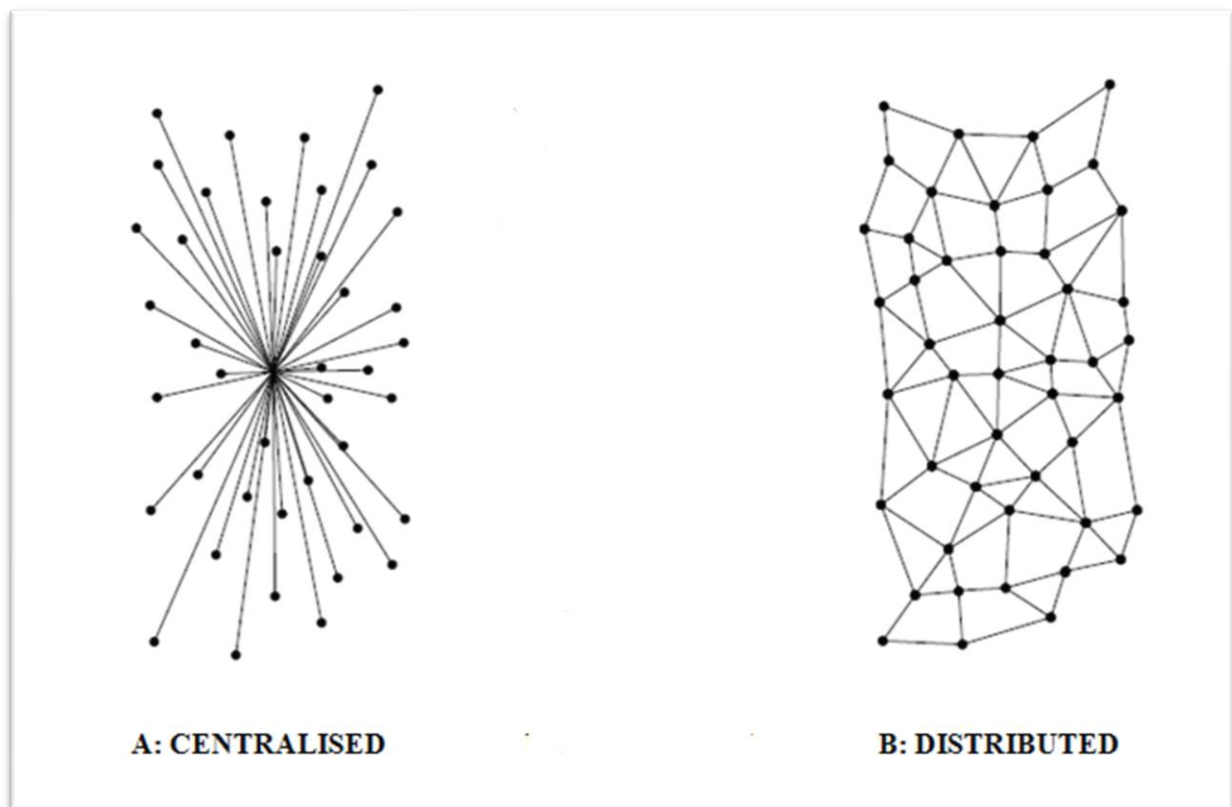


Figure 2. 3: *Types of Networks (Mercy Corps, 2017)*

These independent updates and decentralised storage gives the DLT the distinctive benefit of transparency, as data is visible across all nodes. Data security is enhanced as the updates are automatically replicated therefore making it difficult to manipulate transaction, making the database immutable and secure. This means that having more nodes in the network increases transparency and immutability of the data stored (Kaur et al., 2021). The key features of transparency and immutability of DLTs create additional benefits of accountability and trust (Coppi & Fast, 2019; Kubler et al., 2023).

DLTs use the peer to-peer network that has been used for a long time (Mercy Corps, 2017). However, the use of Blockchain began in 2009, after Satoshi Nakamoto wrote a white paper titled "*Bitcoin: A Peer-to-Peer Electronic Cash System*" about the Bitcoin, a visioned kind of digital currency, as a way to make asset transfer among entities via a peer-peer network. Based on the article, parties conducting business rely on a financial intermediary such as a bank, a credit card company or a third-party payment portal like PayPal to validate and process payments. These intermediaries are important as they help to create trust regardless of our capability to monitor their actions, as individuals feel confident that if they transact through a third party, they will not be taken advantage of. The financial intermediaries act as the centralised systems and in order to help reduce people's uncertainties when conducting commercial transactions online, they have built complex systems and databases, which increases time, costs and inconveniences, without fully eliminating fraud risks (Nakamoto, n.d).

Satoshi Nakamoto continues to explain that to enable digital currency, a new system is required where a set of rules or protocols governed by cryptographic proofs forms the basis of building trust instead of relying on financial intermediaries. In the new system, the network users are responsible for validating transactions through a consensus mechanism, about who owned or transferred a form of value at any point in time. Nakamoto thus created a platform that could

act as a distributed public database, which means anyone has access to it, but no one can control it. This platform is today known as Blockchain - 'it is a machine for creating trust', The Economist (2015). The blockchain allows collaborations amongst entities to transact and share information 'with previously unheard-of levels of trust and transparency' (Radziwill, 2018). The blockchain has complex technical capabilities but has a simple idea; - 'It's a platform for everyone to know what is true' (GSMA, 2017). BCT has evolved beyond its use in cryptocurrencies like Bitcoin (Beck et al., 2018) and is being implemented in other industries through other platforms such as Ethereum or Hyperledger Fabric (Lockl et al., 2020), that allow versatile functions like the use of smart contracts (Gurtu & Johny, 2019). Despite these platform developments, many people still hold the perceptions of Bitcoin when they are referring to BCT (Sedlmeir et al., 2020).

2.8.1 What is Blockchain?

The major difference between the Blockchain and other types of DLT is the form of data storage. As in Blockchain, the data is stored in blocks of information. Therefore, a blockchain is a chain of encrypted data blocks (Gurtu & Johny, 2019) where every block is created to record a transaction(s) (Du et al., 2019). New transactions in form of any token of value or shared data value like financial payments and non-financial transactions like intellectual property (Ko & Verity, 2016) are added to the previous transactions and this forms a chain of blocks, thus making it impossible to tamper with the data stored in the chain due to the replication of the data in the blocks across multiple connected computers (nodes) (Coppi & Fast, 2019).

This illustration is as shown in **Figure 2.4**. The automatic distribution of the blocks of information across all network nodes ensures that all users have the updated information and thus the database eliminates the disadvantage of a centralised system as it creates no single point of failure and control of the records (Sedlmeir et al., 2020). The three key concepts of

blocks and hashing; Mining and proof of work; and consensus mechanisms are the key critical factors that enable the Blockchain technology to function (Macrinici et al., 2018).

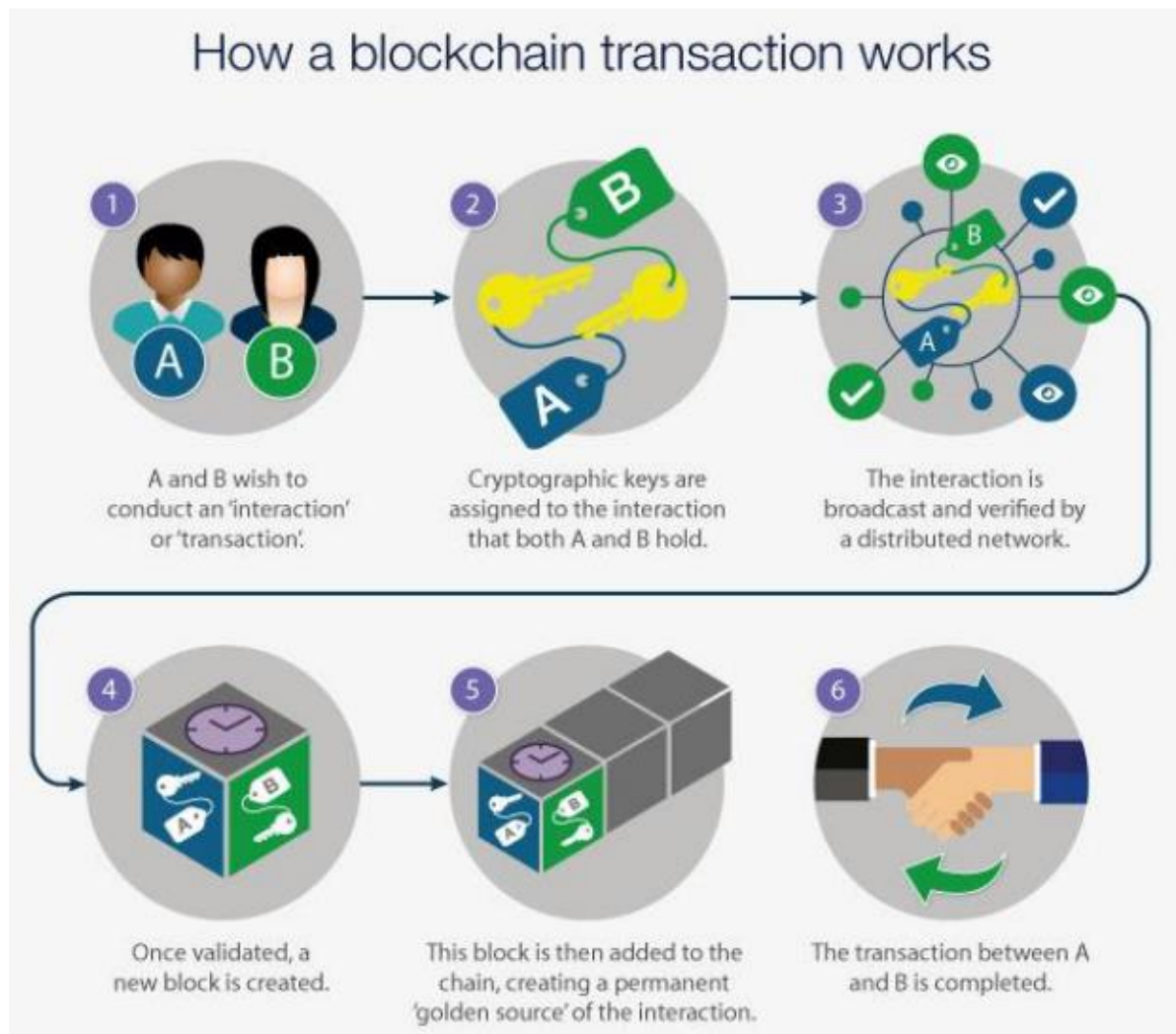


Figure 2. 4: *How blockchain works (Mercy Corps, 2017)*

In the diagram above, the following steps illustrate how the blockchain works.

1. A initiates a transaction to pay B. The key information of this transaction will be the identity of A (payer's ID), the identity of B (receiver's ID) and the amount to be paid.
2. The transaction information is broadcast in the network, where the nodes authenticate the key information (the payer, the receiver, enough credit to transact).
3. If the nodes validate the transaction, the transaction information is recorded in a block and a confirmation message is sent to all nodes in real time.

4. The confirmed block is attached to the previous blocks. The transaction is now complete, and the credit is deducted from A and paid to B.

A hash function takes the key information and returns a number called the hash number. The hash number is useful in validating transactions and forming the blockchain. Each newly created block contains a hash number of the previous block and therefore, if information recorded in the block is modified, it will result in the creation of a new hash number that is different from the hash number of the majority of the blocks and thus other nodes can recognise this and overwrite the content of the different block. The hash numbers or time stamps are immutable thus ensuring security of BCT (Hughes et al., 2019).

2.8.2 Characteristics of Blockchain

The main features of Blockchain are as follows.

a) Distributed

The blockchain design allows distribution and synchronisation of data across multiple nodes. Every participant of the network receives a similar replica of the updated information (Sharma et al., 2020). This decentralised environment uses algorithms to validate transactions into blocks. Since each node holds a similar copy of the updated information, this feature not only eliminates a single point of failure thus making the Blockchain to not only be perceived as a strong and disruptive technology but also ensures data consistency (Yang et al., 2021).

b) Consensus

The integrity of data is ensured by a consensus algorithm. This means that network participants must agree on the execution of the transaction to make it valid, and this eliminates fraudulent transactions from the network (Notheisen et al., 2017). The main types of consensus algorithms used are the Proof of Work (PoW), Proof of Stake (PoS), Proof of Authority (PoA) (Xu et al., 2021) and Practical Byzantine Fault Tolerance (PBFT) (Alrowaily et al., 2023). PoW relies on

computational power to achieve consensus, PoS select validators based on the coins that they are willing to stake as collateral, PoA relies on reputation of validators who are pre-approved to validate transactions, and PBFT is used when majority of the nodes communicate to agree on the state of the system in permissioned blockchains.

c) Anonymity

Blockchain users can interact with their created address without the disclosure of their actual details even if members can view the encrypted transaction details. The public key of BCT is used for data encryption while the private key is used for data authentication (Gurtu & Johny, 2019).

d) Traceable

The timestamps and the digital signatures of the blockchain implies that transactions can be traced back, as new blocks are attached to past blocks, thus making the information in the blocks to be permanent (Kshetri, 2018).

e) Smart contracts

The first proposition of smart contracts was in 1994 but it has recently become popular as a built-in feature of Ethereum blockchains (Pournader et al., 2020). Smart contracts execute protocols such as transfers and payments automatically, when the contracts terms and conditions are met (Kshetri, 2018). Smart contracts are however unperfected by security issues and threats, and the need for an intermediary for external validation (Ølnes et al., 2017). Automation in smart contracts is done to reduce intermediaries functions, but intermediaries are not entirely eliminated as someone is needed to draft and check the compliance of the contract (Pournader et al., 2020).

f) Immutability

Data stored in the blockchain can not be deleted or interfered with. This tamper-proof feature of the blockchain ensures data privacy and security. This feature also makes the blockchain to be auditable (Sheldon, 2023).

2.8.3 Types of Blockchain Architecture

Questions arising from who can run a node in the BCT network, and who need to control what network participants do, forms a basic understanding of the BCT architecture types in its applications in various sectors (Wang, et al., 2019; Chang et al., 2019). **Table 2.5** summarises these types.

Table 2. 5: Types of Blockchains Architecture. Source (Researcher): Adapted from (Kopyto et al., 2020)

Characteristics	Public blockchain	Private blockchain	Consortium blockchain
Network Type	Decentralised	Centralised	Partially centralised
Read Permission	All nodes	Only authorised nodes	Only authorised nodes
Participating Permission	Permissionless	Permissioned	Permissioned
Consensus mechanism	All nodes	Central Authority	Selected nodes only
Efficiency	Low	High	High
Immutability(Tamper-ability)	Nearly Impossible	Possible	Possible

2.8.2.1 Public or Permissionless Blockchain

A public blockchain is open to anyone to run the node with a choice of doing it anonymously. Public blockchains are more transparent and secure as they consist of many active nodes as compared to the private blockchains (Mercy Corps, 2017). All participants in a Permissionless network can perform all tasks such as authenticating transactions, reading, and writing data. Public blockchains are thus viewed as decentralised networks (Li et al., 2021).

2.8.2.2 Private or Permissioned Blockchains

Private blockchains allows only members of a particular entity to run the node (O'Leary, 2017). In a permissioned network, reading, and access duties are limited to authorised persons only.

Private blockchains have a central authority that is responsible for finding consensus and its thus viewed as a centralised network (Mercy Corps, 2017).

2.8.2.3 Consortium Blockchains

Consortium blockchains combines both attributes of the private and public blockchains (Kopyto et al., 2020). Duties are segregated. Some nodes may read or write; others may do both, besides other administrative privileges. This means that decision making nodes are allowed to make consensus by adding new blocks while the reading nodes are only allowed to review the ledger (O'Leary, 2017). These features often make them to be viewed as partially centralised.

2.8.4 Benefits of Blockchain Technology

Ølnes et al. (2017) provided five categories of BCT benefits. These categories are strategic, organisational, economical, informational and technological benefits. The strategic benefits include improved transparency (Pournader et al., 2020), fraud and manipulation prevention and reduced corruption (Kshetri, 2018). Transparency is created by the visible transactions across all nodes. Fraud is minimised as the ledgers are distributed and corruption is reduced as the hash algorithm creates data security.

a) Organisation category

This category includes the benefits of increased trust, auditability, predictive capability and control. The immutability features and decentralised nature of BCT enhances trust and auditability (Notheisen et al., 2017), tracing historical information enhances the predictability of information and control is enhanced by the consensus mechanism that ensures blocks are validated by all nodes of the network (Pournader et al., 2020). The economical category includes clear ownership, reduced costs, and improved resilience. BCT creates clear ownership of data and defines the governance by creating permissions on what each participant can and

cannot do (Notheisen et al., 2017). Costs are reduced by using smart contracts that automate some intermediaries' tasks (Kshetri, 2018). Since the data is distributed, a single point of failure is eliminated thus creating resilience and data security Ølnes et al. (2017).

b) Information Category

This category includes data integrity and data quality, human error reduction, enhancing information access, privacy and reliability. Data is updated in real time and distributed across nodes thus making it to be of high quality (Gurtu & Johny, 2019). The automated transactions reduce human errors, due to the fact that multiple nodes have stored a similar ledger and information can be assessed easily and quickly amongst participants of the network (Pournader et al., 2020) . BCT allows users to conduct transactions anonymously and the use of encryption keys ensures data privacy. Reliability is enhanced as information in the block is immutable unless 51% of the participants agree to change it (Gurtu & Johny, 2019).

c) Technological category

This category includes the benefits of data resilience, security, persistency and immutability and reduced energy consumption. The distributed feature of BCT ensures data resilience and security (Kshetri, 2018; Yang et al., 2021). The information in the blocks cannot be tampered with thus ensuring immutability (Gurtu & Johny, 2019). Increase efficiency and transaction mechanisms reduces the energy consumed by the network (Ølnes et al., 2017).

2.8.5 Drawbacks of Blockchain Technology

Despite the numerous advantages of BCT as discussed in the section above, the blockchain suffers from several disadvantages. One is the issue of scalability. Blockchain networks may face network congestions as users and transactions increase leading to delays (Sanka & Cheung, 2021). The time taken to achieve consensus in public blockchains especially makes it difficult for blockchain networks to handle large-scale operations (Khan, D. et al., 2021).

Additionally, the consensus mechanisms consume lots of energy which raises sustainability concerns (Kouhizadeh et al., 2021). BCT solutions are expensive to develop and implement due to the high cost of the technology, infrastructure costs, training costs, and maintenance costs involved (Kumar & Barua, 2023).

The lack of clear regulatory and legal policies surrounding the blockchain makes it difficult for organisations to implement it (Chittipaka et al., 2023). Blockchain decentralised nature makes it difficult to enforce legal accountability as there's no central authority to account responsibility to (Saheb & Mamaghani, 2021). A lack of stakeholders awareness on BCT adoption benefits (Sarkar et al., 2024), and inadequate collaborations among SC partners fuelled by conflicts of data ownership and IPRs may inhibit a successful blockchain implementation (Waqar et al., 2024). Finally, the issue of interoperability as there are numerous BCT platforms like Bitcoin and Ethereum and these platforms lack standardised data protocols and formats, which hinder their co-operation and makes it difficult for organisations to integrate them across various industries (Prewett et al., 2020).

2.9 Blockchain and Supply Chain Management

Blockchain potential has been considered in SCM due to its distinct characteristics of data security, immutability and traceability however challenges in its adoption in SCM still remain in generating consensus and its governance (Queiroz et al., 2020). Ivanov et al. (2019) argues that traditionally, the company has been good as the SC behind it, but today and in the future, 'the SC will be as good as the digital technology behind it.' Companies are collaborating to use industry 4.0 technologies such as BCT to create trust and transparency in global SCs. An example of this is IBM and Maersk (Scott, 2018). The use of blockchain smart contracts in Maersk will remove manual paper-based processes such as processing bills which will cut down costs by between 15-20% as evidenced by the pilot test of shipping avocados from Kenya's Mombasa port to Rotterdam. All participants like shippers, freight forwarders, ocean

lines, ports and customers authorities will form the blockchain network and as approvals move from one point to the other, the associated information will be captured in the network and updated in real time (Longman, 2020).

The benefits of implementing BCT in SCM include automating transactions, reducing intermediaries due to the use of smart contracts, enhancing data security (Hughes et al., 2019), improving transparency and therefore trust is enhanced (Queiroz et al., 2020), improved regulatory compliance (Teodorescu & Korchagina, 2021) as information is updated in real time thus promoting trade due to speedy transactions, and reduced transaction cost. Based on a literature review by (Kshetri, 2018), BCT contributes to SCM strategies of costs reduction, quality guarantee by providing the exact data of product information such as temperature and humidity, enhancing speed through digitising processes, increasing dependability by exerting pressure to SC partners to be accountable, ensuring flexibility and reduced risks by revisiting past transactions in case of disputes amongst parties and eliminating counterfeit products. Wang, B. et al., (2020) add that BCT will ensure sustainability by providing visibility on the environmental and social aspects of SCs,

Litke et al. (2019) illustrate that the elements of BCT that affects SCs are scalability, performance, consensus, privacy, cost, and location.

- a) Scalability - BCT will offer a platform for SC participants to communicate and share information on a global scale with ease.
- b) Performance - BCT features that enhances data privacy, integrity and quality and eliminating human errors and fraud will improve system performance
- c) Consensus- the BCT consensus mechanisms such as PoW and PoS will enhance SC data immutability

- d) Privacy- due to the use of anonymity and pseudonymity of BCT to its users, activities can be conducted safely in the SC while ensuring confidentiality of the participants involved.
- e) Location- SC transactions involving information sharing and payment transfers can be done anywhere across the globe and speedily thereby creating efficiency of processes.
- f) Cost- The automation of SC processes like use of smart contracts in BCT will offer an economic solution thus increasing the efficiency of the SC.

2.10 Blockchain and Humanitarian Supply Chain Management

With the unmatched disruptions the HSCM is experiencing, HOs are challenged to adopt vital technologies to face the difficulties, and improve performance while enhancing accountability to donors and responding to the vulnerable communities. Some of the challenges faced by HOs today are attributed to the inadequate information sharing between the partners due to trust issues amongst the stakeholders. The BCT is already making transformations in SCM as discussed in the section above, as it guarantees one truth version in a trust-less environment (Beck et al., 2018). The blockchain holds significant potential to revolutionise the humanitarian sector. The following review shows the drivers, benefits and barriers of adopting BCT in HSCs.

2.11 Systematic Literature Review of the Blockchain in HSCM

Systematic literature review (SLR) is a method of organising, synthesising and identifying emerging paths and opportunities and grasping important agendas, inconsistencies and limitations based on past studies (Queiroz et al., 2020). In the past, SLR was applied in established fields (Tranfield et al., 2003) like medicine but recently SLR has been used successfully in other fields like SCM (Queiroz et al., 2020). A case in point is Roberta Pereira et al., (2014) who applied SLR in examining the role of procurement in achieving SC resilience from a sample size of 30 papers retrieved from a literature review of 13 years. SLR has also

been used in HSCM. Abidi et al., (2014) used SLR to identify the state of art, gaps and challenges in performance measurement in HSCM using a sample of 52 papers from 1970-2012. Polater (2021) used SLR to identify the current literature using dynamic capabilities view in HSCM. They did not define the year scope but based on their findings, no paper on this area was published prior to 2012 and hence their final review was on a sample size of 9 papers from their initial population of 257 papers from 2012 to September 2020.

Blockchain is a disruptive technology which is on the exploratory stage and the main reason of conducting SLR in this research was to find out the extant literature of blockchain application in HSCM and identify the state or art on its potential role, synthesize on its challenges and report on the gaps. Pournader et al., (2020) used SLR to discuss evolving themes and applications of BCT in SCs, logistics and transport using 48 journals. Wang, Y. et al., (2019) used SLR to investigate the influence of BCT on future SC practices and policies from an analysis of 29 papers while (Khanfar et al., 2021) used SLR to identify the application of BCT in Sustainable manufacturing and SCM from an analysis of 21 papers.

The SLR in this research followed the four stages of planning, searching, screening, and extraction/synthesis and reporting as provided by (Tranfield et al., 2003). The research protocol followed is as shown in **Table 2.6**.

Table 2. 6: SLR Protocol Details: Source (Researcher). Adapted from (Tranfield et al., 2003)

Research Stages	Research protocol:	Details description
Planning:	Research Plan	Developing the research question
Searching:	Database:	Scopus and Web of Science
	Publication type:	Peer-reviewed journals
	Language:	English
	Search field:	Title, Abstract and Keyword
	Search strings:	Humanitarian* AND Supply Chain* AND Blockchain*
Screening:	Inclusion criteria:	Articles within the research scope aim.

	Exclusion criteria:	Articles outside the scope of the research aim, conference proceedings, books and book chapters and gray literature.
Extraction& reporting:	Data extraction:	Thorough reading and summary recording in Microsoft Excel extraction form
	Data analysis:	Qualitative analysis

2.11.1 Stage 1: Review Planning

On this stage the research question for the review was outlined as follows:

What are the challenges, opportunities and gaps for BCT applications in HSCs?

2.11.2 Stage 2: Searching

Based on the above RQ, two databases, Scopus and Web of Science were used as the search engines for the sources of data for this study as they have been mainly used by other authors for SLR (Moosavi et al., 2021). The review started on February 2022 and no period for the search was chosen as this was an exploration since BCT in HSC was at an infant stage. The search on these databases based on the search strings revealed that the first paper on BCT in HSCM was published in 2018. Therefore, the analysis limits publications from 2018 to April 2022.

The search strings were selected keenly to ensure that they meet the main aim of the study. Three categories of keywords were used.

1. Keywords related to "Humanitarian operations"
2. Keywords related to "Supply Chain Management"
3. Keywords related to "Blockchain Technology"

Therefore, the search strings used were (Humanitarian*) AND (Supply Chain*) AND (Blockchain*). This procedure searched the keywords within the title and abstract.

2.11.3 Stage 3: Screening

To ensure objectivity, the researcher determined the criteria that formed the basis for inclusion and exclusion of articles retrieved. The inclusion was on peer reviewed articles only that were within the scope of the RQs. Articles that were outside the research scope e.g. BCT in healthcare were excluded. Conferences proceedings, books and books chapters and gray literature was excluded to ensure a standardised process for articles. These articles were however used throughout, in writing up and support of claims in this study.

The defined protocols identified 45 articles. 24 of these were from the Scopus database while the remaining 21 were from Web of Science database. The papers were exported to RefWorks (reference management software) to remove duplicates, leaving 24 articles. After reading abstracts and titles of these 24, only 9 papers fit the pre-defined criteria for review.

2.11.4 Stage 4: Extraction, Synthesis and Reporting

A descriptive and thematic analysis on the remaining 9 articles was conducted to answer the first and second RQs respectively. Descriptive analysis helps in explaining the scope, methodology and features while thematic analysis highlights the main outcomes of the research and provide gaps and directions for further research (Abidi et al., 2014).

Microsoft Excel was used to prepare a data extraction form where categories of data were formed identifying keenly the main themes or focus of the paper, which was retrieved by numerous readings of each article. This form provided a summary that is useful in not only synthesising information to make conclusions from the analysis but also providing a holistic view for the readers to reflect on the findings.

2.11.5 SLR Findings

Figure 2.5 shows the visual cloud of the most frequent words of the SLR.

inclusion criteria. Turkey had the lead with the research on BCT on HSC. The rest of the countries held a publication of one paper as presented in [Table 2.7](#).

Table 2. 7: Author's Country and year of publication

Country	2012-2017	2018	2019	2020	2021	2022 (to April)
Canada	-	-	-	1	-	-
Finland	-	-	-	-	1	-
India				1		
Iran	-	-	-	1	-	-
Netherlands	-	1	-	-	-	-
New Zealand	-	-	-	1	-	-
North Korea	-	-	-	-	1	-
Norway	-	-	-	-	1	-
Pakistan	-	-	-	-	1	-
Turkey	-	-	-	2	-	-
UK	-	-	-	1	-	-
USA	-	-	-	1	-	-
Notes:	All countries according to authors' affiliation were accounted for, therefore main author's country and co-author's country was considered twofold.					

2.11.6.1 Papers published in Journals

[Table 2.8](#) shows the papers published by each journal. The International Journal of Production Research accounts for the biggest numbers of papers based on the SLR. Surprisingly, no paper was published in the top Journal of HSCM. This could suggest that the topic of BCT in HSCM is still in its infancy stages.

Table 2. 8: Journals and number of papers published

Journal	Paper
International Journal of Operations & Production Management	1
Computers in Industry	1
IEEE	1
Disasters	1
Journal of Global Operations and Strategic Sourcing	1
Technology in Society	1
The International Journal of Logistics Management	1
International Journal of Production Research	2

2.11.7 Thematic Analysis

The researcher categorised articles based on the objective, focus or theme, theory and major findings of the paper to give an in-depth analysis to draw our discussions. The categories are as illustrated in **Table 2.9**.

Table 2. 9: Categorisation of the articles

Authors	Objectives	Focus	Theory	Methodology	Major Finding
(1)	Exploring the drivers and challenges of blockchain applications in HSC	Key drivers and Barriers of BCT	Contingent RBV	Empirical: Focus groups & 11 Interviews	8 key drivers and 7 barriers identified. BCT can improve transparency and trust in HSCs.
(2)	To establish the influence of operational SC transparency and swift trust on humanitarian collaboration and SC resilience	Swift trust SC transparency Collaboration SC resilience	Organisational Information Processing theory and Relational View	Conceptual and Empirical: Framework developed, and survey done. 256 respondents	BCT has a positive influence on ST, OSCT and CO and these positively influence SCR

(4)	To provide a review of blockchain adoption barriers in HSCM	Barriers of BCT _____	Empirical: 27 expert's interviews and integrated approach using Fuzzy Delphi and Best-Worst method (BWM) was used	14 barriers identified but only 9 were accepted. Regulatory uncertainty ranked as the most important barrier
(3)	To examine how BCT benefits could reduce the impact of HSCM barriers	BCT roles on HSCM barriers _____	Empirical: experts' questionnaire and (IF-DEMATEL) and (IF-ANP) approaches used	The most important barriers than BCT can help to eradicate in HSCs are organisational barriers. Trust is the most important role of BCT
(5)	To identify and model BCT implementation barriers in HSCM	BCT barriers _____	Empirical: Experts, fuzzy best worst method approach used with sensitivity analysis	Categorised barriers into four major groups and data privacy, ownership and security issues barriers were amongst the most important barriers

(7)	To design and validate guidelines for blockchain projects in HSCs	Design requirements	_____	Empirical; 12 interviews and focus groups	Context, technology and intellectual property related requirements, and humanitarian principles should be considered when designing humanitarian BCT projects
(8)	To examine the influence of BCT on cross-sector partnerships	Resource sharing, Trust	Social Exchange Theory (SET)	Conceptual: Framework developed	The BC-enabled framework can improve efficiency and flexibility of humanitarian operations
(6)	To integrate BCT, AI and 3D printing to tackle humanitarian challenges	Benefits of the integration	_____	Theoretical (case study) & Conceptual framework	All these emergent technologies would thus help in improving the flow of logistics, finances and information in HSCs.

(9)	To examine how integration of IoT with BCT can help in improving transparency, public trust and coordination in HL	Benefits of the Integration	Transactive memory systems (TMS)	Empirical: survey and hypothesis testing	Humanitarian performance is improved by the integration of IoT and BCT as they create transparency which improves trust and coordination
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Based on the SLR, the application of BCT in HSCM is novel. The papers analysed mainly focus on the key drivers, benefits, challenges of BCT application in HSCM; and only a few focus on its implementation by considering the design requirements to be considered, when executing humanitarian blockchain projects. These themes are illustrated in [Table 2.10](#) and are discussed below the table.

Table 2. 10: Thematic Analysis in the SLR

Theme	Area	Reference
BCT Key Drivers	Accountability	1
	Visibility	1, 3
	Traceability	1
	Trust	1
	Collaboration	1
	Time efficiency	1
	Reducing administrative work	1
	Enhancing cross-sector partnership	1
	External Pressure (donors & HOs)	1
	Minimal fraud disputes	1
	Enhanced security	1

BCT benefits/roles	Commitment	1
	Swift trust	1,2,
	Transparency	1,2,3
	Collaboration	2
	Resilience	2
	Trust	3
	Immutability	3
	Security	3
	Traceability	3
	Disintermediation	3
	Auditability	3
	Automation	3
	Processing Speed	3
BCT Adoption barriers	Engagement issues	1, 5
	Lack of knowledge, technical skills and training	1,4, 5
	Lack of resources	
	Data privacy, ownership and security concerns	1
	Regulatory problems	1,5
	Scalability issues	
	Governance challenges	1,4
	High sustainability costs	1
	Funding issues	1
	Technological complexities	4,5
	Interoperability issues	5
BCT Frameworks	Critical design requirements: Context, Technology, & Organisation requirements	7
	Resource sharing concept	8
	Integration with AI & 3D	6
	Integration with IoT	9
	Role in enhancing swift trust, collaboration and resilience	2

BCT with technologies	integration with other	Integration with AI and 3D Potential benefits:	6
		Increased collaboration	
		Decreased lead time	
		Increased transparency	
		Improved budget forecasts	
		Enhanced operations	
		More victim's empowerment	
		Integration with IoT	
		Potential benefits:	
		Improved transparency	9
Notes: Reference		Public trust enhancement	
		Improved coordination	
		Improved HL performance	
		1= (Baharmand et al., 2021a); 2= (Dubey et al., 2020); 3= (Ozdemir et al., 2021); 4= (Sahebi et al., 2020); 5= (Patil et al., 2021); 6= (Rodriguez-Espindola et al., 2020); 7= (Baharmand et al., 2021b); 8= (L'Hermitte et al., 2021); 9= (Khan, et al., 2021)	

2.11.7.1 Key drivers of Blockchain Application in HSCM from the SLR

There are many motives behind the application of BCT in HSCM. These include improved collaborations amongst all HSCM players and cross-sector partnerships, improved transparency and traceability as all transactions across the network will be visible to all nodes, improved accountability to donors for efficient use of resources, enhanced security due to the immutability of the records stored in a blockchain database, and enhanced trust due to accurate information sharing across the network. Other drivers include the potential to reduce administrative costs while saving time as middlemen are removed and lowering the risks of disputes due to elimination of fraud across the network. Pressure from donors or other HOs is also a key driver to ensure accountability of HOs (Baharmand et al., 2021a; Ozdemir et al., 2021).

2.11.7.2 Benefits and roles of Blockchain application in HSCM from the SLR

The literature revealed that most of the above drivers are also the benefits and roles of BCT in HSCM. This is because it is the roles and the potential benefits of the technology that would create the motive for organisations to implement it. Other benefits not mentioned in the driver category above is the advantage of automation and auditability that blockchain provide as manual processes are eliminated especially in conducting transactions with smart contracts and auditability is enhanced by the accuracy of the automated records. Based on the findings of (Ozdemir et al., 2021) the most important benefit of BCT in reducing HSCM barriers is trust, immutability security, transparency and traceability. The least significant is removing intermediaries. This benefit is however significant in other supply chains like in agriculture (Kamble et al., 2020) and this can be argued that there are many middlemen in such sectors, and this causes delays and inefficiency in the SC.

Although blockchain has been argued to eliminate many barriers in HSCs such as organisational, inter-organisational, regulatory, donor and beneficiary barriers, inter-organisational barriers were the most important to be solved by BCT as revealed by the SLR. These barriers include delivery time barriers, coordination issues, trust issues and information sharing problems. This is critical in decision making in the humanitarian sector as organisations can gear their resources and BCT investment plans towards the specific task they would want to solve. Dubey et al. (2020) also found out that BCT enhances swift trust, which is important for temporal team formation, when a disaster occurs to ensure quick response. This swift trust created by BCT enhances collaboration and SC resilience.

2.11.7.3 Barriers of Blockchain adoption in HSCM from the SLR

The challenges that inhibit the adoption of BCT in HSCM include lack of support from top management, incompatibility of the technology with the organisation culture and with existing

technology within organisations, lack of readiness for the technology and change management issues, complexity of the technology, lack of legislation and governance for block-chain based systems, few implementation cases of the technology, inadequate knowledge and training, high costs of sustaining the technology, scalability issues, integration issues with existing legacy systems, minimal engagements with the technology, problems related to data privacy, ownership and security, funding issues for testing and piloting the technology, inadequate resources both financial and non-financial to implement the technology, market-based risks arising from constant fear of BCT users of price fluctuations, contractual risks arising from disagreements about the roles of each participant in the network, infrastructure issues such as internet and energy, operational restrictions, uncertainties in value proposition, and media backlash risk (Baharmand et al., 2021a; Sahebi et al., 2020; Patil et al., 2021).

The study by Baharmand et al. (2021) showed that the most significant challenges are lack of resources, issues related to data privacy and engagement issues due to the reputation associated with HOs of their reluctance to take risks. Patil et al., (2021) argue that the most important barriers to BCT adoption in HSCM include the technology and cost complexity, funding issues, and data privacy and security issues. Sahebi et al., (2020) presented the most significant challenges in BCT adoption in HSM to be issues related to uncertainties in regulation, lack of knowledge and training of employees on the use of the technology and high sustainability costs once the technology is implemented. Since these studies used opinions from experts, we can conclude that the most significant barriers of BCT adoption in HSCM varied due to the nature of experts used in these studies.

2.11.7.4 Blockchain Integration with other technologies from the SLR

BCT integration with IoT helps in improving transparency in the humanitarian sector which is important in enhancing public trust and coordination thus improving the overall performance in HL. Khan et al. (2021) argues that BCT can be integrated with AI and 3D printing to support

the flow of information, finances and logistics across HSCs. Information flow is enhanced by the immutable features of BCT and its decentralised nature that enables it to transmit information in real time. The enhanced transparency and visibility by BCT enable financial resources to be traceable and this makes all the parties in the humanitarian network to be accountable. The logistics flow is enhanced by the accuracy and visibility of information and accuracy of all transactions and these aids in decision making. BCT smart contracts also ensure automation of processes that creates logistics efficiency.

2.11.7.5 Blockchain Frameworks from the SLR

Baharmand et al. (2021) designed a framework for humanitarian blockchain projects while considering humanitarian principles of humanity, neutrality, impartiality, independence, and dignity. The framework was validated from data collected in blockchain projects in Kenya and Jordan and the applicability of the model was done in Vanuatu. They concluded that infrastructure, end-users, ethics, stakeholders and privacy are requirements that should be considered in blockchain design contexts, while scalability and intellectual property should be considered in technology and organisation requirements respectively. L'Hermitte et al. (2021) provides a conceptual framework for sharing logistics resources during emergency operations. The proposed framework contains a blockchain interface that connects users and suppliers of logistics resources and trust is the central element of the framework that has potential to enhance efficiency and flexibility of operations.

Rodriguez-Espindola et al. (2020) provides a framework for solving humanitarian challenges on the 2007 Tabasco flood in Mexico using an integration of blockchain, AI and 3D printing. Due to the challenges of use of outdated and inconsistent information sharing, lack of proper need assessments, poor transparency, accountability and budget control, and failure to reach victims in all areas, (Rodriguez-Espindola et al., 2020) argue that 3D can help AI to find alternatives for reaching isolated areas, and blockchain can help in real time information

sharing that help in creating visibility, transparency and accountability. These BCT benefits would then support AI and 3D, AI can thus help in decision making by enhancing 3D efficiency and increasing the potential of the blockchain. All these emergent technologies would therefore help in improving the flow of logistics, finances and information throughout the humanitarian network. On the other hand, (Khan, et al., 2021) provided a conceptual framework of integration of IoT with blockchain to create transparency. The hypothesis was later tested, and the results showed that there was a positive influence of integration of BCT and IoT on HL performance. This integration improved coordination and public trust thus enhancing HL performance.

2.11.7.6 Theories used in Blockchain application in HSCM in the SLR

There were five theories used by four papers in the SLR. One paper used two theories. These theories are: Contingent Resource based view (Baharmand et al., 2021a) , Organizational information processing theory (Dubey et al., 2020) , Relational view theory (Dubey et al., 2020) , Social exchange theory (L'Hermitte et al., 2021) and Transactive memory system theory (Khan et al., 2021).

a) Contingent Resource-based View (CRBV)

Resource-based view theory (RBV) explains that each organisation owns diverse resources that gives it a competitive advantage and differentiate it from other organisations (Barney, 1991). This theory however fails to explain the conditional aspect of organisational resources, as primary resources alone are not enough to sustain competitiveness, and therefore attention should also be given to other complementary resources (Chae et al., 2014).

CBRV explains that the value of resources is dependent on the environment context, and the connection between primary and complementary resources (Aragón-Correa & Sharma, 2003). Primary resources are the internal assets and capabilities of a firm that enables it to compete

such as a company's financial and HR capabilities, while complementary/secondary resources are resources outside the firm that influence how a firm's primary resources perform such as market conditions and competition (Sedera et al., 2016). In the SLR, CRBV was used by (Baharmand et al., 2021a) in addressing how BCT can improve trust and transparency as these variables are contingent and contextual to specific challenges like local acceptance, stakeholder cooperation, and technological infrastructure. Their findings suggest that the application of blockchain had a positive influence on trust and transparency in the humanitarian context.

b) Organisational Information Processing Theory (OIPT)

OIPT helps in explaining how information can be used effectively especially when undertaking tasks that are uncertain and interdependent (Galbraith, 1974). The level of uncertainty is measured by the difference between the information quantity required to perform the task, and the quantity already in possession by an organisation (Zhu et al., 2018). Firms may enhance information processing by investing in both vertical information systems, which allow them to process data efficiently, and horizontal information systems, which enhances coordination of functions, thus improving organisational performance (Yu et al., 2021). OIPT was used by (Dubey et al., 2020) to support their argument that the capability to process information can help to create swift trust amongst actors of HSCs. Their findings revealed that SC transparency had a positive influence on swift trust.

c) Relation View Theory (RVT)

RVT explain that an organisation can enhance its competitiveness by the relations it has with its partners (Dyer & Singh, 1998). These collaborations can create joint contributions thus enhancing a firm's competitive edge (Moshtari, 2016). RVT in this SLR was also used by (Dubey et al., 2020) to support their argument that an organisation technological capability will influence both the behaviour of the organisation, and the people using the technology. This theory further support that the swift trust established using OIPT above, and collaboration

amongst humanitarian actors help in creating resilience after a disaster event. Their findings showed a positive influence of swift trust on collaboration, and when these two factors were combined, they jointly influenced HSC resilience positively.

d) Social Exchange Theory (SET)

SET describes the interactions between individuals from the viewpoint of intangible benefits and costs. People engage in social interactions or relationships to maximise benefits like support, honour and resources, and minimise costs like effort and time (Ma et al., 2021). SET also assumes that different kinds of social interactions create reciprocal exchanges which facilitate reciprocal relationships, psychological contracts and mutual obligations thus forming a framework for inter and intra organisation transactions and resource exchanges (Ma et al., 2021). According to Ming-Tien Tsai & Cheng (2012), SET deals with intrinsic rewards that cannot be measured quantitatively, and it engender feelings of trust, gratitude and personal obligation thus making it an important theory for understanding workplace behaviour. In this SLR, SET was used by (L'Hermitte et al., 2021) to propose a blockchain-enable framework that would enhance resource sharing during emergency operations based on trust and perceived benefits from the exchange.

e) Transactive Memory System Theory (TMST)

TMST explain how people in relationships develop a shared system for converting, storing and retrieving information about different important areas (Wegner, 1995). TMS help in analysing processes and outcomes of groups by examining how diverse individual minds combine and communicate information amongst them (Roundy, 2020). Therefore, individuals in a group take responsibility of different information domains, trust the expertise of the other group members, and work towards being better like their group experts (Roundy, 2020). According to Madison et al. (2021) TMS comprises of a cognitive process that defines the encoding and storage of collective knowledge before it is required to perform a task, and a cognitive structure

that is a database that comprises of each individual unique contribution of knowledge to the group.

The cognitive process helps to understand how interactions in the shared system occurs, and this is done by distributing and communicating information. The cognitive structure on the other hand helps in understanding where knowledge lies in the shared system, by finding out who knows what or who is the experts in what areas in the shared system (Madison et al., 2021). TMS is therefore important in explaining how individuals in a group acquire, gather, utilise, and organise information to accomplish goals at an individual, group or organisational level (Roundy, 2020). In this SLR (Khan et al., 2021) used TMS to explain that technology facilitate sharing of information and coordination amongst humanitarian players, but for this to be effective, transparency must be ensured to create trust amongst the stakeholders. Their findings revealed a positive influence of blockchain integration with IoT, on transparency, trust, and coordination and these three variables are critical in enhancing HL performance.

2.11.8 Gaps

The SLR revealed the following gaps

1. Most authors argue that blockchain has a positive effect on collaboration amongst humanitarian partners. More research is required to elaborate on what platforms should be used and how they should be governed. If private blockchains are selected for the network for instance, who gets to control the system? Who gets reading permissions and who is permitted to write on the blockchain?
2. Blockchain drivers, benefits and barriers to adoption have been discussed in detail but further research about the influence of blockchain on organisation culture should be explored.

3. Blockchain has a key feature of immutability, which means that once a transaction is entered into the network, it cannot be changed. This feature is a key driver to its adoption. As HOs plan on the initial adoption process, how can all participants be confident that the first information input in the database is accurate and authentic, as this will always remain in the network even if stakeholders agree to update it later?
4. The frameworks reported in current literature do not consider validations from diverse participants of HSCs actors (majorly done with NGOs only.). Validations with inclusion of diverse HSC actors (government, development partners, local NGOs., etc.) is required for future work.
5. Further research offering legal guidelines of implementation of the blockchain in HSCs is required especially in intellectual property rights. Further to this, as cross-partnerships have been encouraged in BCT, the role of smart contracts in HSCs need to be examined giving clear illustration of the legal challenges facing smart contracts in these collaborations.
6. Going with the KYC ‘Know Your Customer’ feature that is commonly used by financial institutions like banks for managing the identities of their customers, this research argued that the humanitarian sector can use this feature by calling it KYB ‘Know Your Beneficiary’ to manage the identities of beneficiaries. HOs can collaborate with the government, banks, or telecommunication companies to share the details of the beneficiaries in real time and avoid re-registering the victims thus saving time and eliminating duplication of efforts.
7. Collaborations in HSCs are often challenged by conflicting goals and mandates. What mechanisms will be used to ensure clear and common goals are achieved in blockchain adoption and scalability?

8. The theories used in the SLR were mainly from management or social sciences contexts and using technological theoretical frameworks to explore BCT adoption in HSCM is required
9. Further research about blockchain maturity models is required. To the best of the researcher knowledge, and at the time of conducting the SLR (Feb - April 2022) there existed no blockchain maturity model for HOs to benchmark upon. A maturity model would be useful to identify the requirements, both financial and non-financial, necessary for HOs to adopt the blockchain.
10. In addition to a maturity model, there lacked a Blockchain-enabled Framework to guide on the BCT adoption decision.
11. Most of the papers relied on a single method of data collection, like either a survey or an interview. Those with two methods were mainly a multi-method which combined a conceptual framework or secondary data with an interview, or heuristic methods with an expert interview. More research on BCT in HSCs is required, using a mixed methods approach.
12. Although some authors from the SLR have illustrated the role of blockchain in enhancing trust and swift trust in the humanitarian sector, more exploration of digital trust is needed. How does digital trust influence coordination and cross-sector partnerships? Should collaboration efforts be minimised as a result?

2.11.9 SLR Conclusion

From the SLR, only four papers drew their arguments from use of theories. The major theories used in the SLR are Contingent Resource based view, Organizational information processing theory, Relational view theory, Social exchange theory and Transactive memory system theory. Although five frameworks were identified by the review, only two gave a view of designing blockchain-enabled projects. Out of these two ones was conceptual and this means that more

validated frameworks in different contexts are required when investigating different design requirements.

The review reveals that most of the research conducted is empirical. Only two papers were purely conceptual. These conceptual papers were used in proposing frameworks and used qualitative research methods of case studies and secondary data analysis. Features and drivers of blockchain application were theoretical. The roles and benefits which were driven by the unique features and drivers of BCT were validated empirically. Barriers were also analysed empirically. These three categories of roles, benefits and barriers of blockchain adoption in HSCs mainly relied on experts, with methods such as fuzzy best worst methods, IF DEMATEL and sensitivity analysis, were used to rank and classify these categories in order of their importance. Only two papers conducted quantitative analysis by testing hypothesis from a survey. This can be explained by the novel nature of this topic in this sector. However, more quantitative studies and mixed methods studies are required for further research of BCT in HSCs. The SLR also conclude that there is generally a lack of evidence, because most of the empirical studies analysed above got data from experts and not from the organisations or stakeholders of HSCs. This research aimed to fill the gaps identified in the SLR by designing and developing the blockchain-enabled framework that could potentially act as a roadmap to guide HSC stakeholders on BCT implementation. Validation of the framework involved key stakeholders from diverse HOs who could give opinions on improving the framework and give deeper insights on the requirements needed by HOs to successfully implement the blockchain.

2.12 TOE (Technology-Organisation-Environment) Theoretical Framework

TOE model was used in this thesis to ground the variables that were used in determining the feasibility of blockchain in Kenya's HSC through the questionnaire survey. TOE model was also used in the interviews to identify the critical factors that could influence BCT

implementation in the Kenya HSC. Tornatzky & Fleischer developed the TOE model in 1990 and since then, it has been used extensively in the literature, to analyse factors that influence the adoption of different IT systems like mobile technologies (Wang, et al., 2016); social media digital tools (Orji et al., 2022); and Cloud-based ERP (Usman et al., 2019). TOE framework has also been used in blockchain studies in the construction industry (Wu et al., 2023); banking industry (Kajla et al., 2024); and SCs (Guan et al., 2023; Chittipaka et al., 2023). There were no explicit studies using TOE framework in blockchain adoption in HSCs, which is a critical literature gap. TOE theory was considered in this study as it illustrates that adopting and implementing technological innovations involve consideration of three critical aspects of technological, organisational, and environmental contexts (Usman et al., 2019), which are crucial factors to be considered by HOs, if they were to implement BCT successfully.

2.12.1 Technology Context

Technological context entails the characteristics of the technology innovation, and this influence the readiness of an organisation to adopt it (Oliveira et al., 2014; Legesse et al., 2024). Relative advantage which are the benefits organisations would get from adopting BCT, could determine HOs acceptance of BCT. These benefits include immutability, transparency, and data security and privacy, as users are mindful of sharing personal and sensitive information (Chittipaka et al., 2023). Other determinants within the technological context include compatibility and complexity. Compatibility with existing system, data formats and protocols could influence a higher acceptability (Guan et al., 2023). Complexity on the other hand, is the extent to which individuals perceive the innovation to be difficult to use. If they perceive that the innovation will be difficult to use, then adoption of the new technology will be low (Boakye et al., 2024).

Malik et al. (2021) conducted a study on factors influencing BCT adoption in Australia and they found that the critical technological factors were perceived benefits, information

transparency, disintermediation and compatibility of the blockchain with existing systems. Moreover, Legesse et al., (2024) explored the factors that influence blockchain adoption in the Ethiopian national quality infrastructure and they found that compatibility of the blockchain with the current systems was the most significant technological factor over its relative advantage. On the contrary, Chittipaka et al., (2023) study on the factors that influence BCT adoption in SCM in Malaysian SMEs, found that compatibility had a moderate effect on the intention to adopt BCT, but technological factors such as relative advantage and trust were critical. Guan et al., (2023) study on the predictors of BCT adoption in SCs of Chinese firms found out that relative advantage was the most critical factor while compatibility and complexity did not take prominence in influencing BCT adoption, thus suggesting that Chinese firms were more interested on BCT benefits than its risks. Boakye et al., (2024) conducted a study on determinants of BCT adoption in Ghana SMEs and they found that relative advantage, cost and complexity were the most critical factors for BCT adoption.

2.12.2 Organisational Context

Organisational context entails the characteristics of an organisation adopting an innovation. It involves the ability in terms of resources and capabilities that an organisation must possess, to adopt an innovation. Critical factors are integrating the organisation culture with the technology adoption which can be driven by top management support towards the innovation (Kosmol et al., 2019). Budgetary requirements are also a key determinant to technology adoption due to the initial investment costs and learning costs as employees need training to get acquainted with the system (Boakye et al., 2024). Organisation size has been found to have a great influence on technology adoption (Chittipaka et al., 2023), with bigger firms having a higher adoption rate as compared to smaller ones, due to the availability of slack resources (Wang, Yi-Shun et al., 2016).

Kajla et al., (2024) conducted a study on the determinants of blockchain adoption in the banking industry in India and their study revealed that the organisation context was the important dimension with factors such as IT resources and financial resources playing a critical role, followed by environmental factors, and BCT technological factors had the least influence on its adoption in the banking sector. Legesse et al., (2024) in their exploration study in Ethiopia found that top management was the most critical factor as the leaders will help reduce BCT resourcing challenges. The results of these two studies, were like Chittipaka et al., (2023), who found IT resources and top management support to be critical, in their exploration of BCT in Malaysia. Then again, Boakye et al., (2024) study in Ghana SMEs did not find top management support to be a critical predictor of BCT adoption.

Chittipaka et al., (2023) study, however, found that organisation size, which was not studied by (Kajla et al., 2024) and (Legesse et al., 2024), had a moderate effect on BCT adoption. Guan et al., (2023) study on Chinese firms revealed that organisation size, and organisation readiness to technical expertise had a positive influence on BCT adoption. On the contrary, Guan et al., (2023) study found that cost was not a critical factor for firms to consider in BCT adoption, as the Chinese government supported organisations with an innovation fund, and this finding was different from the studies of (Chittipaka et al., 2023; Kajla et al., 2024), who found cost to be critical.

2.12.3 Environmental Context

Environmental context entails the characteristics of the environments in which organisations operate. Competitive pressures are key determinants as firms are more likely to adopt a new technology to have a competitive edge, if they feel threatened by their peers in terms of customer retention, and market share extensions (Guan et al., 2023). Government regulations also influence firms to adopt new technology as the government can enforce rules and policies that would favour blockchain adoption, or make its adoption complex (Chittipaka et al., 2023).

Other external factors are demand uncertainties and trust issues (Orji et al., 2022; Kajla et al., 2024), supplier-side digital readiness, and institutional factors such as political, social and market environments, that a firm operates in (Kosmol et al., 2019).

Kajla et al., (2024) found out that the banking industry can not completely adopt blockchain and reap its benefits, due to the environmental constraints of limited government policies and regulations that do not fully support BCT adoption. Chittipaka et al., (2023) found that competitors and business partners pressure, and regulatory support were significant drivers of BCT adoption in Malaysian SMEs. Guan et al., (2023) found environmental factors to be the least important in BCT adoption, as compared to technological and organisation factor. On the environment factors, competitive pressure was more significant than market dynamics amongst the Chinese firms. Boakye et al., (2024) found that environmental factors of competitive pressure and market dynamics were statistically insignificant in BCT adoption in Ghana SMEs.

Table 2.11 illustrates the dimensions considered in this thesis, for determining the factors that influence BCT adoption in the Kenya HSC. These dimensions, apart from the donor support that has been developed under the environment as HSC relies on donor funding, have been used by several studies to evaluate the factors that could influence BCT adoption in different industries. These TOE dimensions were used in the guidance of the questionnaire and interview design in this research.

Table 2. 11: TOE dimensions for BCT adoption

Dimension	Characteristics	Reference
Technology	Complexity	(Guan et al., 2023)
	Compatibility	(Park, 2020; Malik et al. 2021)
	Relative advantage: Information security, privacy protection, technology trust,	(Lu et al., 2021)

Organisation	Top management support	(Lu et al., 2021; Legesse et al., 2024)
	Organisational readiness (financial resources, human and technological resources)	(Kamble et al., 2021; Kajla et al., 2024)
Environment	Regulatory support (Government)	(Chittipaka et al., 2023; Boakye et al., 2024)
	Donor support	(Researcher)

2.13 Conclusion

Blockchain technology started as a ‘hype’ due to its interesting features. Further research has been done to unveil its challenges, and frameworks have been conceptualised and others validated, with an objective of identifying the design requirements that should be considered before implementation by HOs. Despite research efforts of BCT in HSCM, there remain gaps that need further exploration. This thesis focused on the design of humanitarian blockchain projects by building a Blockchain-enabled Framework for a blockchain-based HSC, which was validated by Kenya HSC stakeholders. A blockchain architecture that uses smart contracts and KYB features for collaboration and identity management respectively was provided to illustrate blockchain value to HSC stakeholders. A feasibility study was conducted through a survey to identify whether Kenya HSC stakeholders view BCT as necessary and explore the factors that influence their intention to adopt the blockchain, grounded on TOE model. This thesis, therefore, aimed to contribute to gaps 4, 6, 8, 9, 10, and 11 listed in section 2.11.8.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter discusses the methods that were adopted in conducting the research, including the research philosophy, research design and data collection tools.

3.1 Research Process

This research was guided by the research onion provided by Saunders and Lewis (2012) which includes philosophies, approaches, strategies, and data collection techniques. The research process adopted is shown in **Figure 3.1**.

3.2 Research Philosophy

To explain the philosophical concepts guiding the research methodology used in this thesis, it is important to discuss the core philosophical concepts of epistemology and ontology. Ontology studies the theory of existence and the nature of reality (Kivunja & Kuyini, 2017). It helps to seek answers to questions about the things that exist in the world, and how they can be grouped (Al-Ababneh, 2020). Realist ontology believes that reality is independent of our perceptions, that is, reality exists regardless of our ability or inability to observe or measure it. Relativist ontology, on the other hand, believes that reality is dependent on social constructions. That is, individuals create reality based on their perceptions and experiences (Kivunja & Kuyini, 2017). Epistemology is the study of knowledge, and it addresses questions about what constitutes knowledge, and how we acquire knowledge. Ontology is therefore articulated through epistemology, due to its relevance in shaping objective and subjective worlds (Hothersall, 2019).

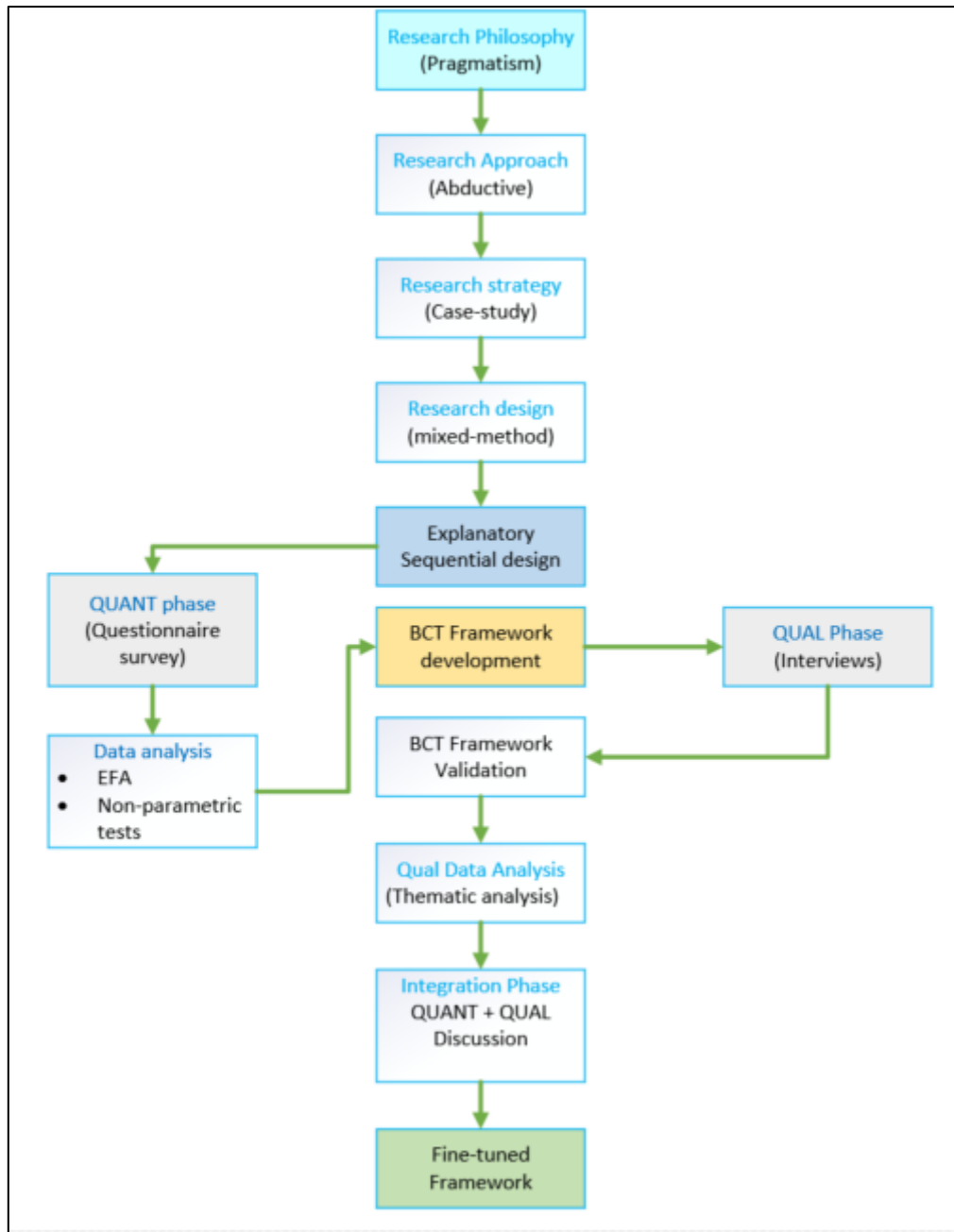


Figure 3. 1: *Thesis Research Process*

Research philosophy explains perceptions on how data of a phenomenon should be collected, analysed, and used, as these perceptions guide the research methods (Al-Ababneh, 2020). Additionally, research philosophy informs the research methodology that forms the basis for selecting the research strategy and design, formulating the research problem, and collecting, analysing, and processing the data of a particular phenomenon (Zukauskas et al., 2018; Kivunja & Kuyini, 2017). The main strands of research philosophy are positivism, realism,

interpretivism, and pragmatism (Saunders & Lewis, 2012). Positivism employs a highly structured method that enhances replication, and the results developed are generalisable as it strives to explain the causal relationships between variables (van der Riet, 2012).

Realism argues that objects under investigation are independent of our knowledge of their existence and facts are constructed by social relationships (Hunt, 2018). Interpretivism advocates the need to understand human differences in a social environment and develop interpretivist theories that are intimately grounded in the real world (Leitch et al., 2010). Pragmatism, on the other hand stresses the role of research questions and objectives in determining the research philosophy, and it involves the use of both quantitative and qualitative data collection methods (Dolan et al., 2022). Pragmatism is guided by non-singular reality ontology, and relational epistemology (Kivunja & Kuyini, 2017). Non-singular reality means that more than one reality exists, which is dependent on how individuals perceive and interpret reality. Relational epistemology means that a researcher determines what methods to use based on the research aims.

This research adopted the pragmatism approach as it focuses on problems, and relevance of RQs, and emphasises offering a practical solution (Kivunja & Kuyini, 2017). The problem in this research is the challenges in Kenya HSCs that can be minimised by BCT adoption. The practical solution is a roadmap that will guide key HSC stakeholders in the decision to invest in BCT. Baker and Schaltegger (2015) assert that the pragmatism approach helps in explaining the true value of a statement in its usefulness for enacting change, rather than just portraying an accurate representation of the phenomena to the external world. De-Boeck et al. (2023) also noted that practical solutions that integrate data analytics, such as BCT usage in HSCs, are needed through academics and practitioners' collaborations, which is what this research aimed at doing.

3.3 Research Approaches

The major research approaches are deduction and induction. In the deductive approach, researchers test the existing theories through hypothesis development, and the research results are generalisable, with generalisability being from general to specific (Yoon, 2012). In an inductive approach, known premises are used to form or generate a theory, with generalisability being from specific to general (Azungah, 2018). This research adopted an abductive approach as both deductive and inductive approaches were used for different research questions. Abductive reasoning is especially valuable when you're in situations where the data doesn't give you a clear answer or when the information you have is not complete, so you need to form the best possible explanations that can guide your next steps in research (Haig, 2005).

Abductive reasoning is used throughout this research to generate and refine explanations as the research moves from the quantitative phase to the qualitative phase. Based on the patterns observed in the quantitative data, plausible explanations were generated to form questions on the interview guide, where expert interviews were conducted with key stakeholders in the Kenya HSC. The qualitative data provided richer, more in-depth insights that helped to explain the patterns or gaps found in the quantitative phase. Conaty (2021) highlights the benefit of using abductive approach in case studies is its ability to interactively bridge empirical data and theoretical frameworks, as researchers can develop richer insights by moving back and forth between real-world observations and existing theories, rather than applying rigid deductive models or relying solely on inductive generalisations, especially in complex or underexplored contexts. Abductive approach accommodates surprising findings and allows generation of plausible explanations grounded in both data and theory (Conaty, 2021). This approach allowed for validating the framework and examining the social and cultural factors surrounding technology adoption in Kenya, which are considered important in BCT adoption (Essien et al., 2024).

3.4 Research Strategies

The strategies used when conducting research are mainly experiments, case studies, action research, grounded theory, ethnography, and archival research (Saunders & Lewis, 2012). This research focused on a case-study, in which the Kenya HSC was studied. Martinsuo and Huemann (2021) augmented that using case studies to solve specific problems can make a novel contribution to a relevant field. Similarly, authors such as (De Boeck et al., 2023) have recommended the studies of context-related cases, through qualitative research, to build on blockchain studies in HSCs. Vega (2018) recommended the use of case studies when conducting HL research using four stages of why (purpose), what (RQs), how- practicality (data collection techniques) and how- conceptually (how the case is theoretically built) and blockchain studies in HSCs such as (Baharmand et al., 2021), have adopted these stages when conducting case study research

Kenya offers a contextual relevance of exploration of BCT due to its humanitarian complexity, food aid distribution challenges coupled with transparency and accountability issues, and a lack of visibility in DRO, and these challenges could be solved by the blockchain. Kenya also offers relevance to blockchain evaluation, as the IFRC and KRCS were among the first HOs to pilot blockchain applications in the humanitarian sector worldwide (Saad et al., 2022). Other charitable cases like Grass Roots Economic Foundation (Ussher et al., 2021), Mercy Corps and CARE have used blockchain for cash transfers in Kenya (Hart, 2024). Interestingly, Kenya has shown a growing acceptance of digital technology, with the innovation of mobile money (MPESA) that involves making monetary transactions via mobile phones. Yin (2018) asserts that case study research is important as it helps to provide an in-depth understanding of a phenomenon, in a real-world context, and recent recommendations to explore blockchain use in different industries and contexts (Sansone et al., 2023), justify the country's suitability for exploration, to provide practical insights that can be replicated in other regions and industries.

3.5 Research Design

The major research designs are exploratory, explanatory, and descriptive research designs. According to Byrne (2016), In an exploratory study, a researcher seeks to gather new insights into a research area, which involves asking new questions. In an explanatory study, the researcher seeks to study the research problem to explain or clarify variables or findings, and in a descriptive study, the researcher aims to produce an accurate representation of the objects under study. This research used a mixed-method design. A mixed-method design ensures the collection of both quantitative and qualitative data, thus combining the strengths of both methods (Saunders & Lewis, 2012; Fischer et al., 2017). This design is important in complex situations, where using a single method may not be sufficient in addressing the research problem (Kuusio et al., 2021; Neves et al., 2025). Smith & Karl (2020) revealed the need for a mixed methodology when conducting humanitarian research as it allows for triangulation of results, which makes results more reliable.

This thesis adopted the explanatory sequential design that starts with a quantitative (QUANT) phase followed by a qualitative (QUAL) phase (Teerawongpairoj et al., 2024). Quant data was collected through a questionnaire survey. After the quant data analysis, the researcher then proceeded to collect qualitative (QUAL) data, using expert interviews selected from key stakeholders in the Kenya HSC. Qualitative data helped to explain Quantitative data (Creswell & Plano Clark, 2018) and validate the blockchain-enabled framework. Several blockchain studies in SCs like (Mubarik et al., 2020; Awal & Chowdhury 2024) have used this research design. The exploration on BCT feasibility, awareness, readiness and attitudes in the quantitative phase was useful in getting initial thoughts about these dimensions. Based on the survey results, further exploration and explanation of the identified themes through interviews, were conducted to provide deep insights into the RQs.

3.6 Quantitative Phase

Quantitative research seeks to answer questions such as ‘how many’ and ‘how much’ (Elliott et al., 2017). In this thesis, quantitative research through a questionnaire survey was conducted to identify the feasibility of BCT in the Kenya HSC. A survey-based instrument is effective in measuring behavioural constructs, despite its challenges with common method bias (CMB) (Monreal & McCorkle, 2021). This challenge was reduced by designing a questionnaire that could be answered by multiple stakeholders in the Kenya HSC. The questionnaire design was significantly influenced by past studies on blockchain adoption in HSCs such as (Khan et al., 2021), and the TOE framework due to its inclusion of three dimensions of technology, organisation and environment factors, which are helpful in determining the factors that influence technology, and BCT adoption (Qatawneh, 2024; Mauro et al., 2024). The questionnaire had a five Likert scale, one to five, ranging from strongly disagree to strongly agree respectively. This scale is used in other blockchain studies (Awal & Chowdhury 2024). The questionnaire that was designed via Qualtrics, is as shown in [Appendix 1](#). Several blockchain studies in HSCs, such as (Dubey et al., 2020; Khan et al., 2021; Masudin et al., 2021; Dubey et al., 2024) have used questionnaire surveys in their data collection.

The questionnaire, which was submitted online, also aimed at evaluating the factors considered important in influencing new technology adoption by HSC stakeholders and identifying their awareness of BCT. Initially, the questionnaire targeted evaluating readiness to BCT only. However, after a pre-test pilot that was done by HSC professionals in Nairobi and Laikipia Counties, and two Professors in Innovation, the need to re-adjust the contents was raised due to the perception of low awareness on BCT in Kenya HSC. This lack of BCT knowledge by respondents turned out to be the case, after the actual data collection.

Pre-tested questionnaires through expert opinions and pilot studies minimise difficulties in answering the questionnaire by respondents, thus increasing data validity and reliability

(Oflazoglu & Oflazoglu Dora, 2017). Based on the pilot's and expert's recommendations, the questionnaire was divided into four parts. The first part addressed demographic information of the respondents, part two was a feasibility study to assess operational challenges in Kenya HSC, part three addressed factors influencing innovation adoption, and part four was purely based on BCT. Part four had to be strictly filled by only those respondents with good or excellent knowledge of BCT, which helped to minimise CMB. These respondents were asked questions about their concerns regarding BCT, and their intentions to adopt it. The categorisation of the questionnaire in parts also ensured an inclusive approach, where all respondents answered questions regarding innovation readiness, with the aim of using these responses to determine the factors that are considered important when adopting new technologies (with extension of BCT) in Kenya.

3.6.1 Sampling Strategies

The target population of this study were the key Kenya HSC stakeholders- the government (both national and county government), NGOs, and development partners. Researchers can use different sampling techniques when selecting samples for data collection from the target population. The major ones are probability and non-probability techniques (Santos, 2018). Probability sampling involves selecting a sample at a random, where each member of the target population has a chance of being selected, as there exists a sampling frame to select from (Landwehr et al., 2024). Probability sampling includes employing sampling techniques such as simple, cluster, systematic and stratified random sampling.

In non-probability sampling, members of a given target population do not stand an equal chance of being selected, as there is no complete list/sampling frame of the total population to choose from (Mitu Akter et al., 2024). Non-probability sampling includes techniques such as quota, purposive, snowball, and convenience sampling. This research adopted multi-stage sampling techniques. In 2022, upon request, the researcher received a list of active NGOs in Kenya from

the Kenya NGO Coordination Board. The list had 715 active NGOs operating in Kenya. The researcher used purposive sampling to select only NGOs involved with humanitarian activities. These were 345 organisations. To ensure representativeness, simple random sampling was then applied to select a final sample size of 182 NGOs (calculated using a confidence level of 95% and a margin error of 0.05) based on standard sample size determination methods (Krejcie & Morgan, 1970; Cochran, 1977). The researcher then sent an email to each one of them. Six out of the 182 organisations emailed back to say that they were not involved with DRM issues. The researcher also received numerous undelivered prompts ‘mail not delivered- address not found.’ The undelivered emails were 66. The researcher went to the NGO’s website that had returned a non-delivery message. Unfortunately, most of the websites were missing, while others had not updated their new addresses. Only two NGOs were contacted via emails using new addresses found. This gives a total of 110 NGOs that received the questionnaire.

Since Kenya is affected mostly by droughts and floods, populations in the ASAL counties are affected the most. There are 26 ASAL counties and therefore, these counties were targeted purposefully, out of the 47 counties that are operational in Kenya. Most national government DRM institutions are in Nairobi (HQ). Therefore, a purposive sample to include Nairobi County was done. This gives a total of 27 counties. Emails were sent to these counties as well. The contents of the emails were the University Introduction letter, and a Qualtrics link to the questionnaire. A request to share the questionnaire to HSC employees within the organisation (snowballing), was written in the email. Emails were sent to development partners like WFP and KRCS. Some HOs personnel, especially those in INGOs working in Kenya, were contacted via LinkedIn. Some studies in BCT adoptions such as (Khan et al., 2021) have used social media networks to target HOs respondents. Purposive and snowballing sampling techniques used ensured that the most suitable individuals in the selected organisations answered the questionnaire (Creswell & Plano Clark, 2018; Oke et al., 2024).

3.6.2 Quantitative Data Analysis

116 responses were received from the survey, and these are considered a good number as it is within the 100-200 threshold recommended by (Memon et al., 2020; Karyani et al., 2024). SPSS 26.0 package software was used to analyse the survey data. Reliability of data, which should be tested before conducting quantitative data analysis, was performed using Cronbach Alpha (Paul et al., 2024). The researcher used descriptive statistics such as frequencies, as they are useful in analysing the demographic information of the respondents (Oflazoglu & Oflazoglu Dora, 2017). Additionally, inferential statistics such as Friedman tests (Gurgun et al., 2022; Lin & Opdyke, 2024) were used to rank factors considered important at influencing new technologies adoption in Kenya HSC. The same tests were used to rank those factors that should be considered more when implementing BCT in the Kenya HSC, as provided by respondents with good and excellent BCT knowledge.

3.7 Development of the Blockchain-enabled Framework

Following the data analysis from the survey, key challenges that existed in the Kenya HSC that would be solved by blockchain solutions were identified. The results also provided the most and the least critical factors that stakeholders consider in the implementation of new technologies. Finally, the survey results provided the most critical concerns regarding BCT implementation. These findings were supplemented with the literature, to develop the blockchain-enabled framework. Baharmand et al. (2021) and Hart et al. (2024), are among the few papers to develop frameworks for BCT adoption in HSCs, and their frameworks were developed following a literature review. Supplements from the literature included both academic and grey literature, as recommended by (De Boeck et al., 2023), as most practitioners do not publish their reports in academic journals, and ignoring such sources reduces the impacts of BCT in offering sustainable solutions in HSCs. The survey findings also acted as a foundation for interview questions that are provided in the interview guide in [Appendix II](#).

3.8 Qualitative Phase

Qualitative research focuses on the 'how' and 'why' questions (Elliott et al., 2017), and it offers the flexibility required to explore complex situations (Creswell & Creswell, 2023) such as the challenges inherent in Kenya's HSC. In this study, semi-structured interviews from key stakeholders from the Kenya HSC, which provide flexibility across interviewee's (Silverman, 2020), were used to explain more on the quantitative results, and to validate the developed blockchain-enabled framework. A few blockchain studies in HSCs, such as (Baharmand et al., 2021; Hart, 2024), have used qualitative methods like interviews for data collection.

3.8.1 Sampling Techniques

It was necessary that the framework be validated by experts on DRM and humanitarian, and these are NGO and government supply chain and logistics managers, disaster operations managers, disaster technical and technology experts. Just like the surveys, purposive sampling and snowballing sampling techniques were used to identify the interview participants to validate the blockchain architecture as these techniques would ensure the selection of participants with rich information (Arslanlı et al., 2024). The selected participants all had experience with previous technological adoptions in their organisations, as this would provide in-depth perceptions of requirements that organisations needed to satisfy, to adopt new technologies like BCT.

The survey results showed that many respondents had no BCT knowledge, followed close by those who had little knowledge about BCT, compared to the very few that had good and excellent BCT knowledge. This challenge of a lack of a large number of BCT experts in HSCs, has been acknowledged by prior studies (Coppi & Fast, 2019; Baharmand et al., 2021a). Therefore, the researcher developed introduction briefs, prior to the interviews, to explain about BCT, to the interview experts that were sampled due to their DRM involvement and rich knowledge, but did not know or knew little about the blockchain. The researcher conducted an

official visit to the organisations to reach participants from the national government and county government, development partners, and NGOs. From the interactions with the experts, they would recommend another expert, from inside and outside the organisation; thus, a snowballing sampling technique was useful. Snowballing techniques are useful to research inadequately covered phenomena, which is BCT in this case, as this technique ensures that the researcher gets to identify individuals with the knowledge and experiences useful for the study (Hennink et al., 2020). Due to time, cost, distance and security concerns, a convenience sample (Birgili & Demir, 2022) of seven counties was used. Security concerns have been a major concern inhibiting collection of data in specific disaster affected regions amongst researchers (Sabri et al., 2019). The researcher visited the NGOs and development partners present in these countries. These counties were also among the 27 counties that participated in the questionnaire survey.

The recommended participants from outside the organisation were mainly from the private sector, and other NGOs, and they all had good knowledge about the blockchain. The interviews with the snowballed external participants were conducted online via Zoom. An introduction letter from the university, research ethics & permit from NACOSTI, a participant consent form, an introduction brief of BCT, and the blockchain-enabled framework to be validated were provided during the interviews to all the participants. Interviews were recorded where possible, and in cases where participants did not give consent to recording, notes were taken.

Saturation point was reached at 30 interviews, at the point where further interviews could not benefit in theory building (Rowlands et al., 2016). Two interviews were not used in the analysis as they were not elaborate. For instance, a participant, when asked about the challenges that they face when conducting humanitarian DRM activities, they would say; - nothing, if asked about the model, - they would say 'it's okay.' These interviews were less than 10 minutes long, while the interviews were scheduled to be 45 minutes to 2hrs, depending on cultural factors

such as use of high context communication (many words to explain a point), and follow-up prompts, based on the participant's responses. The two interviews not used were from participants in the county government. These two participants did not give permission to record the interviews. Twenty-eight interviews were therefore used in the data analysis.

3.8.2 Framework Validation

To validate the blockchain-enabled framework, participants were asked about its practicality. They were asked about the sequential building blocks of the framework, to identify if there were blocks that were missing, blocks that should be removed or blocks whose sequence should be re-arranged. Participants were also given an opportunity to improve the BCT-enabled architectural design. Moreover, they were asked about the potential benefits they perceive the Kenya HSC would get from adopting BCT, and the challenges their organisations would face in implementing it.

3.8.3 Qualitative Data Analysis

Transcriptions of the interviews were done and Nvivo software was used to analyse the data. Based on the nature of the data, different data analysis techniques such as content analysis, discourse analysis, ethnometry and thematic analysis can be used (Oflazoglu & Oflazoglu Dora, 2017). Deep text analysis and numerous readings were done to code the texts into recurring themes, and thematic analysis was used for the analysis of the coded themes and the final write-up to provide detailed and reliable findings. Thematic analysis ensures that patterns within data are identified, analysed and interpreted (Miri et al., 2024). The researcher used an inductive approach to code themes as they emerged from the raw data. The researcher drew upon existing literature to determine the appropriate codes to use based on an initial understanding of the data. The data was re-read to ensure consistency and ensure that all data was coded. These codes were validated by the supervisor, to ensure an accurate categorisation of the themes.

During the coding, sub-categories were developed from the initial codes- indicated by child from parent by Nvivo, and blockchain studies in SCs have used similar coding approaches (Essien et al., 2024; Jimenez-Castillo et al., 2024). In the write-up, descriptive analysis, that included direct citations from the respondents, was used to support the codes established (Ofiazoglu & Ofiazoglu Dora, 2017; Yin, 2018). Reliability of data was achieved by following the ethical considerations in data collection and analysis, getting diverse participants to represent the Kenya HSC, recording the interviews, and providing quotations from the participants on the coded themes (Miri et al., 2024; Güler & Albayrak, 2024). Validity was ensured from triangulation with literature reviews and integration with the quantitative study done in the first phase.

3.9 Data Integration Phase

Integration is the stage where mixing quantitative and qualitative data collection or analysis methods occurs, which can be done at the beginning of the study, at an intermediate stage depending on the research design, or at the data interpretation stage (Ivankova et al., 2006). Integration of quantitative and qualitative data was done in two stages. First, the partial integration where the quantitative data was analysed, to get themes that would form questions for the interview guide, and full integration of both datasets was done when discussing the research findings.

3.10 Fine-tuning the Blockchain-enabled Framework

The final proposed Blockchain-enabled Framework for the Kenya HSC was refined based on the insights gained from the interviews, to ensure that it was localised for the Kenyan context, and that it addressed stakeholder concerns. Concerns in the Framework, and the organisation structures of Kenya DRM in the architectural design stage, were addressed when refining and presenting the validated Blockchain-enabled Framework.

3.11 Ethical Considerations

Axiology guides on the ethical considerations that should be made when conducting research (Kivunja & Kuyini, 2017). It emphasises the need for researchers to be guided by ethical values of maintaining privacy of participants and their data, respecting their social and cultural aspects and minimise participant's physical and psychological harm (Kivunja & Kuyini, 2017). This research was approved by the University's ethics committee. A research permit to conduct field work in Kenya to collect qualitative data was approved by NACOSTI. A participant information sheet that guaranteed participants confidentiality and anonymity of data, as well as a participant consent form, were given to the interviewees to get their consent to continue with the interview and to record it. These four documents are as shown in [Appendices III to VI](#). The questionnaire also ensured that the respondents gave consent to proceed. Confidentiality of participants was maintained throughout the data collection, analysis and write-up. The participants' codes have special characters aimed at concealing their identities.

3.12 Conclusion

This thesis adopted the explanatory sequential design that starts with a quantitative phase followed by a qualitative phase. The main data collection tools used were a questionnaire survey and expert interviews. The researcher ensured ethical data collection, coding, analysis and write-up procedures were used.

CHAPTER FOUR

BLOCKCHAIN TECHNOLOGY FEASIBILITY STUDY IN KENYA - QUESTIONNAIRE SURVEY QUANTITATIVE DATA ANALYSIS

4.0 Introduction

This chapter reports on the quantitative data analysis of the questionnaire survey. The Quantitative phase was useful in conducting the BCT feasibility study in Kenya and explorations on BCT awareness by HSC stakeholders. This phase was also useful in guiding the Blockchain-enabled Framework, which is discussed in chapter five. As noted in chapter three, section 3.6, a pilot test was conducted before distributing the questionnaire. From the pilot, the contents of the questionnaire were slightly adjusted to ensure that only participants with good BCT knowledge answered questions about factors that could influence blockchain adoption in HSCs. Another recommendation from the pilot study was to include a section in the questionnaire that would allow all participants to respond to questions about factors they considered important in general technology adoption in HOs, rather than focusing solely on BCT questions. This suggestion was based on the experts' expectation of low awareness of BCT adoption in HOs, a concern that was confirmed during actual data collection. These recommendations were incorporated into the final questionnaire design. The questionnaire content is discussed in the analysis sections below.

4.1 Quantitative Data Analysis

The number of responses received from the survey was 116, 13 out of these had only completed the questions partially, with more than three quarters left unanswered, by the end of the survey. Due to the nature of these missing values, list-wise deletion was considered appropriate (Peng et al., 2023), and 103 questionnaires were used for data analysis.

The total number of questions, which include questions within sub-categories, was 60. The questionnaire was organised into four parts as follows.

- a) Part one was for asking demographic questions of the participants.
- b) Part two asked for a feasibility study of the blockchain to assess whether blockchain is needed in the Kenya HSC
- c) Part three gauged whether support to implement innovation is available from the top management, organisation infrastructure, and external support
- d) Part four of the questionnaire, was dedicated to asking questions about blockchain technology.

To ensure that only respondents with good or excellent knowledge of BCT answered part 4, respondents were first asked to rate their BCT knowledge, and the following logic criteria was employed in Qualtrics based on their responses.

- a) If a participant ticked no BCT knowledge, they were directed to the last section, to submit earlier responses (Parts 1, 2, and 3), and the questionnaire ended. Respondents with no BCT knowledge were 35.
- b) If a participant ticked little BCT knowledge, they were directed to answer the next two questions, which asked if they knew whether their organisation had any involvement with blockchain (current BCT status), and their intention to adopt it, before clicking submit to end the questionnaire. Respondents with little BCT knowledge were 38.
- c) If a participant ticked, good or excellent BCT knowledge, they could answer all Part 4 questions that focused on BCT, before clicking submit to end the questionnaire. Respondents with good and excellent BCT knowledge were 26 and 4, respectively, to make a total of 30 that answered part 3.

Because of this skip logic criteria, there were missing values in the system, as shown in [Table](#)

4.1.

Table 4. 1: Representation of the survey design

Part	Description	Question/variable	N	Missing Value
1	Demographics	4	103	0
2	Feasibility	14	103	0
3	Innovation Support Assessment	22	103	0
4	Blockchain	20		
		Blockchain knowledge	103	0
		Status and intention	68	35
		Compatibility, complexity, regulation	30	73

As a result of this categorisation, data analysis was done in four parts. **Table 4.2** shows the analysis conducted in each part of the questionnaire.

Table 4. 2: Representation of Statistical Analysis conducted in the four questionnaire parts

Part of the Questionnaire	Statistics Conducted	Reason
1: Respondents Demographic information	Descriptive Statistics • Frequencies	To identify the overall picture of the data
2: BCT Feasibility study	Descriptive Statistics • Means and Std deviation • EFA analysis	To summarise data sets and identify patterns and group related variables in the data
3: Drivers of innovation adoption	Inferential Statistics • Friedman tests • Post-Hoc tests	To determine whether there are significant differences in factors influencing innovation adoption in Kenya (and by extension BCT)
4: Blockchain technology-knowledge, challenges.	Descriptive Statistics • Frequencies Inferential Statistics • Friedman tests • Post-Hoc tests	To identify the overall picture on blockchain knowledge and determine any statistically significant differences on factors influencing BCT adoption

4.2 Analysis of Part One of the Questionnaire

The SPSS tool was used to analyse this part of the questionnaire. As this part of the questionnaire was mainly focused on the demographics of the respondents, descriptive statistics employing frequencies and percentages were used.

4.2.1 Which one of the following best describes your Organisation?

Majority of the respondents were from INGOs with 36 respondents while the UN agencies were only 4, as shown in **Figure 4.1**. 5.8% of the respondents were in the ‘other category and when asked to specify which one, one was from a church organisation, and the other five were from the private sector, with two specifically citing a startup and telecommunications company, directly involved with DRM activities in Kenya.

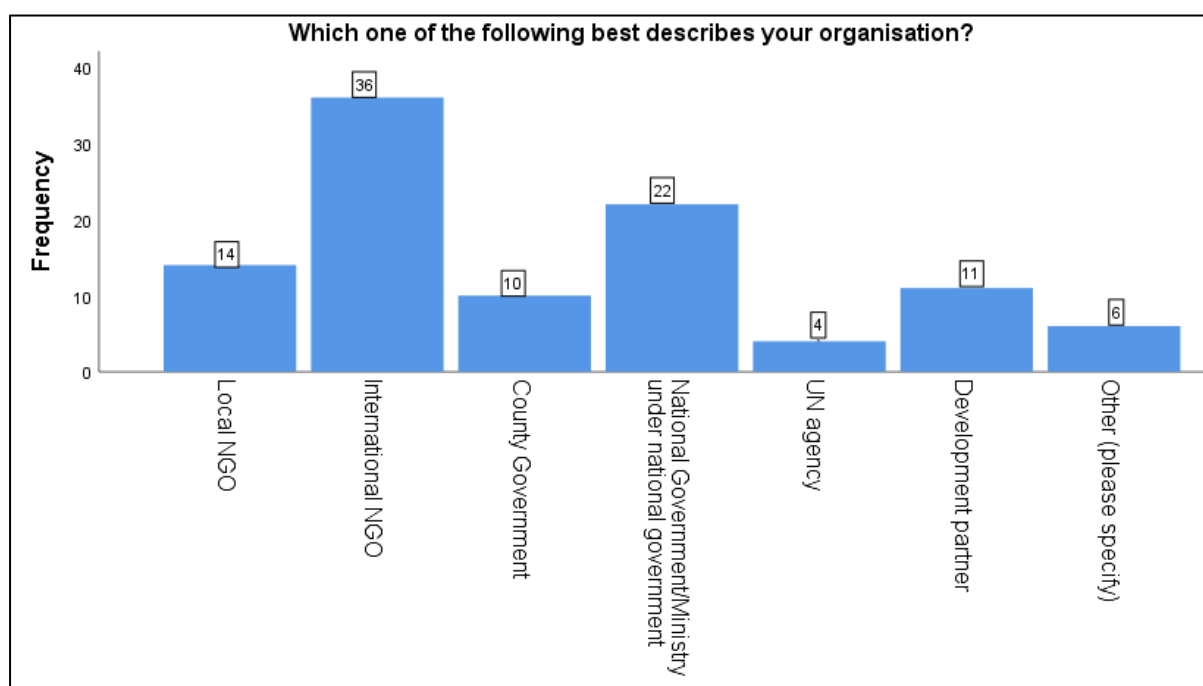


Figure 4. 1: *Respondent's organisation type*

4.2.2 How many Employees does your Organisation have?

Most organisation participants had more than 200 employees, with an insignificant difference between organisations that had 50-100; and 100-150 employees as illustrated in **Table 4.3**.

Table 4. 3: Organisation size of the respondents

Parameter	Description	Frequency	Valid percentage
Number of Employees	Less than 50 employees	20	19.4%
	50-100 employees	15	14.6%
	100-150 employees	14	13.6%
	More than 200 employees	54	52.4%
N		103	

4.2.3 What is your Highest Level of Education?

The majority of the respondents had an undergraduate degree, who were 52, while only 3 respondents had a certificate, as illustrated in [Figure 4.2](#).

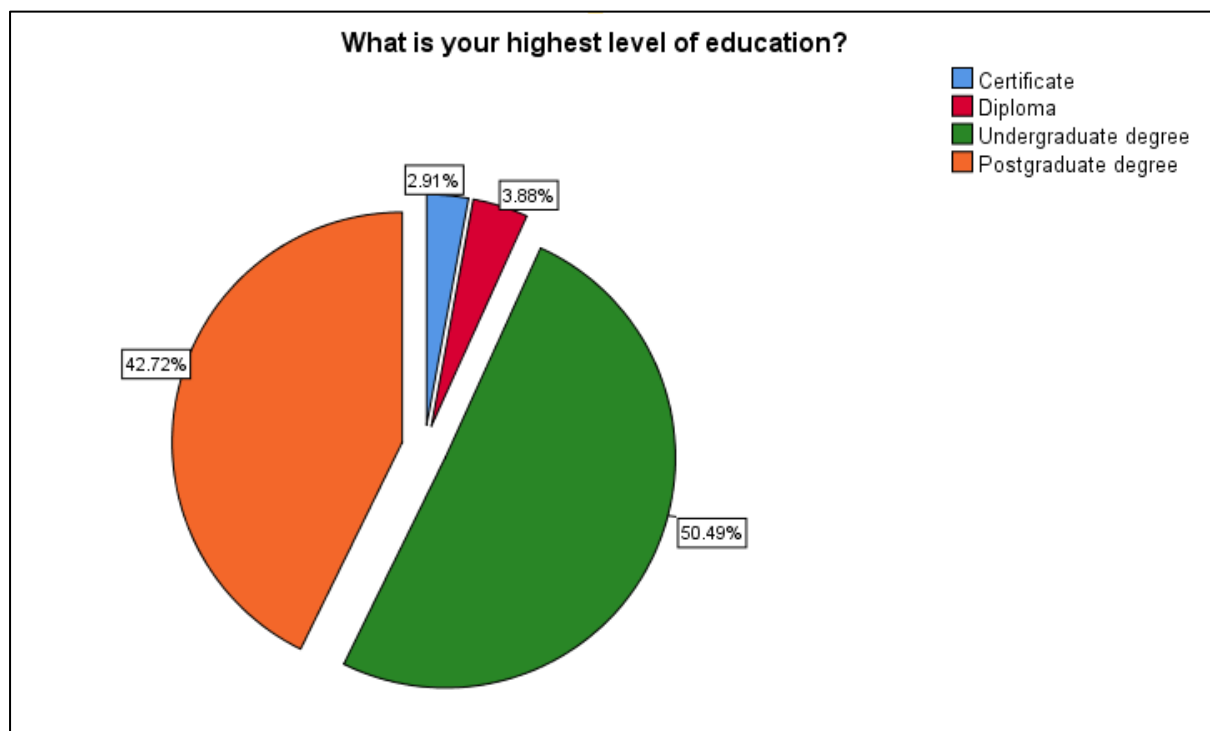


Figure 4. 2: Level of Education of the respondents

4.2.4 What is your Age in Years?

As can be seen, majority of the respondents belonged to the age group of 26-33 years, who were 48, as shown in [Figure 4.3](#). No significant difference was between the age groups of 34-41 and 42-49, as these had 20 and 22 respondents respectively.

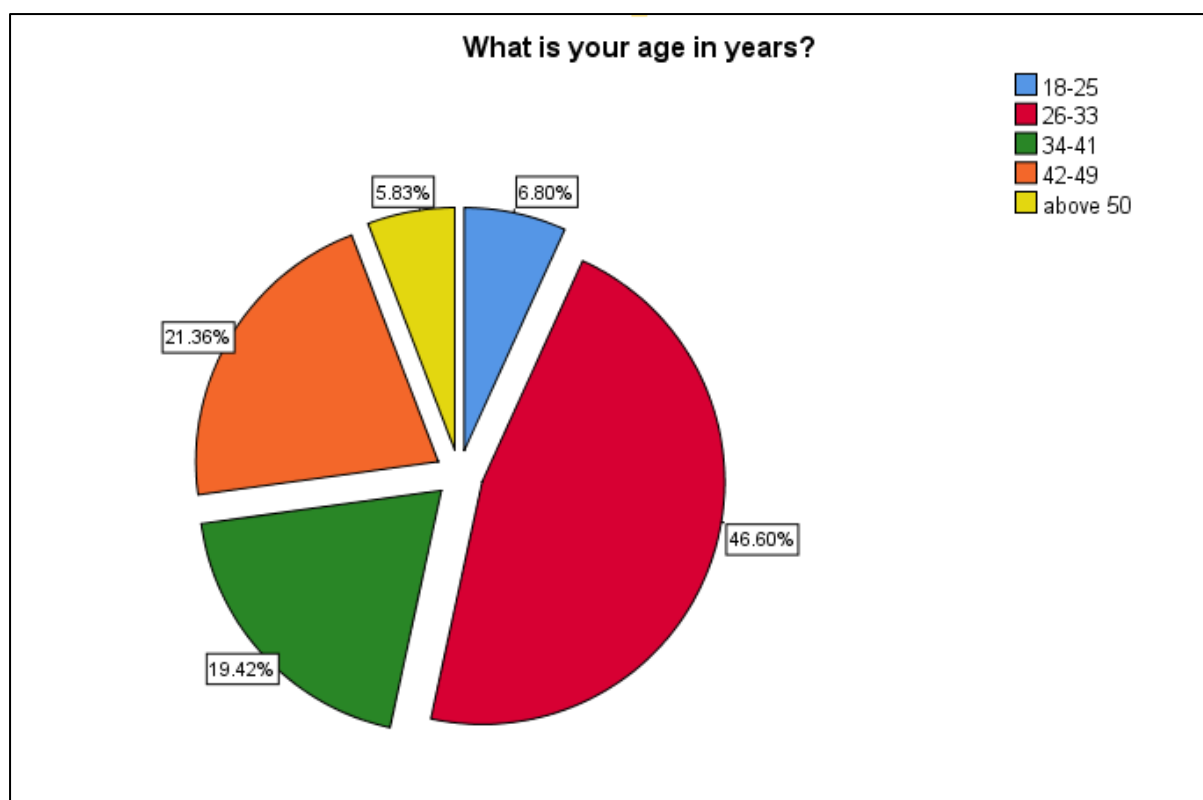


Figure 4. 3: *Age of the respondents*

4.3 Analysis of Part Two of the Questionnaire

This part of the questionnaire is for a feasibility study of the blockchain to assess whether blockchain is needed in the Kenya HSC. The SPSS tool was used to analyse this part of the questionnaire. Reliability of data was checked before running tests on the feasibility study. Cronbach's Alpha was conducted to test the reliability (internal consistency) of the 14 items that were measuring BCT feasibility (Guan et al., 2023), as shown in **Table 4.4**.

Since the alpha value in **Table 4.4** is greater than 0.7, this means that there was an acceptable internal consistency, and the items are consistently measuring the same concept of the feasibility of the blockchain (Guan et al., 2023).

Table 4. 4: Reliability Statistics

Case Processing Summary			
		N	%
Cases	Valid	103	100.0
	Excluded ^a	0	.0
	Total	103	100.0
a. Listwise deletion based on all variables in the procedure.			
Reliability Statistics			
Cronbach's Alpha		N of Items	
.906		14	

4.3.1 Responses of the Feasibility Study

Participants were asked to respond to statements, which involved their experiences when working with other humanitarian partners in Kenya HSC, aimed at testing for blockchain feasibility. A Likert scale of 1-5 was used, where 1 = Strongly disagree and 5 = strongly agree. **Table 4.5** illustrates the mean distribution and standard deviation of their responses. The data shows that there is a lack of trust amongst humanitarian partners, with moderate concerns about information reliability, process inefficiency and tracking shared data. There was a high concern about data privacy and confidentiality, coupled with coordination visibility, and transparency issues. Although the data shows a low concern about delays in transactions dependence, reconciling shared data was perceived to be difficult. Most respondents believed that humanitarian intermediaries added costs and complexity, and they would prefer systems that involved community participation in decision making. There was a low concern for data security and integrity and moderate concerns about manipulations and abuse of HO's systems. The findings from the feasibility study suggest that there exist operational challenges of trust, coordination, transparency, visibility, traceability and many intermediaries that increases complexity in Kenya humanitarian operations.

Table 4. 5: Responses of the feasibility study

Statement	Mean	Std Dev
Information Reliability Concerns	3.80	1.22
Data security and Integrity Concerns	3.18	1.36
Process Inefficiency	3.64	1.33
Difficulty in tracking shared data	3.78	1.21
Difficulty in shared data reconciliation	4.05	1.25
Data privacy and confidentiality issues	4.04	1.23
Lack of visibility in coordination	4.02	1.12
Lack of transparency in compliance and regulation issues	4.08	1.37
Difficulty in tracking disaster aid supplies	4.02	1.09
Lack of trust	4.11	1.14
Intermediaries' costs and complexity	4.24	1.08
Delays caused by transaction dependence	3.23	1.40
Manipulations and system abuse	3.69	1.32
Lack of community participation in decision-making	4.27	1.15

N = 103

4.3.2 Factor Analysis (Exploratory Factor Analysis, EFA)

The results of the feasibility study, which was measured using 14 items, were used to conduct an EFA. These items are illustrated in [Table 4.6](#). The EFA aimed at identifying items that could be grouped together to form broader themes (Yong & Pearce, 2013). These themes were to be evaluated in the interviews. Several blockchain studies such as (Okanlawon et al., 2023; Bleik, 2024; Panghal et al., 2024) have used EFA in their data analysis. For an EFA to be conducted, a sufficient sample size must be used. The sample size of 103, which is (>50), was sufficient (Zeynivandnezhad et al., 2019).

Table 4. 6: 14 Feasibility items

Initial	Label of the item
VAR00001	Data reliability
VAR00002	Data security
VAR00003	Process inefficiency
VAR00004	Tracking tasks
VAR00005	Data reconciliation
VAR00006	Data Privacy
VAR00007	Visibility
VAR00008	Transparency
VAR00009	Tracking supplies
VAR00010	Trust
VAR00011	Intermediary cost
VAR00012	Dependency delays
VAR00013	System abuse
VAR00014	Community Participation

Besides the feasibility data meeting a sufficient sample size of greater than 50, two tests, as shown in **Table 4.7** were done to test whether the data was satisfactory to conduct an EFA (Bleik, 2024).

Table 4. 7: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.844
Bartlett's Test of Sphericity	Approx. Chi-Square	822.613
	df	91
	Sig.	.000

KMO Measure of Sampling Adequacy was **0.844**, and a Bartlett's Test of Sphericity significance was **0.000**, and since the P-values of the tests were (**>0.05**) and (**<0.001**) respectively, the data was therefore satisfactory to conduct an EFA (Zeynivandnezhad et al., 2019). When conducting EFA, the data does not necessarily need to conform to normality tests especially when Likert scales were used in collecting the data (Rossoni et al., 2016), such as

this research. Maximum likelihood extraction was used, as the goal was to consider a model that could give a perfect fit of the variables (Rossoni et al., 2016) and not to necessarily proceed with confirmatory factor analysis.

Each construct in the communalities table that is derived from conducting an EFA, should have a value of (**>0.5**) to be considered sufficient (Saunders et al., 2023). Item 14 (community participation), had a factor loading that was (<0.5), as shown in [Appendix VII \(a\)](#), and therefore, it was removed and the model run again. After re-running the model, all the constructs had a factor loading of (>0.5) as shown in the communalities table in [Appendix VII \(b\)](#). Data from the pattern matrix, [Appendix VII \(c\)](#), however, indicated that item 3 (process inefficiency), had a factor loading of (<0.5), and therefore it had to be removed. The model was run again using 12 items, and these items met the (>0.5) criterion, as shown in the communalities [Table 4.8](#).

Table 4. 8: Factor loadings of 12 Feasibility items

Communalities	
Initial	Factor Loading
Data reliability	.558
Data security	.589
Tracking tasks	.651
Data reconciliation	.713
Data Privacy	.608
Visibility	.616
Tracking supplies	.651
Trust	.657
Intermediary cost	.548
Dependency delays	.593
System abuse	.599
Transparency	.541

Three factors were extracted from the EFA as shown in the Pattern matrix [Table 4.9](#). These factors had a **cumulative variance of 70.84%**, (Factor 1: 48.22%; Factor 2: 12.91%; Factor 3:

9.71%) as shown in [Appendix VII \(d\)](#), which indicates that the three factors explain 70% of variability in the data (Zeynivandnezhad et al., 2019).

Table 4. 9: Three factors were extracted from the EFA

Pattern Matrix^a			
	Factor		
	1	2	3
Transparency	.828		
Tracking supplies	.747		
Intermediary cost	.697		
Data security	.659		
Data reliability	.599		
Trust	.562		
Data reconciliation		.960	
Tracking tasks		.733	
Visibility		.694	
Data Privacy		.613	
System abuse			.865
Dependency delays			.694
Extraction Method: Maximum Likelihood. Rotation Method: Promax with Kaiser Normalisation. ^a a. Rotation converged in 5 iterations.			

Promax rotation method was selected for the EFA, as it allows for correlated factors. The factor correlation matrix is shown in [Table 4.10](#).

Table 4. 10: Factor correlation matrix for the three factors derived by EFA

Factor Correlation Matrix			
Factor	1	2	3
1	1.000	.559	.440
2	.559	1.000	.513
3	.440	.513	1.000

The three extracted factors in [Table 4.10](#) have values below 0.6 and this means they have moderate correlation between themselves (distinct but related). Factor (1 vs. 2 = 0.559; 1 vs. 3 = 0.440; 2 vs. 3 = 0.513).

4.3.2.1 Grouping of the three extracted factors.

The researcher may label the extracted factors from the EFA, using an inductive approach (Zeynivandnezhad et al., 2019). The three factors were named based on the characteristics of the grouped items. Reference was done to [Table 4.9](#) when grouping the items.

Factor 1: Operational Transparency

Items under this category involved issues of lack of operational transparency and captured the need for BCT to improve these concerns, which would in turn lead to improved trust and data integrity, thus eliminating intermediaries who add costs and complexity in the Kenya HSC.

Factor 2: Collaborative Privacy

Items under this category involved issues in coordination in data sharing and reconciliation and captured the need for BCT to streamline data updates, which will enhance visibility and tracking tasks while maintaining data privacy when sharing data amongst the Kenya HSC stakeholders.

Factor 3: System Integrity

Items under this category involved current governance systems and captured the need for blockchain to enhance system integrity by eliminating system abuse and manipulations, and minimising latency caused by transaction dependencies, thus ensuring that the Kenya blockchain-enabled HSC system is efficient and self-sustaining.

After conducting an EFA, a CFA should be done to validate the factors (Zeynivandnezhad et al., 2019). In this study, however, the aim was not to purely validate these factors, but it was to

explore how these factors manifested in practice, and the specific relevance of blockchain in addressing concerns of data security, process inefficiencies and decision-making involving multiple stakeholders in the Kenya HSC. This would give a more practical implication based on the humanitarian context. The EFA, therefore, served as an important foundation for structuring the interview guide shown in [Appendix II](#), with questions on what are the operational challenges encountered in Kenya HSC? Which of these challenges could be solved by the blockchain? How is coordination currently governed, and could blockchain improve it? What measures are in place to ensure data privacy of shared information and ensure security of the disaster information management systems (DIMS)?

4.4 Analysis of Part Three of the Questionnaire

Respondents were asked to respond to questions, to assess factors that influence adopting of new technology in their organisations. This assessment could reveal factors that are viewed as important by HSC stakeholders in the adoption of new technology, which may help guide BCT adoption. Inferential statistics were conducted to identify which of these factors were considered to be statistically significant. Before starting the statistical analysis, a normality test was conducted to determine the most suitable test to analyse the data. **Shapiro-Wilk** and **Kolmogorov-Smirnov (K-S)** normality test was conducted to test for normal distribution (Oke et al., 2024). The p-value for both tests was (0.00), which is (<0.05), and therefore, the data was not normally distributed, and non-parametric tests would be suitable for its analysis (Kwak et al., 2019). Results of the normality tests are shown in [Appendix VIII \(a\)](#).

4.4.1 Friedman Test

Friedman test, which is a non-parametric test, helps to identify if there is a significant difference in treatment across multiple variables, when comparing more than two related groups (Pereira et al., 2015). It is the opposite of the two-way ANOVA for parametric tests (García et al., 2010). This study aimed to determine if there is any statistically significant difference between

independent variables of top management support, organisation readiness, and external support in new technology adoption in the Kenya HSC. Studies such as ((Ngongo et al., 2019), have tested hypotheses on the interaction of the three TOE determinants in influencing technology adoption, to access their collective impact on technology adoption.

H₀: There is no significant difference between top management support, organisation readiness, and external support in new technology adoption in the Kenya HSC.

H₁: There is a significant difference between top management support, organisation readiness, and external support in new technology adoption in the Kenya HSC.

The Friedman test was conducted on the 22 items representing the top management support (6), organisation readiness (10) and external support (6). The test had a p-value of (0.00) as shown in [Table 4.11](#).

Table 4. 11: Friedman test statistics

Test Statistics ^a	
N	103
Chi-Square	233.613
Df	21
Asymp. Sig. p-value	.000

a. Friedman Test

Since this p-value was (<0.05), the decision was to reject the null hypothesis (García et al., 2010). This means that organisations did not view all factors equally when adopting new technology. The mean ranks of the three independent variables are shown in [Table 4.12](#).

4.4.1.1 Top management support constructs

Top management support was more significant than organisation readiness and external support. Championing for external collaborations with external partners and industry expertise to gain insights about new technologies, was identified as a CSF. Effective leadership that

provides vision and direction followed closely, and having top management that promote an innovative culture, was also identified to be crucial in implementing new technologies. These factors were reported to be more critical than having top management take financial risks in allocating budgets and employing highly qualified personnel to operate new technologies.

Table 4. 12: Friedman's mean ranks

Variable	Construct	Mean Rank
Top Management Support	Org Strategy	12.50
	Leadership	14.13
	Risk Taking	12.47
	Pilot Projects	13.17
	Collaborations	14.34
	Innovation Culture	13.19
Organisation Readiness	Change Culture	11.94
	Awareness	13.10
	Tech Expertise	12.26
	Tech Assessment	10.59
	Roadmap	11.82
	Resources	7.45
	Training	10.49
	Risk Plans	9.06
	Policy advocacy	10.42
	Implementation	10.52
	Teams	
External Support	Donor Support	12.63
	Govt laws	8.91
	Past donor support	12.59
	Govt Funding	8.62
	Peer pressure	11.14
	Vendor partnerships	11.67

4.4.1.2 Organisation readiness constructs

The high-ranking on-innovation awareness, technology expertise, change culture and implementation roadmap suggest a critical need for HOs to stay informed about new

technologies and their benefits, and cultivate in-house technical expertise to successfully implement these technologies. Due to the fluctuating environments that HSCs operate in, having an adaptable change culture to overcome innovation resistance, and a clear technology implementation roadmap was considered significant. However, having risk plans to mitigate the adverse impacts of new technologies and having adequate budgetary allocations for new technology acquisition and maintenance were however not considered as influential factors in new technologies adoption.

4.4.1.3 External support constructs

The high-ranking in donor support for ICT initiatives, and past donor support for innovation underscore the critical role of consistent and reliable funding to implement and sustain innovation. This high ranking could explain the low ranks in resources (in organisation readiness constructs), low ranks in financial risk taking of leaders (in top management constructs), and low ranking of government funding (in external support constructs), as HOs rely mostly on donor support, which was reported to be a CSF for new technology adoption. Vendor partnerships had a high ranking too and this underscore the importance of having good relationships with technology vendors for enhanced technical support, which is crucial in HSCs contexts, as they generally lack advanced technical skills, as compared to commercial SCs. In contrast, government laws ranked lowly, indicating that while regulatory support is necessary, it plays a support role, rather than a central role to new technology adoption in Kenya.

4.4.2 Post-Hoc Test

Following the Friedman test, a post hoc test was conducted with adjustments for false positives using Bonferroni correction (Derrac et al., 2011). After the adjustments, only pairs of samples having a p-value of **<0.05 were considered significant**. Reporting of adjusted p-value (APV) is recommended as it considers that multiple tests were conducted thus eliminating Type 1 errors (García et al., 2010). Type I error (false positives) occurs when the research rejects the

null hypothesis when in fact, it's true, while Type II errors occur when the research fails to reject the null hypothesis when in fact, it's false (Akobeng, 2016). Groups related to factors like leadership, collaborations, innovation culture, and donor support were consistently rated higher ($APV = 0.000$), than groups related to factors like resources, government support, and risk plans, – even after the Bonferroni correction.

4.5 Analysis of Part Four of the Questionnaire

This part of the questionnaire was dedicated to asking questions about blockchain technology. Descriptive and statistics tests were conducted for this section.

4.5.1 Blockchain Knowledge

In this thesis, no knowledge of blockchain means that participants had never heard of BCT. Little knowledge means that participants have heard of BCT through aspects like cryptocurrencies but had no knowledge of how it works. Good knowledge means that participants know how blockchain works and its applications beyond cryptocurrencies. Excellent knowledge means that participants had in-depth knowledge of BCT, its technical details, and its future potential or may have developed it. **Figure 4.4** shows the respondent's ratings on BCT knowledge.

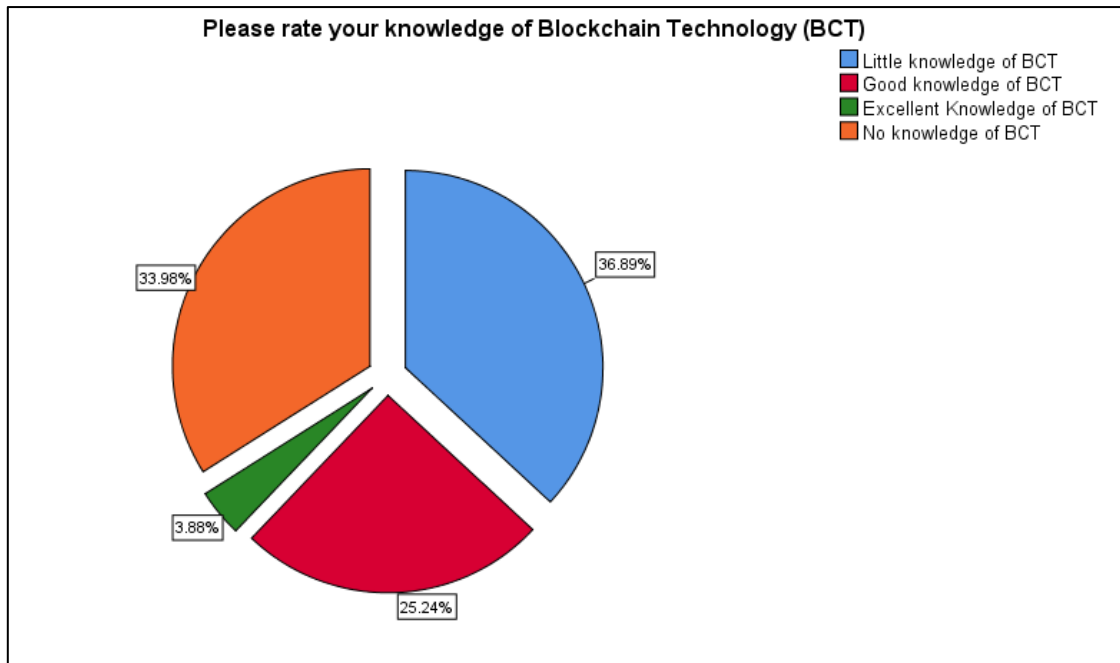


Figure 4. 4: *Respondent's ratings on BCT knowledge*

Majority of respondents had heard of the blockchain but were not aware of how it works as shown in figure. There was also a non-significant difference between those who had no BCT knowledge, and those with little BCT knowledge, as represented by 35 and 38 respondents respectively.

4.5.2 Status of BCT Involvement in Organisations

Respondents who had little, good, and excellent knowledge of the blockchain were asked if they knew about the status of BCT involvement in their organisation. Majority of the respondents had no idea as to whether their organisation had any BCT involvement. Of those that were aware, there is a positive outlook and attitude towards BCT, as many organisations were reported to be interested, and searching information about the blockchain. The responses are shown in [Figure 4.5](#).

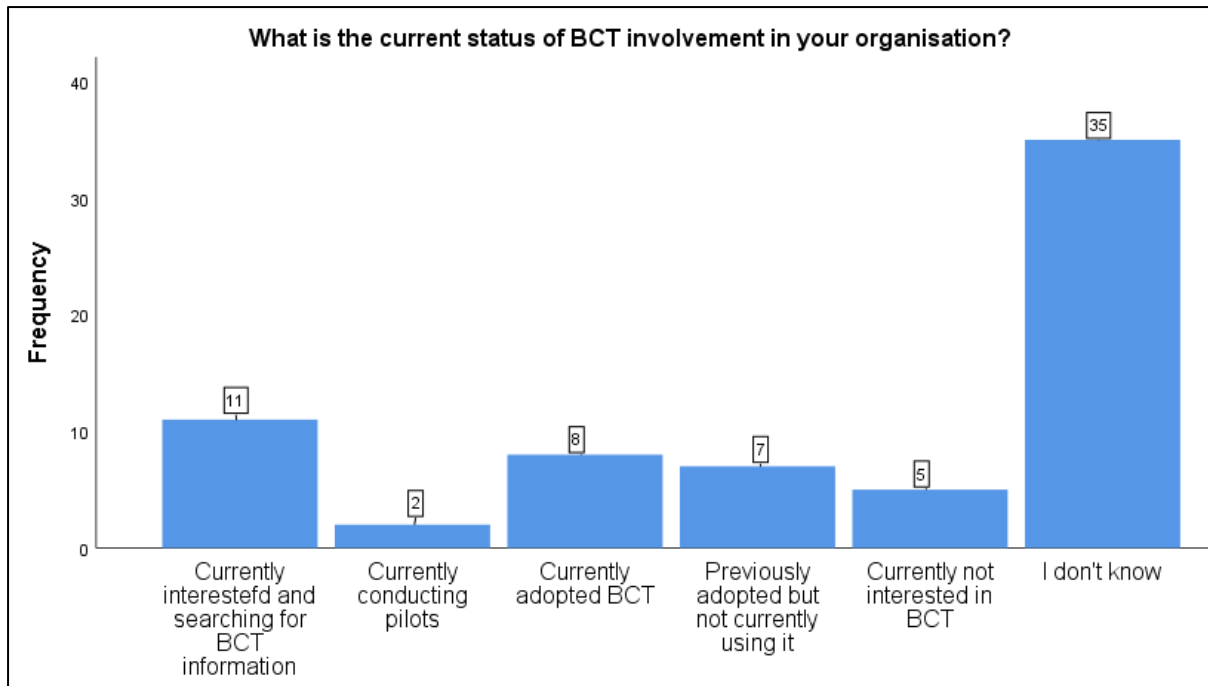


Figure 4. 5: *Status of BCT involvement in organisations*

4.5.3 Intention to adopt the Blockchain

The 68 respondents who had little, good, and excellent knowledge of blockchain were asked about their intention to adopt BCT. Respondents' ratings on their intention to adopt blockchain are as shown in **Table 4.13**.

Table 4. 13: Intentions to adopt blockchain

Statement	Mean	Std Dev
My organisation intends to adopt BCT in the near future	3.16	1.14
I strongly recommend Kenya Humanitarian partners to use BCT in their operations	4.40	.794
I strongly believe that BCT adoption in HSCs will largely benefit them	4.46	.818
N = 68		

Majority of the respondents would strongly recommend blockchain usage in Kenya HSC, however, many respondents also reported to be neutral about their organisation's intentions to adopt BCT soon.

4.5.4 Inferential Statistics: Friedman test

Before starting the statistical analysis, a normality test was conducted to determine the most suitable test to analyse the data. Kolmogorov-Smirnov and Shapiro-Wilk tests were conducted to test for normality (Makigusa et al., 2020), and both tests presented P-values of (<0.05) as shown in [Appendix VIII \(b\)](#). Since these p-values were less than 0.05, normality was violated (Kwak et al., 2019), and therefore, non-parametric tests would be suitable for analysing it.

Friedman test was conducted to determine if there is any statistically significant difference between independent variables of compatibility, complexity, and regulatory support in relation to adopting BCT in the Kenya HSC. The following hypothesis was derived:

H₀: There is no significant difference between compatibility, complexity and regulatory support in adopting BCT

H₁: There is a significant difference between compatibility, complexity and regulatory support in adopting BCT

The test statistic had a p-value of (0.000) as shown in [Table 4.14](#).

Table 4. 14: Test Statistics

Test Statistics ^a	
N	30
Chi-Square	90.114
Df	12
Asymp. Sig.	.000

a. Friedman Test

Since this p-value was (<0.05), the decision was to reject the null hypothesis. This means that there is a significant difference between compatibility, complexity and regulatory support in adopting blockchain technology. Friedman test also ranked the means of the constructs used in

each independent variable. In total, there were 13 items for all the variables. Compatibility (4), Complexity (5), and Regulatory support (4). **Table 4.15** shows their mean ranks.

Table 4. 15: Friedman mean rank results

Variables	Constructs	Mean Rank
Compatibility	Interface	9.65
	Values	9.85
	Infrastructure	7.88
	Operations	9.23
Complexity	Mental Effort	6.97
	Breakdown	5.52
	Time consuming	5.55
	Scalability	5.60
	Complex_HSC	4.62
Regulatory Support	Laws	6.15
	Regulations	7.25
	Policies	7.17
	Guidelines	5.57

4.5.4.1 Compatibility Constructs

The constructs related to compatibility had a higher mean rank, which means that participants found these factors to be more important or agreeable, than those related to complexity and regulatory support. Values had the highest mean rank, indicating that participants considered compatibility with the firm corporate culture and values as the most critical factor in BCT adoption in the humanitarian sector. Infrastructure had the lowest rank in this category, indicating that BCT compatibility with organisation culture and humanitarian operations aspects were more critical than the hardware and software of the firm.

4.5.4.2 Complexity Constructs

The constructs related to BCT complexity had lower mean ranks as compared to compatibility and regulatory support, indicating that participants found these factors less favourable or agreeable. Mental effort which had the highest mean rank in complexity indicates that

participants perceived blockchain usage requires significant mental effort. Scalability, time-consuming and breakdown all clustered around the same rank, indicating that participants recognise these factors to have an influence on blockchain adoption but with a similar significant effect. The item on blockchain is too complex for humanitarian disaster operations received the lowest mean in this category, indicating that participants perceive the complexity of the blockchain in requiring too much mental effort is a significant barrier to its adoption rather than BCT being complex in handling humanitarian disaster operations.

4.5.4.3 Regulatory Support Constructs

The constructs related to regulatory support constructs had a mid-range to high mean ranks, indicating that participants found these factors important, and this reflects the perceived importance of government legal and policy support for BCT adoption. Regulations and policies had the highest rank in this category, indicating that participants perceive regulatory frameworks and government policies to be the most critical regulatory factors in BCT adoption. Laws had a slightly lower rank, implying that while current laws are crucial, they were not perceived as sufficient or well-defined in supporting BCT adoption. Guidelines ranked the lowest, indicating that having clear guidelines in BCT adoption in DRM was perceived to be less important than having regulations and policies framework by the government to support BCT development and implementation.

4.5.5 Post-Hoc Tests

After conducting the Friedman test a post-hoc test was conducted to show the pairwise comparisons in the constructs, as shown in [Appendix IX](#). The Post Hoc results included an adjusted significance values (APV) using the **Bonferroni correction**, which adjusted the multiple comparisons, thus reducing the chances of Type I errors (false positives).

Figure 4.6 shows the network visualisation of the pairwise comparison following the Post Hoc tests. Each node in the figure represents a construct in the compatibility, complexity and

regulatory support predictors of blockchain adoption. The corresponding numbers in the construct (nodes) indicate the mean ranks. The lines connecting the nodes represent the pairwise comparison between constructs with the colours indicating their significance after adjustments.

- The **red lines** indicate a statistical significance difference between constructs, after the Bonferroni adjustments e.g. (Interface vs. Mental effort. P-value = 0.008, APV = 0.594)
- The **blue lines** indicate no statistical significance difference between constructs after the Bonferroni adjustments e.g. (Scalability vs. Values. P-value = 0.000, APV= 0.002)
- **No lines** between constructs indicates no significant difference between constructs both before and after the adjustments e.g. (Laws vs. Infrastructure. P-value = 0.085, APV= 1.00)

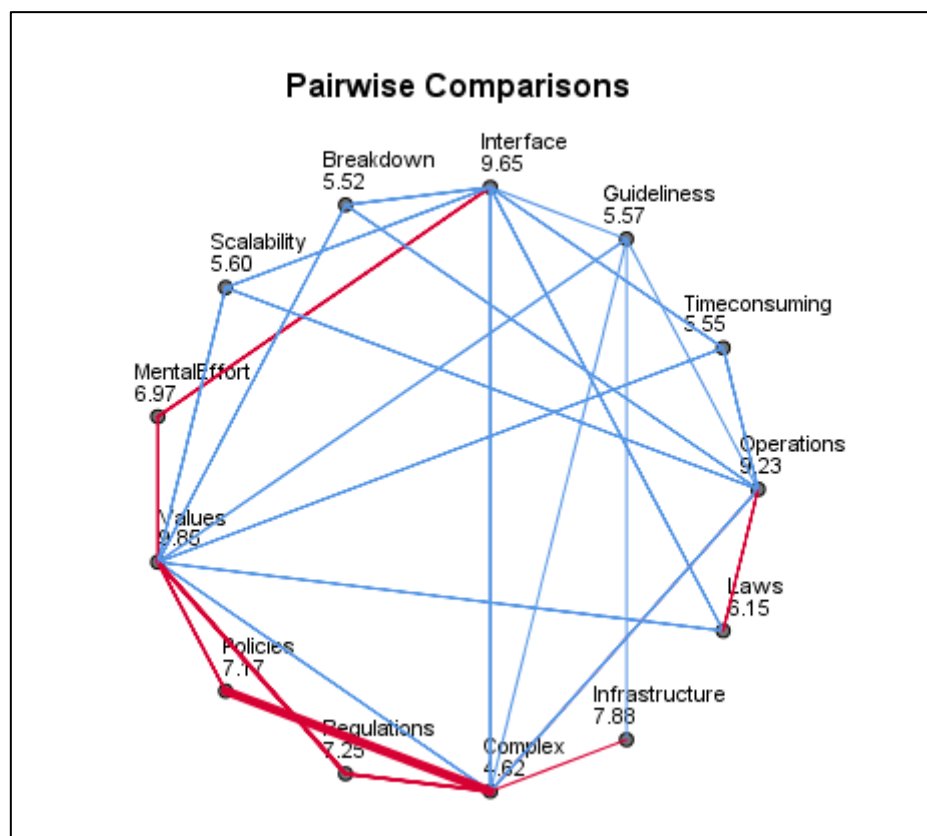


Figure 4. 6: The network visualisation of the pairwise comparison

4.5.5.1 Discussion after Bonferroni Adjustments

a) Blue lines

Following the post-hoc results in [Appendix IX](#), comparisons between complex with operations, complex with interface, and complex with values had a significant difference that remained unchanged after Bonferroni adjustments, with an **APV of less than 0.05**. Complexity was rated much lower than operations, interface and values, suggesting that while participants perceived BCT complexity to be a major challenge in its adoption, compatibility-related factors of interface, values and operations are rated as more critical in BCT adoption. Comparison between breakdown with operations, breakdown with interface, and breakdown with values was also significant before and after the adjustments as shown in Figure 4.6. Breakdown was rated significantly lower than operations, interface, and values suggesting that while participants perceived breakdown as a challenge to BCT adoption, compatibility-related factors of interface, values and operations are rated as more critical in BCT adoption.

b) Red lines

Some of the constructs had a Sig p-value below 0.05 but after the Bonferroni adjustment, the APV's went above 0.05 and these differences are not considered statistically significant. These constructs are highlighted in red colour in [Figure 4.6](#). Examples include Mental effort vs. Values, and Operations vs. Laws. A high change in significant difference before and after the adjustments is indicated by a thick red line in the same figure. Example is Complexity vs Policies (P-value = 0.011, APV = 0.875). This means that complexity was viewed similarly to policies after the adjustments.

c) No lines

Constructs with no connecting lines between them in [Figure 4.6](#), means that there were no statistically significant differences between them, as their APVs **were above 0.05**. Examples

include Complexity vs. Breakdown and Guidelines Vs. Scalability which had an APV of 1.000 in both cases. This imply that participants perceive these constructs similarly and therefore there is no meaningful difference in how they rate them. Moreover, there was no significant difference between most complexity and regulatory constructs suggesting that participants viewed these constructs similarly.

4.6 Conclusion

Most respondents were from INGOs, and their organisation had more than 200 employees. Additionally, most of the respondents had an undergraduate degree and were between ages of 26-33 years. From the Quant findings, BCT is needed in the Kenya HSC to provide value in the areas of trust, transparency, coordination, privacy and security. To do so effectively, stakeholders should be trained about the technology as most respondents did not have knowledge about the blockchain. Those that did, believed that blockchain must be compatible with existing systems to enhance its acceptance in the humanitarian sector. Development partners were leading in BCT adoption and BCT pilots. These actors can therefore demonstrate blockchain practicality to the other HSC stakeholders.

Top management support was considered critical in making innovation decisions in the Kenya HSC and therefore, involving leaders at an early stage could accelerate BCT adoption. Surprisingly, factors such as organisation resources and government support through funding, were ranked low as donor support was said to be critical in innovation funding. These implications led to interview guide questions as shown in [Appendix II](#). How does leadership influence the adoption of new technologies in your organisation? How do you think leadership will support blockchain technology in your organisation? How do employees react to changes brought about by new technologies? How important is donor support in adopting new technologies in your organisation? What factors were considered in evaluating the decision to adopt the current technologies that your organisation is using? What are the potential barriers

to BCT adoption in your organisation (complexity, compatibility, regulations)? What requirements does your organisation need to meet to adopt the blockchain?

CHAPTER FIVE

DEVELOPMENT OF THE PROPOSED BLOCKCHAIN-ENABLED FRAMEWORK

5.0 Introduction

This Chapter focused on how the Proposed Blockchain-enabled Framework, and its associated models/systems were developed. A proposed blockchain-enabled architecture model for the Kenya HSC is also provided, with illustrations of how the blockchain could be used in humanitarian operations.

5.1 Studies guiding the Development Process of the Blockchain-enabled Framework

The researcher designed the humanitarian Blockchain-enabled Framework through the analysis of the literature, and insights from the data collected through the questionnaire survey. There were no Blockchain-enabled implementation Frameworks in HSCs. Therefore, a benchmark from Blockchain adoption models in other sectors (Wang et al., 2016; KPMG, 2018) and Industry 4.0 Implementation Framework (Jena & Patel, 2023) were used. Industry 4.0 includes disruptive technologies like BCT and considering its implementation framework provides valuable insights for innovation due to its emphasis on meeting the dynamic needs of the digital economy (Singh et al., 2024).

5.1.1 Blockchain Adoption Models

Wang et al. (2016) provided a blockchain adoption procedure of three stages in which organisations in any industry can use in the BCT implementation. **Table 5.1** summarises those stages.

Table 5. 1: BCT Implementation Stages (Wang et al., 2016)

Stage	Key focus	Explanation
Feasibility study: meeting four or more conditions qualifies for BCT adoption	Do multiple parties share data?	need of common information by the parties
	Do multiple parties update data?	parties take an action that requires data changes and updates of records
	Is there a requirement for validation?	participants need to trust validity of records
	Do intermediaries add costs and complexity?	Removal of intermediaries would help reduce costs
	Are interactions times sensitive?	Benefits of reducing delays
	Are there interactions with the transactions?	Dependence of transactions created by the participants
Development Stage	Requirement analysis	Requirements to influence adoption
	Architecture design	What network to use/structure
Operation Stage	Replacement procedure	Keep the existing system running and use BCT as a backup
		Run the BCT and use the existing system as a back up
		Operate BCT as a stand-alone system

The above model guided the development of the feasibility study for the quantitative phase, discussed in chapter four. This study formed part of the first building block of the proposed blockchain-enabled framework. The proposed framework also included an awareness phase, in cases where HOs had conducted a feasibility study and were already in the process of adopting the blockchain or had already adopted the blockchain. This stage was missing from (Wang et al., 2016) model. Wang et al. (2016) BCT model was also missing the performance measurement stage, and this was included in the proposed blockchain-enabled framework as

5.1.2 Industry 4.0 Implementation Framework

Jena and Patel (2023) developed a road map that guide organisations in Industry 4.0 implementation for the India Automotive Industry, as shown in [Figure 5.1](#).

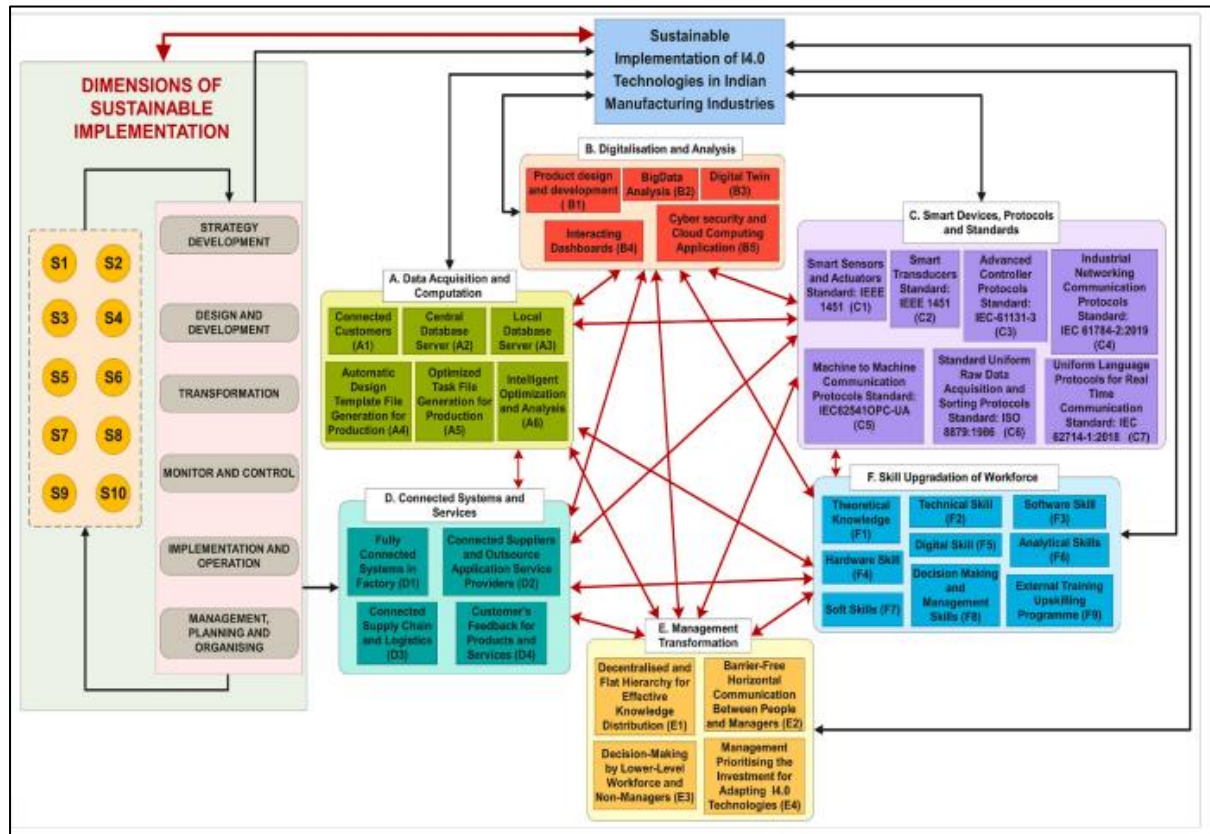


Figure 5. 1: *Industry 4.0 implementation Framework (Jena & Patel, 2023)*

The framework involves six stages as outlined below:

1. Strategy development - formulating long-term strategies after extensive forecast-based research on Industry 4.0 to uncover its benefits and barriers to making a value-based decision
2. Design and development – developing a sustainable design incorporating feedback loops to fix any existing design flaws
3. Transformation– changing organisation infrastructure and mindset to accommodate industry 4.0 technologies

4. Monitor and control – this helps to reduce system failure, which can be achieved through predictive analytics
5. Implementation and operation – Ensuring a seamless integration of smart systems with existing systems for cost efficiency
6. Management, planning and organisation – ensuring teamwork between management and employees in continuous improvements.

This framework guided the design phase of the proposed blockchain-enabled framework, as it was deemed important for HSC stakeholders to view a concept of how they would interact with the blockchain if it was to be implemented in their organisations. This framework also had an implementation and operation phase. Wang et al. (2016) operation stage focused on the decision of either replacing the existing system with blockchain or integrating existing system with BCT. Jena and Patel (2023) framework also had a monitoring and control stage for reducing system failure. This stage was considered appropriate for the development of the proposed blockchain-enabled framework to correct errors and learn from them to ensure sustainability of the blockchain-enabled system.

5.1.3 Insights from the Quantitative Data Analysis

From the feasibility study in chapter four, the results shown that Kenya HSC had operational challenges that could be solved by BCT. It also revealed that there was little awareness about the blockchain among the respondents. HOs were at different BCT adoption stages, with majority of the respondents that had no knowledge of the blockchain having no knowledge about their organisation current status of BCT adoption. These results informed the first phase of the blockchain-enabled framework of feasibility study/awareness. Moreover, the survey results revealed a significant difference on how stakeholders viewed organisational and environmental factors in influencing technology adoption among HOs, with top management support being found to be critical. These factors were grounded on the TOE model. These

insights formed the third phase of the framework of ‘Critical dimensions for blockchain acceptance/readiness assessment.’ From the survey, questions like ‘do you think your organisation will implement the blockchain in the near future’ received diverse views. Interestingly, participants who had good knowledge of the blockchain and had not implemented it in the organisations, disagreed with the statement. Using abductive reasoning, one plausible explanation is about system inefficiencies and the need for meeting certain requirements before these organisations could successfully implement the blockchain. This led to the development of the ‘implementation phase’ after readiness assessment, which can be gauged by use of a maturity model as proposed by Wang et al. (2016). Based on the above stages, the proposed blockchain-enabled framework was formulated.

5.2 Proposed Blockchain-enabled Framework for Kenya HSC

The framework consists of 5 stages, as shown in **Figure 5.2**. The framework represents the road map that could potentially guide blockchain implementation in Kenya HSC.

In this section, the stages are also referred to as the building blocks. These stages are:

1. Conducting a feasibility study/ raising awareness
2. Conceptual design of the proposed humanitarian supply chain framework
3. Critical dimensions for blockchain acceptance and readiness assessment models
4. Implementation
5. Performance measurement.

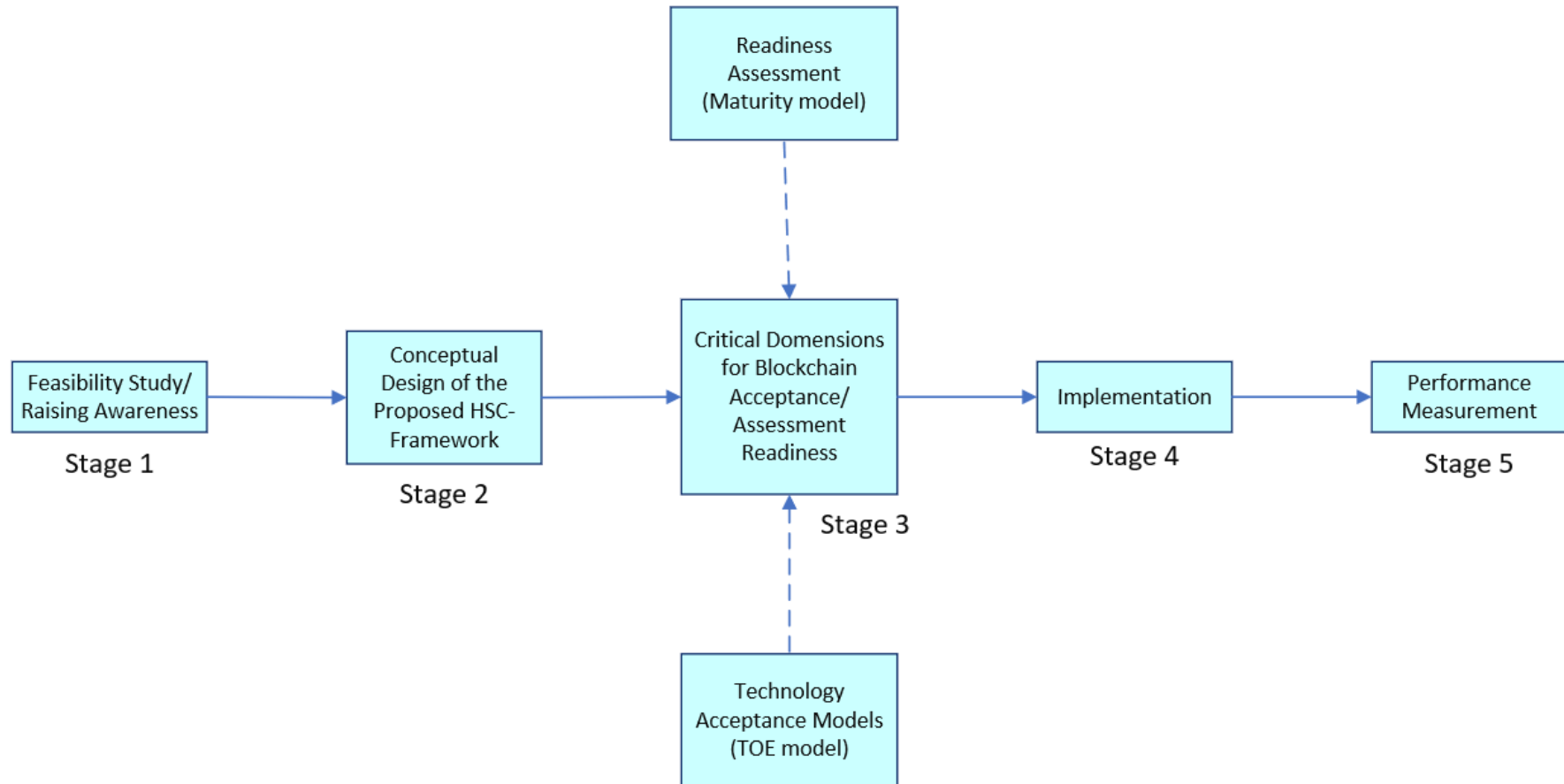


Figure 5. 2: *Proposed Blockchain-enabled Framework for the Kenya HSC*

5.3 Proposed Blockchain-enabled Framework Building Blocks

Each building block is explained below.

5.3.1 Stage One: Feasibility Study/ Raising Awareness

Before implementing blockchain, it is vital for stakeholders to conduct a feasibility study to identify why they need BCT or to create awareness of the technology in situations where requirements are known. According to Wang, et al. (2016) a set of six conditions are listed as illustrated in **Table 5.1**, and if a partner in the chain meets four or more conditions, then BCT would bring great potential if adopted. From the literature document analysis (Menya and K'Akumu, 2016; Nyandiko, 2020), and the feasibility study quantitative data results, Kenya HOs meet most of the conditions for BCT implementation. The conditions for BCT adoption in Kenya HSC are shown in **Figure 5.3**, with BCT having potential to solve operational transparency, collaborative privacy and system integrity issues within the Kenya HSC.

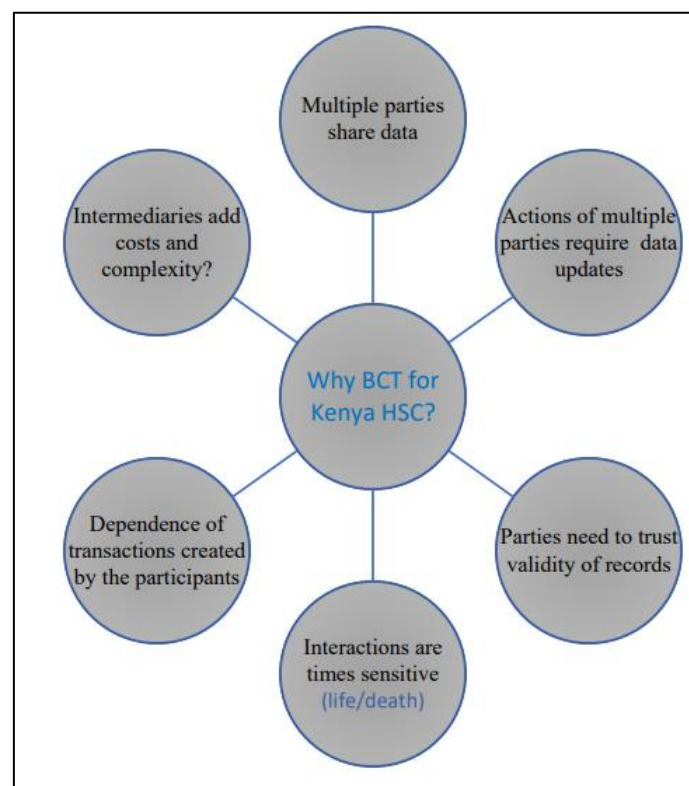


Figure 5. 3: *Why BCT for Kenya HSC? Adapted from (Wang, et al., 2016)*

5.3.2 Stage Two: The Conceptual Design of the Proposed HSC Framework

The design of the blockchain-enabled architecture model could help stakeholders visualise how blockchain will be used in DRM across the four stages of mitigation, preparedness, response and recovery. Before designing the blockchain architectural model, the current DRM structure was developed.

5.3.2.1 Kenya Current DRM Structure

Figure 5.4 illustrate the framework of Kenya DRM structure, which was developed by conducting a literature document analysis of the country's DRM policy (Republic of Kenya, 2017).

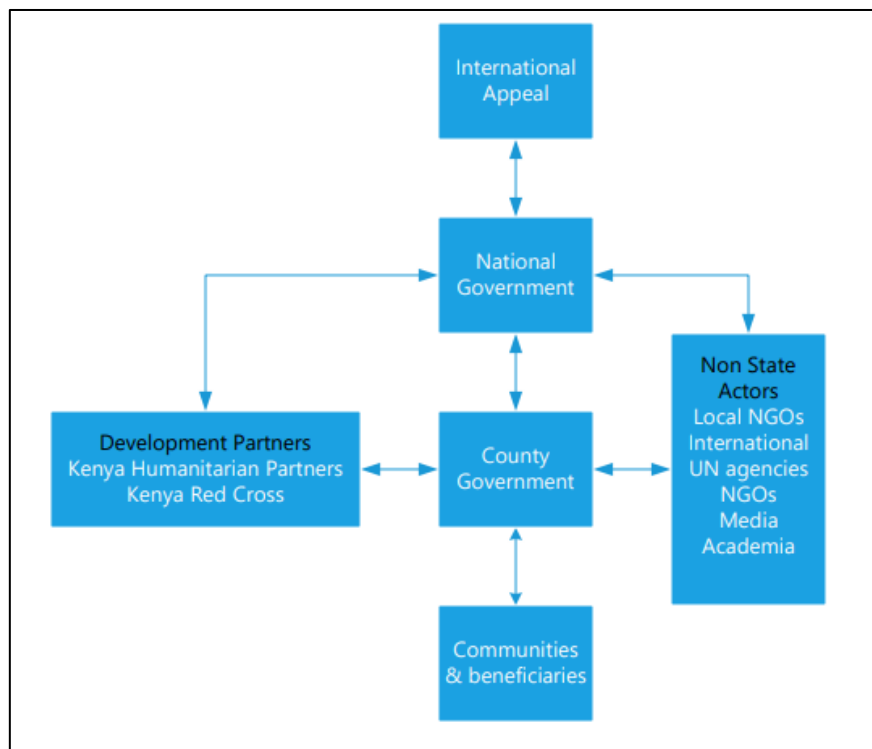


Figure 5. 4: Kenya DRM structure

5.3.2.2 The Proposed Design of the Blockchain-enabled DRM Architecture Model

The proposed BCT architecture model is shown in **Figure 5.5**. In this figure, when key stakeholders use the blockchain for humanitarian operations, the following processes take place.

1. Beneficiaries are registered at the county level and their information is stored in the blockchain.
2. The Kenya Meteorological Service (KMS) and the Famine Early Warning Systems Network (FEWS Net) provide data about weather changes to cushion against floods and droughts, which are the major disasters in Kenya. This data is stored in the blockchain
3. Data types stored in the blockchain, such as aid-distribution, funds, and evacuation details of those affected by disasters, are shared amongst the partners at the county and national government levels, in real-time, for improved decision-making.
4. BCT smart contracts are used to coordinate with other external parties like hotels that offer temporary accommodation for the evacuated persons or suppliers who need to supply medical supplies.

Under the conceptual design phase, diagrams were provided for blockchain usage in different humanitarian operations, to show visuals to key stakeholders on how they could interact in the blockchain. Some of the uses are as follows. Blockchain usage for:

- a) Procurement and delivery of aid items
- b) Cash transfers
- c) Beneficiary registration and authentication
- d) Coordination of humanitarian stakeholders

In the above BCT usage that have been discussed in detail from section **5.3.2.3** to **5.3.2.6** below, design decisions to be made are the blockchain platform to use, decision on what each partner's role is, and decision on who to share information with and for how long the partner can hold the shared information.

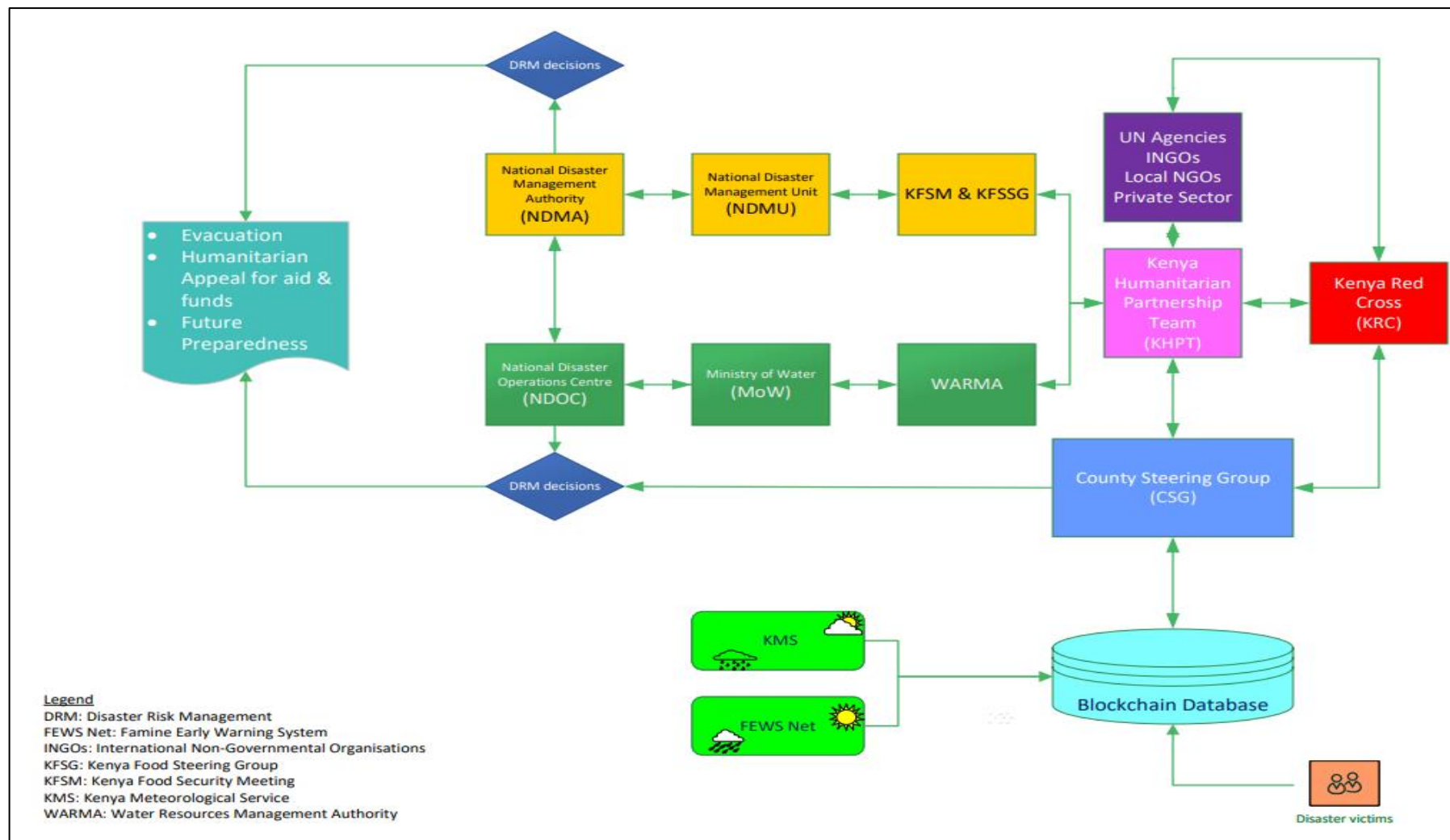


Figure 5. 5: *Proposed Blockchain-enabled architectural design model for Kenya HSC*

The blockchain-enabled design model can enhance Kenya's humanitarian efforts due to the enhanced features of trust, transparency, immutability and smart contracts presented by the blockchain (Pournader et al., 2020). **Figure 5.6** proposes different uses of blockchain at the pre-disaster phase (mitigation and preparedness) and the post-disaster phase (response and recovery). The following are the four use cases in stage two of the architectural model.

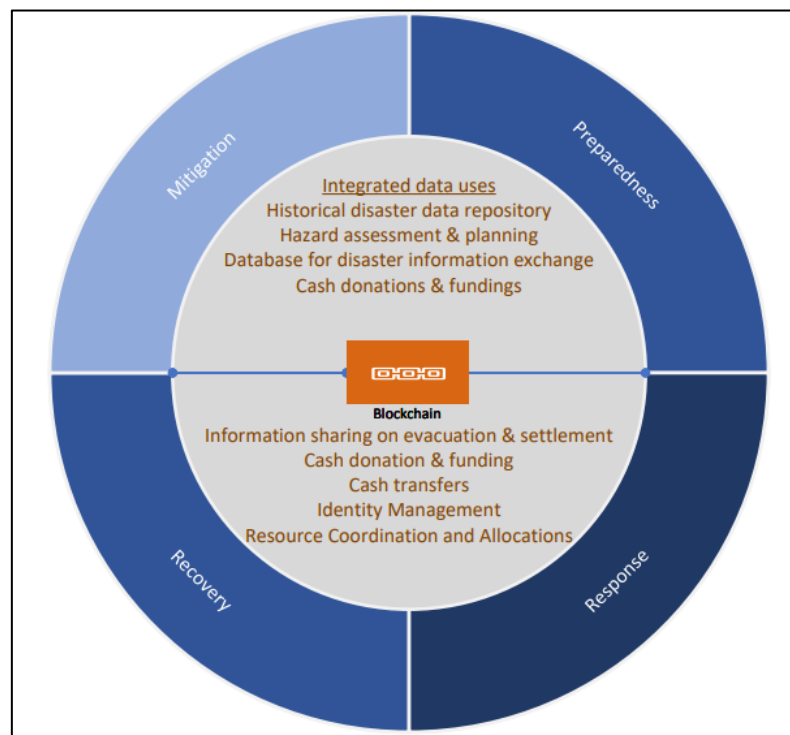


Figure 5. 6: Blockchain application in pre- and post-disaster phases

5.3.2.3 Blockchain usage in Kenya HSC for Procurement and Delivery of Aid Items

Under the design stage, an example of the use of BCT in disaster response is illustrated in **Figure 5.7**. A permissioned blockchain is proposed, which requires that a few stakeholders, e.g., a coordinating entity (CE) like WFP and/or a coordinating government body like NDOC have the authority to validate and create new blocks (transactions). In contrast, the other designated users/ stakeholders can participate in the consensus process, in a consortium blockchain platform (Kopyto et al., 2020). PoA and PBFT consensus mechanisms can be used in permissioned blockchains (Alrowaily et al., 2023). The use of a hybrid blockchain model which combines the strengths of both public blockchain (e.g. **Etherum**) and private blockchain

(e.g. **Hyperledger Fabric/ Hyperledger Besu**) to create a scalable, transparent, and privacy-focused HSC framework is recommended for HSCs in this research. This ensures that donors and the public get transparency, while NGOs, suppliers, and governments maintain data privacy and efficiency.

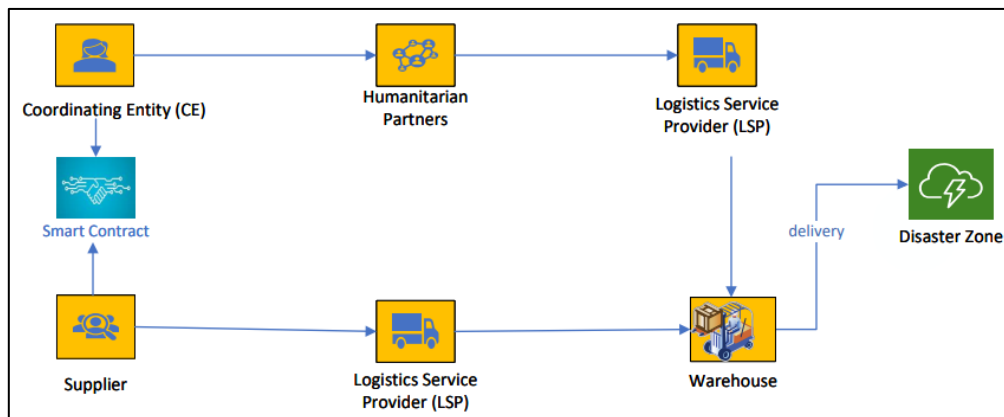


Figure 5. 7: *BCT usage in disaster response (Saad. et al., 2022)*

“The key steps of Figure above are highlighted below:

1. a) Coordinating entity (CE) enters a smart contract with a pre-qualified supplier
 - b) CE creates an order of the aid goods to the pre-qualified supplier and defines the consignee (central warehouse). They enter the details in the blockchain.
 - c) Supplier enters the goods and carrier details into the blockchain and initiates delivery to the logistics service provider (LSP). He then hands over the goods to the LSP who accepts them, and they enter these details into the blockchain.
 - d) LSP hands over the goods at the central warehouse and the consignee inspects and accepts the goods and they both enter these details in the blockchain.
2. a) CE informs humanitarian partners (NGOs, donors, private companies) of the aid items required.

- b) Partners hand over the goods to the LSP who accept them, and they both enter these details in the blockchain
 - c) LSP handovers the goods at the central warehouse, and the consignee inspects and accepts the goods and enters these details in the blockchain.
3. The goods are ready to be dispatched to the disaster zones/ to the victims who will then be identified through a pre-determined means, for instance verifying their identity through fingerprints scans to authenticate the biometric information registered in the blockchain.”

5.3.2.4 Blockchain usage in Kenya HSC for Cash Transfers

Donor funding is critical in HSCs and there has been a shift in how donations are made from giving physical items like food, medicines, and clothes to giving cash. Cash donations are preferred as they are easier to make and empower victims to make more choices, thus restoring their dignity (Saad. et al., 2022). Organisations such as the World Food Programme (WFP) are accepting donations in digital forms, such as cryptographic currencies (Saad et al., 2022).

Figure 5.8 illustrates how blockchain can be used in disaster response and recovery to track donated assets and this enhances transparency and reduces fraud and corruption in the Kenya HSC, “by following the steps:

1. The coordinating entity (CE) defines the project goals, and the budget required from the stakeholders or the public, including the project details to register to the platform. Any willing stakeholders e.g., a donor, create an account in the CE platform and receive an encrypted private key and an anonymised public key.
2. The stakeholder then deposits some currency to the CE blockchain platform. If the currency received is in a fiat currency, the CE converts it into digital currency and records its value as a token.

3. The digital token is sent to the victim affected, who takes it to a local partner to the CE, e.g., bank that converts the digital currency to fiat currency. The beneficiary can meet their needs and use the donation for income generation activities which helps victims to gain resilience after disasters.”

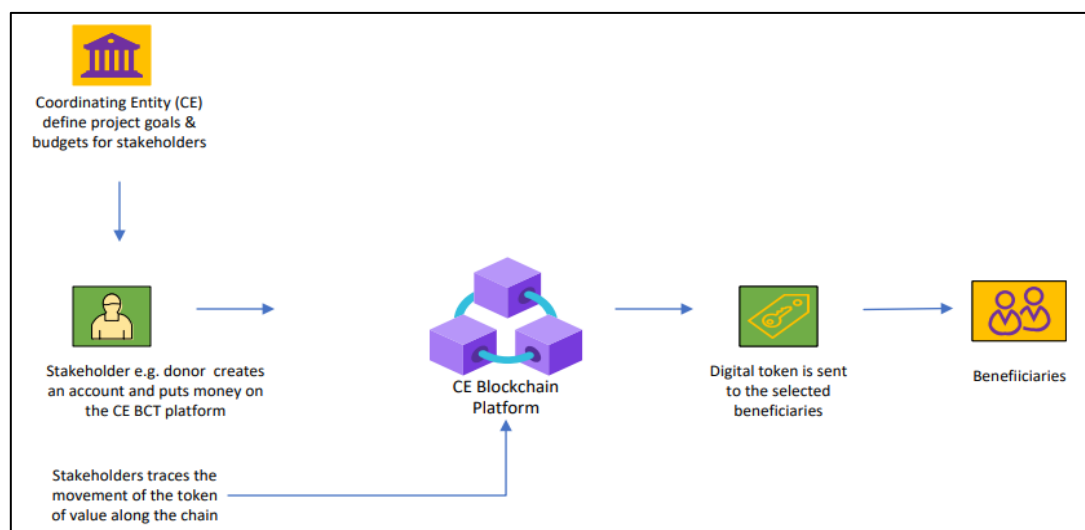


Figure 5. 8: *BCT usage in donation, transfer and tracking of funds (Saad. et al., 2022)*

5.3.2.5 Blockchain usage in Kenya HSC for Beneficiary Registration and Authentication

Digital wallets can also be used like smart cards by the coordinating entity to send support to beneficiaries. For example, NDMA has the Hunger Safety Net Programme (HSNP) that assists communities largely affected by drought in ASAL regions (NDMA, n.d.). From the interviews, to identify beneficiaries, NDMA works closely with chiefs and local leaders. After beneficiaries are verified by the community, they are registered, and they open a bank account for the remittance of money (digital cash). This cash transfer model has helped beneficiaries to cater for their basic needs in a dignified way but it's not efficient as it requires identity documentation for opening the bank account and these may get lost during the disaster event.

Moreover, it is difficult for another stakeholder, e.g., NGO, to identify which beneficiary has benefited. They may assist the same person twice (duplication of efforts) and this limits the number of people who benefit from aid. Also, the mandatory requirement of having a bank

account may limit access to aid from refugees, who in most cases, have no identification documents to open an account. Using blockchain could help NDMA to reduce costs, and share beneficiary information instantly in the blockchain, for optimal use of aid resources. **Figure 5.9** illustrates how this process can be done. UN World Food Program (WFP) used BCT in the building blocks projects for cash and aid disbursement to beneficiaries. The steps below explain these processes.

1. NDMA registers the beneficiaries and records their biometric information in the blockchain.
2. NDMA allocates a fixed amount to the beneficiaries and issues them with a smart card (like the one used by insurance companies).
3. The beneficiary then goes to an NDMA partner (bank, telecommunication (MPESA/ airtel) shop, store etc.) with the smart card and requests to withdraw the money/buy a good/service.
4. The approved partner checks the smart card and fingerprint of the beneficiary, and validates their information, if authentic. The NDMA partner issues the money/goods/service to the beneficiary.
5. NDMA reimburses the partners for the approved transactions.
6. NDMA then sends this information through the blockchain to the other key humanitarian partners, upon request to avoid duplication.

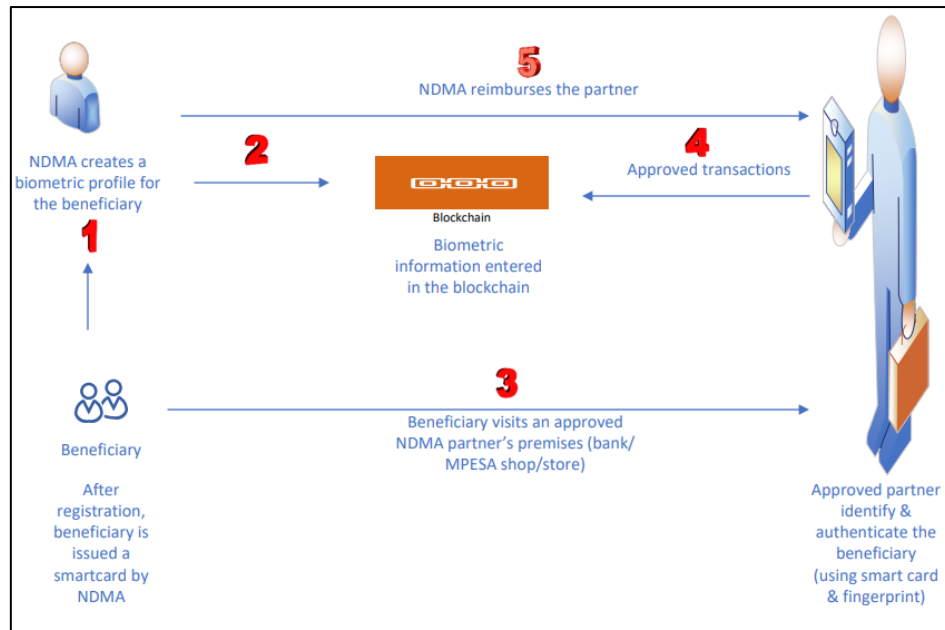


Figure 5. 9: BCT usage in beneficiary registration and authentication

5.3.2.6 Blockchain usage in Kenya HSC for Coordination of Humanitarian Stakeholders

Figure 5.10 illustrates how BCT can aid in the coordination of stakeholders. The stakeholders include government, local and international actors, the military, media, logistics companies and suppliers (Prasanna & Haavisto, 2018).

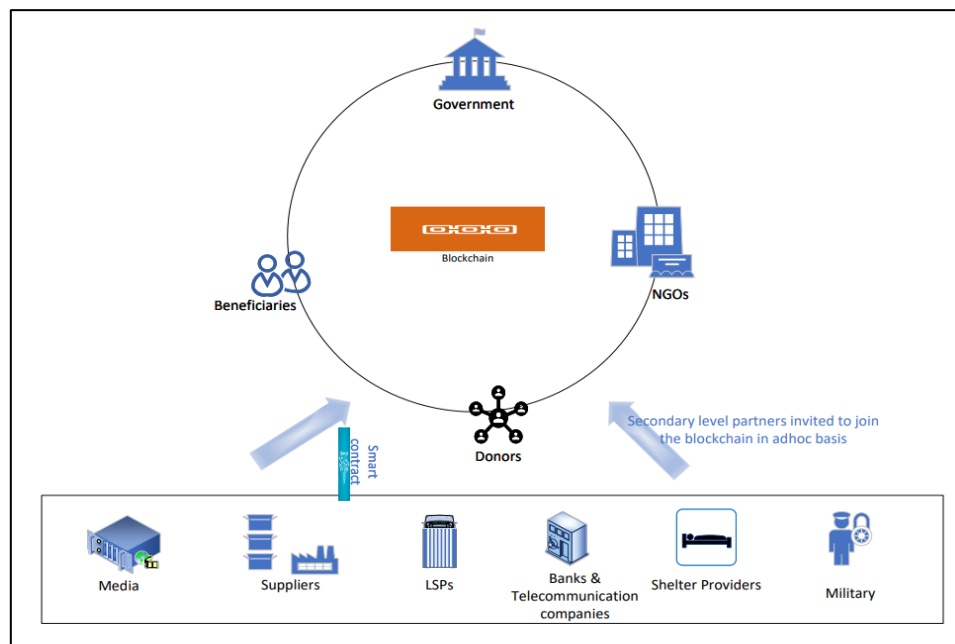


Figure 5. 10: BCT usage in Coordination of HSC partners (Saad. et al., 2022)

In **Figure 5.10**, the researcher has categorised stakeholders into two; - Primary and secondary stakeholders. Primary stakeholders, who are represented in a circle in the figure, are needed for nearly all disasters to meet beneficiaries' needs and these include the host government (both county and national), NGOs and donors.

The secondary stakeholders, represented in the rectangle in the figure, are needed on an ad hoc basis. Smart contracts can be used to coordinate with the primary and secondary stakeholders (Foluke et al., 2024). For instance, NGOs can get into smart contracts with suppliers to supply key medical aid, and LSP can transport the materials to the disaster zones. In some disasters like terrorism, the host government adds the military to the blockchain for improved response. Smart contracts can be used with shelter providers like hotels for temporary accommodation.

5.3.3 Stage Three: Critical Dimensions for Blockchain Acceptance and Assessment Readiness

Under this stage, the stakeholders should assess their readiness to adopt BCT. Technology acceptance models and maturity models are used to identify the extent to which stakeholders are ready to adopt the blockchain (Lu et al., 2021; Wang et al., 2016).

5.3.3.1 Blockchain Technology Acceptance Model

Many models have been developed to gauge acceptance of technology. These models are based on theories such as UTUAT, DOI, TAM and TOE. The research applied the TOE model as shown in **Figure 5.11**, due to its recognition of external environmental factors that can influence BCT adoption. A detailed discussion on TOE model was done in chapter two under the theoretical framework section.

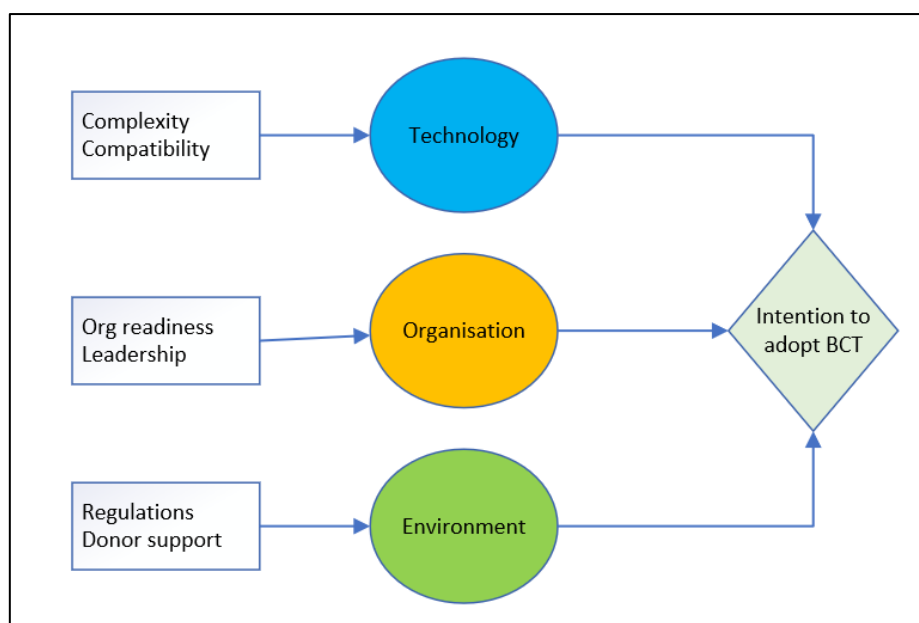


Figure 5. 11: *TOE model*

5.3.3.2 Blockchain Technology Readiness Assessment Model (Maturity model)

In addition to the TOE model, a maturity model could help HSC stakeholders to gauge their readiness. Little has been done about developing blockchain maturity models. At the time of developing this architecture, there existed no maturity model for BCT in the humanitarian sector. This study relied on blockchain maturity models in any industry such as (Wang, et al., 2016; KPMG, 2018) and blockchain maturity model in the agricultural SC (Ronaghi, 2021). Wang, et al. (2016), proposed a generic BCT maturity model with three dimensions of technology, market and regulations. The maturity model has 5 levels ranging from initial to optimised. These levels are explained in [Table 5.2](#).

Table 5. 2: Generic BCT maturity levels. Adapted from (Wang, et al., 2016)

Stage	Explanation
Initial	It is the chaotic and ad hoc status of a new technology
Repeatable	It is the borrowing of experiences from similar products
Defined	The new technology is standardised and document
Managed	A proposal for standard metrics to be used for qualitative evaluation
Optimising	Continuous improvement and optimisation of the new technology

KPMG (2018) developed a blockchain maturity model with ten dimensions which are the risk areas that organisations need to assess themselves against before adopting blockchain. **Figure 5.12** illustrate these dimensions.

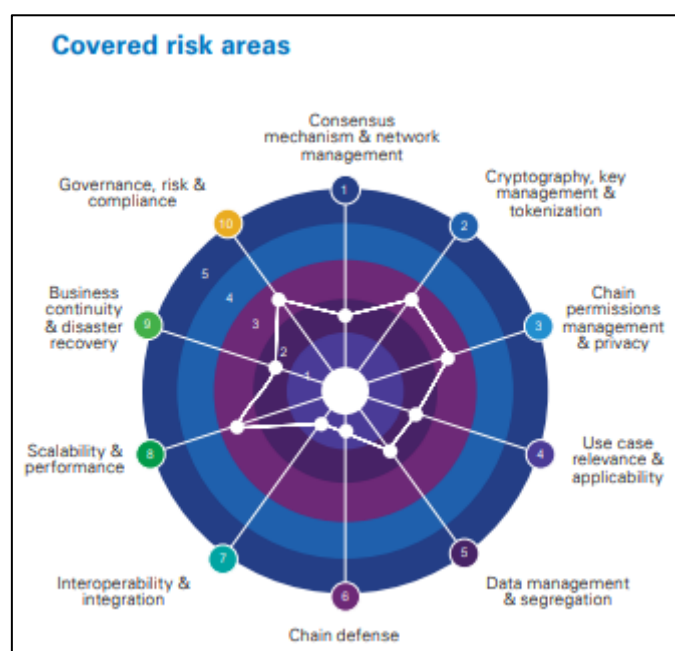


Figure 5. 12: *KPMG Maturity model dimensions*

KPMG (2018) also proposed five levels of maturity from initial to optimised. The explanations of these levels are shown in **Table 5.3**.

Table 5. 3: KPMG Maturity model levels. Adapted from (KPMG, 2018)

Level	Characteristics
Initial	Unpredictable processes that are poorly controlled and reactive
Managed	Projects have characterised processes and are often reactive
Defined	Organisations have characterised processes and are often proactive
Quantitatively managed	Measuring and controlling processes is possible
Optimising	Continuous improvement of processes

KPMG (2018) proceeded to provide a road map that guides organisations in assessing their maturity in ten days as shown in **Figure 5.13**.

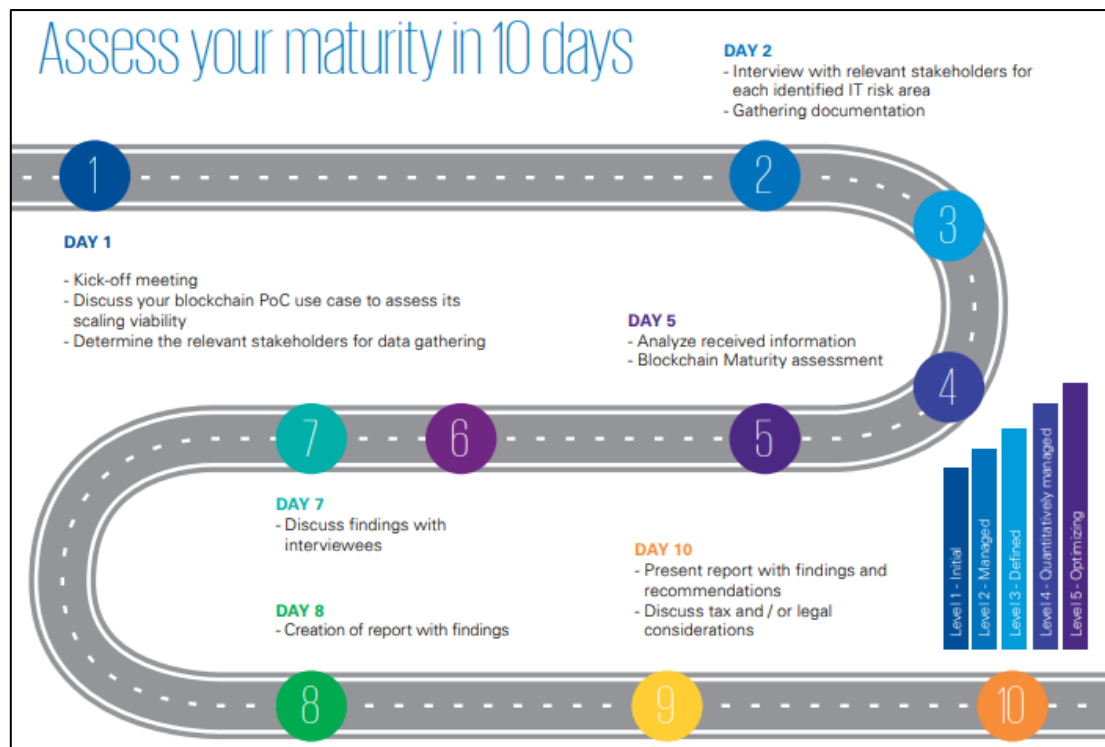


Figure 5. 13: *Roadmap for assessing BCT maturity (KPMG, 2018).*

Lastly, Ronaghi (2021) proposed a blockchain maturity model in the agricultural SC using nine dimensions of maturity items as illustrated in **Table 5.4**.

Table 5. 4: BCT Maturity dimensions for agricultural SC (Ronaghi, 2021)

Dimension	Exemplary maturity item
D ₁ -Strategy	Implementation blockchain roadmap, Adaption of business models
D ₂ -Governance	Suitability of technological standards, Protection of intellectual property
D ₃ -Leadership	Management competences and methods, Willingness of leaders
D ₄ -Culture	Value of ICT in company, Transparency, Knowledge sharing
D ₅ -People	ICT competences of employees, openness of employees to new technology
D ₆ -Customers	Digitalization of services, Utilization of customer data
D ₇ -Operations	Decentralization of processes
D ₈ -Products	Product integration into other systems, Individualization of products, Tracer
D ₉ -Technology	Sensors, Utilization of mobile devices

Just like the generic blockchain maturity models by (Wang, et al. 2016; KPMG, 2018), Ronaghi (2021) proposes five levels of maturity from initial to optimised. The explanations of these levels are as shown in **Table 5.5**.

Table 5. 5: Maturity levels for BCT. Adapted from (Ronaghi, 2021)

Stage	Explanation
Ignoring	Do not know about BCT applications improving information flows
Defining	Know about BCT applications improving information flows but do not use it
Adopting	Some BCT applications improving information flows are implemented
Managing	Many BCT applications improving information flows are implemented
Integrated	All possible BCT applications improving information flows are implemented

This study considered six assessment dimensions as shown in **Figure 5.14**, which are:

- 1) Strategy – Long term plan for BCT adoption with clear guidelines on how it will align with business values and provide value.
- 2) Leadership – Strong leadership for championing for BCT and actively guiding on its implementation
- 3) Governance – Rules, processes and decision-making structures for managing BCT projects and ensuring compliance with regulations
- 4) Culture – Organisation mindset in adopting BCT
- 5) Technology – Tools & infrastructure required for BCT adoption
- 6) Resources – Human & Financial resources to support BCT adoption

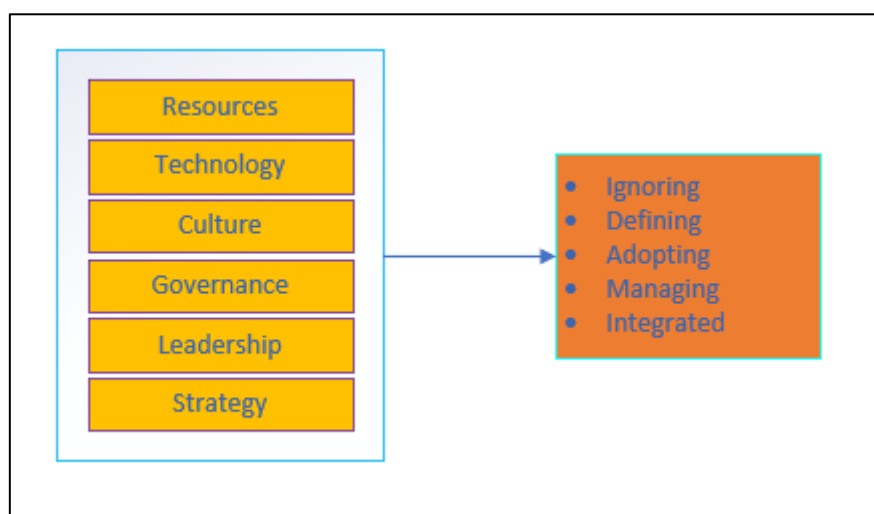


Figure 5. 14: Proposed Maturity model dimensions for BCT implementation in the Kenya HSC

Each of these dimensions has a 5-maturity level as discussed in **Table 5.6**.

Table 5. 6: Proposed BCT maturity levels for the Kenya HSC

Stage	Explanation
Ignoring	Do not know about BCT applications in HSCs
Defining	Know about BCT applications in HSCs but do not use it
Adopting	Active BCT testing, with small-scale implementation projects
Managing	Using BCT and actively managing it
Integrated	BCT is fully integrated into HSC organisation's core operations

5.3.4 Stage Four: Implementation

After conducting the readiness assessments, Kenya HSC stakeholders can know their current position with respect to the dimensions given in the maturity model and the factors critical in influencing BCT adoption as given by the TOE model, and this know-how will allow them to plan the changes that they need to develop, to adopt blockchain successfully.

5.3.5 Stage five: Performance Measurement

After implementation of the technology, the organisations will need to maintain their blockchain systems and make continuous improvements and establish performance metrics for the evaluation of costs and benefits of the new blockchain-enabled systems.

CHAPTER SIX

NVIVO-BASED THEMATIC ANALYSIS OF EXPERT OPINIONS ON KENYA'S HSC

6.0 Introduction

This chapter focused on the qualitative data analysis of the expert interviews in Kenya's HSC conducted to explain and expound on the Quantitative results. The thematic analysis was done using NVivo 12 Software. Questions about the current technologies being used by HOs and the factors that were considered in their adoption were asked in the interviews to help identify the factors that could be crucial in BCT adoption. Further to these, an exploration of data privacy and security of current systems was conducted. Participants were also asked about the current structure of DRM in Kenya and the challenges faced, to validate the need for BCT implementation identified by the quantitative results. The Qualitative phase was also useful in validating the Blockchain-enabled Framework and further exploration of the requirements Kenya HSC stakeholders should meet to implement blockchain successfully, which is presented in chapter seven.

6.1 Qualitative Data Analysis

The researcher conducted a total of 30 interviews. Two interviews were not used in the analysis as they were not elaborate. The remaining 28 interviews were therefore used in the data analysis. **Table 6.1** illustrates the distribution of participants in ASAL counties of Isiolo, Kajiado, Kilifi, Kitui, Narok; and Nairobi County (the capital of Kenya that houses many HQs to HOs).

Table 6. 1: Distribution of Participants

County in Kenya	No. of Participants
Isiolo	7
Kajiado	4
Kilifi	3
Kitui	2
Nairobi	11
Narok	3
Total	30

The interview focused on:-

1. Kenya DRM structure, coordination mechanisms used by HSCs and the operational challenges they face.
2. Current technologies used in DRR, and how they were evaluated for adoption, and how the current systems ensure data privacy and security for beneficiary information.
3. Blockchain awareness, its drivers and disadvantages.
4. Validation of Blockchain-enabled Framework and the proposed blockchain-enabled architecture design model for the Kenya HSC, and the perceived benefits and barriers of adopting the architecture model in Kenya. An assessment of the requirements HSC organisations must meet for blockchain implementation to be successful was also conducted.

This chapter focuses on only points 1-3 above. After interview transcriptions, thematic analysis was used for coding data into themes, using Nvivo Software. **Direct quotations have been done to support the coded themes and no grammatical error was corrected, if any from the direct quotes.** The themes from the data analysis are discussed below.

6.2 Kenya DRM

Respondents were asked questions on the Kenya DRM structure, coordination mechanisms used by HSCs, and the operational challenges they faced in their DRR activities in Kenya.

6.2.1 DRM Process in Kenya

Q: What is the current structure of humanitarian DRM in Kenya and how are disasters managed in the country?

6.2.1.1 DRM Structure

For the key participants in this study which included the national and county governments, development partners, private sector and NGO's, the data analysis on DRM in Kenya shown that the DRM is mandated to both the county and national governments in Kenya with a focus of a tiered approach, where DRR efforts are made at the grassroots level of villages and communities level, upscaling to the county then the national and international levels. Collaborations in DRR is achieved by local and international NGOs, CBOs, FBOs, academic institutions, and the media. There is no single body that coordinates disasters in Kenya, but droughts are coordinated by NDMA, while floods are coordinated by NDOC. Other ministries, however, have the mandate for other DRR activities like the Ministry of health that must respond to diseases epidemics.

“We have no organisation responsible for coordinating all disaster issues, and we must have one, and this organisation must be legally constituted. It must have the legal backing for accountability purposes. Currently, all ministries have been given responsibilities. Two ministries that are very important in floods and droughts coordination. The Ministry of the Interior and National Administration (MoI) where NDOC is situated, and the Ministry of Arid Lands and East African Community and Regional Co-operations in which NDMA is located.” Participant, 18NG.

The Department of Special Programs, which is under MoI, helps in purchasing and distribution of relief aid, and that the distribution is aided by security officers under the same ministry. The police are the first responders of any crisis happening at the grassroot levels.

“Under the Ministry of Interior there is the department of Special programmes which is the one that deal with the purchase of food, non-food items, storage and

distribution. Because we have got a very good chain of communication in this Ministry and the chain of personnel who are able to give us all the information that we want, we aid in security during the distribution. We have the National Police Service (NPS, and we have the National Government Administration Officers (NGAO).” Participant, 18NG.

For the National administration, the chain goes from the village administrator to the ward administrator, then the Sub- County level then to the County level that is headed by the Governor. This Chain of command is followed during DRR response and management.

“We have a village administrator. At the ward level, the ward administrator, then you have the sub- county administrator, then the governor has his cabinet composed of County Executive Committee members and the County Executive Committee (CEC)s that constitute his county or rather the county cabinet and this allows for the tiered response of disasters in Kenya but for us to intervene at the national level, we must ensure that the county government has agreed that they actually need assistance..” Participant, 18NG.

6.2.1.2 Coordination Mechanisms used for DRM in Kenya

When managing disasters in Kenya, coordination mechanisms are used. The data analysis on the coordination mechanisms used resulted in 9 themes as illustrated in **Figure 6.1**. Transcripts discussions of these thematic areas are shown in **Appendix X**.

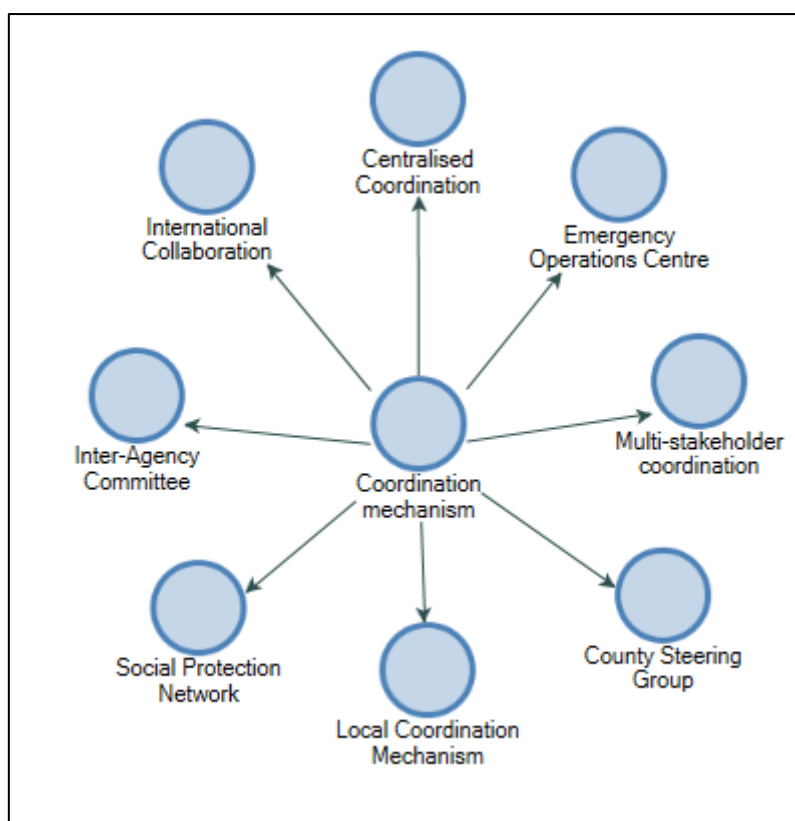


Figure 6. 1: *Coordination mechanisms in Kenya HSC*

6.2.1.3 Kenya DRM Phases

Kenya responds to her disasters in four phases of mitigation, preparedness, response and recovery. The activities involved in each stage are shown in **Table 6.2**.

Table 6. 2: Activities conducted across DRM Phases in Kenya

Mitigation	Preparedness	Response	Recovery
Development of laws to prevent calamities	Disaster preparedness trainings	Provision of relief aid, cash transfers, and medical assistance	Financial assistance to vulnerable communities
Development of finance policies to ensure accountability	Information sharing for improved preparedness	Information sharing	Community training for long-term adaptations
Community sensitisation about disasters and prevention	Policies and regulations supporting preparedness	Resource mobilisation and coordination	Livelihood support for economic recovery

Ensuring water security	Community training on disaster preparedness	Financial inclusion
Early information sharing for better decision-making	Conducting food security assessments	Traditional coping mechanisms
Community development programs (e.g., animal feeds, boreholes)		Water tracking
Continuous monitoring of development programs		Monitoring and evaluation of rebuilding efforts
Distributing social services		Tracing of people
Promoting immunisation and advocating for children's rights		Rebuilding infrastructure

6.2.2 Challenges Facing Humanitarian Supply Chains in Kenya

Q: What are the main challenges affecting humanitarian supply chains in Kenya?

The data analysis on the main challenges in the Kenya humanitarian sector resulted in 24 thematic areas as shown in **Figure 6.2**.

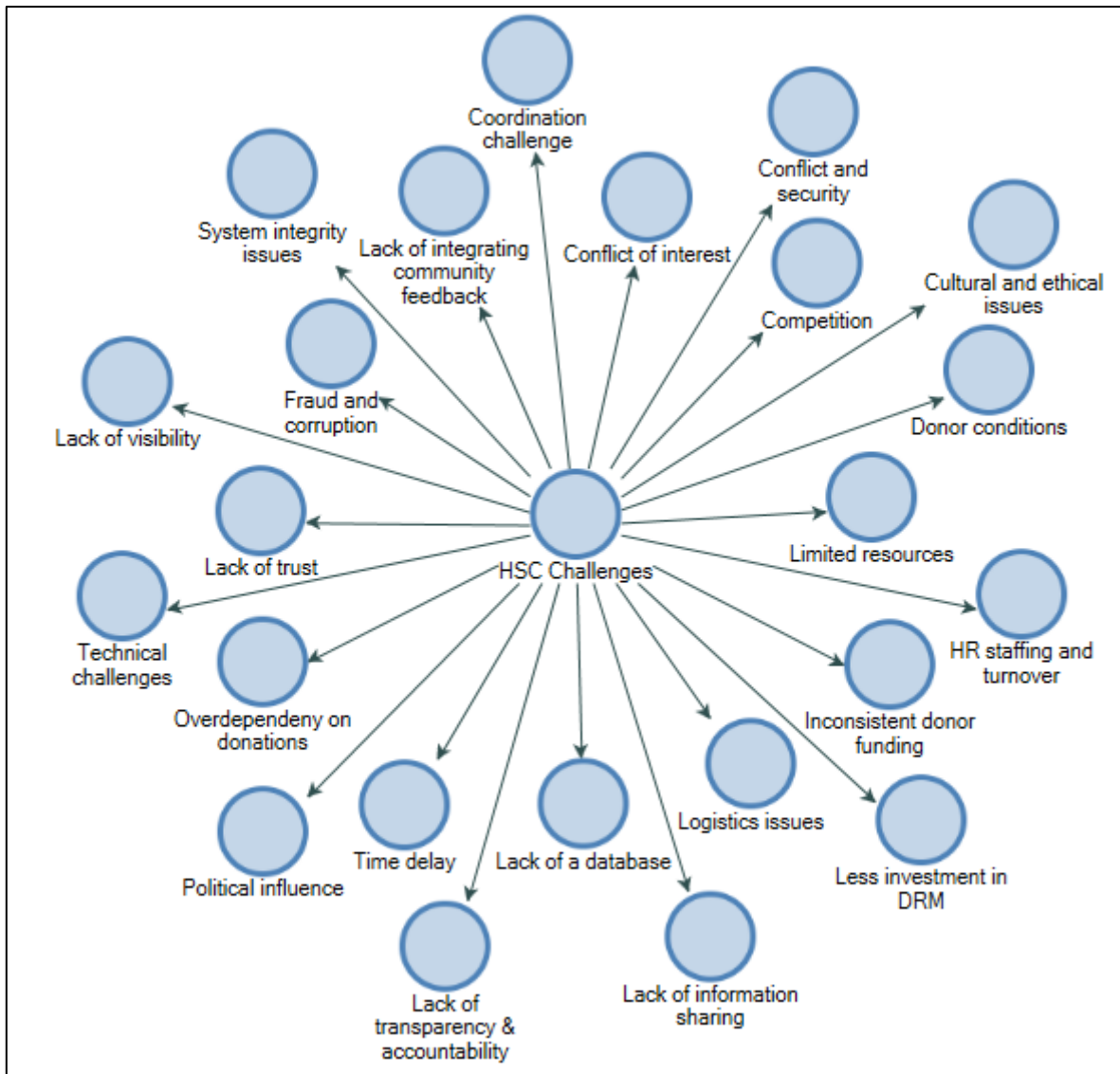


Figure 6. 2: *HSC challenges in Kenya*

a) Coordination challenge

Many NGOs were concentrating in one area especially the central areas of the ASAL counties, which are accessible, and few NGOs went at remote areas of the same counties. This issue led to **duplication of efforts** and was also creating trouble for the locals, who felt overwhelmed by sharing their data with too many HOs.

“We have an overlap. Certain NGOs overlap projects. You know that NGO A has done a project in this location and then you will find again the same influence is also targeting the same, so all the NGO B & A are supporting one community.”

Participant, 4SN.

Coordinating beneficiaries from sparsely distributed areas was a problem, and that made partners overconcentrate on a single large area.

“Because these people across these counties (ASAL) are sparsely distributed. Bringing them together is a very big issue.” Participant, 26NG.

Additionally, development partners pursued projects that the government was unaware of, and therefore other development partners were assigned the same project due to lack of communication. **The lack of communication** was fuelled by **lack of commitments, and lack of trust** amongst the partners.

“First is lack of commitment from partners. There is lack of trust from partners too. They won’t disclose how much resources they have used, they may give a vague figure like 2M- but will say they don’t know the activities.” Participant, 21NG.

There was a lack of willingness by partners to coordinate on DRR due to differences in capacities and resources amongst themselves. Some roles within government agencies were overlapping, like sanitation, which is part of the ministry of water, and the ministry of health. These overlapping roles made coordination difficult.

b) Conflict of interest.

Politics played a huge role in DRR policy formulation, and implementation. Intermediaries within the Kenya HSC also added complexities due to the conflicts of interest.

“First government is very hectic, very hard to deal with. There are a lot of interests around. There are a lot of politics around. You will find that if you are not giving any allowances, you are likely taken less serious or even your issue is not taken in, and that's the issue and if you don't give money, you get no support. The government acts as if they are doing us a favour. The entire humanitarian chain, every party has needs, and have conflict of interests.” Participant, 1SN.

Conflict of interests was fuelled by the diverging goals of the partners, which added costs and complexity to the whole SC.

“As an NGO, we only supplement what the government does and therefore, it become very hard for us also to work with the government, given that they have their own priorities, and also influence and the fact that the government expects money. Actually, not for the community, not for the affected community, but the allowances and failure to give them these means no support from them. And even NGO's nowadays they are joining the league of the Government where they promise but they do not deliver yet most of them are signatory to core humanitarian standards.” [Participant, 1SN](#).

c) Conflict and security issues

Relief food distribution required police officer's help to avoid carjacking and sometimes death.

“Food is a security issue for we have had issues of near stampede cases of people fighting for the food and this could even lead to death.” [Participant, 1JC](#).

Most development partners concentrate in some central parts as they shy away from going to remote areas because of security concerns. For resilience initiatives like commercial offtake of animals in ASAL regions, the government assist external traders by providing transport and security.

“We do commercial offtake and that is organised for buying of livestock and because of security issues, sometimes traders will shy away from reaching there. So, we provide like transport subsidy to help them reach there, and we make security arrangements for them.” [Participant, 5SG](#).

d) Cultural and ethical issues

Some development partners collected data from beneficiaries with a promise of using it to help them, and sometimes the help was not offered while other times, there was **no consent of getting data** from the beneficiaries. The ethical issues suppressed data and **project ownership** by beneficiaries. Other ethical issues included **diversion of funds**, and reluctance of the donors to be accountable.

“There are cultural and ethical issues as some donors do not get consent from the community. Ownership of projects from the community is lacking. Additionally, funding never go to the right people, the donors source money for themselves, using the government declaration and when the government asks for an audit, they have an attitude towards the government like saying that the government has no capacity to monitor and evaluate their books.” Participant, 21NG.

Other unethical issues included doing sub-standard work for development projects, failure to complete recovery projects, and allocating development projects in poor locations. There were also manipulations of food distribution ledgers, where relatives to chiefs were written and given aid instead of the aid going to the affected people.

e) Competition of NGOs for government support

Some NGOs bribed government officials to support their projects.

“Since we have different actors who are now committing to this issue of humanitarian aid, we find that all of us are like competing, and in that competition, you find that for my organisation, they don't encourage anything to hand out or cash for allowances to government, probably lunch. But you'll find another NGO B, is giving like \$120.00 for allowances to the government. Some even goes to \$25 per day despite also giving lunch. So, you will find that if you are not giving any allowances, you are likely taken less seriously, or even your issue is not taken in and that's the issue.” Participant, 1SN.

f) Donor's conditions for funding

Conditions set by donors in providing aid to disaster beneficiaries were found to be unfair, and not inclusive.

“The conditions set by the donors for giving aid like a beneficiary need to have a telephone- these are poor people, they can't afford phones, and if they do, they sell them to get food. In some cases, beneficiaries need to open a bank account, what if they don't have the identification documents? That means they get nothing.” Participant, 21NG.

g) Lack of resources

ASAL regions suffered from lack of water and boreholes were sought after to counter this, but the rehabilitation and construction of boreholes was costly, and there were limited funds to engage in such projects. Moreover, the boreholes breakdown frequently, especially during the drought period, as they run for longer than normal, and the resources for frequent maintenance on these were limited. Other projects related to water like water boozers, and pipelines, were also very expensive and were reported to be likely unsustainable.

“We still have those hotspots that we have not been able to reach water. Areas like Mordagacia, bordering Garissa County, I think where you can get good water for consumption is around 70 kilometres from there, so you can imagine doing a pipeline for 70 kilometres it's not easy. It's a very costly affair where you have to tank a water for a whole village. It's likely unsustainable.” Participant, 5SG.

Resources such as equipment and vehicles were inadequate, for both the government and development partners. The limited number of ambulances and firefighting equipment affected response time to disasters. A participant from an NGO complained that their organisation which operates internationally, provided less facilities as compared to their counterparts in developed countries, which raises an issue on inclusivity in international co-operation.

“We were doing the research in other countries, and in developed countries, our equivalent of each ward in every County, they have an ambulance, but for us, you'll find that in Kilifi County we have less than 10 ambulances, which are really well equipped and operating well, these are very few. And you may find when there is a massacre that has happened, responding to it is an issue. On the fire vehicles, you'll find we have a challenge because the vehicle will come but you'll find that first there is no water, or it's faulty.” Participant, 14LN.

In some cases, human resources would be present, but equipment would be absent or vice versa. For example, in drowning incidents, divers may come to the rescue, but there were no gears, and this would make the rescue operation to be ineffective. DRR recommendations provided

by researchers were reported to be difficult to implement, due to resource constraints, which made it difficult to achieve resilience against disasters.

h) Staffing for human resources

A high rate of staff turnover was reported. This led HOs to employ temporary staff. The use of temporary staff was challenging as some of them disappeared with data collection tool kits assigned to them. There was also a lack of technical skills for repair of water suppliers.

“The personnel that are normally involved because they are not permanent, they are temporary employees. Sometimes they can decide to disappear, or they can decide to be unresponsive. They can also decide to quit after you have given them gadgets. We give them very expensive gadgets, and they can decide to disappear with them.”

Participant, 22NG.

i) Inconsistent donor funding

Funding for resources from donors was challenging coupled by donor inconsistency to sustain funded projects till completion.

“There is a resource funding challenge. A donor can wake up tomorrow and cut off your funding thus creating un-sustained operations for our programmes and employees.” *Participant, 12LN.*

Similarly, disaster response phases were supported more than disaster prevention phases.

“When there is looming drought, the donor support is there, but when the season is good, you don't find such support from them.” *Participant, 4SN.*

j) Less investment in DRM through policy, education and infrastructure

There are DRR legislation challenges in the country, and DRR policies in the county levels like Kajiado were not fully operationalised. There was also an overlap of responsibilities in the same county as the emergency fund was also handling DRM responsibilities.

“I don't think disaster response is fully devolved. We have policy limitations because as I said, the county has a disaster management act that was passed, but it has not

been operationalised. We want to operationalise disaster management unit, because as it is, we are an emergency fund, but we are doing disaster management functions.”

Participant, 11JC.

There were little efforts from the government in creating awareness on DRR in the public, which bred ignorance about disasters.

“Disaster management is a relatively new concept, and most people associate issues of disaster humanitarianism with the Red Cross, to the extent that you might find somebody telling you that, that one is Red Cross mandate, it’s not ours.” Participant, 17NG.

k) Logistical issue of storage and transportation of relief food.

County governments lacked a stand-by food and non-food items to capacitate them in disaster response.

Additionally, relief food was costly, and it added transportation expenses, and thus, HOs preferred cash transfers interventions.

“We have the logistical issues of receiving physical food. We have issues of storage. You have a full container of food and then probably it rains overnight, and water goes through there, and besides, it’s a lengthy process to transport it, and we don’t even have enough money, so it’s even better to send cash.” Participant, 11JC.

Logistical issues were faced in rescue services, as collaborating with government agencies was difficult, as they asked for reimbursements in everything including airtime.

“There are logistical challenges during rescue. For instance, they will say, ‘we don’t have fuel, airtime’, They will just ask you if there is a transport reimbursement or airtime reimbursement.” Participant, 13LN.

l) Lack of information sharing amongst partners.

NGOs were unwilling to share beneficiary lists with county governments. Information sharing with communities was hindered by cultural issues and a lack of skills and knowledge to respond

to disasters. The use of village leaders, through the *Nyumba-Kumi* initiative, was used by NGOs and the government, for community training and sensitisation.

“You cannot put men and women together in the discussion because in this community, women do not talk in front of men. So, if you need to hear their problems or needs, they won't tell you.” Participant, 8JN.

A lack of information sharing made coordination to be challenging.

“You tell them to share with us their resource envelope so that we can plan together and also distribute the interventions across. They may not like fully to reveal what they have. So sometimes you find an area is over concentrated by some agencies and others are left out.” Participant, 24NG.

m) Lack of a database

In most county governments, there was no database to record beneficiary data, and volunteer data. This challenge led to collection of data many times, sometimes re-collection of the same data, which was time consuming and expensive.

“We have a huge challenge because we don't have a database, and that's why we wanted to develop this disaster information management system, so that we can have a database of all the households. Like I said earlier, we are forced again to collect data and now and then.” Participant, 2SC.

Some HOs had individual databases in their companies but lacked a database that could be accessed by many partners, to improve information sharing in real time, and enhance traceability.

“We are in the process of establishing a single registry for the HSNP. As at now, we have not rolled it. So right now, you come to our offices, we are able to provide that data to you as an organisation, and because I told you our key role is coordination, we are like the magnet that pulls people and everyone knows if I need this data, I can access it through NDMA. But we are in the process of running the single registry so that all the households, probably someone is receiving our HSNP, the same person are getting help in the Social

Protection Department, and these people living with disability, we can harmonise so that we do not have the same household having multiple cash transfers.” Participant, 5SG.

n) Lack of transparency

Some HOs avoided audits to evade accountability. Additionally, there was a lack of transparency in cash and food distribution, as manipulation of ledgers was common, and the intermediaries were too many with divergent interests.

“We do activity-based funding, and when we are monitoring on other partners, they hide programs because they had not started, therefore there is issues of transparency and accountability and avoiding audits and we would like to know- how much did you use? How did you spend it as you sourced it for our people. There is manipulation of distribution ledgers. How do we remove intermediaries? We don’t need them! Let’s be direct to ‘Wanjiku’ (the commoners) and not to get half while they were meant to get full.” Participant, 21NG.

o) Time delays

DRR approvals took time, which delayed response interventions. Government bureaucracy delayed project approvals, making them stall or take longer than necessary.

“In terms of keeping time, like I want to do an intervention, and this intervention, I want to like do it in location A & B. Calling for this meeting for government officials, is a challenge and unless they attend, you cannot go anywhere unless they give you a go ahead to enter a set of communities, and therefore you have to schedule and reschedule and this is very challenging. Sometimes it takes a week or even a month to respond to an email. It depends because someone can read and if he finds out that the email doesn't fit him, he keeps quiet. So, until you come, when you come, you are told that he is not around. He has gone for his training where they normally go for training, to have allowances. It's so frustrating.” Participant, 1SN.

Lengthy processes were involved in data sharing, which made response initiatives ineffective.

“Even receiving the data from the data collectors takes quite some time because the source down at the ward level, they have to pile the data, send to the sub-county,

who compile and send it to the county. The county then compiles and sends it to us. That's quite some time.” [Participant, 23NG](#).

p) Political influence

Change in political leaders caused a delay in the formation of a centralised coordination authority for DRM in Kenya.

“Forming institutions in government is a very difficult process because every government that come to power every five years, has got its own thoughts of how government should work, which institutions should be created, and which ones should be withdrawn, and this has negatively impacted the formation of a centralised agency for coordinating disasters in the country.” [Participant, 18NG](#).

Politicians also took credit for development projects done by the NGOs, to win elections, and they influenced development partners to develop certain regions.

“If a governor comes from a certain community, or even a government employee within this county come from certain community, he tries to tilt the intervention towards his community against the affected community, and this is against the core humanitarian principles of impartiality and neutrality.” [Participant, 6SC](#).

q) Overreliance on donor funding

NGOs over relied on donor’s funds, which was not sustainable. Similarly, beneficiaries over-relied on cash transfers, which could lead to conflicts issues in future if they lack such assistance.

“Even now, the problem that we are having is that, you'll find a family was burning charcoal before they were into this cash program, once they got into it, they relaxed. So, assuming now when we are doing the retargeting, and they are thrown out of the first group of beneficiaries, we could have more problems. If they are not sensitised on the need to look for alternative investments using this money, we can leave them in more problem than we found them.” [Participant, 26NG](#).

r) Technological challenges

Keeping up with the evolving nature of technologies gave HOs difficulties in scaling up, coupled with a lack of technical skills required to operate them.

I think one thing is technical challenges, some within your control, and others out of your control, and then the ever-changing technologies. Over time, we've had the push for data warehouses. We've seen that for a couple of years now, and then when people have just settled into that warehouse, now we are having more technologies coming up. Participant, 27NN.

s) Lack of trust

A lack of trust was preventing information sharing and coordination among partners.

“In fact, that's a thing...the suspicion because you ask for some data and people will tell you why? In fact, it's a challenge due to also issues of competition, like the case in handling certain things that an organisation wants to do then it comes to share with the rest, there could be some other organisation who can run faster with information and go ahead of everyone and catch the opportunity.” Participant, 3SN.

t) Lack of visibility

Due to lack of visibility in the procurement process, HOs suffered from supplier manipulations.

“We ended up supporting the water shortage with water trucks, which is very expensive because it has to go through a procurement process and the contractor charges doubles of the amounts he wants because he takes an opportunity, and you have no option, and also taking water from very far, makes the process expensive.” Participant, 1SN.

u) Lack of accountability

Government officials were reluctant to approve documents to avoid taking responsibility for approvals.

“When you want to take an approval physically because they did not respond to your email, you come to the chief officer, he tells you to go to this person. You go to that person who also sends you to another person, until you give up.” Participant, 1SN.

v) Fraud and corruption

Some HO staff were corrupt as they diverted aid money to their personal accounts.

“I found one person who was a programme person who was channelling the money that's selected for orphans to his account” Participant, 1SN.

Funds were also diverted from WASH programs developed for the community, as managers of water boreholes took loans with funds meant to sustain these projects, thus leading to collapse of the projects.

w) System integrity issues

Hacking in the government eCitizen portal was reported where data of citizens can be stolen or manipulated when seeking for government services like registration for IDs, which are mandatory for cash transfers to beneficiaries.

“There are a lot of hacking, and we find that currently the Huduma number (ecitizen identification number) was hacked and there was no information about the hackers.” Participant, 23NG.

6.3 Technologies used in Kenya DRR

Participants were asked about the technologies currently used in Kenya DRR efforts and what factors were crucial in their adoption. They were also asked about how they identify beneficiaries and how they ensure beneficiary data is secure.

6.3.1: DRR Technologies

Q: What technologies do you use for your DRM efforts?

The data analysis on the main technologies used in DRR in Kenya are shown in **Figure 6.3**. These technologies are-: Artificial Intelligence; Websites and Bulletins; Database office; Drones; Early warning systems; GIS; Letters; Mobile phone applications; Radio; Remote sensing; and social media. These tools were also used in physical or virtual meetings to discuss DRR activities in the country.

A participant shared how they are integrating their **EWS with AI technology**.

“We want to enhance technology in terms of incorporating machine learning into the early warning system so that we can have more accurate decisions and feedback. We are doing that on vegetation cover index that it can be able to get a picture of a livestock say cattle, and we tell it this cow is malnourished, or this cow is healthy. This is to train it to generate an accurate response of such a picture in future.”

Participant, 24NG.

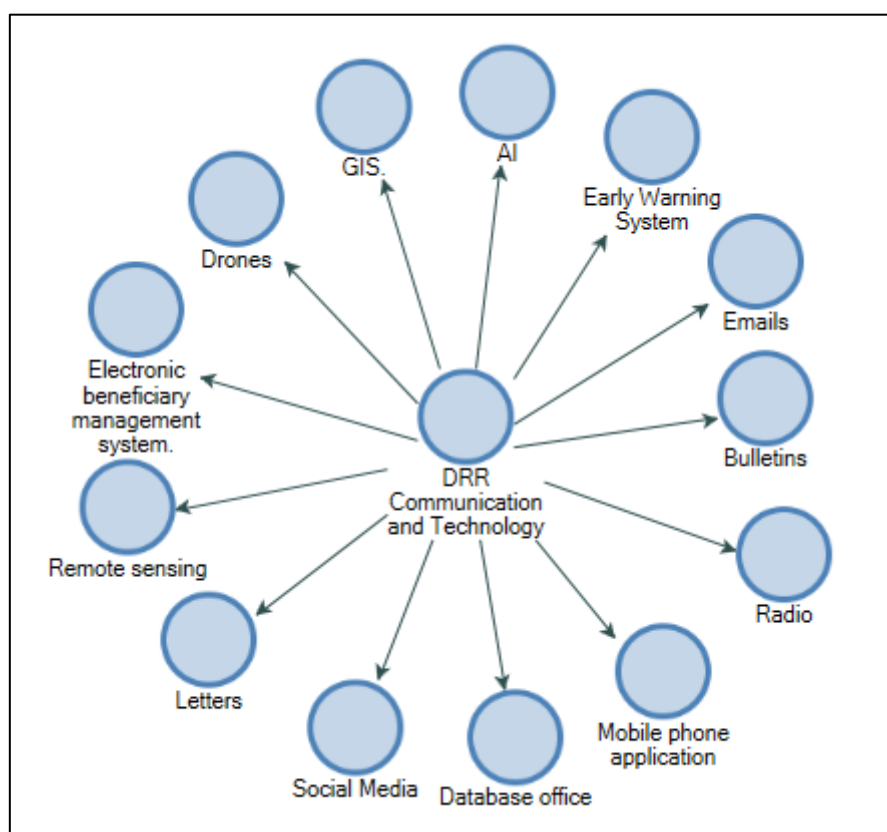


Figure 6. 3: *DRR Technologies used in Kenya*

AI chatbots were embedded in HO's telegram to assist members of the public in answering queries, which reduced queues of beneficiaries in their offices. Other ways of sharing information with the public were using **monthly bulletins** that were embedded in their organisation's website, which also host other platforms like the knowledge management portal.

Most respondents shared that they have a database office. Examples included:

1. Child protection information system,

2. NIMS system for data storage of Sendai monitors,
3. DES Inventors database,
4. the AX system,
5. Microsoft excel and Power Bi,
6. An enhanced single registry that acts as a beneficiary management information system and collaboration tool,
7. SQL and Azure database.
8. ERP system
9. MIS database
10. DIMS

Social media like WhatsApp was useful in communication and WhatsApp groups acted as a platform for coordination. Other social media platforms mentioned were X and Instagram. Participants revealed the use of **remote sensing, satellites, PET (pictorial evidence technology), web-GIS for EWS**. The use of **radio** was still prevalent especially in marginalised communities due to its wide coverage and affordability as it didn't require purchase of internet bundles. **Drones** were used by some NGOs for data collection and rescue operations and were majorly used during covid-19 for fumigations of markets in counties like Kajiado. Most government organisations stated that they are in the process of adoption of drones.

“We are considering having drones to help in collecting proper data like vegetation data information which will be more accurate.” [Participant, 18NG](#).

Mobile phone applications like **emails** and in some cases, **letters** were used to communicate DRR information.

“We wrote some letters and shared with churches, mosques etc. to allow form 4 leavers to come to a sponsored computer classes through DOT.” [Participant, 9JN](#).

Mobile apps like Trim are used for DRR.

“Trim is an app that we use to collect the weather-related aspect, the data on weekly basis, and also it gives us the information on how the vegetation behaves with time.” Participant, 1SN.

Kobo collector toolbox, which is an open data tool kit installed in phones or tablets were used in beneficiaries’ data collection. Other platforms like Rapid Pro were used.

“Recently, we developed a platform like a two way communication like messaging with households or individuals regarding certain aspects. it's something we call Rapid Pro.” Participant, 23NG.

6.3.2: Factors Considered Important in Influencing Innovation Adoption

Q: How important are top management support, organisation readiness and external support factors in influencing technology adoption in Kenya

6.3.2.1 Top Management Support

Top management supported new innovations through championships and led teams in the transition process from experimentations and piloting to implementation. Leaders were willing to allocate budgets towards innovations. Only a few respondents conveyed a lack of support from the management. Some respondents were unaware about the support from the executives, due to high turnover in top management staff.

“It's not easy to tell because right now we have new managers who have hardly settled down, and we do not know their outline or major theme. We do not know their attitude towards technology but In the past, I can say no, there wasn't too much interest as it was not being prioritised.” Participant, 17NG.

“Yes, they’re very supportive and the mostly the most interesting part is even when it is like a pilot model, they will make sure every person who is in that disaster operation line get involved, even if it is online, through zoom or physically, to get that information which can really making us improve our operations.” Participant, 14LN

“Mm-hmm, right now I can say no. I can just be honest. Right now, we have not gotten any assistance from their side, but we’re just surviving.” Participant, 9JN

6.3.2.2 Organisation Readiness

Data analysis on organisation readiness resulted in three sub-themes of innovation culture of organisations, the presence of an ICT strategy and technical skills of ICT staff.

a) Innovation Culture

Employees were open to new technologies however there were some resistances to change due to fear of the unknown especially with the older employees. Age and education levels played a significant role in adoption of technology in HO’s.

“There is good culture in uptake of ICT innovations here. From what we have here, people normally want to try new things. Of course, change at times get some form of resistance, but if you convince the leadership or the decision makers, they will always want to try new things. They ensure people’s culture is incorporated into that cause any other time we have something that we are working on, we usually want to use the local knowledge of how things are done, what challenges are there and now based on these, we can see how we can better transition the change. Up take is varied. It depends on age, literacy is limiting, but substantial progress has been made as people are trained through whenever such a transition is in place” Participant, 7SN.

b) ICT Strategy

Most participants mentioned that they had an ICT strategy but were unaware about its incorporation of exploring new technologies. Most county governments did not have an ICT strategy due to the lack of a national DRR policy to guide them on the way forward. Most government ministries had strategies in place and plans to digitise their processes.

“The first one would be to have a policy in disaster management. We do not have. The moment you don’t have a policy, you don’t have a strategy. So those strategies are derived from the policies as that will give you more on how to get there” Participant, 17NG.

“We have a strategy for implementing ICT solutions. Like now we have several things that are happening like machine learning. We’ve completed our data centre like three months ago and now we can be able to explore and expand our activities.” Participant, 26NG.

“We have digitalisation strategy in place. That plan is there to digitise a lot of the data that we have in the ministry and the agriculture sector transformation strategy is one of the pillars we have. I think it’s on pillar 8, which is on innovation, digitisation and things like that because things are changing. Like now the ministry was exploring issuing fertilisers to farmers through an e-voucher system. It is being done.” Participant, 23NG.

For NGOs, participants stated that there was an ICT strategy, but it didn’t mention about exploration of new technologies.

“I think they have a global IT level management and a country level, it's there. I think they are receptive to technology and there are rules that they follow when trying to adopt the new technologies. We also have an M&E team to explore these innovations.” Participant, 4SN.

c) ICT Technical skills

Most HOs had an ICT department, but it was moderately equipped, and the technical staff were good at doing IT system maintenance, but there was a lack of specialised technical skills like software engineers. Only a few HOs had highly qualified technical staff who were trained often.

“We have an ICT but they're basically dealing with whether the computer is working well. In a scale of 1 to 5, I would give them a 3. They have their own challenges of internet and machines, unavailability of current machines. I don't know whether we have those software engineers, I don't see right now like we have software engineers there” Participant, 17NG.

6.3.2.3 External Support from Donors

HOs received donor support in terms of the ICT innovation, and capacity building for staff for skills acquisition. Donors supported only initiated projects or proposals that came from the HOs. Some participants however reported that they were unaware of the donor support towards ICT but were aware of donor support towards other DRR development projects. Donor support was either a one-off affair or continuous until the end of the program. For most NGO's that relied entirely on donations, the management was responsible for allocations of ICT budgets.

“We have had a history with our development partners who have been here for long and I think even now they are coming early to support our initiatives. You realise interventions by our fellow partners will mainly come in the direction that the user ourselves have requested, we must identify what we require to fill our gaps, then we ask them to come in. They help us to develop our frameworks, help us to do our trainings to ensure sustainability of our efforts”. Participant, 19NG.

“Yes, like right now we are working together with some, who are offering technical assistance and capacity building to assist us to digitise profiling of farmers that is like registration. They are supporting us to develop a system that can be able to do that and even other institutions like regional centre for satellite imagery.” Participant, 23NG.

“We have a number. For the databases for hunger safety net is being funded by World Bank. They also funded us in developing the ERP System and several MIS databases. They fund the complete cycle of acquiring, installation and even the training.” Participant, 24NG.

6.3.3 Beneficiary Registration and Identification

Q: What are the ways in which you identify beneficiaries to support in your DRR interventions, and how do you ensure that their identity is secure?

Respondents were asked to explain how they identified and verified beneficiaries, to ensure that they only gave relief-aid to those in need. From the data analyses, beneficiaries were identified and verified through community meetings. The beneficiary identification method was somewhat similar for the organisations of the participants interviewed in this study. The difference is that for government ministries, there was a requirement for beneficiaries to have a bank account, to facilitate the cash transfer whereas for NGOs, cash was transferred directly to the beneficiaries via mobile money like MPESA.

Here are the key processes of the beneficiary registration process.

1. Conducting risk assessments to identify the extent of the hazards, and the most affected individuals.
2. Determine the priorities as at the time of disaster occurring – is it food? Water? Medical supplies? Security?
3. Formulate a committee and set up a criterion for targeting the vulnerable community members. – will it be the elderly? Lactating mothers? People with disability? Children? Etc. This criterion is also based on donor guidelines given to organisations.
4. Register households while asking questions based on the above criteria. Observations are also used for triangulating the data.
5. Categorise households from richest to poorest and get a list of the most vulnerable who deserve the aid.
6. Call for a community meeting called ‘baraza’ where community members verify the list. The process is called Community based validation (CBV).
7. Generate a final validated list of beneficiaries and categorise it into two groups. Group 1 is for the very needy beneficiaries that receive aid unconditionally, throughout the project phase, while Group 2 is for the next most needy beneficiaries that only receive aid during the alarm phase of drought.

8. The beneficiaries open a bank account, and they need documents like a national ID and their biometric information is taken.
9. Cash is transferred to their accounts, and they can use it in any way that they wish.

Other organisations however give vouchers instead of cash transfers.

Regarding **data security**, HOs had security protocols that governed beneficiary data to be safe. Forms of security measures used included use of passwords, IP protocols, firewalls, use of different approvals for sharing beneficiary information, and staff trainings on cyber security threats.

6.4 Blockchain Technology

Participants were asked about their awareness of the blockchain, and their perceptions on the drivers and disadvantages of the BCT, and the requirements needed for blockchain to work in DRR efforts in Kenya.

6.4.1 Blockchain Knowledge

Q: Do you know about blockchain technology?

Respondents were asked if they had heard about BCT or knew about it and how it works. Out of the 28 respondents, 7 of them had good knowledge of the blockchain, 6 of them had little knowledge of the blockchain and the remaining 15 of them had no knowledge of the blockchain. Information about the blockchain and how it works was provided to those with little and no knowledge of the blockchain (to get their perceptions on it in the next sections).

a) Good BCT knowledge

For the blockchain experts, they gave a brief explanation of the technology and believed that it would work for the Kenya HSC. Here are some of their thoughts.

“Yes, I’m aware of the blockchain and it has good potential for the humanitarian sector. You don’t need one person, because you want to boost on the authenticity.

Blockchain eliminates that single kind of setup. The whole idea of blockchain is you don't have one person responsible for something. So, the whole idea is you have a team of guys, this team of guys, each of them understands the rules and each of them know what they're supposed to do.” [Participant, 15TG](#).

“I’m a software engineer. I've not created a software that involve blockchain now, but I have interacted with blockchain itself. Don't look at the technology, just look at the events. How it works, that's now a different conversation. So, you can treat it as an event, which is transactional, in that case then it can address humanitarian challenges. Now, at the end of it all, we realise that it's a software. The moment you call it a software it means you can do whatever you want outside that technology. So, it means if you want to enforce security, you can enforce security outside that technology because for you to accept a miner, there's some configurations they need to do. For that matter, to be able to compete with other miners for transactions means someone must approve something for them to add this person there. So that's our security addition now, it doesn't have to access the public Ledger. This is not Bitcoin now, it's an access control issue.” [Participant, 20NG](#).

“I know about blockchain. I know in terms of data security, not that it's going to help, it's already helping. That's what I would say, yeah. It's just that whenever people say blockchain, it appears like going to pick something and then just utilising it. If you go and ask someone if they use blockchain, they might deny it. They might tell you no, we don't use that, but then you realise you already use that because it's what Microsoft has embedded within Azure and Azure is what we are using.” [Participant, 27NN](#).

b) Little BCT knowledge

Respondents with little knowledge of blockchain said:

“I’ve heard about the blockchain but I'm not that acquainted into it.” [Participant, 2SC](#).

“Blockchain technology... it’s something I've been researching on but even me I've not been sensitised that much on it. Since I heard about it, I've been researching it and was asking my colleague, how we can go about it.” [Participant, 14LN](#).

“I know a bit about Blockchain. We have not piloted it. Not yet. But even the concept itself, it is not very clear yet.” Participant, 22NG.

c) No BCT knowledge

The following are some of the statements given by those respondents who had **no knowledge about BCT**.

“Blockchain technology? No, I’m not aware! What is it?” Participant, 6SC

“I’m not aware of the blockchain, can you please explain it.” Participant, 10JC.

“Blockchain? Maybe you can explain it first.” Participant, 28RG.

“Well, personally I’m not aware of the blockchain.” Participant, 1SN.

6.4.2 Blockchain Drivers

Q: What are the drivers for blockchain adoption in DRR in Kenya?

The data analysis on the enablers of BCT adoption in DRR in Kenya resulted in 9 thematic areas as shown in **Figure 6.4** with the data security and traceability being mentioned by majority of the respondents. Transcripts for the thematic areas on BCT drivers in Kenya are shown in **Appendix XI**.

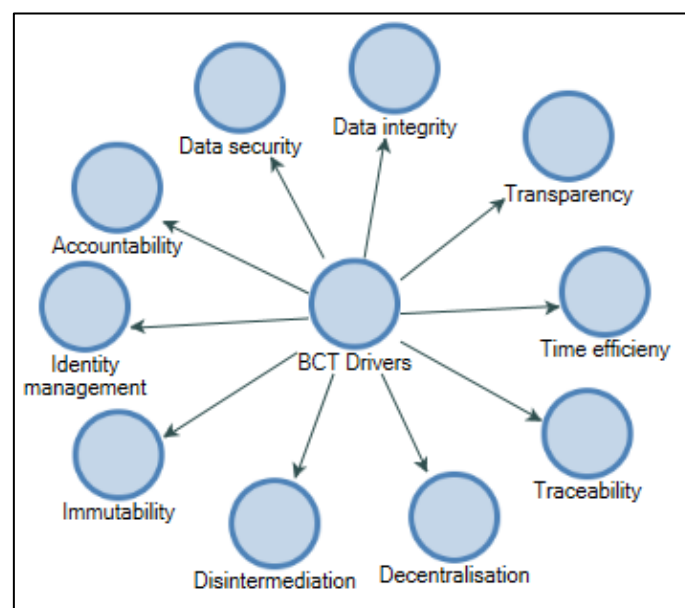


Figure 6. 4: Drivers of BCT adoption in Kenya HSC

6.4.3 Blockchain Disadvantages

Q: What are the disadvantages of Blockchain Technology?

The data analysis on the disadvantages of BCT in DRR in Kenya resulted in 9 thematic areas as shown in **Figure 6.5**.

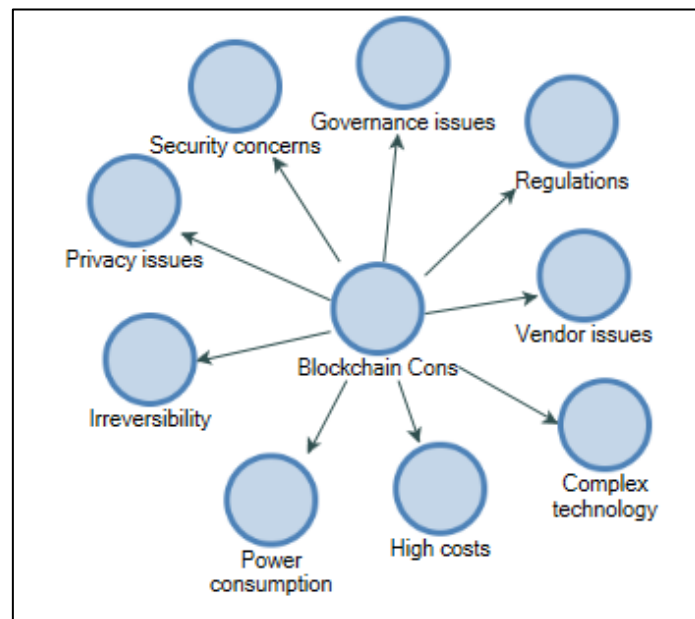


Figure 6. 5: *Disadvantages of BCT*

Governance and regulatory concerns were mentioned by most of the respondents. Transcripts for the thematic areas on BCT drivers in Kenya are shown in **Appendix XII**.

6.4.4 Intention to Adopt the Blockchain

Q: Do you think that your organisation will adopt the blockchain? Will blockchain work for the Kenyan HSC?

Most respondents shown great interest in BCT and said that they would **explore and champion for its adoption** in their organisations. These are some of the statements they gave:

“We piloted it in other counties but not here. If they launch it, we will be using it and it's a good thing. I've seen it working well in other places, even in WFP and it's something good.” Participant, 9JN.

“So, I would say a lot of organisations or departments are trying to implement something like this framework but they really don't know what it is. Like now here the term is not the blockchain but if, have a look at our processes, you will find that in a way they are abiding to this.” Participant, 5SG.

Some respondents however argued that the intention to adopt blockchain **was a yes and a no. Yes, because it helps to ensure data authenticity and no because there are ways of achieving the same without adopting it.**

“We are already adopting it, and organisations can adopt it in terms of data security, among other things but then as I was saying, there are so many ways to achieve the same without having to go a certain way while also maximising on the returns and minimising on the expenses.” Participant, 27NN.

The other respondent argued **a yes for intention to adopt due to the immutability** of the blockchain, **but for its feature of trust, the participant believed that the current data they get from their partners is reliable and there was no incentive to manipulate the data**, his statement however denotes that manipulation could be possible were there an incentive to get from it and this justifies the need for BCT in DRR efforts.

“We trust the data we receive from our partner's and we hope it will give us 100% right data about the beneficiary specific information compared to what we are having here because now like for the registration of IDs, you cannot have one ID number registered twice in the system, but you can physically meet two IDs with the same ID number in the streets. We also trust that the information that we get like from NHIF and NSSF is true. These people it will be very hard for you to collude with them. All those departments are different and again, what is the benefit? This is not millions of funds, it's just small money. How much will you spend to collude with these people? But if the focus is on updating and not deleting data from the database, then yes! ...I think it will help us a lot to achieve our aimed goals, because the goal of this cash transfer programme, is to reach to that very vulnerable person in the community. So, if through blockchain we can follow a straight line to targeting that person, I think we can say that we have over-achieved our own goal” Participant, 26NG.

The same participant above said that their organisation was using the single registry that is provided by the Ministry of Social Protection in Kenya. In this single registry, he explained that **different partners also share information on the platform, but everyone govern their own data**, and that means that no one is responsible for updating the other person's information, and in that case, he reasoned that blockchain was of no need. When asked about the role of the Ministry of social protection in this platform, he said,

“This database is funny because as much as we are saying it is an enhanced single registry, it is not only solely owned by the Ministry. We have our database, they have their database, depending like the Department of Children can access their database. So, we have different databases which are moulded to one. This one maybe you can say they are managing, it’s not that there is anything that they are doing to that data, because it is fed to various databases. What they see is what we are doing. If it’s something that we need to update, it’s us who’ll update here. So, once we have updated it to our system, now it will automatically update to their database.”

[Participant, 26NG.](#)

Some respondents were however convinced that **BCT was not needed due to security concerns.**

“But now I’m wondering, if I have the information about our ministry here, why should I give it out to the blockchain to store it, if I can store it myself? I don’t want to store it in the cloud, I have my hardware spread all over the Country, I’m storing in there, people don’t even know where they are, except those who work with me. So why should I again take it elsewhere, where other people are able to access?”

[Participant, 17NG.](#)

Other participants expressed doubts in BCT adoption due to the little information about it, as compared to other disruptive technologies like AI.

“To tell you the truth, we’re still assessing them. I’m not sure about blockchain, where you think that information cannot be altered, you’ll be shocked at the way that information will be altered, as they are experts in these kinds of things. But AI is

something that is surprising a lot of people because with AI, most of the information is just available to everybody.” Participant, 18NG.

6.5 Conclusion

Despite the trends that Kenya has made to improve her DRR like using a tiered response, coordination, and technology, she still suffers from operational challenges of fraud and corruption, lack of transparency and visibility, and lack of a shared database that securely protect DRR data. Blockchain technology, albeit known by a few interviewed participants, can offer solutions to most operational challenges identified in Kenya HSC. Most participants were optimistic about BCT capabilities of ensuring security and traceability in humanitarian operations. Leaders were said to be supportive of innovation through championship and fostering a good innovation culture to minimise the resistance that comes with new technology adoption, which portrays a positive outlook on their intention to recommend BCT adoption in their organisations. Although most HOs had an ICT strategy, only a few were aware on its incorporation on exploration of new technologies. Besides, most technical skills were on technology maintenance and most ICT departments were moderately equipped. Investments in infrastructure and technical skills are required to operate sophisticated tools like the blockchain. BCT cons on governance issues, lack of regulatory support from the government and its high cost, could make HO’s especially local NGOs shy away from investment, especially if other technologies meeting their business needs at lower costs are available.

CHAPTER SEVEN

VALIDATION OF THE BLOCKCHAIN-ENABLED FRAMEWORK

7.0 Introduction

This chapter focuses on the validation of the blockchain-enabled framework. The validations were conducted via expert interviews. The validation included the framework and its subsequent models like the architectural design model where participants were asked about

7.1 Validation of the Blockchain-enabled Framework

The following two questions were asked to validate the framework.

7.1.1 Interview Feedback on the Blockchain-enabled Framework

Q: What are your thoughts on the proposed Blockchain-enabled Framework for the Kenya HSC? Are there any building blocks that are missing, or any that are present and needs to be removed, and why?

Most respondents stated that the framework was complete, and they agreed with the building blocks without having to add or remove anything. Some participants however, suggested the following improvements to fine tune the proposed framework.

1. Unpack the main points to include the details of each stage for more clarity.

“I think just feel like maybe if you can like, unpack. The feasibility studies on what really takes this because you know before we raise awareness, we need to do, we have to look at a lot of that's cut across the dimensions of politics, look at the economic issues, social issues. Also, shouldn't this be design? (pointing at conceptual design) Participant, 8JN.

“There's also the bit of maintenance and also upgrades and such things.” Participant, 26NG.

2. Remove the feasibility stage and begin with creating awareness.

“Personally, I feel like for the feasibility, I think we are already there because we need it, it is not a secret that we need it. Let's start with creating awareness.” Participant, 11JC.

3. Add the piloting stage before the implementation.

“At the stage where you develop a prototype for the technology, maybe through a simulation exercise (could be the second stage of the conceptual design), after this stage, I feel like you should develop a pilot stage for the same. The pilot also gives you answers or questions for the next stages.” Participant, 12LN.

4. Add a training stage.

Some respondents believed that the training stage should be added after the awareness while others felt that it should be done after the design stage or at every stage.

“You need to develop that conceptual framework for this, after that then now you go for the Training and capacity building, for the stakeholders, then after the training you can come up and set up a pilot. Through a workshop, you set up your systems to mimic a real-life situation.” Participant, 5SG.

5. Include performance measurement mid-way.

“For me, rather than making it linear, I would say you don't measure performance at the end. You should come with a conceptual framework where at all these stages you are measuring performance. You can make measuring somewhere in the middle so that it looks like a Vienn so that measuring can count in each stage.” Participant, 5SG.

6. Insert reverse arrows to incorporate feedback for continuous improvement BCT

“As you measure performance, you need to have a kind of feedback system. A lot of issues will come up. The learnings from the implementation, it need to be taken back into this cycle to improve things. Like feedback... These arrows should not just be following like that, they should come back.” Participant, 8JN.

“So as a technology, does it have room for improvement? Because where is it? Where does it fit, of course those are the outcomes of the tracking, but it would be good to capture after that performance, indicate an arrow on how you now link that feedback to continuous improvement of the technology.” Participant, 5SG.

7.1.2 Critical Stage of the Blockchain-enabled Framework

Q: What is the most critical stage in this framework?

The data analysis on the most critical stage in the blockchain-enabled framework resulted in three thematic areas of **creating awareness, the design stage and readiness assessment stage**.

Majority of the respondents stressed the importance of creating awareness amongst key stakeholders about BCT.

“ Awareness is basically what you need to do, and capacity building of our people in the country, maybe identify various departments and maybe champions for these blockchain project who can now be enlightened on the need to use this technology because it's a good one. Then these champions will sensitise their departments or their organisation or NGOs.” Participant, 11JC.

Respondents who believed that the design stage was the most critical attached its significance in getting things right.

“I think the design involving people in the design ensures that you get it right? Where you are coming up with the design framework, unless you are clear on the framework, unless you get it right on the framework, then you'll always have challenges as you move forward.” Participant, 10JC.

A few respondents believed readiness to BCT by having the appropriate infrastructure was crucial.

“I think all the stages are very important. It depends on the user, especially technology acceptance models here, maybe in the community you might have a lot of difficulties like internet connectivity.” Participant, 4SN.

7.2 Categorisation of the Validated Blockchain-enabled Framework

Wang, et al. (2016) proposed three BCT implementation phases of Feasibility, Development and Operation phase. In this thesis, the stages of the blockchain-enabled framework were categorised into 5 phases as shown in **Table 7.1**.

Table 7. 1: Phases of the validated Blockchain-enabled Framework

Phase	Associated Stage
Initial phase	Raising Awareness
	Readiness Assessment
Design phase	Design
Development phase	Pilot Testing
	Performance measurement and conformance to requirements
Deployment phase	Physical Implementation
	Training
Maturity phase	System live
	Maintenance and continuous improvement

7.3 Initial Phase

7.3.1 Raising Awareness

The objective of this stage is to create an understanding of BCT to the Kenya humanitarian stakeholders, by explaining what it is, how it works, its potential benefits, drivers and drawbacks and the use cases in HSCs. Raising awareness could involve organising workshops and seminars with the multiple stakeholders to address misconceptions about BCT and encourage buy-in.

7.3.1.1 Awareness Criteria

Figure 7.1 represents the key activities for the awareness stage.

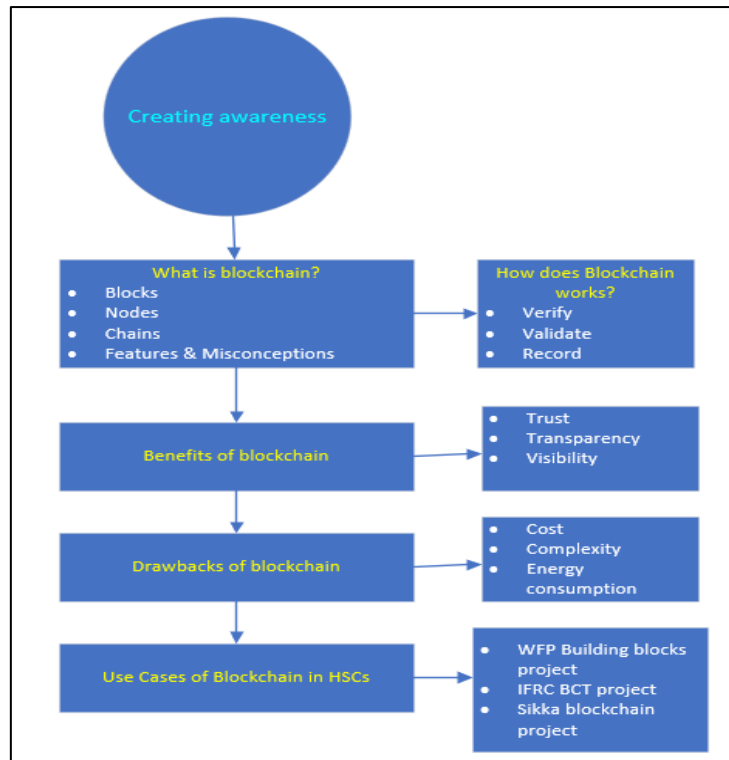


Figure 7. 1: *Awareness criteria*

7.3.1.2 Blockchain Value in Key Humanitarian Phases

Based on the interview transcriptions on the DRM activities in each phase of mitigation, preparedness, response and recovery; and the key challenges faced when managing disaster risks in Kenya as discussed in chapter six, blockchain could provide value in the areas of transparency and visibility thus reducing fraud and corruption. The key areas of blockchain value are illustrated in **Figure 7.2**. More detailed discussion on the activities of each disaster phase and the challenges faced, and the value of blockchain in reducing these challenges is shown in **Appendix XIII**, where green denotes for high-value areas whereas amber denotes for moderate areas of blockchain value addition.



Figure 7. 2: Blockchain value across the disaster management phases in Kenya

7.3.2 Readiness Assessment

The readiness assessment will help organisations to assess their ability to adopt BCT. Participants gave their views on what requirements are needed by HOs to successfully adopt the blockchain.

7.3.2.1 Requirements for Successful Blockchain Implementation in Kenya HSC

Q: What requirements do you think needs to be met for blockchain to work in Kenya HSC?

The data analysis on the requirements that need to be met resulted in three thematical areas; Technological requirements; Environmental requirements and Organisational requirements. Sub-themes were explained under each thematical area.

7.3.2.1.1 Technological requirements

a) BCT design

Responders were concerned about who the developers of the blockchain were. **The vendors should have similar values** to those of the HOs.

“NGOs are very, very, very, sensitive and before they like own such kind of technology, they must have taken a lot of research, like for us, we look who are the developers? It's not all about the app, but it's all about what is behind this app. So, even money, like I give you \$100 million for this project, they will not take it. It's all about the values of the organisation. If it is accepted that means the background is clean.” Participant, 1SN.

Blockchain developers must **integrate the human rights aspects in the design** of DRR blockchain-enabled models.

“Why are we looking at the developers of the technology? Because we are the rights-based organisation. Are the developers in any way, contributed to violation of human rights in anywhere? So probably you will find that the developer was going against climate change like is he or she is the head of the company that is violating the human right. That kind of validation is what most of organisations look at.” Participant, 1SN.

Design of the blockchain-enabled models must ensure **accountability** to beneficiaries.

“Why am I stressing on this? It is because this is the human rights aspect. Constitutionally, these people have rights. They have right to information. Right to be supported, and then you promise them, and then you disappear! So how can this accountability be applied in the design of the blockchain system?” Participant, 1SN.

Blockchain should be designed to **integrate climate adaptation** to make it more attractive to stakeholders.

“So mitigation and preparedness are things we are looking at, if blockchain technology can help us in these two, as opposed to response, it would be great for us. So how do we use the blockchain for that preparation to mitigate risks? I would also suggest for your proposed blockchain-enabled disaster management structure, let it

focus more on risk reduction because also when we talk about climate change, we are looking at incidences of adapting more than mitigation.” Participant, 2SC.

Blockchain system for DRR should be designed to **incorporate feedback** from the grass-root levels, where communities input their thoughts about it, based on their requirements.

b) Financial resources and technical skills

Blockchain systems could require high costs to be installed and train staff.

“From the look of things that one needs a more advanced system, and that requires more capital, more money into it to come up with such a system. It's not some that you can say you can do it. You have to get an IT expert to do that.” Participant, 4SN.

c) Scalability

Blockchain should be improved to make it better as the more usage it gets, the latency rates and **scalability** will improve.

“The developers need to be improved it better, better, or something that can be scalable.” Participant, 4SN.

d) Interoperability

BCT should allow for integration with other systems that organisations currently have or are willing to develop. A responder who had done a blockchain pilot project shared this.

“Another issue that came up as a result of the pilot, is to ensure that we have sort of a database to basically look into the vulnerability levels of the community. So, I remember during that blockchain project, we were also developing such a system that categorises the needs of our beneficiaries, and we were hoping that such a system, together with the blockchain and digital IDs, will shorten the times for our disaster response.” Participant, 7SN.

Likewise, blockchain could be more effective if it was **integrated with other systems** like cloud technologies, rather than being used as a stand-alone technology. The decision to integrate the blockchain with other technologies, however, will depend on the value it brings and the nature of the existing systems.

By leveraging pre-existing solutions like Azure, organisations can harness the benefits of BCT without the need for direct implementation, or development.

“Then you realise in as much as we will say we are not going directly for blockchain, the technologies we are utilising, Azure already has blockchain within it, and it's what is helping with logging, just ensuring that we have authorisation and maintenance of our data integrity. But you cannot say maybe a bank will utilise it directly, like I'm just going to the market to buy blockchain, no. It's now where you get technologies, which have already taken advantage of Blockchain. What I'll tell you is this is already in place. Like blockchain adoption is already happening. Yeah, not independently, but it's already happening.” Participant, 27NN.

e) System integrity

BCT should ensure that data integrity and confidentiality is maintained, and that **security controls** are in place to prevent unauthorised access to data.

“Probably now, the issue would be the access to that information as there is information that you wouldn't want everyone to access it. Therefore, there should be provision for that. I would see it as a challenge in exposing beneficiaries' data, if that can be controlled, it would be effective.” Participant, 12LN.

Additionally, security should also be for the **system itself**, by allowing the building of more application layers, to enhance the system security.

“The more people you need to convince to get access to information, the better because it is not very easy to get to have the whole team colluding to do something that is not right. There is some form of security there, the other security that is required is of the system itself. How is it configured? How has it been developed to ensure that you don't have infiltrators getting into the system and stealing people's data.” Participant, 23NG.

“For now, we restrict the data to Ministries, departments and agencies. However, if we are going to brief the (KHPT), the Kenya Humanitarian Partnership Team, then we can give them slightly more data, for control purposes.” Participant, 18NG.

f) Governance issues

The more open the blockchain was, the better the rules governing the decision making, as it would be done in a transparent manner.

“If it's more open, the more transparent it gets. And like I was saying, everything in the world today is going that direction. So even in the rest of the things like coordination and data sharing, can be done through the blockchain.” Participant, 23NG.

HOs should develop guidelines for **data security and governance** of blockchain systems.

“A few questions that can guide you on blockchain requirements, is that who is liable for what? Who are you inviting, and which type of information are they supposed to access? What security measures have you put in place to disseminate information that you have collected from the disaster victims. For how long, or for what period of time, should partners access this information? Decisions have to be made on that, and the blockchain should give provisions for that.” Participant, 12LN.

Another aspect on governance was the **decision to use centralised or decentralised platforms** as a respondent mentioned that it was impossible to decentralise key aspects of DRR due to loss of control, and **having a centralised platform but with decentralised rules** of data sharing in the blockchain would help.

“You see you cannot decentralise some other services, and because if you decentralise it, we will not be servicing together. You can't run a parallel system, that is not centrally, because this is a national issue. If it is drought, the report that would normally be generated at the county level, contributes to the national report.” Participant, 16TG.

Alternatively, going for **public platforms** could ensure more authenticity for transactional operations.

“It's all about computing. How many miners can you have? Because the more the miners, the better the authenticity, and making it false proof. Having a platform with one miner is as well as having no platform at all.” Participant, 20NC.

g) Blockchain Awareness

There is need for more people to **know about the blockchain** and how it works, to enhance its adoption. When creating awareness about the BCT, participants articulated that stakeholders should be taught that the blockchain is not a risk platform, as this will ensure that they advocate for its adoption. A different participant noted that the people who are trading in the bitcoin, are unaware about blockchain, and are trading out of curiosity.

“We need people to understand the blockchain technology system fully. Majority of the people don't understand it. Even me, I vaguely understand it, when you bring the idea about bitcoin, people are surprised and give you a funny look. Not just even those people, even our leaders, as there is not much information that have been shared about the usage of the technology.” Participant, 1SN.

Participants did not refer their systems to be blockchain-enabled, although they acknowledged to be adopting systems with similar principles as the blockchain. The recognition of implicit adoption of blockchain principles implies a potential opportunity for organisations to explore formal adoption of BCT.

“So I would say a lot of organisations or departments are trying to implement something like this blockchain-enabled framework, but they really don't know what it is. Like now here the term is not the blockchain, but if we have a look at our processes, you will find that in a way they are abiding to this.” Participant, 26NG.

h) User acceptance and ownership

Acceptance of the blockchain by its users would enhance its adoption.

“The idea is not just for ensuring that the blockchain systems are running as they should, but also for ensuring buy-in by the people or users of the system.” Participant, 7SN.

User-ownership could contribute to sustainability, and ease blockchain implementation due to the value it brings to HO's.

“They must accept the blockchain as something that can deliver something for them because they keep asking questions to ask you where has it worked? What has been its challenges? So, if you cannot explain that they'll tell you, “No! we don't want this. There must be total ownership of the system, and they should see the need for this system.” Participant, 8JN.

i) Ease of use

Blockchain should be **user-friendly**. Its ease of use may accelerate its adoption, and this can be determined at the design level, by ensuring that users give their feedback about the ease of navigating through it.

“Blockchain has to be user friendly. Should someone get into our system and be able to just navigate smoothly and get what they want, not to get there and then get stuck?” Participant, 23NG.

j) Data reliability and trust

Integrity of data in blockchain systems, particularly regarding the methodologies used for data collection, and validation should be ensured. Blockchain could enhance data reliability and trust through consensus mechanism that confirm data validity before storing it in the blockchain.

“And we also have issues of reliability of the data based on the methodology that has been used in collecting the data. How can the blockchain address this? We must have those rules that govern the kind of data that is there, because if somebody uses the data, maybe from our system and it doesn't work the way they thought it would work. Of course, we need to absolve ourselves because you know, our data is not accurate right now. Because I've said it is data that is collected. So, for instance, if you're telling them, that's the average production in a certain county, this March, that is an estimate. It's not actual. If you are looking for the actual figure in our data, you cannot say they told me this, and it is this.” Participant, 23NG.

k) Upgradability

Blockchain should be adaptable, and upgradeable, to meet the changing requirements and standards of the HSC to remain relevant and effective in an evolving technological landscape.

“Another factor to consider for the blockchain is, you know, these technologies keep on changing so at least something that even if it's changing something that can be upgraded.” Participant, 24NG.

l) Selective immutability

While blockchain technology inherently offers complete immutability for recorded data, participants of this study suggested that it should consider **selective immutability**, which can be achieved through carefully designed protocols, or applications that allow for controlled updates or changes, while maintaining the integrity of the underlying data.

“The first step lets have the original information, if there are any amendments that should happen after that, they should not affect this initial information. We should identify the areas that we want to remain constant and the areas that can be updated. We can identify the measures or the guidelines that should be taken while making the changes to those areas.” Participant, 26NG.

m) Inclusivity

Participants were interested to know if BCT could help organisations integrate community input into decision-making processes, and takes appropriate actions based on the feedback received. Others suggested that there should be SOPs governing its implementation **to reach to the community level**.

“How can the system incorporate the feedback, and the complaint feedback from the community back to this, so that those who are the CSG that are planning for this community, to be able to know that this is not happening, to make the system so accountable.” Participant, 1SN.

7.3.2.1.2 Organisation Requirements.

Under the second theme of the requirements organisations need to fulfil to adopt BCT, the data analysis resulted in the following sub-themes.

a) **Change management**

The focus on **preparedness of the people for technological change** suggests a need for training, education, and skill development to ensure that personnel have the necessary knowledge and capabilities to leverage blockchain effectively, which includes understanding the fundamentals of BCT, its potential applications, and how to implement and manage blockchain-based solutions.

“And now I was thinking... the one of preparedness. We've been talking about preparedness of the people in terms of technology. Yes, it's very important because most of these people we are dealing with are people who stay in the reserve areas and are not skilled on technology.” Participant, 6SC.

More so, there needs to be **change management** that will address any transitional resistance.

“Here, we call it like the theory of change, if we translate the process, where you visualise how the results look like by planning, and it takes a lot of research so that you can make an informed decision.” Participant, 1SN.

Communication during transition is important to ensure complete acceptance of BCT to avoid losing the capital invested.

“If you don't check if people are ready to accept, they might reject it when we make a lot of investments in terms of not only financial resources, in terms of training, in terms of human resources and all that and later on, we discover people don't even want this.” Participant, 2SC.

b) **Training**

Organisations should prioritise **training**, have SOPs governing BCT usage, and create **awareness** about BCT, so that people can understand its capabilities.

“Majority of the people here don't understand it. The awareness is really important for people to appreciate the kind of things that blockchain can do. There is need for such sensitivity. To have that conversation with the people that these are the specific areas that we are targeting the technology to assist.” Participant, 7SN.

The training offered should incorporate theoretical knowledge and practical exercises, such as simulations, to reinforce learning and ensure competency.

“We can talk about so many things like funding, bring money here, do this but after bringing all this, you say you've trained people. Did they conceptualise it? Are they able to internalise? So once that simulation exercise is successful, then you know that now they can do it as they had actually done it.” Participant, 17NG.

c) Collaboration with BCT experts and other HSC stakeholders

The use of IT experts and consultants could help HOs make a good investment decision and facilitate BCT adoption process.

“The biggest challenge we always have as IT people is doing things that seem to solve your problem but do not solve the business problems. So, involving the right people to ensure that you have the right backup is important.” Participant, 27NN.

Under **inter-institutional alignment**, stakeholder participation in BCT adoption by having joint capacity building programmes will enable HOs to align with each other's activities and establish processes, procedures, and mechanisms to solicit, collect, and address feedback effectively.

“You know we need to share your data; we need data from you, and we want to share it in this mode via the blockchain, but now if you build our capacity and they are not aware of it, we are not going to move, they'll say no. It has to be the stakeholders, the people who share the interest that we have to be together, so that now we are starting from the same page.” Participant, 23NG.

d) Leadership

Implementing blockchain in organisations requires **top management support**. Due to blockchain capabilities of enhancing transparency, traceability and accountability, responders reported that it would face lots of resistance, especially from leaders, who like to be in control, but now cannot control transactions within the blockchain.

“If you try to bring a system that will bring sanity to some of these things, obviously expect resistance. That’s why you really need to engage with these people. The leaders, the users of this system so that they agree with you. Yes, this has more benefit for us, yeah.” Participant, 8JN.

Involving top management could **aid in ownership** of blockchain projects, however, managers need to be held accountable during and after the implementation process.

“Of course, bringing in the management, you have to do that. We must be involved otherwise that innovation will belong to someone else, and we are the ones who are implementing, so we must be involved... and when we plan together, we shouldn’t change the plans.” Participant, 19NG.

e) Infrastructure readiness

Assessing factors such as **network capabilities, computing resources, storage capacity**, and security protocols should be done in HOs before implementing BCT.

“Some areas don't even have networks. So, it becomes a problem now when they are adopting technology, we need to ensure that is, and even the infrastructure is in. Other stages for blockchain implementation like piloting and creating awareness, we can do, but not unless we have machines; the laptops or the desktops, then this will be problematic to a successful implementation.” Participant, 6SC.

f) Financial resources

Significant **capital investment** to fund various aspects of the adoption process, which includes acquiring technology platforms, investing in R&D efforts, hiring skilled professionals, and implementing training and education initiatives to build organisational capabilities must be budgeted for.

“From the look of things, blockchain needs a more advanced system, and that requires more capital, more money into it to come up with such a system. It's not something that you can say you can do it. You have to get an IT expert to do that, and it requires money.”

Participant, 4SN.

g) Innovation Culture

Innovation culture included digitisation of processes and conducting M&E to measure performance. **Digitisation of Processes** focuses on the use of digital documents, records and workflows that are necessary for blockchain adoption. The organisation's transition from traditional paper-based processes to digital or electronic systems not only improve efficiency and accessibility but it also creates sustainability of organisation's operations.

“In fact, NDMA is going paperless, more awareness should be made, to improve on the manual processes to digitise them, for other organisations too, to facilitate information sharing on the blockchain.” *Participant, 16TG.*

The need for **Monitoring and Evaluation** is essential for continuous improvement of BCT adoptions by HOs.

“The blockchain pilot we did was essential in providing feedback, and organisations should do the monitoring and evaluation as you progress to get the feedback and improve from the lessons.” *Participant, 7SN.*

Additionally, M&E could aid HOs in making integration decisions. For instance, HOs may integrate BCT with the existing systems to combine the strengths of both systems, while mitigating any limitations of a single system. A **proof of concept (PoC)** is necessary before any migrations can be done to using the blockchain entirely.

“We already have a knowledge-based system, we will evaluate and see, is it better than what we have or is it doing the same thing, or can we integrate the two? But that will depend on the top decision and the availability of funds.” *Participant, 16TG.*

7.3.2.1.3 Environmental Requirements.

a) Policy and regulatory requirements

There is need to update the current policies and laws to accommodate issues of data governance and control in the blockchain.

“The policy framework needs to also be considered. It's very critical especially to avoid maybe people using that data in a wrong way. For that I think some work needs to be put in place.” Participant, 4SN.

Updating laws to accommodate blockchain will require a collaborative, and adaptive approach that balances regulatory objectives, with the potential benefits and risks of BCT. For this to be effective, training of legislatures on BCT is critical, as they will only regulate BCT, if they know how it works and what its benefits and risks are. Other suggestions were to update existing **DRR policies**, or formulate them in counties, where they were entirely missing.

“The world is moving so fast, and things are constantly changing, so laws need to equally change. Like recently, we have seen the issue of the World Coin where Kenyans had their irises scanned voluntarily, for a monetary exchange. We haven't even learnt about what really transpired, and a lot needs to be done.” Participant, 7SN.

a) Government support for innovation

Participants noted that the Kenya is focusing on the digital economy and organisations including the government ministries needed to migrate to this.

“The current setup is on the digital economy and a lot is now going towards ICT, there's need to digitise a lot of the data that we have in the ministry, to ensure inter-institutional alignment, which will require funding from the government.” Participant 19NG.

b) Social and cultural factors

HOs should communicate information related to BCT to the community in a manner that resonates with their values, preferences, and expectations.

“The Community can resist if you will not package your information well. But the moment you package your information well, they usually accept and give the necessary information.” Participant, 14LN.

An assessment model was developed capturing the above thematic areas. Further information from the interviews revealed that participants were concerned about BCT vendors. Therefore, a vendor dimension was added (from the proposed maturity model dimensions in chapter five. See Figure 5.14). The culture was also modified to include societal culture to meet both organisation and community culture and values. The BCT assessment dimensions are shown in **Figure 7.3**, and they include:

1. Strategy – BCT implementation plan
2. Leadership- top management support, change management
3. Governance -Laws, policy limitation, decision-making structures & consensus
4. Social & cultural factors – values from employees and communities; change-user requirement.
5. Technology – infrastructure, tools, skills, digitisation of data
6. Resources – finance, hr, investment, maintenance
7. Vendors- values, expertise, benchmarking cases

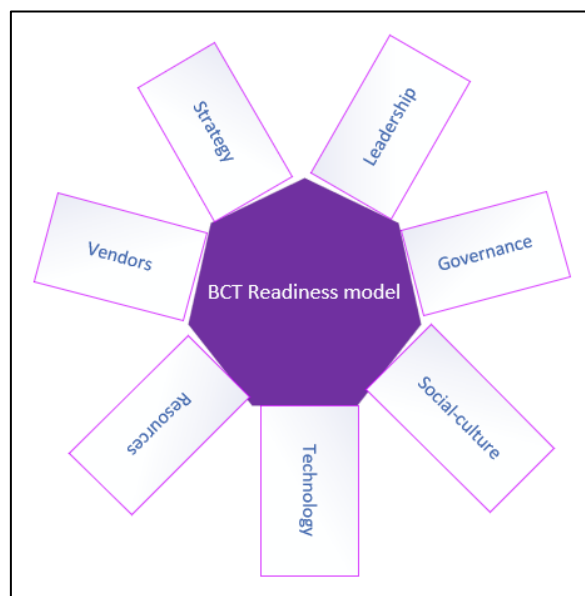


Figure 7. 3: Blockchain assessment model

The assessment model dimensions ranges in five maturity levels from initial to integrating as shown in **Figure 7.4**. Further explanations on the maturity levels in each assessment dimension are shown in **Table 7.2**.

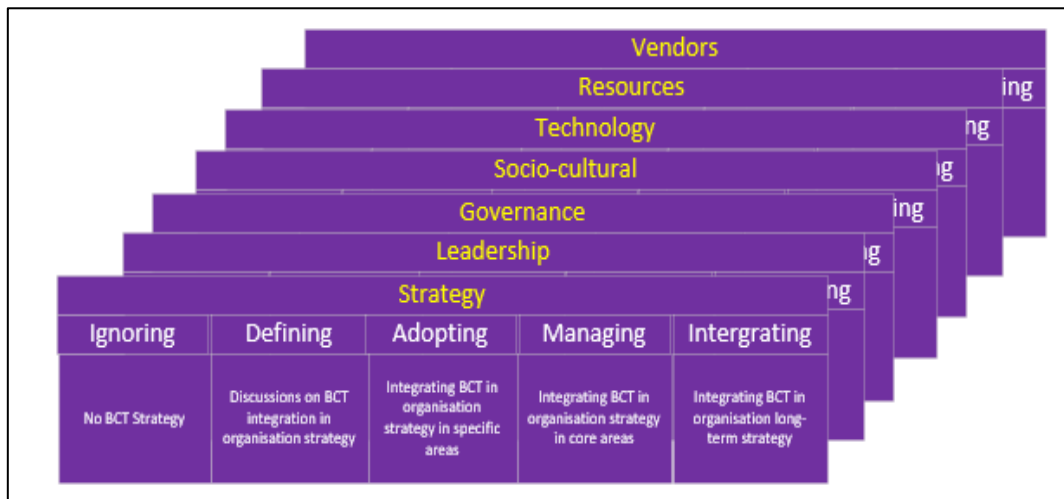


Table 7. 2: Refined maturity levels for BCT implementation in the Kenya HSC

Dimension	Maturity Levels				
	Ignoring	Defining	Adopting	Managing	Integrating
Strategy	No BCT strategy	Discussions on how BCT could be integrated in organisation strategy	Integrating BCT into organisation strategy for specific areas only - testing	Integrating BCT into core parts of organisation strategy	Integrating BCT in organisation's long-term strategy
Leadership	No interest in BCT	Exploration of BCT	Support of BCT pilots & small-scale projects	Driving BCT initiatives fully	Driving strategic use of BCT
Governance	No BCT governance structures	Basic governance discussions with no structures in place	Governance structures for managing pilot projects	Governance structures are fully established	Fully integration of BCT governance structures with broad practices
Sociocultural	No openness to BCT	Acceptance of the idea of BCT, with efforts to build community trust	Supporting BCT experimentation internally, with engagements from community members	Usage of BCT in daily operations, with regular communication from communities	Fully embracing of BCT, with strong trust and respect for social values and encouraging community feedback
Technology	No exploration of BCT architecture & tools	Explorations of BCT architecture & tools	Basic architecture & infrastructure established for experimentation	Well-developed infrastructure and system integration	Full integration of BCT into organisation's infrastructure
Resources	No BCT resource allocation	Allocations for BCT Exploration	Allocations for BCT pilots, small-scale implementation	Allocations for BCT operational use	Long-term allocations for BCT innovation
Vendors	No interaction with BCT vendors	Exploring on BCT vendors and researching those that aligns with organisation's values	Engagements with BCT vendors on small-scale projects, prioritising those with similar humanitarian values	Establishment of formal partnerships with BCT vendors that share similar humanitarian values	Establishment of long-term agreements with BCT vendors, building relationships based on shared humanitarian values

7.4 Design Phase

The objective of the design stage is to develop the BCT architecture model that incorporates key HSC stakeholders. In the design stage, a consortium blockchain platform is recommended to combine the benefits of transparency and confidentiality. HOs stakeholders must establish the design principles such as who interacts with them in the blockchain and what roles they will have. Other consideration includes where the data will be stored. Will it be stored on the cloud or in the blockchain or in both?

7.4.1 Validation of the design of the Blockchain-enabled Architectural Model for Kenya HSC

Validations of the architectural design model was done through expert interviews.

Q: What do you think about the proposed conceptual design of the blockchain-enabled architecture model of the Kenya HSC?

The following suggestions were also provided:

1. Insert arrows from the CSG to other stakeholders like the national and local NGOs.

“The fact that this information has reached the CSG, it has reached all the stakeholders within the county because we are party to this and it's mandatory for all NGOs and CBOs. That means you can just extend some arrows that's going to like point to all of them.” Participant, 1SN.

2. Insert reverse arrows to show incorporation of community feedback into the system.

“You should also get the feedback mechanism from the community because going to have to the Community level. You should give that allowance in the design such that you're able to get the feedback from the community for improvement and for faster response.” Participant, 2SC.

3. Add communities as part of the key stakeholders- not just beneficiaries and don't put them at the very bottom.

“I have a problem as putting the communities down there because they are part of the stakeholders and not necessarily all information that goes to this database is

about them and you see as it is, there is even no feedback to them or anything there.”

Participant, 5SG.

4. Include key ministries that are missing from the design and use ministries instead of departments for simplicity and inclusivity.

“And again, a mention of just a few organisations here would not work very well. Someone who is not Red Cross, who is not UN agencies, who is not Warma or Ministry of Water. A livestock person will ask you, where am I? and they do a lot. Kenya Forest person would ask you where am I? so, you would rather use government agencies, humanitarian organisations, community-based institutions, academic institutions, etc without mentioning names. If it's here, (beginning of the diagram), just say Climate Information Services, don't mention the source. So that everyone will try to find their space in those themes or in those agencies or institutions.” *Participant, 5SG.*

One respondent however articulated that the use of departments was better as using the whole ministry is ambiguous.

“So if you say, like the Ministry of Arid Lands and East African community, if you add it here, it may sound irrelevant because it's only NDMA that deals with disaster. I think it's wise if you adopt the specific department.” *Participant, 26NG.*

5. Remove the name ‘disaster victims’ and call them survivors.

“We don't call them victims. We call them survivors. It's the stigmatising. Imagine someone calling you a HIV victim.” *Participant, 5SG.*

6. Categorise the database in different sections to showcase the different information that is being shared.

“Here in this database, you don't need to like partition it? You see here you just say it's a database. We already talking about climate information, drought information, safety net protection issues, and in my weirdest thinking, you just ought to partition this.” *Participant, 5SG.*

7.4.2 Validated Design of the Blockchain-enabled Architectural Model for the Kenya HSC

Figure 7.5 illustrates the architectural design model for blockchain-enabled HSC of Kenya, which incorporated the above feedback. The current Community Based Validation (CBV) process for beneficiary identification in Kenya is sufficient. Biometrics information on beneficiaries should, however, be added for easy validation. Smart contracts with pre-defined protocols should be made with registration of persons departments for validation. The blockchain-validated identities are maintained in the system with agreed rules on how to share such data with other HSC partners.

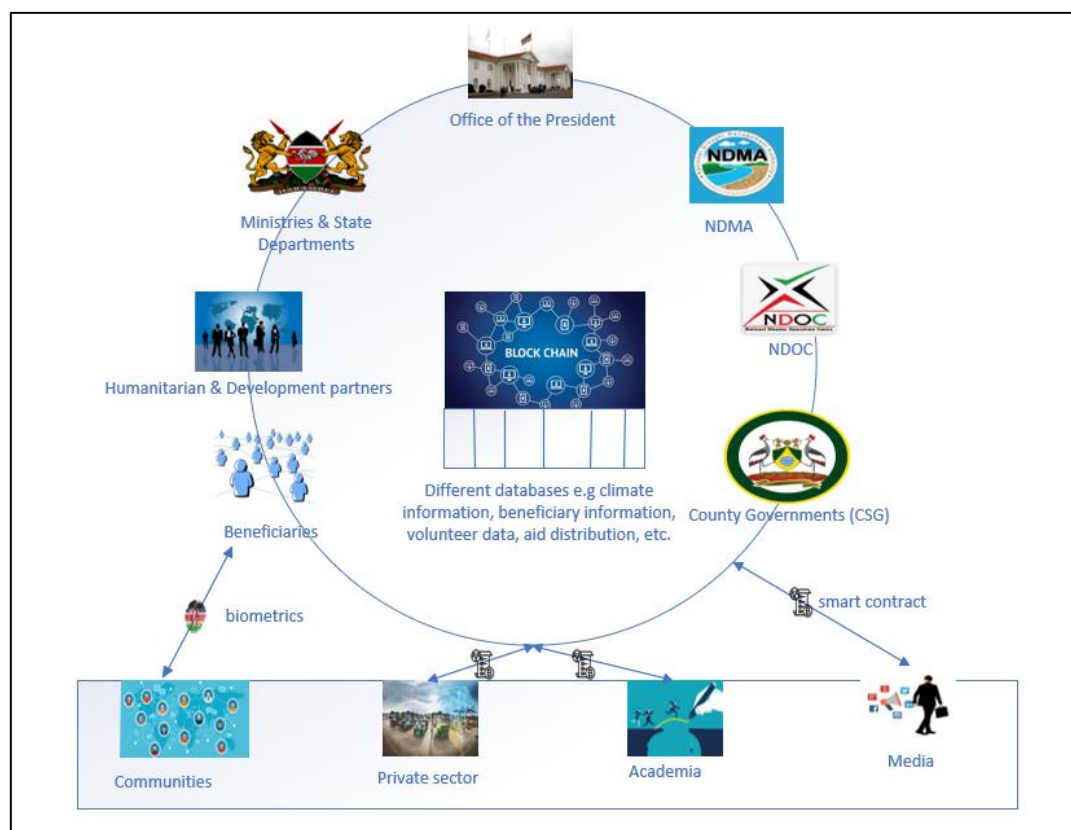


Figure 7. 5: *Validated Design of the Blockchain-enabled architecture model for the Kenya HSC.*

Respondents were also asked about the benefits and potential barriers to adopting this design. The discussions on these are provided in section below.

7.4.3 Potential Benefits of the Blockchain-enabled Architectural Model in Kenya HSC

Q: What benefits could be derived from adopting this blockchain-enabled architectural model in Kenya HSC?

Figure 7.6 shows the identified 11 themes on the benefits of the BCT-enabled design. Most participants cited the benefit of elimination of fraud and corruption, improved coordination and digital identity management. Transcripts for the thematic areas on these benefits are shown in **Appendix XIV**.

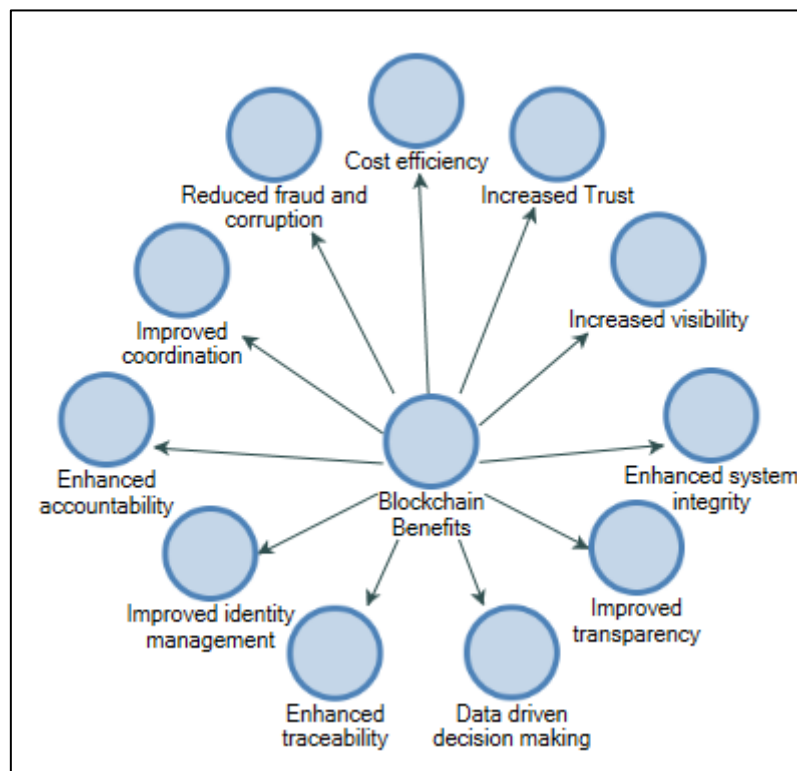


Figure 7. 6: *Benefits of the blockchain-enabled architecture model of Kenya HSC*

7.4.4 Potential Barriers to adopting the Blockchain-enabled Architectural model in Kenya HSC

Q: What are the potential barriers to adopting this blockchain-enabled model in Kenya HSC?

The data analysis on the potential barriers to the adoption of the blockchain-enabled architecture in Kenya resulted in 14 thematic areas as shown in **Figure 7.7**, with lack of technical skills, poor network coverage in marginalised areas and resistance to change being mentioned by most of the respondents. Transcripts for these potential barriers are shown in **Appendix XV**.

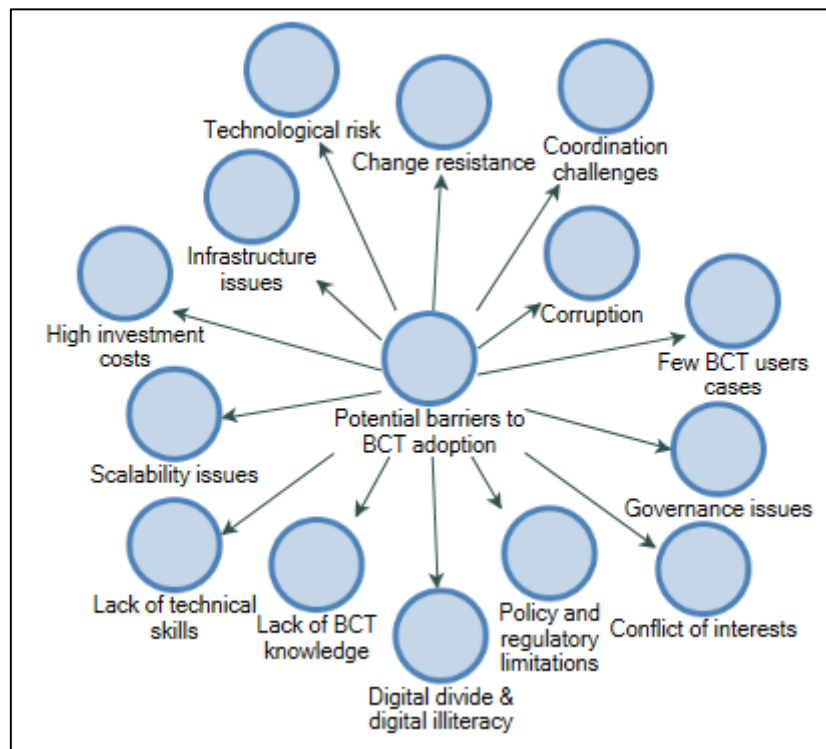


Figure 7. 7: Potential barriers to BCT adoption in Kenya HSC

The researcher categorised the barriers into 5 categories:

- a) *Knowledge and skills barriers*, which included- lack of technical skills, lack of knowledge of the blockchain, and high digital illiteracy levels especially in remote areas.
- b) *Financial and infrastructure barriers*, which included- high investment costs, infrastructure issues, and lack of a good network coverage.
- c) *Practical Implementation barriers*, which included- few BCT user cases for benchmarking, coordination challenges due to trust concerns and resource divide

amongst stakeholders, technological risks like data integrity done for eyeball scans, and scalability issues.

- d) *Regulatory and Governance barriers*, which included- government control as government may reject the decentralised and excessive transparency of the blockchain, law and policy limitation, and corruption that could distort information before it is recorded in the blockchain or lead to unfair governance due to influence of the power of stake in consensus mechanisms.
- e) *Social and cultural barriers*, which included- resistance to change from both employees and the communities.

7.5 Development Phase

The development stage included pilot testing and performance measurement to ensure conformance to requirements.

7.5.1 Pilot Testing

After HSC stakeholders assess their readiness and are ready to adopt the blockchain, organisations need to have pilot projects to build momentum towards BCT. The first step could be identifying a specific use case, such as cash transfer, for the pilot project. The pilot project should involve collaboration with a small group of HSC stakeholders. A set of key performance indicators should be set up in the pilots. When the pilots become successful, employee's attitudes towards BCT could improve.

7.5.2 Performance Measurement & Conformance to Requirements

The pilots help in identifying problems before implementing BCT. If the piloted projects conform to KPI requirements, then HOs can proceed to the next stage of physical implementation. If there is non-conformance, then issues should be checked in the design phase before repeating the pilot.

7.6 Deployment Phase

The deployment stage included the physical implementation of BCT and training of personnel.

7.6.1 Physical Implementation

After successful pilot testing of a specific use case, the objective of this stage is to roll-out BCT physical implementation. Full implementation of BCT may take time and hence a BCT implementation plan, which is adequately funded, will ensure a smooth transition.

7.6.2 Training

In the validated framework, physical implementation and training are done parallel, as it may take time to fully implement BCT across all HO's operations at a go. Some organisations may, however, decide to first implement BCT fully in all areas (system live in the next stage), then train staff.

7.7 Maturity Phase

The maturity phase included full BCT operational system and its maintenance for sustainability

7.7.1 System Live

After implementation and training of personnel, the BCT-enabled system is operational, and HO's will begin to get the full benefits of the blockchain.

7.7.2 Maintenance and Continuous Improvement

The objective of this stage is to continuously improve the blockchain, maintain and upgrade it based on HSC user-requirements and technological advancements. Further trainings on lessons learnt will ensure sustainability of the system.

7.8 Validated Blockchain-enabled Framework for Kenya HSC

From the phases discussed above, the Refined framework with 9 stages is as shown in **Figure**

7.8. These stages are:-

- a) Raising Awareness

- b) Readiness Assessment
- c) Design
- d) Pilot Testing
- e) Performance measurement and conformance to requirements
- f) Physical Implementation
- g) Training
- h) System live
- i) Maintenance and continuous improvement

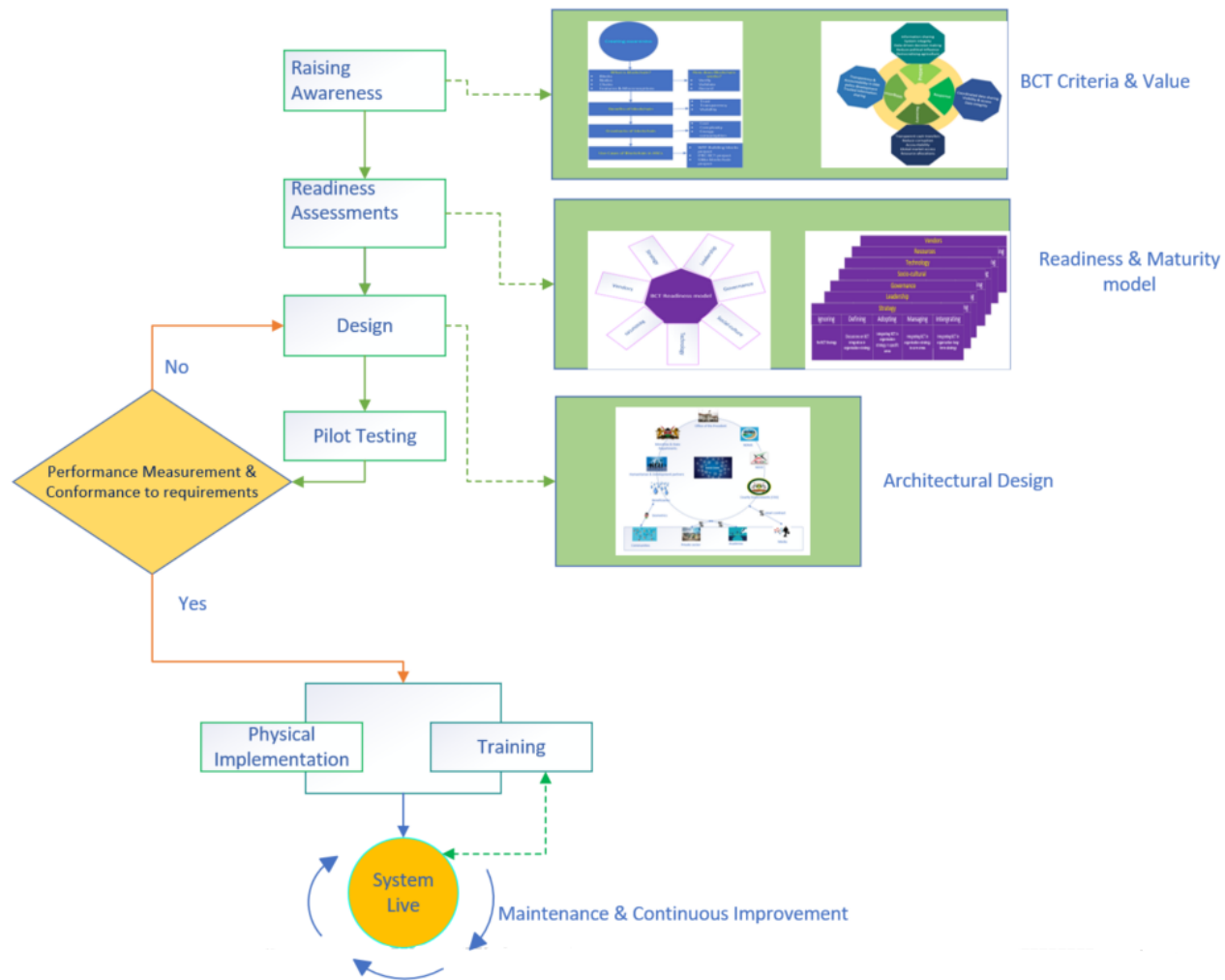


Figure 7. 8: *Validated Blockchain-enabled Framework for Kenya HSC*

7.9 Conclusion

The validated blockchain-enabled framework had nine stages that incorporated stakeholders' views. These stages could guide HOs in blockchain implementation process from the initial phase to full deployment and maturity phase. Raising awareness was identified as the most critical stage for a successful BCT implementation. Stakeholders insisted that BCT systems should improve continuously based on user's feedback. A model on BCT value across the four stages of DRM is provided at the awareness stage for HSC stakeholders to guide stakeholders on the decision for partial or full-scale implementation of the blockchain. A maturity model is provided at the readiness stage for HOs to gauge their readiness to implement BCT. Stakeholders provided their views on the benefits of adopting the BCT-enabled architecture model, where coordination amongst HSC partners and digital identity management would improve. Although the experts were optimistic on BCT potential in transforming Kenya's HSC, potential barriers to its adoption especially lack of infrastructural readiness coupled with low funding issues could stall its immediate implementation.

For HOs to accept the blockchain, its developers need to have similar values with HOs and offer customisable design that fits humanitarian needs like having selective access control features, to protect identities of the vulnerable. Organisations need good vendor partnerships to guide in BCT implementation. Regulatory support through laws and policies is required by the government to encourage more BCT adoption in Kenya HSC. Donor support is also required for financing blockchain projects. While donor support is paramount, ensuring that local needs are integrated in BCT implementation strategies should be done, to ensure that the innovation programs are not solely aligned to donors' priorities.

CHAPTER EIGHT

SUMMARY AND DISCUSSIONS ON THE FINDINGS

8.0 Introduction

This Chapter involved the integration and interpretation of the Quantitative and the subsequent Qualitative results presented in the previous chapters. The discussions were done in line with the research objectives. Objective one, which was “to conduct a comprehensive literature review to assess the research landscape, challenges and opportunities for blockchain technology applications in humanitarian supply chains” has been left out in this chapter, as it was discussed comprehensively in chapter two.

8.1 Objective 2 Summary

Objective 2: To assess the current structure of the humanitarian disaster risk management in Kenya and evaluate its effectiveness in reducing disaster risks (RQ2).

A multi-method approach was used to meet this objective. A document analysis on Kenya’s DRR and interviews were used. There is no single body that coordinates all disasters in Kenya, despite there being a pending DRM Bill, that recommends the formation of one. Droughts are coordinated by NDMA, while floods and other emergencies are coordinated by NDOC. This structure implies a need for a centralised body to coordinate all disasters to avoid duplication of efforts amongst government agencies. The interviews validated secondary data on Kenya’s DRM structure (Republic of Kenya, 2010; Menya and K’Akumu, 2016; Nyandiko, 2020). The results of the coordination mechanisms used in DRR in Kenya indicates a commitment of the actors to work together at the county and national level, while relying on each other’s resources. Leveraging on technology, especially mobile applications like WhatsApp, for easy communication and information sharing, enhanced Kenya’s HOs response efforts. From the

DRR activities conducted in all the four disaster phases, the common activities in each phase were information sharing and communication, and coordination. The similarity of these functions across all phases, indicates their critical role in ensuring efficiency in DRM. Investing in tools that would enhance information sharing and coordination (Jahre & Jensen, 2010) could improve Kenya's HSC operations significantly.

There is a structured process in registering and categorising beneficiaries in the Kenya HSC, and application of security control protocols in their systems for data security. The structured registration process ensures that beneficiaries are validated by the communities through a community-based validation (CBV) exercise. Conducting a CBV implies that there is a fair system in place that is transparent for ensuring an equitable resource distribution. It also instils trust in the system. Additionally, this process ensures that no vulnerable person is left behind, and this contributes to the inclusivity of DRR. The conditional and unconditional cash transfers, which targets the average and most needy beneficiaries respectively, provide a safety net to people based on their needs. Continuous monitoring and impact evaluations are conducted every 5 years to re-categorise and re-validate the groups, which represents an adaptive system. Security control protocols indicate a system that protects beneficiary data, while ensuring approvals before data can be changed indicate a system that maintains data integrity.

While the above beneficiary identification and security control measures are satisfactory, the approvals create delays, and replacing these with smart contracts could reduce the delays substantially. Additionally, the requirements of having bank accounts to get the cash transfers may limit the reach to vulnerable populations who are unbanked, or refugees. Having a digital identity and securing this information in the blockchain could ensure wider reach and enhanced data security (Kaur et al., 2021). In case of any grievances in the CBV process, there is a case management file filled from the chief levels (village) to sub-county level, which is then acted

upon at the national level. The case management process is not automated. Having an automated dispute resolution system with smart contracts activation, could significantly reduce approval delays and bureaucracies (Kshetri, 2018).

Despite the above trends in improving DRR, Kenya HSC is faced by numerous challenges ranging from information sharing challenges, coordination, and resource mismanagement. Most of these challenges in Kenya HSCs were consistent with those found in the literature (Drummond & Crawford, 2014; Development Initiatives & DFID, 2017; Nyandiko, 2020; Mbiyozo & Owino, 2024). The challenges that were missed in these literatures were lack of consideration of cultural and ethical issues during data collection; Lack of project ownership by communities; Lack of technologically driven data especially in remote ASAL counties; Lack of trust amongst stakeholders; Donor's conditions for funding like ownership of a mobile phone to receive aid; Technological challenges on the difficulty to keep-up with evolving technologies; and political ownership of development programs to lure communities during elections. Offering solutions that incorporate blockchain technology for enhanced trust, accountability, transparency and visibility (Kshetri, 2018; Pournader et al., 2020; Sahebi et al., 2020), could lead to better management of beneficiary data, better collaborations and enhanced DRR response in Kenya.

8.2 Objective 3 Summary

Objective 3: To determine the feasibility of blockchain technology in the Kenya humanitarian supply chain and evaluate differences in how stakeholders perceive the factors influencing their readiness to adopt it (RQ2 & 3).

A mixed-method approach was used to meet this objective. A questionnaire survey and interviews were undertaken. Results from the feasibility study, in the quantitative survey, cements the need for BCT solutions in the Kenya HSC. The high mean scores in lack of

community participation in decision-making, indicates a need for a more inclusive system, and the blockchain's decentralised capabilities will be beneficial. Other issues such as lack of trust and transparency in disaster aid supplies, could be addressed by blockchain's immutability and transparency features. (Baharmand et al., 2021; Dubey et al., 2020; Ozdemir et al., 2021). The EFA results were validated by the interviews, and they indicated BCT's role in achieving operational transparency, collaborative privacy, and system integrity issues within the Kenya HSC.

Interesting perspectives arose from participants, when asked on whether the blockchain could work for the Kenya HSC. Majority believed that the technology was much needed and could work. A few participants, however, gave mixed reactions that were both a yes and a no. The yes was in support for BCT's role in solving specific challenges of coordination, transparency, and data security. The no was indicated by their notions that other technologies that are cheaper, could be used to get the security benefits offered by the blockchain. Another reason for the no was because each party was responsible for updating their own data, in cases where they had a shared database, and partners trusted information they received from each other, thus did not see the need for the blockchain. These mixed reactions implies that while blockchain is recognised for its superior features, it may not be considered essential by some HOs, who might feel that their existing technologies are meeting their business needs. Other implications include the importance of assessing the value that BCT could bring to justify the high investment decision in its implementation (Kumar & Barua, 2023).

The national and county governments both showed interest in the blockchain, by indicating that they are currently exploring it, and this exploration implies an opportunity for blockchain usage not only in HSCs, but also in other public sector services like land registry. If capacity building is done effectively, it could enhance regulatory reform, which could be the driver in championing for blockchain solutions for public sector governance (Chittipaka et al., 2023).

The high citation on the lack of interests by local NGOs to adopt BCT indicate a disconnection between its potential, and the organisation needs or capacity. This could be due to less resources, which may prioritise the organisation's operational needs rather than strategic innovation needs. Interviews presented similar results, as development partners and the UN agency participants had more awareness about the blockchain and little to no awareness was in local NGOs and county governments.

For organisations that had already adopted or piloted for the prototype of blockchain, BCT was giving assurance to communities about their resources, and was enhancing traceability, and time savings during cash transfers. However, it was hindered by inadequate regulations, and vendors shortages. Participants adopting the blockchain used Ethereum and Azure. These participants noted that the Bitcoin is slower, and more suitable for transactions, rather than asset management, which requires smart contracts. The use of blockchain via Azure implies the unnoticed adoption of blockchain, which could be more widespread than perceived, as it could be embedded in cloud services, to enhance data integrity. This usage also indicates a knowledge gap on BCT awareness, as this subtle interweaving of BCT with third party infrastructure means that users get its benefits, without having to seek it out directly, or knowing about its presence.

Top management support factors like leadership are more critical in influencing new technology adoption in Kenya, compared to organisation readiness and external support factors. Leadership represents internal capabilities of a firm, which is conducive for technological change, despite external challenges like a lack of government support (Legesse et al., 2024). Where it was surprising that resources were rated low in the surveys, donor support, which was ranked high could be an important source of funding for innovation within the Kenya HSC. The interviews validated that simply having resources, may not guarantee the blockchain's success, if leadership and innovative culture are missing within HO's. Issues

around top management turnover was reported in the interviews, which could have a negative impact on BCT adoption, and having innovation champions could be useful, to ensure commitment to innovation goals (Kajla et al., 2024).

Donors were reported to support many innovation aspects like buying the required infrastructure and offering training on the same. This support enhances the internal capabilities of the organisation, thus influencing technology adoption positively. However, there was an uneven awareness of donor support amongst interview participants, which implied an internal communication gap. There were also inconsistencies in the donor funding for ICT projects. Continuous funding portrays a sustainable approach to maintaining ICT programs, but could also create dependency on donor funds, which limits the organisation's ability to innovate independently (Olaogbebikan & Oloruntoba, 2019). The one-off funding from donors is, however, unsustainable and could lead to stalled ICT projects.

In the interviews, the culture to technological uptake was said to be good, just as indicated in the surveys, and this implies that there may be a high acceptance of new technologies (Kabra et al., 2017), by Kenya HSC actors, which is a positive outlook for the blockchain. The lack of awareness of an ICT strategy or its contents, and subsequent delays in its development due to top-bottom directives, portrays a missed opportunity to explore cutting-edge technologies like the blockchain to leverage on HO's capabilities. Some ministries had strategic plans for digitisation, which is good, but others did not, and these inconsistencies make coordination ineffective. Additionally, descriptions of ICT departments as "moderately equipped" indicate an infrastructure limitation that may limit HO's ability to invest in blockchain.

Compatibility factors were perceived to be the most critical drivers to BCT adoption, particularly corporate values and interface compatibility that include compatibility with the firm data formats and processes. These results coincide with that of (Legesse et al., 2024) who

found that compatibility of BCT with the organisations current infrastructure, could greatly influence its adoption. Regulatory factors were rated highly, after compatibility factors. Participants stated that laws on data privacy will safeguard information shared in the blockchain, and guide on the rules that enable stakeholders to determine who has access to data, and for how long, and for what purpose the shared data can be used. Participants with no BCT knowledge questioned about who controls the servers in BCT networks, and this indicates concerns on the control and policing of blockchain networks in Kenya HSC. Although complexity factors had a lower ranking compared to regulatory factors, there was a high perception that BCT requires a lot of mental effort, which is as a significant obstacle in its adoption. Boakye et al., (2024) empirical research found complexity to be a significant barrier in BCT adoption, and they suggested that increasing awareness of the blockchain could overcome it.

8.3 Objective 4 Summary

Objective 4: To develop the Blockchain-enabled Framework (RQ3).

The development of the Blockchain-enabled Framework was conducted through literature exploration of industry 4.0 implementation frameworks and blockchain models, and insights from quantitative data analysis. There were no blockchain implementation frameworks in HSCs found in the literature at the time of developing it in this research. Therefore, a benchmark from Blockchain adoption models (Wang et al., 2016; KPMG, 2018) and Industry 4.0 Implementation Framework (Jena & Patel, 2023) was conducted. Industry 4.0 includes disruptive technologies like BCT and considering its implementation framework provide valuable insights for innovation due to its emphasis on meeting the dynamic needs of the digital economy (Singh et al., 2024).

Wang et al. (2016) blockchain adoption model for any industry consisted of three stages of conducting a feasibility study, development of the BCT, and Operation of BCT. This model gave an important foundation for conducting a feasibility study for BCT in Kenya HSC to evaluate the current challenges faced by humanitarian partners that could be solved by the blockchain. The feasibility study from the quantitative phase formed part of the first building block of the blockchain-enabled framework. The proposed framework also included an awareness phase, in cases where HOs had conducted a feasibility study and were already in the process of adopting the blockchain or had already adopted the blockchain. This stage was missing from (Wang et al., 2016) model. Wang et al. (2016) BCT model was also missing the performance measurement stage, and this was included in the proposed blockchain-enabled framework as HOs need to set key performance indicators for BCT implementation and measure its performance over time to ensure sustainability of the system.

Following the insights of the quantitative data phase on the factors that key stakeholders found important in influencing technology adoption in Kenya HSC, there was a significant difference on how stakeholders viewed organisational and environmental factors, with top management support being found critical. These insights formed the building blocks of 'Critical dimensions for blockchain acceptance/readiness assessment' which was the third phase of the proposed blockchain-enabled framework. In (Wang et al., 2016) model, on the second stage of BCT development, the authors recommended the use of maturity models in assessing readiness for BCT adoption.

The industry 4.0 Implementation Framework by (Jena & Patel, 2023) consisted of six stages of strategy development, design and development, transformation, monitor and control, implementation and operation, and management, planning and organisation. This framework guided the design phase of the proposed blockchain-enabled framework, as it was deemed important for HSC stakeholders to view a concept of how they would interact with the

blockchain if it was to be implemented in their organisations. This stage was critical in defining which stakeholder did what and it helped in determining the most suitable blockchain platform to use. Different use cases of the blockchain were given under this stage, for instance, a conceptual map on how stakeholders would coordinate and send relief items, and cash, and store information in the blockchain. Jena and Patel (2023) framework coupled with the quantitative data analysis gave insights to the ‘implementation’ phase of the proposed blockchain-enabled framework. From the survey, questions like ‘do you think your organisation will implement the blockchain in the near future’ received diverse views. Interestingly, participants who had good knowledge of the blockchain and had not implemented it in the organisations, disagreed with the statement stating that their organisation would not implement the blockchain in the near future. Using abductive reasoning, one plausible explanation is about organisational system inefficiencies, and the need for meeting certain requirements before these organisations could successfully implement the blockchain. This led to asking of the question on the requirements needed to implement the blockchain successfully, during the interviews. Therefore, the final proposed blockchain-enabled framework consisted of five phases from feasibility study/awareness to performance measurement.

8.4 Objective 5 Summary

Objective 5: To validate the blockchain-enabled framework through an interview, and refine the framework based on the feedback (RQ3).

Validation of the framework was done via interviews. The implications of the validations of the Blockchain-enabled Framework for the Kenya HSC are numerous. First, focusing on awareness stage could promote collaboration in understanding of the blockchain and reduce resistance to implement it by the stakeholders (Boakye et al., 2024). BCT knowledge barriers, could impede its adoption as people are unlikely to advocate, or adopt an innovation they barely know about (Sahebi et al., 2020). Piloting could also mitigate risks that could be costly before

full-scale implementation (Izadi et al., 2023). Conformance to predefined requirements and incorporation of feedback loops, ensures that errors can be detected and solved early, thus saving costs before the actual implementation. The recommendation of feedback loops also indicates that the blockchain system should evolve based on user experiences, and stakeholders needs, to make it culturally and contextually inclusive, and this adaptivity ensures that the BCT system remains relevant over time. The lack of specialised skills may make HOs struggle to adopt blockchain and stakeholder's recommendations on training, promotes technical skills and preparedness to use the system (Chittipaka et al., 2023). Leung et al., (2024) supports that BCT should be taught through a constructivist and pragmatism approach, of using group discussions and simulations, respectively.

Despite the benefits that could be derived from the implementation of the blockchain-enabled architectural design model, such as improving transparency, accountability and reducing fraud and corruption, BCT implementation in Kenya could be faced by significant financial, infrastructure and cultural barriers. A multi-strategy means of tackling these barriers to smoothen BCT implementation and get its full benefits is required (Patil et al., 2021). For a successful implementation of blockchain in Kenya HO's, blockchain vendors should have similar values with HOs to ensure that BCT systems do not violate human rights and lead to exploitation. Baharmand et al. (2021b) empirical research advocates for designing humanitarian blockchain projects that are consistent with humanitarian principles of humanity, neutrality, impartiality and independence.

BCT design should also integrate climate adaptation elements and focus more on DRR issues such as integrating BCT with early warning systems and construction of resilient flood-based or drought-based infrastructure like dams for improved accountability. Moreover, humanitarian blockchain projects should be designed to incorporate grass root community feedback for inclusive decision making. From an organisation perspective, there should be a

tangible value for BCT implementation, based on the problems that it will solve in, rather than just implementing it due to its hyped features. Collaborations of HOs with external expertise is also needed to enhance knowledge and skills transfer, which could attract infrastructural funding for BCT adoption.

8.5 Conclusion

BCT has great potential for transforming the humanitarian sector in Kenya and creating awareness about its potential to HSC stakeholders is critical for its widescale acceptance and possible adoption. Blockchain should be adaptable and upgradable to meet changing humanitarian needs, and the evolving nature of blockchain standards. Despite the promises that blockchain brings in the humanitarian world, more focus on improving the quality of data entered in the BCT system is required, to ensure that it's corrupt and error free. The current system of validating beneficiaries through CBV is satisfactory and could be the starting point of integrating the collected data in the blockchain for enhanced security.

CHAPTER NINE

CONCLUSIONS, RECOMMENDATIONS, CONTRIBUTIONS TO KNOWLEDGE, LIMITATIONS AND FURTHER AREAS OF STUDY

9.0 Introduction

This chapter provided a conclusion based on the evidence collected from the research and subsequently provided recommendations for the Kenya HSC, with implications for the humanitarian sector. An outline of notable contributions of this research are discussed, followed by an acknowledgement of research limitations, and a highlight of further areas of study.

9.1 Conclusions

In conclusion, BCT has great potential for transforming the humanitarian sector as noted by the SLR. Despite its recognised benefits, the practical implementation of BCT in HSCs is limited. Moreover, HOs lack a contextualised practical guide for BCT implementation, largely due to the social and cultural challenges they face in different environments. This thesis aimed at identifying the critical challenges facing the Kenya HSC, which could be addressed by the blockchain, and developing a Blockchain-enabled Framework, which could potentially act as a roadmap to guide the Kenya HSC stakeholders on BCT implementation process. BCT promises to significantly reduce the challenges of operational transparency, collaborative privacy, and system integrity issues within the Kenya HSC, ultimately strengthening the country's disaster resilience and providing a pathway to an accountable and sustainable HSC system.

The research adopted a mixed-method approach, specifically the explanatory sequential design, which starts with a quantitative phase, followed by a qualitative phase. Majority of Kenya HSC

stakeholders had little or no knowledge about BCT, which makes awareness a critical phase for wide-scale adoption of the blockchain. The findings also highlighted a mixed landscape of blockchain awareness across different types of organisations, with development partners being more knowledgeable, and having conducted pilots or adopted the blockchain. There was limited and no BCT awareness amongst the government officials, particularly the county government, and local NGOs, which signifies that more education on BCT should be targeted to these areas. The government officials, especially at the national level, claimed to be searching for BCT information actively, as compared to local NGO's, which shows an opportunity for BCT awareness that could possibly lead to its adoption at the national government level.

Leadership, collaboration with external experts, innovation culture and awareness, and donor support are CSFs when considering the adoption of new technologies (and by extension, BCT) in Kenya. Surprisingly, factors such as organisation resources and government support through regulations and funding, were ranked low, which could be explained by the findings that donors funded most of their ICT innovation from setting up infrastructure to training of staff. There was a lack of awareness of the risks of new technologies, which suggests an optimism bias that focuses only on the benefits of an innovation, neglecting its risks. Having a detailed risk mitigation plans for innovation, with adequate budget allocations to support its implementation is required by HSCs.

Respondents who had good and excellent knowledge of the blockchain perceived the importance of compatibility, complexity and regulatory support differently, when evaluating how these variables could influence BCT adoption in Kenya. Compatibility factors were perceived to be the most critical, and hence, HOs should have standardised protocols for easy interoperability of BCT with existing systems. Complexity issues, in that BCT requires much mental effort, was perceived to be the most problematic, thereby suggesting that reducing BCT

complexity, would enhance its adoption in the humanitarian sector. These outcomes suggest the need for considerations on user experience, privacy and security, and interoperability in the design of HSC BCT projects.

The final validated framework consisted of five phases from initial planning to the maturity phase. The final validated blockchain-enabled architecture, incorporated diverse stakeholders, as recommended by the participants, which promotes inclusivity in DRM as recommended by Sendai Global Framework for DRR. Majority of respondents in the Kenya HSCs could recommend BCT usage in Kenya HSC, which indicates a recognition of BCT benefits in HSCs. Most of those who had not adopted BCT, were unsure of whether their organisation could adopt the blockchain immediately, particularly due to a lack of knowledge about it, financial and infrastructural barriers. Respondents were worried about BCT's privacy and security due to association with fraudulent activities like Silk Road, and thus stronger regulations and compliance to ethical standards in BCT usage is required.

Blockchain is needed to solve operational challenges of the Kenya HSC, as the country continues to grapple with recurring humanitarian crises. Its implementation should, however, be done carefully and ethically, and not from the perspective of implementing it due to its hyped features, but from a strategic perspective that considers the cost and benefit analysis derived from adopting it. Cooperation between blockchain designers and developers, and HSC stakeholders is required to develop customisable designs that are user friendly. HSC partners need to address the barriers to BCT adoption. For instance, they should facilitate data availability by showing willingness to share data in the blockchain, and doing so with only approved persons, to enhance data privacy and security. Finally, the three-dimensional requirements of technological, organisational and environmental factors are the critical missing links to a successful BCT adoption in the Kenya HSC.

To date, there is a lack of systematic research on the drivers, benefits and barriers to BCT adoption in the Kenya HSC. This research has successfully contributed to this and developed a framework that guides on BCT implementation, while denoting the areas where blockchain could provide the greatest value in managing disasters in Kenya. Future studies should focus on validating this framework in other countries to enhance the generalisation of results in HSCs.

9.2 Recommendations

Following the insights from the surveys and interviews, the study recommends that stakeholders within the Kenya HSC leverage BCT capabilities to solve specific challenges of trust, coordination, transparency, accountability, and beneficiary identity management inherent in the humanitarian sector (Links to awareness stage of the BCT-enabled framework). HOs should, however, conduct a cost-benefit assessment to verify whether their existing systems are adequate in solving some issues such as security and transparency, without the need for investing in the blockchain. Where their existing systems provide some features such as security, but not other desirable features like transparency that enhances trust, they could consider hybrid solutions where the traditional systems are integrated with blockchain features such as smart contracts to have both costs and efficiency benefits (design and physical implementation stages).

The Kenyan government should give priority to DRR issues like the national DRM Bill and policy with clear provisions for ICT innovation to guide HSC stakeholders, particularly government agencies on developing interim and localised ICT strategies to meet their needs. Collaboration between government agencies is needed, both at the national and county levels, with the provision of resources and capacity building to help bridge the digital divide gap between them and improve ICT readiness in government. A centralised DRM body like the proposed NADIMA, should be established to ensure effective coordination of DRR in the

country, and ensure that national policies and DRM laws incorporate blockchain usage. This will ensure they offer oversight on blockchain ethical use in DRR to ensure alignment and compliance.

The uneven awareness of the blockchain calls for blockchain developers to tailor strategies for different knowledge groups, like continuously meeting the needs of those with good knowledge and the early adopters, while at the same time educating those with little or no knowledge and the late adopters. Education and awareness campaigns should be done to introduce blockchain to key humanitarian stakeholders. Targeted awareness amongst stakeholders such as local NGOs, the national and county government is needed to be at par with development partners. Cross-sectoral collaborations with development partners could help in enhancing this awareness and should be cultivated to share best practices. Additionally, due to financial hurdles and the nature of the non-profit making model of HOs, developing low-cost, customisable and user-friendly blockchain applications could widen its adoption in HSCs (awareness stage). Blockchain developers should also focus on designing flexible vendor BCT architecture, which does not depend on a specific vendor. This will give HOs the flexibility to switch between different vendors, without vendor-lock in, or integrating with tools and software from different vendors. This flexibility also means that during the maintenance and upgrade of the blockchain, each part can be replaced or upgraded separately without affecting the whole system (design stage).

HOs should improve on internal communication and ensure transparency on donor funds allocations and disbursements to strategic areas like those of ICT, as some participants were un-aware of donor funding on ICT programs. To ensure a sustainable way of funding ICT projects such as BCT adoption, it is important that HSC stakeholders allocate sufficient budgets towards funding and maintaining ICT infrastructure. This way, technology is prioritised strategically in achieving DRR long-term goals. Due to the reported high turnover of

leadership, HOs should put in mechanisms that drive innovation even in the absence of active leadership, like developing long-term technological advancements roadmaps, with dedicated teams to maintain the momentum for innovation initiatives. HOs need to upskill their ICT staff in specialised technical skills such as software engineering and cyber security, to shift their focus from providing operational solutions only to developing innovative solutions. To bridge the technology generation gap, HOs should focus on the development of age inclusive training methods, to minimise blockchain complexity fear and ensure buy-in across all generations (readiness assessments, training, maintenance, and continuous improvement stages).

9.3 Contributions of the Thesis

The contributions of this research are multi-faceted, as explained in the following points: -

1. The SLR reveals a wide range of gaps in BCT application in the humanitarian sector. The results of the SLR were published, and to the best of the researcher's knowledge, it was the second SLR done on the subject after (Hunt et al., 2022), and the SLR was unique in that it provided the humanitarian cases applying blockchain as pilot projects or full-scale implementation. The SLR also provided an overview of the theoretical frameworks that drive explanations of the blockchain. Another notable contribution from the SLR is the recommendation of the know your beneficiary (KYB) feature for the blockchain in HSCs.
2. The study adopted a mixed method approach, particularly, an explanatory sequential design, which is lacking in BCT studies in HSCs. This is an addition to the limited mixed methods research in BCT studies in general and in the humanitarian sector.
3. To the best of the researcher's knowledge, this study is among the first in the literature to conduct a feasibility study for the blockchain in HSC, through a survey, and explore blockchain awareness amongst HSCs. Most studies that have adopted a questionnaire

aimed at evaluating factors that influence BCT adoption in HSCs, which this research has also added to, using a case study from a different context, as what has been studied.

4. To the best of the researcher's knowledge, this study is also among the first to use EFA in extracting feasibility items that can be grouped together for further exploration. These items form a foundation that other researchers can use to conduct a CFA in future studies.
5. While there are high hopes from the first evidence from IFRC and KRCS, of the potential of BCT in the Kenya HSC, to date, there is a lack of a systematic research on the drivers, benefits and barriers to BCT adoption in the Kenya HSC. There also lacks studies on models or frameworks that could guide in BCT implementation, and the design implications of these blockchain frameworks. This research has successfully contributed to that by not only developing the framework that guides the step-by-step method of implementing the blockchain but also discussing the implications of these designs in a humanitarian context and developing sub-sequent models and use cases to showcase the value proposition of the blockchain, to the Kenya HSC stakeholders.
6. The formulation of the blockchain-enabled architectural model and its improvement through Kenya HSC stakeholders feedback, reflect a shift to designing humanitarian blockchain projects that are decentralised, inclusive and feedback driven, thus promoting humanitarian principles and ethics.
7. The research contributes to the development of an assessment and maturity model and refining the dimensions from interview insights. The maturity model shows the requirements HOs need to look out for, organised into 5 maturity levels that are clearly explained to help HOs gauge themselves to evaluate their readiness to adopt BCT successfully.

8. The validated Blockchain-enabled Framework by the key stakeholders of Kenya HSC shows an improved framework based on their feedback, which is scalable across other countries' areas, such as BCT usage in land registry. The framework could also serve for other countries or regions facing similar humanitarian challenges. The Blockchain-enabled Framework for the Kenya HSC offers a transformative potential for enhancing trust, coordination, transparency, accountability and adaptation of humanitarian operations, and the building blocks ensure that the process is inclusive, driven by data and that it addresses local needs, making it a sustainable system for DRR in Kenya. This framework provides a foundation for Blockchain-enabled Frameworks in HSC literature, that is severely lacking.
9. The BCT exploration in Kenya identified the unnoticed adoption of blockchain, which could be more widespread than perceived, as it could be embedded in cloud services such as Microsoft Azure to enhance data integrity. It also indicates a knowledge gap in its awareness amongst humanitarian stakeholders, as this subtle interwoven with third party infrastructure means that users benefit without having to seek it out or knowing about its presence. This finding opens, a narrative discussion about BCT awareness, which requires further exploration.
10. A notable contribution is also the use of the TOE theory, not only in identifying the factors of BCT adoption in HSCs, but also in assessing the requirements that HSCs need to adopt blockchain. To address the potential barriers in implementing blockchain, the study analysed the requirements from the theoretical perspectives of the TOE model.
11. As new explorations on BCT applications in HSC continue to emerge, most studies focus on stand-alone HOs like WFP. This study's contribution is that of using an ecosystem perspective- including NGOs, development partners, county and national

governments, and the private sector, and this diversified perspective offers a robust solution to solving the complexities involved in HSCs, as the findings of this study imply the coordination of efforts from the value system actors are needed, to reap maximum benefits from BCT.

9.4 Limitations and Further Areas of Study

The Blockchain-enabled Framework was validated by stakeholders from the Kenya HSC. Due to this boundary limitation, future studies for different countries can seek to conduct validation surveys and interviews, using the same building blocks of the BCT framework to uncover any differences in the configurations that will be proposed. Additionally, more BCT studies are required in Kenya to increase the internal validity of these results. An extension of the validation of the Blockchain-enabled Framework in Kenya could be done in future studies to include other groups such as CBOs, FBOs and beneficiaries to get their views on the BCT framework and architecture model.

Although a maturity model was developed by the researcher, and further modified using insights from interviews, it was not explicitly validated like the blockchain-enabled framework and the blockchain-enabled architecture model. Future studies could validate or advance this maturity model by following these dimensions to assess the levels at which HSC stakeholders are and gauge their readiness for blockchain.

Although this study adopted a mixed-methods approach, validating the framework involved interviews only, and future studies may advance the validation by using questionnaire surveys too. Additionally, the final responses from the questionnaire survey of those respondents with good and excellent knowledge of the blockchain were less, which can be explained by the novelty of the blockchain and the case study boundary of location and industry – Kenya HSCs, therefore, the findings of this study should be taken with caution as they are not generalisable

to all HSCs and other industries, and further blockchain evidence-cases are required in different geographical locations and industries.

Challenges identified in this research were the low number of BCT experts. Interviews from some of the recommended persons (through snowballing), in HOs that were using BCT like UN WFP, did not happen, as the participants were unavailable each time they gave the researcher an interview appointment. The UN office in Nairobi was very difficult to access due to security concerns, and the researcher wrote them a letter, requesting for interviews, and dropped it physically, and sent a copy via email, but they did not reply. The KRCS HQ was also adamant in allowing me access to the innovation department despite meeting all the requirements that they asked me to do, like writing emails and letters to the CEO. I was however, privileged to interview KRCS participants in the counties.

Further areas of study based on the evidence provided in this research are: -

1. Exploration of the benefits and drawbacks of using BCT in third-party and cloud computing infrastructure such as Microsoft Azure.
2. Exploration of the legal challenges facing IPRs in the blockchain.
3. Assessing how blockchain interoperability with other technologies like AI and IOT could support long-term DRR goals.
4. An impact assessment of the long-term benefits and drawbacks of BCT implementation on HSC performance, with moderating effects on organisation size, for HOs already adopting the blockchain, through longitudinal studies.
5. An examination of BCT's policy and regulatory landscape in HSCs, particularly across data privacy, ethics, and coordination with international stakeholders that involves cross-border transactions.

6. An investigation on how the blockchain-enabled architecture model in HSCs affects local communities, particularly in areas of trust, engagement, governance and decision-making and data ownership rights.
7. An exploration of the environmental impacts of implementing BCT in HSCs, particularly in regions vulnerable to climate-related crises.
8. Future studies should conduct CFA using the EFA items done on the feasibility study.
9. Future studies should conduct regression analysis to identify the influence of the indicated factors on TOE model on BCT adoption in HSCs

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List of Appendices

Appendix I: Questionnaire Survey

The primary purpose of this survey is to identify your views on the operational challenges of humanitarian disaster management and how new technologies may help to address them. Additionally, it aims to capture your opinions on using Blockchain Technology if you have any experience in that area. The questionnaire contains three parts and should take 10-20 mins to fill.

Data collected will be treated with confidentiality and it is for educational purposes only

Please indicate whether you consent to continue with the survey.

- ☐ I consent
- ☐ I do not consent

Part 1: General Participant Information

1. Which one of the following best describes your organisation?

- ☐ Local NGO (Non-Governmental-Organisation)
- ☐ International NGO
- ☐ County Government/Ministry under County Government
- ☐ National Government/Ministry under National Government
- ☐ UN agency
- ☐ Development partner (e.g. Kenya Red Cross; Kenya Humanitarian Partnership Team)
- ☐ Other (please specify)

2. How many employees does your organisation have?

- ☐ <50
- ☐ 50-
- ☐ 100
- ☐ >200

3. What is your highest level of education?

- ☐ Certificate
- ☐ Diploma
- ☐ Undergraduate degree
- ☐ Postgraduate degree
- ☐ Other (please specify)

4. What is your age in years?

- ☐ 18-25
- ☐ 26-33
- ☐ 34-41
- ☐ 42-49
- ☐ >50

Part two : Disaster Operations issues and Disruptive Innovations Feasibility

Please respond to each statement in the next sections by indicating the degree of agreement or disagreement by using the following scale (1 = strongly disagree; 5 = Strongly agree)

5. Feasibility Study

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I have concerns about the accuracy or reliability of the information I receive from our humanitarian partners		☐	☐	☐	☐
I have concerns about data security and integrity in our current systems		☐	☐	☐	☐
My current processes that involve multiple parties are inefficient		☐	☐	☐	☐
I find it challenging to track the progress and status of tasks in our processes.		☐	☐	☐	☐
It is difficult to reconcile data across multiple systems when working with my humanitarian partners		☐	☐	☐	☐
I am concerned about data privacy or confidentiality when sharing information with my humanitarian partners	☐	☐	☐	☐	☐
I think there is a lack of visibility in the coordination of activities with our humanitarian partners, leading to misunderstandings or conflicts.	☐	☐	☐	☐	☐
I perceive a lack of transparency in the compliance requirements and regulations	☐	☐	☐	☐	☐
It is difficult to trace the origin and destination of disaster aid supplies	☐	☐	☐	☐	☐
I perceive a lack of trust in our governance structures which hinders information sharing.	☐	☐	☐	☐	☐
Intermediaries in our humanitarian supply chain add costs and complexity	☐	☐	☐	☐	☐
I perceive delays in our current systems due to dependence of transactions created by other partners	☐	☐	☐	☐	☐
I feel that our current governance systems are susceptible to manipulation or abuse	☐	☐	☐	☐	☐
Our current systems do not allow community participation in decision-making processes.	☐	☐	☐	☐	☐

Part three: Drivers to new technology adoption

Please respond to each statement in the next sections by indicating the degree of agreement or disagreement by using the following scale (1 = strongly disagree; 5 = Strongly agree)

6. Top Management support

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Our management has a strategy to use new innovations in disaster management					
Our management provides strong leadership and engagement in implementing new innovations					
Our management is willing to take risks associated (financial and organisational risks) with implementation of new innovations					
Our organisation's top management encourages experimentation and pilot projects to explore the feasibility and potential of new innovations					

Top management supports and facilitates the collaboration with external partners to gain insights and expertise in new innovations	☐	☐	☐	☐	☐
Our top management champions a culture of innovation and continuous learning of new innovations	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

7. Organisation readiness

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Our organisation has a culture that embraces innovation and technological change	☐	☐	☐	☐	☐
Our organisation has a clear understanding of the potential benefits and challenges associated with implementing new innovations	☐	☐	☐	☐	☐
Our organisation has the necessary technical expertise to operate new innovations	☐	☐	☐	☐	☐
We have conducted an assessment of our current infrastructure and systems to determine their compatibility with new innovations	☐	☐	☐	☐	☐
Our organisation has a well-defined strategy (roadmap) for implementing new innovations.	☐	☐	☐	☐	☐
	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
We have allocated sufficient budget to support the implementation of new innovations	☐	☐	☐	☐	☐
Our organisation has a process in place to educate and train employees about new innovations.	☐	☐	☐	☐	☐
We have assessed the potential risks and security considerations associated with implementing new innovations and have plans in place to mitigate them.	☐	☐	☐	☐	☐
Our organisation has engaged in discussions with regulators to explore policies and standards related to new innovations	☐	☐	☐	☐	☐
We have identified key personnel within our organisation who will be involved in the implementation and governance of new innovations	☐	☐	☐	☐	☐

8. External support

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Our donors support adoptions of new innovations	☐	☐	☐	☐	☐
The government encourages the implementation of disruptive technologies in disaster operations through policies and laws	☐	☐	☐	☐	☐
Our key donors have always supported our ICT initiatives in the past	☐	☐	☐	☐	☐
The government provides financial support for our ICT initiatives	☐	☐	☐	☐	☐
Other humanitarian partners influence our decision to adopt new technologies	☐	☐	☐	☐	☐
We have established partnerships with technology vendors to facilitate the implementation and integration of new innovations	☐	☐	☐	☐	☐

Part four: Blockchain Technology in Humanitarian disaster management.

Blockchain technology is a decentralised digital ledger and a platform that allows everyone to know the truth. Information stored in the blockchain cannot be changed and this ensure data security.

Adopting blockchain in the Kenyan Humanitarian Supply Chain would promote transparency in resource allocation for disaster programs to ensure fairness and ensure that allocated aid goods and funds reaches the intended beneficiaries.

All humanitarian partners can also share data (weather, aid requirements, disaster victims that need help, donor information) in real time and this help in faster decision making for disaster response.

9 . Please rate your knowledge of Blockchain Technology (BCT)

- ☐ Little knowledge of BCT
- ☐ Good knowledge of BCT
- ☐ Excellent knowledge of BCT
- ☐ No knowledge of BCT

Criteria:

1. If a participant ticks no knowledge, questionnaire ends
2. If a participant tick little knowledge, they answer only question 3 and 15 below. Only a participant who ticks good and excellent knowledge answer all questions below.

10. What is the current status of BCT involvement in your organisation?

- ☐ Currently interested and searching for BCT information
- ☐ Currently conducting pilots
- ☐ Currently adopted BCT
- ☐ Previously adopted but not currently using it
- ☐ Currently
- ☐ not
- interested
- in BCT I
- don't know

11. Please answer the questions below ONLY if you have 'Good/ Excellent knowledge of blockchain'.Compatibility

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Blockchain technology (BCT) usage is compatible with our current business operations (formats, data, processes and interface)	☐	☐	☐	☐	☐
BCT is compatible with our firm's corporate culture and values	☐	☐	☐	☐	☐
BCT is compatible with the existing hardware and software of the firm	☐	☐	☐	☐	☐
	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
BCT usage is compatible with all aspects of humanitarian operations	☐	☐	☐	☐	☐

12. Complexity

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Using blockchain technology (BCT) requires a lot of mental effort					
Using BCT is frustrating (vulnerable to breakdown)					
Using BCT is time consuming					
BCT applications are complex to scale-up					

BCT is too complex for humanitarian/disaster operations	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

13. Regulatory support

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
The current laws and regulations are sufficient to support BCT usage	☐	☐	☐	☐	☐
Regulatory clarity is necessary for wider adoption of BCT	☐	☐	☐	☐	☐
The government has established a policy and regulatory framework to support BCT development and implementation	☐	☐	☐	☐	☐
There are clear guidelines from regulatory bodies on BCT adoption in DRM	☐	☐	☐	☐	☐

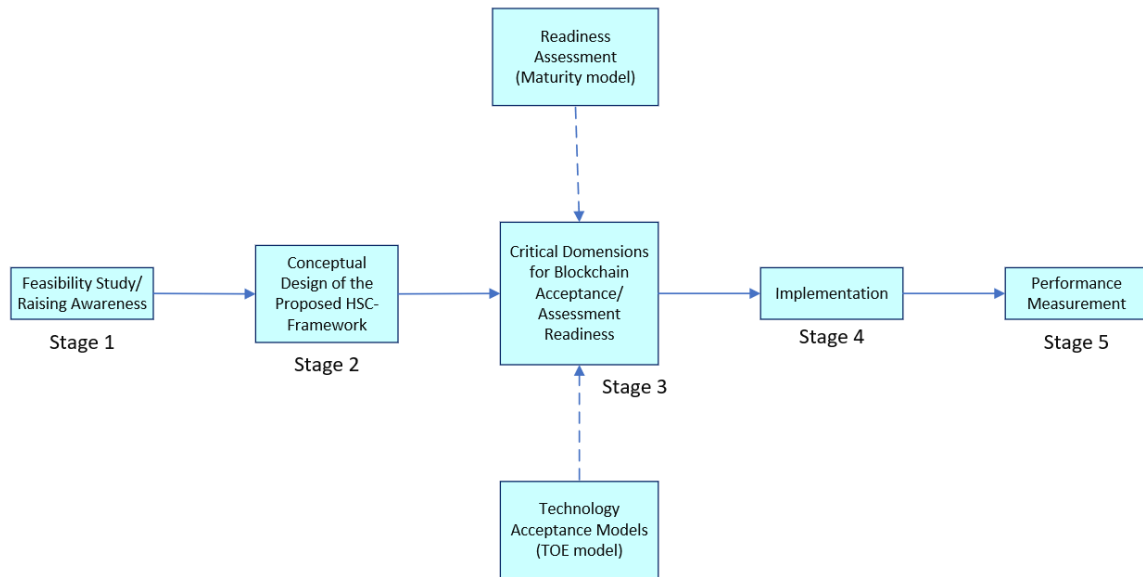
14. Intention to Adopt Blockchain

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
1. My organisation intends to adopt blockchain technology in the near future	☐	☐	☐	☐	☐
2. I would strongly recommend that humanitarian organisations in Kenya to use blockchain for disaster management operations	☐	☐	☐	☐	☐
3. I strongly believe that the adoption of blockchain technology in the humanitarian supply chains will largely benefit disaster management operations.	☐	☐	☐	☐	☐

By clicking submit, you will not be able to use the back button to edit your responses.

Appendix II: Interview Guide

1. What is your role in this organisation?
2. What challenges do you encounter when managing humanitarian DRM activities? How do you coordinate with other actors?
3. What technologies are you using for DRM activities? What factors influenced their adoption?
4. How do you ensure data privacy and security in your current systems?
5. What is the culture of accepting new technology like in your organisation?
6. How familiar are you with the concept of Blockchain Technology? (Researcher explains BCT to those with no/little knowledge)
7. Has your organisation conducted any research on the potential benefits, limitations or pilot tests of BCT adoption for your organisation? If yes, which cases did you explore and what were the outcomes?
8. Have you implemented any blockchain solutions in your organisation? If yes, which ones? Did you face any challenges in the implementation process and how did you address them? What benefits did you get?
9. The figure below represents the key stages that organisations need to follow to adopt BCT. This framework provides a road map for BCT implementation decision. The stages are 1) Feasibility study/raising awareness 2) Designing their proposed operations 3) Conducting readiness assessments; 4) Implementation and 5) Performance Measurement



- a) Do you agree with the above building blocks that form the Blockchain-enabled Framework? Why/why not?
 - b) Which stages in this architecture do you believe are more critical?
 - c) Are there any relevant blocks (steps) that are missing, and you believe should be considered?
 - d) Are there any blocks that should be removed?
 - e) Are there any other concerns/information that you would like to add about the framework?
10. Does your organisation have a drafted strategy to support innovation/blockchain implementation?
 11. Are the corporate leaders championing for new technology adoption/blockchain adoption in your organisation?
 12. Are there defined rules and laws in your organisation that govern data sharing and IPRs?
 13. Are there any external opportunities from donors/government to support BCT implementation in your organisation?
 14. Do you have an IT department? How equipped is it?
 15. What are the IT skills and competencies of your employees?

Appendix III: University's Ethics Approval

Thesis chapter(s)	Research study	Ethics review reference	Approval date
3	ER47798622	See attachment below	13/12/2022

Converis

Help | Student: Maina, Jemimah - Jemima

Dashboard > Read message

Dashboard

Ethics Reviews

Persons

Organisations

Notifications

Statistics

From: SYSTEM | Sent: 13/12/2022 09:42 | Category: INFORMATION

Subject: Converis - Ethics Review - Approval

Status change comment

DO NOT WRITE ANYTHING IN THIS NOTES BOX AS IT CAN BE SEEN BY ALL OTHER USERS. Proceed to select the workflow status

Dear Jemimah

Title of Ethics Review: [Improving Humanitarian Supply Chain Management Performance in Kenya through Coordination and Blockchain](#)

Ethic Review ID: ER47798622

The University has reviewed your ethics application named above and can confirm that the project has been approved.

You are expected to deliver the project in accordance with the University's research ethics and integrity policies and procedures<https://www.shu.ac.uk/research/ethics-integrity-and-practice>.

As the Principal Investigator you are responsible for monitoring the project on an ongoing basis and ensuring that the approved document project may be audited by the University during or after its lifetime.

Should any changes to the delivery of the project be required, you are required to submit an amendment for review.

Wishing you success you with your study

Kind regards,
Ethics Research Support

*** This is an automatically generated email, please do not reply ***

Appendix IV: NACOSTI Research Permit



REPUBLIC OF KENYA

Ref No: 410353



NATIONAL COMMISSION FOR
SCIENCE, TECHNOLOGY & INNOVATION

Date of Issue: 14 March 2023

RESEARCH LICENSE



This is to Certify that Ms.. Jemimah Maina of Sheffield Hallam University, has been licensed to conduct research in accordance with the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Busia, Homabay, Isiolo, Kilifi, Kiambu, Lamu, Laikipia, Nairobi, Narok, Tanariver on the topic: Improving Humanitarian Supply Chain Performance in Kenya using Blockchain Technology for the period ending : 14/March/2024.

License No: NACOSTI/P/23/23913

410353

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR
SCIENCE, TECHNOLOGY &
INNOVATION

Verification QR Code



NOTE: This is a computer generated license. To verify the authenticity of this do
Scan the QR Code using QR scanner application.

See overleaf for conditions

Appendix V: Research Participant Informed Consent Form

Study Title: Improving Humanitarian Supply Chain Management Performance in Kenya Blockchain Technology Integration

Name of researcher: Ms Jemimah Maina

Name of supervisors: Prof. Sameh Saad, Dr. Ramin Bahador and Prof. Terrence Perera

Name of University: Sheffield Hallam University, Sheffield, UK.

Thank you for agreeing to take part in my research study. Please take a moment to read the information below and acknowledge your consent by ticking the response that applies.

Particulars	Yes	No
I have read the Information Sheet for this study and have had details of the study explained to me.		
I am under no obligation to take part in this research. Participation in this study is entirely voluntary.	☐	☐
I also have a right to withdraw from the study at any time and all information given by me will be discarded immediately by the researcher. I have right to withdraw without giving a reason for my withdrawal or to decline to answer any particular questions in the study without any consequences to my future treatment by the researcher.	☐	☐
I have a right to read whole consent form before taking part in the interview process.	☐	☐
I have understood my right to raise any question or concern (if I have any) before, during and after the interview.	☐	☐
I agree that I have understood that the interview recording will be transcribed and will be used as part of this study only. The interview will last about 30-45 minutes approximately.	☐	☐
I agree to be a part of this research and the way my interview will be used in this study.	☐	☐
I also give consent to be recorded with live recording option in the zoom application as part of the interview.	☐	☐
I have understood and agreed all the terms for anonymity and confidentiality maintained during this research.	☐	☐
My questions about the study have been answered to my satisfaction and I understand that I may ask further questions at any point	☐	☐

I agree to provide information to the researchers under the conditions of confidentiality set out in the Participant Information Sheet.	☐	☐
I consent to the information collected for the purposes of this research study, once anonymised (so that I cannot be identified), to be used for any other research purposes (for example, future publications or conference presentation).	☐	☐
I wish to participate in the study under the conditions set out in the Participant Information Sheet.	☐	☐

By signing this participant consent form, I am indicating my approval for my participation in this research by beginning of the interview.

Participant's Signature: _____ **Date:** _____

Participant's Name (Printed): _____

Contact details: _____

Researcher's Name (Printed): Jemimah Maina

Researcher's Signature: _____

Researcher's contact details:

Please keep your copy of the consent form and the information sheet together.

Appendix VI: Participant's Introduction & Information Sheet

Improving Humanitarian Supply Chain Management Performance in Kenya through Blockchain Technology integration

The University undertakes research as part of its function for the community under its legal status. Data protection allows us to use personal data for research with appropriate safeguards in place under the legal basis of **public tasks that are in the public interest**. A full statement of your rights can be found at: www.shu.ac.uk/about-this-website/privacy-policy/privacy-notices/privacy-notice-for-research. However, all University research is reviewed to ensure that participants are treated appropriately and their rights respected. Further information at: www.shu.ac.uk/research/excellence/ethics-and-integrity

Purpose of the research

Blockchain technology is a public transaction digital ledger and a platform that allows everyone to know the truth due to its key features of decentralization where the ledgers are distributed across multiple computers in the same network, immutability which makes data to remain unaltered, data provenance that enables tracking transactions from their source and anonymity as it conceals the real identity of individuals publicly but recognizes them uniquely using pseudonyms.

Blockchain technology adoption in the Kenyan Humanitarian Supply Chain would Promote transparency in resource allocation for resilience programs to ensure fairness, Enable sharing of climate change information for better preparedness and decision making, Promote collaborations due to enhanced trust, Provide a database of relevant stakeholders and their roles in DM at all stages, Provide a database of all recipients of aid and linking them to the necessary platforms e.g., temporal shelters, transport facilities etc in disaster response and recovery stage and Promote registration of refugees and IDP through proper linkage to the relevant platform like banks, telecommunication partners, government agencies and maintaining this information in a decentralised database.

The aim of the research is to design and validate a block-chain enabled framework for Kenya HSC.

Why have you asked me to take part?

Your organisation is part of the Kenya humanitarian supply chain and key stakeholder information is necessary for the adoption of this technology

Do I have to take part?

It is up to you to decide if you want to take part. A copy of the information provided here is yours to keep, along with the consent form if you do decide to take part. You can still decide to withdraw at any time without giving a reason, or you can decide not to answer a particular question.

What will I be required to do?

To answer the questions asked to the best of your knowledge and disclose relevant information

Are there any possible risks or disadvantaged in taking part.

They are no envisaged risks, but you are encouraged to participate so as to achieve maximum benefits as highlighted in the section below.

What are the possible benefits of taking part?

Researching the readiness of organizations in adopting blockchain can provide valuable insights that facilitate successful adoption, mitigate risks, and drive innovation in disaster management so as to make disaster operations more efficient and this help in saving more lives and property in an event of a disaster.

How long is the whole study likely to last?

This will be cross-section research lasting from April-September 2023

How can I find out about the results of the study?

The results will be published upon the completion of the research and link to the publication will be shared upon request.

Details of who to contact if you have any concerns or if adverse effects occur after the study are given below.

Researcher/ Research Team Details:

You should contact the Data Protection Officer if: • you have a query about how your data is used by the University • you would like to report a data security breach (e.g. if you think your personal data has been lost or disclosed inappropriately) • you would like to complain about how the University has used your personal data DPO@shu.ac.uk	You should contact the Head of Research Ethics (Dr Mayur Ranchordas) if: • you have concerns with how the research was undertaken or how you were treated ethicssupport@shu.ac.uk
Postal address: Sheffield Hallam University, Howard Street, Sheffield S1 1WBT Telephone: 0114 225 5555	

Appendix VII: EFA Supporting Data

a) Communalities table for all 14 Feasibility constructs

Communalities	
	Initial
VAR00001	.567
VAR00002	.598
VAR00004	.681
VAR00005	.721
VAR00006	.610
VAR00007	.622
VAR00009	.655
VAR00010	.676
VAR00011	.620
VAR00012	.629
VAR00013	.603
VAR00003	.508
VAR00008	.543
VAR00014	.438

b) Communalities table for 13 Feasibility constructs (after removing Variable 14)

Communalities	
	Initial
VAR00001	.567
VAR00002	.589
VAR00004	.666
VAR00005	.715
VAR00006	.608
VAR00007	.618
VAR00009	.654
VAR00010	.670
VAR00011	.559
VAR00012	.621
VAR00013	.603
VAR00003	.505
VAR00008	.543

c) Pattern matrix for the 13 Feasibility constructs

Pattern Matrix ^a			
	Factor		
	1	2	3
VAR00008	.840		
VAR00009	.739		
VAR00011	.694		
VAR00002	.670		
VAR00001	.611		
VAR00010	.540		
VAR00005		.963	
VAR00004		.755	
VAR00007		.693	
VAR00006		.626	
VAR00003	.363	.365	
VAR00013			.851
VAR00012			.691
Extraction Method: Maximum Likelihood.			
Rotation Method: Promax with Kaiser			
Normalisation. ^a			
a. Rotation converged in 6 iterations.			

d) Total variance explained by 3 constructs derived by EFA

Total Variance Explained				
Factor	Initial Eigenvalues			Rotation Sums of Squared Loadings ^a
	Total	% of Variance	Cumulative %	Total
1	5.786	48.220	48.220	4.432
2	1.549	12.910	61.130	4.244
3	1.165	9.710	70.840	3.011
4	.761	6.343	77.183	
5	.592	4.936	82.119	
6	.480	4.001	86.120	
7	.426	3.554	89.674	
8	.366	3.047	92.722	
9	.284	2.366	95.088	
10	.230	1.917	97.005	
11	.216	1.798	98.803	
12	.144	1.197	100.000	

Extraction Method: Maximum Likelihood.
a. When factors are correlated, sums of squared loadings cannot be added to obtain a total variance.

Appendix VIII: Normality Tests

a) Normality test for top management, organisation readiness and external support variables

Tests of Normality of New Technology readiness constructs; N= 103						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Org Strategy	.275	103	.000	.809	103	.000
Leadership	.242	103	.000	.812	103	.000
Risk Taking	.268	103	.000	.834	103	.000
Pilot Projects	.310	103	.000	.790	103	.000
Collaborations	.294	103	.000	.766	103	.000
Innovation Culture	.287	103	.000	.817	103	.000
Change Culture	.272	103	.000	.823	103	.000
Awareness	.286	103	.000	.817	103	.000
Tech Expertise	.258	103	.000	.827	103	.000
Tech Assessment	.234	103	.000	.863	103	.000
Roadmap	.233	103	.000	.868	103	.000
Resources	.190	103	.000	.901	103	.000
Training	.229	103	.000	.882	103	.000
Risk Plans	.174	103	.000	.893	103	.000
Policy advocacy	.213	103	.000	.861	103	.000
Implementation Teams	.190	103	.000	.881	103	.000
Donor Support	.193	103	.000	.850	103	.000
Govt laws	.193	103	.000	.915	103	.000
Past donor support	.200	103	.000	.883	103	.000
Govt Funding	.195	103	.000	.852	103	.000
Peer pressure	.181	103	.000	.900	103	.000
Vendor partnerships	.232	103	.000	.886	103	.000
a. Lilliefors Significance Correction						

b) Normality tests for Compatibility, Complexity and regulatory support variables

Tests of Normality of BCT adoption constructs; N= 30						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.

Interface	.325	30	.000	.831	30	.000
Values	.292	30	.000	.844	30	.000
Infrastructure	.211	30	.001	.908	30	.013
Operations	.237	30	.000	.845	30	.000
MentalEffort	.294	30	.000	.855	30	.001
Breakdown	.308	30	.000	.844	30	.000
Timeconsuming	.308	30	.000	.823	30	.000
Scalability	.297	30	.000	.860	30	.001
Complex	.257	30	.000	.834	30	.000
Laws	.203	30	.003	.899	30	.008
Regulations clarity	.206	30	.002	.916	30	.021
Policies framework	.203	30	.003	.903	30	.010
Guideliness	.221	30	.001	.862	30	.001
a. Lilliefors Significance Correction						

Appendix IX: SPSS Pairwise comparison of Compatibility, Complexity and Regulatory Support Constructs that influence BCT adoption

Pairwise Comparisons					
Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig. ^a
Complex-Breakdown	.900	1.006	.895	.371	1.000
Complex-Timeconsuming	.933	1.006	.928	.353	1.000
Complex-Guideliness	-.950	1.006	-.945	.345	1.000
Complex-Scalability	.983	1.006	.978	.328	1.000
Complex-Laws	-1.533	1.006	-1.525	.127	1.000
Complex-MentalEffort	2.350	1.006	2.337	.019	1.000
Complex-Policies	-2.550	1.006	-2.536	.011	.875
Complex-Regulations	-2.633	1.006	-2.619	.009	.688
Complex-Infrastructure	3.267	1.006	3.249	.001	.090
Complex-Operations	4.617	1.006	4.591	.000	.000
Complex-Interface	5.033	1.006	5.006	.000	.000
Complex-Values	5.233	1.006	5.204	.000	.000
Breakdown-Timeconsuming	-.033	1.006	-.033	.974	1.000
Breakdown-Guideliness	-.050	1.006	-.050	.960	1.000
Breakdown-Scalability	-.083	1.006	-.083	.934	1.000
Breakdown-Laws	-.633	1.006	-.630	.529	1.000
Breakdown-MentalEffort	1.450	1.006	1.442	.149	1.000
Breakdown-Policies	-1.650	1.006	-1.641	.101	1.000
Breakdown-Regulations	-1.733	1.006	-1.724	.085	1.000
Breakdown-Infrastructure	2.367	1.006	2.354	.019	1.000
Breakdown-Operations	3.717	1.006	3.696	.000	.017
Breakdown-Interface	4.133	1.006	4.111	.000	.003
Breakdown-Values	4.333	1.006	4.309	.000	.001
Timeconsuming-Guideliness	-.017	1.006	-.017	.987	1.000
Timeconsuming-Scalability	-.050	1.006	-.050	.960	1.000
Timeconsuming-Laws	-.600	1.006	-.597	.551	1.000
Timeconsuming-MentalEffort	1.417	1.006	1.409	.159	1.000
Timeconsuming-Policies	-1.617	1.006	-1.608	.108	1.000
Timeconsuming-Regulations	-1.700	1.006	-1.691	.091	1.000
Timeconsuming-Infrastructure	2.333	1.006	2.320	.020	1.000
Timeconsuming-Operations	3.683	1.006	3.663	.000	.019
Timeconsuming-Interface	4.100	1.006	4.077	.000	.004
Timeconsuming-Values	4.300	1.006	4.276	.000	.001
Guideliness-Scalability	.033	1.006	.033	.974	1.000
Guideliness-Laws	.583	1.006	.580	.562	1.000

Guideliness-MentalEffort	1.400	1.006	1.392	.164	1.000
Guideliness-Policies	1.600	1.006	1.591	.112	1.000
Guideliness-Regulations	1.683	1.006	1.674	.094	1.000
Guideliness-Infrastructure	2.317	1.006	2.304	.021	1.000
Guideliness-Operations	3.667	1.006	3.646	.000	.021
Guideliness-Interface	4.083	1.006	4.061	.000	.004
Guideliness-Values	4.283	1.006	4.260	.000	.002
Scalability-Laws	-.550	1.006	-.547	.584	1.000
Scalability-MentalEffort	1.367	1.006	1.359	.174	1.000
Scalability-Policies	-1.567	1.006	-1.558	.119	1.000
Scalability-Regulations	-1.650	1.006	-1.641	.101	1.000
Scalability-Infrastructure	2.283	1.006	2.271	.023	1.000
Scalability-Operations	3.633	1.006	3.613	.000	.024
Scalability-Interface	4.050	1.006	4.028	.000	.004
Scalability-Values	4.250	1.006	4.227	.000	.002
Laws-MentalEffort	.817	1.006	.812	.417	1.000
Laws-Policies	-1.017	1.006	-1.011	.312	1.000
Laws-Regulations	-1.100	1.006	-1.094	.274	1.000
Laws-Infrastructure	1.733	1.006	1.724	.085	1.000
Laws-Operations	3.083	1.006	3.066	.002	.169
Laws-Interface	3.500	1.006	3.481	.001	.039
Laws-Values	3.700	1.006	3.680	.000	.018
MentalEffort-Policies	-.200	1.006	-.199	.842	1.000
MentalEffort-Regulations	-.283	1.006	-.282	.778	1.000
MentalEffort-Infrastructure	.917	1.006	.912	.362	1.000
MentalEffort-Operations	2.267	1.006	2.254	.024	1.000
MentalEffort-Interface	2.683	1.006	2.669	.008	.594
MentalEffort-Values	2.883	1.006	2.867	.004	.323
Policies-Regulations	.083	1.006	.083	.934	1.000
Policies-Infrastructure	.717	1.006	.713	.476	1.000
Policies-Operations	2.067	1.006	2.055	.040	1.000
Policies-Interface	2.483	1.006	2.470	.014	1.000
Policies-Values	2.683	1.006	2.669	.008	.594
Regulations-Infrastructure	.633	1.006	.630	.529	1.000
Regulations-Operations	1.983	1.006	1.972	.049	1.000
Regulations-Interface	2.400	1.006	2.387	.017	1.000
Regulations-Values	2.600	1.006	2.586	.010	.758
Infrastructure-Operations	-1.350	1.006	-1.343	.179	1.000
Infrastructure-Interface	1.767	1.006	1.757	.079	1.000
Infrastructure-Values	1.967	1.006	1.956	.050	1.000
Operations-Interface	.417	1.006	.414	.679	1.000
Operations-Values	.617	1.006	.613	.540	1.000

Interface-Values	-.200	1.006	-.199	.842	1.000
Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.					
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.					
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.					

Appendix X: Transcripts on the Themes for Coordination Mechanisms used in Kenya HSC

a) Local coordination

Community groups gather at the wards and village levels, to manage risks using an inclusive approach to DRR. The local groups help to drive sustainability policies for development projects, as they use the bottom-up approach which focus on people's priorities, thus bringing out people-driven interventions. These groups work with the county government and police officers, during disaster response.

“At the county level, we have this groups called Community managed disaster risk groups where they group themselves in each village and wards. We have representatives of the youth, women, and the elderly. With these groups, you have the representation of that community.” Participant, 24NG.

b) International collaborations

HOs worked with foreign countries by sharing DRR knowledge and resources. Regional coordination was also done with partners from COMESA region.

“We are also lucky that we had a project in the UK's space three years back and they were able to train us on acquisition of data, or use of data from other acquisition centres using UK space agency and we call that the SAT DRR project which enhanced communication, and situation assessment, and improved our capacity to effectively plan and respond to disasters.” Participant, 18NG.

c) Centralised coordination

Kenya HSC stakeholders used the **centralised coordination** mechanism to manage specific disasters like drought, done by NDMA. This mechanism involved the use of command-and-

control structures of designated authorities to provide direction, allocate resources, and coordinate response efforts.

“NDMA which is under the Ministry of Arid Lands and East African Community has the mandate to coordinate drought response and it gives all the, all the technical information and in meetings they say that they're being assisted by the government in terms of security, water tracking that involves taking water to areas that are needed through boozers, and fixed wing aircraft, and feeding boreholes.”

Participant, 18NG.

d) County Steering Groups (CSG)

At the county government level, CSGs helps to coordinate disasters at that level. CSG is represented by officials from the national and county government, NGOs and KRC. The CSG holds regular meetings with its members to discuss DRR issues.

“We normally have a group that is called county steering group in each 23 ASAL counties. The CSGs, that is headed by the Governor, who's the head of the county, and usually the CSG is coordinated by the NDMA. So, when a partner or an A non-governmental organisation is working in that county, they normally meet on a monthly basis. When a new agency is coming to a county, they have to register their presence with the County Commissioner, to say where they're working and when they're registering there. Then they're also supposed to be part of this CSG where they say what they are doing.” *Participant, 2SC.*

At the county level, coordination is done on an ad hoc basis depending on the nature of the disaster.

“Coordination just depend on the occurrence. Maybe if it is for boreholes, we work with the Ministry of Water, if it is for fire, we coordinate with the public works as they are the ones with the fire extinguishers and also if it is a matter of education in classroom, we coordinate with the Education department and if it is a matter of health, we coordinate with the health department and so forth.” *Participant, 10JC.*

d) Emergency operations centre

The Emergency operations centre provides a single point where various stakeholders can bring in their relief aid, to be distributed to the affected region. It acts a warehouse or a distribution hub. Security is given by government officials to ensure safety of supplies and personnel to and from, this hub.

“...The food has been allocated, and the pickup points have been established from specific National Cereals and Produce Depots (NCPD), where County commissioners have been told to organise collection. Depending on which items there are in the NCPD, they are given instructions then they organise, they send the officer to go and collect of course, with a security escort like the police. They also need trucks which must be facilitated in one way or another.” Participant, 18NG.

e) Inter-agency coordination

Inter-agencies collaborate with the UN agencies, using the UN clusters like the logistics cluster.

“Periodically, we work with the UNOCHA who come up with the 3W map; Who, What, Where. Which organisations are operating within a County? What are they actually doing there? and Which parts of the county are they operating in?” Participant, 18NG.

f) Social Protection Network

This network provides a database of beneficiaries, and government departments share information with each other, to ensure that beneficiaries do not benefit twice under different programmes. It also acts as a platform for verification of beneficiaries' identities.

“Most partners at the county are requesting us to share with them the database to see the people they can support the cash transfer, and again we are linked with the wider Social Protection Networking in Kenya. In case communities where you are targeting, don't have ID's, we link up with the birth registrar's office to help them secure the ID. We have a way with interacting with their system where you can upload the data, and then they will reach us with the ID numbers, then give us a list of people within this list who are in their database. We also verify the national IDs

through the RP (Registration of Persons) system so it will return either true or false.”

Participant, 26NG.

In this network, there are various data owners like the national ID data owners, NSSF data owners, the Kenya Bureau of Statistics data owners etc. and they collaborate to share data. The Social Network Protection also brings together experts from different government agencies and organisations, to address specific aspects of DRM, such as search and rescue, medical care, and logistics to collaborate on planning, problem-solving, and decision-making related to their respective areas of expertise.

g) Multi-stakeholder coordination

Multi-stakeholder coordination mechanism involves working with the civil societies, NGOs, CBOs and FBOs, SAGAs (semi-autonomous government agencies), the government, media, academia and the private sector. This coordination ensures resource sharing.

“For civil society organisations like the Kenya Red Cross, we always make sure that we work with them because they have got a very good system and structure country wide. They always work hand in hand with the county government, the police, and the NGAO.” *Participant, 26NG.*

Multi-stakeholder coordination is useful in information sharing for effective DRR.

“We collaborate with the county government, particularly the Technical Department; the key department like Gender, Education, Health and the provisional administration, the chiefs, these are the people who are on the ground, and these are the people who actually can give you reports on how things are happening in the community.” *Participant, 11JC.*

Appendix XI: Transcripts on the Themes for Drivers of Blockchain in Kenya HSC.

a) Accountability

BCT ensured that HOs awarded cash to the right beneficiaries.

“The blockchain was basically looking at bringing more accountability because majority of the times it was being tested for the cash and vouchers. I remember during that blockchain project, it was about reducing the turn-around time for us especially by use of cash and voucher system.” Participant, 7SN.

b) Data security and system integrity

Blockchain provided high level of **data security** as information flow fast without manipulation.

“You know, as organisations, everyone wants a safe space for their Information in this era we are generating so much information, loss of information, then the access that is not actually warranted, You heard the other day that our systems, were hacked; the eCitizen. So, I think if we can get safer systems, why not? We need to go to the for them.” Participant, 5SG.

The blockchain makes it virtually impossible to alter previous records without altering subsequent blocks, thereby maintaining **data integrity**

“It's now where you get technologies, which have already taken advantage of Blockchain. Like now, I did mention about Azure. If you go and ask someone if they use blockchain, they might deny it. They might tell you no, we don't use that, but then you realise you already use that because it's what Microsoft has embedded within Azure just to realise some aspect of security, among other things, ensuring data integrity.” Participant, 27NN.

c) Transparency

BCT could help in **transparency** of DRR operations, which is hard to attain in the existing systems.

“You see blockchain comes in to address the aspect of transparency in transactions, it's all about transparency. Issues of transparency unfortunately keep coming up. In software, we do not call it transparency, it's as surety that something happened. So, in blockchain, you look at it from a point of how I can confirm that this thing happened so that makes the transaction authentic.” Participant, 11JC.

d) Time efficiency

Approvals may be done anywhere thus saving time and improving response to DRR issues.

“If someone can just approve transactions while using his phone, or wherever he needs to be, it will be so helpful to the people respond to issues immediately. Also we wanted some server to be installed so that we could use it to relay real time information on the status of all the water infrastructure across the country. So that is one thing that if there's a place where we really need technology, it is the issue of early warnings and water security but that one at the moment we don't have.”

Participant, 17NG.

e) **Traceability**

Blockchain could be **useful in funds transfers** as it involves a transaction that **is easy to trace**, and these comments showed a relationship in disintermediation, accountability and traceability.

“From a transactional perspective blockchain comes in account where bank A can be able to send money in account B in a different institution without having CBK (Central Bank of Kenya) in the loop. Another user is land. Anything that involves transfer can be useful case for blockchain. So, in disaster management, I'll look at it from a secondary point about the whole idea of funding, you realise that generally in Africa we have a problem of accountability. Let's say I'm sending relief food from, point A to point B, if I want to track this movement, you may be able to track the points that it went through, so that one it can really address.” *Participant, 20NC.*

“We were thinking of looking for systems, technological systems to track our work and programmes. We have had similar discussions even at the CSG on drought response, we were not calling it blockchain, but we have had serious discussions about it, and we need to report monthly. We need to report on the 25th of every month what you're doing at a public portal, where every department can see what the others are doing. If there was a technology, maybe now that blockchain could also be introduced to counties, so that there is not this manual way of doing things, that would help.” *Participant, 11JC.*

Blockchain could **trace funds, information and goods**. This would ensure that goods and funds get to the right people, and information could be traced back to correct any errors.

“One good thing about blockchain technology is the component of product tracking. It will first secure the loss of items as there will be proper check and balances to avoid items getting to the wrong people.” Participant, 12LN.

It also gave **assurance to communities** that their resources were being traced back to identify any irregularities.

“For the community level, nothing much was changing for them but of course explaining to them that their missing money could now be traced back to see where it was lost, or following up on any errors made, they were very appreciative of that.” Participant, 7SN.

f) Decentralisation

While some respondents liked the idea of having data controlled in a central place, others were in the opinion that they were not involved in knowing what happens to the data and manipulations can be done to it.

“For us, no we don’t have that decentralised system, but for our partners like the WFP, they have that system. That is what we have been suggesting. For us to come up with a database to tell us who is doing what, and who is helping who. If we have a digital platform that we don’t need to call them, we just log in to the system and find out all the information that you require.” Participant, 11JC.

g) Disintermediation

BCT enables exchange of transactions **without the need for intermediaries** and this is crucial for communities to get the help with less costs and complexities created by middlemen.

“If you tell me, you're going to give me cash of Ksh. 10,000 this month and you delay, and you give me in 2024, and I just keep silent, that is not supporting the communities. So how is that information like community getting access to this information, or like rather having a platform, that does not pass through an individual like me, or another person, but they can use maybe through their phones, to tweet or to send them back information so that everyone accesses, at the same time to be able to respond.” Participant, 1SN.

h) Immutability

Immutability feature was good for the donor agreements as they will **trust the entries**

“The idea was that the donors would be able to see all the entries, and no one would be able to manipulate them because one party could change anything after it has been agreed upon, so that was the problem.” Participant, 7SN.

i) Identity management

Blockchain could help in **identity management** when issuing aid.

“Blockchain helps to avoid such problems of identification. Before we had problems, and challenges when giving aid because everybody wants free things so to avoid that you need to use the proper regulations on how to control such incidents.” Participant, 9JN.

Blockchain could also be useful in **beneficiary registration** as currently they print the name of beneficiaries who counter sign against their names, after their IDs have been verified, on the relief aid collection day. The printed copies may be lost or damaged. Blockchain could also help in refugees' registration and identification.

“If they launch it, we will be using that to register beneficiaries and it's a good thing. I've seen it working well in other places, even in WFP and it's something good.” Participant, 9JN.

Appendix- XII: Transcripts on the Themes for Disadvantages of Blockchain Technology

a) Complexity

BCT is a relatively new technology and is **complex to understand** how it works as compared to other disruptive technologies like the AI.

“The issue of this technology is very new and with a difficult concept to understand. We are learning the upcoming ones like the AI and how they can help our lives to be easier.” Participant, 18NG.

b) Governance

Governing BCT technology is difficult with concerns about who controls the servers, and manages BCT assets.

“This technology comes with now the issue of policing, who actually controls the servers? Besides, which platform do you use, Bitcoin for example is good for transactions, that’s why people easily take money transfer to Bitcoin, than asset management.” [Participant, 20NC](#).

c) Laws and regulations

Laws and regulations in Kenya are yet to be updated to accommodate the disruptive nature of BCT, as the executives who make laws are unaware about BCT.

“Who is advocating for it? You see when you do not have much understanding of what you're working with, then regulating it, or even putting measures in place to work on it, becomes a challenge.” [Participant, 27NN](#).

Participants who had implemented the blockchain raised concerns on **regulations on IPRs**, as it was difficult to implement some issues of IPRs, even if there were such regulations.

“So just like the issue of patency, it might be so clear in terms of law and everything, on how to patent your work or what you've written but now if you steal my code, I don't think we will know how to address it in terms of law.” [Participant, 27NN](#).

d) Cost

Respondents who had already implemented the blockchain added that the **high cost** of BCT implementation may discourage its adoption and especially with small sized NGOs whose main goal is to save lives and may not have resources to invest in this technology.

“One of the biggest things maybe I thought was in terms of cost and then lack of resources to implement that, small NGOs may not have much money.” [Participant, 27NN](#).

e) Immutability

It would be risky to have information that was input wrongly, remaining there forever.

“But my only worry is supposing somebody gets information wrongly there. Not deleting information that you realise that has gotten in wrongly, that is a bit risky. You will end up with a very bulky document, as it doesn't allow deletion. If this happens to all the transactions, how will be the storage?” [Participant, 5SG](#).

f) Energy and power consumption

The mining process **consumes a lot of power** and may not be sustainable.

“Now the mining of the bitcoin, it doesn't necessarily mean that you'll be doing transactions every day, no, because it's who does it better; So, the mobile phone, machine you have, the better the success rate, and it consumes a lot of power.” [Participant, 20NC](#).

g) Security

There were security concerns of BCT being prone to fraud and difficulty to trace the fraudsters.

“Of course no technology is fault-free. Because when you look at what is happening with the bitcoin, you've heard of people complain their money has disappeared without trace. There are people who are very sharp, especially with our youngsters all the time they are behind a computer, and they are very sharp and so good at doing such.” [Participant, 23NG](#).

h) Vendor issues

BCT has **very few use cases** and therefore having issues with it may need to be solved by the **vendors only** and this limits its implementation.

“Who is selling it? Whom will we go to if we encounter issues with the technology given its less application cases? Like for instance we have a system we call DCIQ (Datix Cloud IQ) that integrate basics to the cloud, but amongst our partners, we are the only organisation that is currently using it, so, whenever we have problems, we go only to the vendor, which is not always effective.” [Participant, 12LN](#).

i) Privacy

Blockchain, just like other modern technologies do not guarantee a safe place to individual information.

“But for me, I think I'll go the traditional way because when we used to have typewriters they were a bit slower because of the application, they didn't have applications like the computers do, but in terms of keeping our secrets and being safe, we were safer than we are today.” Participant, 17NG.

Appendix XIII: Blockchain Value for Kenya HSC Disaster risk management

DRM Phase	Activity on each phase based on the Interviews	Relevant HSC Challenges from Interviews	Value of Blockchain (Green/Amber/Red)	Reason
Mitigation	Development of laws to prevent calamities	Political influence, Lack of transparency & accountability	Green	Blockchain's transparency and immutability can help reduce political interference and enhance accountability in law development.
	Development of finance policies to ensure accountability	Lack of transparency & accountability, Fraud and corruption	Green	Blockchain ensures transparency and traceability of financial transactions, reducing fraud and corruption.
	Community sensitisation about disasters and prevention	Lack of integrating community feedback	Amber	Blockchain can moderately improve feedback collection through decentralised platforms, but cultural and logistical factors may still limit its impact.
	Ensuring water security	Logistics issues, Limited resources	Amber	Blockchain can track water distribution and usage transparently, but resource limitations and logistics remain external factors.
	Early information sharing for better decision-making	Lack of information sharing	Green	Blockchain's decentralised and immutable records can ensure timely and trusted information sharing.

	Community development programs (e.g., animal feeds, boreholes)	Logistics issues, Time delay	Amber	Blockchain can enhance transparency in resource distribution but may not directly address logistical inefficiencies.
	Continuous monitoring of development programs	Lack of transparency & accountability, Fraud and corruption	Green	Blockchain enables real-time, immutable tracking of program progress, ensuring accountability and minimising fraud.
	Distributing social services	Logistics issues, Limited resources	Amber	Blockchain can help streamline service distribution by tracking resources, but it requires integration with logistical systems.
	Promoting immunisation and advocating for children's rights	Lack of visibility, Lack of trust	Amber	Blockchain can provide verifiable records of immunisation but requires broader system adoption to address visibility and trust comprehensively.
Preparedness	Disaster preparedness trainings	HR staffing and turnover, Lack of a database	Amber	Blockchain can create verifiable records of training participation, but it does not directly address staffing challenges.
	Information sharing for improved preparedness	Lack of information sharing, Lack of trust	Green	Blockchain's decentralised and tamper-proof system enhances trust and ensures consistent information sharing.
	Policies and regulations supporting preparedness	Political influence, Lack of transparency & accountability	Green	Blockchain's transparency can mitigate political influence and improve accountability in policy implementation.
	Community training on disaster preparedness	Lack of integrating community feedback, HR	Amber	Blockchain can record training outcomes but has limited impact on addressing

		staffing and turnover		community feedback integration or HR issues.
	Conducting food security assessments	Lack of a database, Limited resources	Green	Blockchain can provide a secure, accessible database for storing and analysing food security data, ensuring informed decision-making & democratising agriculture
Response	Provision of relief aid, cash transfers, and medical assistance	Fraud and corruption, Lack of visibility, Logistics issues	Green	Blockchain's transparency and real-time tracking ensure aid reaches intended recipients, reducing fraud and improving visibility.
	Information sharing	Lack of information sharing, Lack of trust	Green	Blockchain ensures verifiable, secure, and real-time information sharing, building trust and improving coordination.
	Resource mobilisation and coordination	Coordination challenge, Limited resources	Amber	Blockchain improves resource tracking and allocation but does not fully address broader coordination challenges.
Recovery	Financial assistance to vulnerable communities	Lack of transparency & accountability, Fraud and corruption	Green	Blockchain ensures transparent and efficient delivery of financial assistance to targeted beneficiaries.
	Community training for long-term adaptations	Lack of integrating community feedback, HR staffing and turnover	Amber	Blockchain can provide proof of training completion but does not directly address feedback or staffing challenges.
	Livelihood support for economic recovery	Overdependency on donations, Lack of trust	Green	Blockchain-based microfinance can reduce dependency on donations and build trust in economic recovery efforts.

	Financial inclusion	Overdependency on donations, Limited resources	Green	Blockchain-powered financial tools can promote inclusivity and reduce reliance on donors by empowering local communities by ensuring global market access through tokenisation
	Traditional coping mechanisms	Lack of a database, Lack of integrating community feedback	Amber	Blockchain can record and preserve traditional knowledge but requires community acceptance and input for maximum impact.
	Water tracking	Logistics issues, Limited resources	Green	Blockchain ensures transparent and equitable tracking of water distribution, improving resource allocation.
	Monitoring and evaluation of rebuilding efforts	Lack of transparency & accountability, Time delay	Green	Blockchain's immutable records enable real-time monitoring and auditing of rebuilding efforts, reducing delays and enhancing accountability.
	Tracing of people	Lack of visibility, Lack of trust	Amber	Blockchain-based digital identities can improve visibility but require broader system adoption to address trust issues comprehensively.
	Rebuilding infrastructure	Fraud and corruption, Lack of transparency & accountability	Green	Blockchain ensures transparency in construction contracts and tracks progress, reducing corruption and delays.

Appendix XIV: Transcripts on the Themes for Benefits derived from adopting the Proposed Blockchain-enabled Architecture in Kenya HSC

a) Enhanced Accountability

The BCT-enabled HSC could help the government, organisations and communities to be more responsible in undertaking DRR activities by ensuring better resource management.

“It would also enhance accountability to our partners, and also within government itself, because some of these resources come from government, and I therefore think it will be a good technology.” [Participant, 2SC](#).

b) Improved Coordination

The BCT architecture could help them in their coordination efforts, and as a result, **reduce duplication of efforts**, and save resources, and ensure all areas are reached by different organisations to serve the vulnerable communities.

“We are trying our level best to ensure that those different groups, those different NGOs, they don't provide the same services and this technology could be helpful. I've been trying to contact other NGOs, to know at least those who have been benefiting from their cash programme. I have not yet got it.” [Participant, 6SC](#).

Through the coordinated efforts of stakeholders, BCT was believed to relieve communities the burden **of sharing their data** to different stakeholders all the time.

“I think the blockchain will really help to avoid that monotony that every time we go to the same people for the very same thing.” [Participant, 5SG](#).

BCT adoptions could enable coordination by ensuring **visibility and traceability** in DRR programs.

“It is good because it avoids duplication of efforts and once the information gets there, it becomes easy and everybody, everybody has access to it there and at least you are able to track back to its origins.” [Participant, 28RG](#).

c) Reduced Fraud and corruption

First, it would help reduce irregularities faced by NGOs at the grassroots due to **political interference**.

“This technology will put the politicians into reality and portray the actual picture, as we need admit to the truth to get solutions. It will be reducing these irregularities which we are facing with the local leaders.” [Participant, 19NG](#).

Second, it would ensure that **funds are channelled to the right persons**.

“Blockchain will ensure that funds are diverted to the right channels, and beneficiaries to reduce their suffering, so I think it will help us a lot to achieve our aimed goals because the goal of this cash transfer programme, is to reach to that very vulnerable person in the community.” Participant, 26NG.

Third, it would help organisations to be **more responsive to DRR** efforts because of reduced **fraud**.

“Lack of the right systems in place make us not achieve our humanitarian goals, and the blockchain can help to fix this. Furthermore, we won’t have any embezzlement of funds, actually, Blockchain can be used extensively even for elections by the government.” Participant, 5SG.

Fourth, it **could help reduce cases of corruption and unethical practices** as everything will be visible and any malpractices will be questioned.

“To be very honest, we have had issues of malpractices but not to a very worrying extent, but yes there have been issues like that. We are faced with these problems and issues of ethics and unfortunately it happens. Sometimes the relief food goes to the wrong hands. During the last drought we had an issue of livestock feed being sold when it wasn’t supposed to be, and we need such a system to restore this.” Participant, 11JC.

Fifth, it could reduce corruption from irresponsible parents **who pay bribes** to avoid responsibilities of children, and this will improve the welfare of kids and minimise neglect.

“Another challenge is on neglect cases where parents don't want to provide for the kid. That is responsibility is 50 by 50. The mother gives out 50. The father gives out 50 and maybe the father is a public officer, or somehow well up, and he gets to corrupt the case to not give anything., and the story ends at police station, and even the mother doesn't know what went on and so she ends up losing hope, and so does the kids. This technology can show this.” Participant, 13LN.

Sixth, it could resolve issues of **missing files** due to corruption,

“I guess we have a challenge on missing files too, as there are times when we go to court with the defilement case, and you hear the file is missing. In the cases involving drugs, you’re told that the file is missing. Fishy stories, just to understand the cases have been corrupted or something.” Participant, 13LN.

Seventh, BCT would help in **eliminating fraud in disbursements** of relief aid and cash.

“The main issue that NGOs and INGOs face is fraud and embezzlement, as different people pose as victims, and they are not supposed to be there. Other people try to fatten the invoices, it would help solve issues to do with corruption.” Participant, 12LN.

Lastly, the blockchain could help address **institutional culture of corruption**.

“As you know, this country we have corruption, sorry to say this, it's like engraved in our system, this blockchain will help fix this.” Participant, 2SC.

d) Reducing Costs

Blockchain would **cut down costs**, as it would automate HO's workflows by **reducing paperwork**.

“If we embrace blockchain technology, the first thing it will do is to cut costs due to better monitoring and reduced paperwork.” Participant, 12LN.

The BCT-enabled architecture would help reduce costs because of improved information sharing, coordination and **enabling data sharing** to cut costs of re-collecting beneficiary data.

“When a disaster hit everyone runs at that area and everyone's resource mobilise so this technology will help really to reduce costs, and strain beneficiaries as every time the community see people, and sometimes they can, be very resistant because they'll say, every time you come to us, taking our details and you are not doing anything.” Participant, 14LN.

e) Increased Trust

The architecture could be useful in enabling HSC stakeholders to **know the truth** about beneficiaries who have already benefited from aid, and this in turn **fosters trust**.

“Then again you see the community will never tell you that they have received help from another organisation, every time, they will be like, ‘yes, we need the help’, so this platform will enables us to know the truth.” [Participant, 1SN](#).

f) Increased visibility

Communities could validate the beneficiary list via the blockchain, to ensure that only the needy ones get help.

“The blockchain has its own advantages and the disadvantages because at any point, if it's accessible by the beneficiaries, they will say they saw a name on the system, that is not a vulnerable person, and this will be good.” [Participant, 5SG](#).

g) Enhanced System Integrity

Also, the **immutable feature of the blockchain** could ensure trust in the BCT-enabled system, thus securing data, as there could be no manipulation of information.

“For me blockchain is a good one, as its tamper-proof. Even if it's ten years to come from now information remains the same.” [Participant, 13LN](#).

Due to system integrity and trust, HSC will be more willing to **share information** amongst themselves.

“It is difficult to share information especially during emergencies. No one wants to share it. Even in terms of follow-up and evaluation. Blockchain will ensures trust as even the information in it cannot be altered.” [Participant, 7SN](#).

Having a **decentralised system prevents data losses** as partners can update the files, if one member of the network loses the data.

“Sometimes you're challenged by data losses of key information, and you know if you lose data for a particular user, at some point to identify whether you have lost the data is a problem, and then if you identify that you've lost it, you have to go back and start afresh.” [Participant, 22NG](#).

h) Improved Transparency

Improved transparency could eliminate unethical practices and enhance trust amongst partners.

“The person who was channelling the money that's selected for orphans, If there were technologies like the blockchain, he would have been known because it took like five years before he was noted, so he was noted on the 5th years (the days of a thief are numbered to 40) and when he was fined, he was not only the one, they had like a programme of people, an enormous numbers with no names receiving the orphans monthly stipend and it came with now the issue of policing and it gave birth to certain technology.” [Participant, 1SN](#).

i) Data storage to enable data driven decision-making

Some county informers mentioned that their county data is not technologically driven, and therefore, having a database that would **store the data, such that they only needed to update it, in real time**, could be helpful. The database could help them map HSC partners based on their locations

“Our data is not technologically driven data, we have to go to the fields to get that information and life is dynamic so this particular data keeps on changing. We have had cases of duplication of effort by partners, by ourselves, and which have also raised a lot of conflicts with the community and the beneficiaries. Really, such a database will really assist us in addressing some of these issues.” [Participant, 2SC](#).

j) Enhanced Traceability

Participants involved in developmental programs said that the BCT-enabled architecture, could be useful in **tracking savings** of their beneficiaries, in a transparent way. Similarly, an NGO that supports ending of FGM practices in Kajiado county expressed that they track girls that they rescue from such practices. This tracking takes place until the age of 24, when they complete school. They believed that integrating this information in a tamper-proof system would be helpful to them. Other participants articulated that having a history of all transactions, and people, in a tamper-proof system, could be easy to **track all their personnel data** for any ethical malpractices.

“That if I would say, I want information of this ID number in this organisation, and then I say include history. I'll get a list of everything that happened to this person since the date they enrolled to this organisation” Participant, 26NG

k) Improved digital identity management

Digital identity management of beneficiaries could make it easier for families and friends to trace **and reconnect with their displaced** loved ones.

“People who want to meet their loved ones. People who got lost, the refugees and they want to trace their loved ones, this system could help.” Participant, 13LN.

Digital identity management could **enhance traceability** in the blockchain.

“10 years back when a kid, was rescued and taken to a children home, and now he is an adult, and he can't trace his or her family. I have some number of youths who are struggling to trace back their families, and of course, everyone needs a family you can call up. You want to help such a person, but you don't know how to trace this information.” Participant, 13LN

Children who are lost or run away and go to children's homes, could be reconnected with their families.

“Where am I going to take this kid? Because the baby doesn't know any other family relative. He only knows the name of the mother, and the name of the father. In other cases, kids ran away from home and comes to the children's home and give us a fake name. So, when you are talking with parents with a lost kid, they wouldn't recognise the lost child as he has been registered with us using a fake name. So, I place them in remand, whereby there is limited freedom, and after watching the lives of his peers he decides to open up although he doesn't tells the whole truth.” Participant, 13LN.

Tracking of missing babies and storing the information in the blockchain could be helpful for ensuring children go back to their rightful parents as parents' information could be verified with necessary bodies like the registration of persons to ensure that the truth is known.

“At times, we normally have a challenge in hospital on abandoned case that went missing. So, the challenge is they don't want to follow the process of adoption, so they go through fishy means to get a kid. So that's why it's so good working with stakeholders because they remind you about such cases, and if that blockchain would makes it easy to track the kid, it would be great because maybe every date a new story comes about a lost kid and I want to chip in and write something and I can connect that kids story to his previous story and so on.” Participant, 13LN.

Blockchain could eliminate challenges of beneficiaries presenting fake IDs

“There are people who are doing the registration of the ID's; is this person the ID that is he has presented? Is he the right person or is somebody who collected or stole an ID and is trying to collect the fertiliser and he's not even a farmer, that is a challenge right now and only way around it is through the coordination of other partners like the registrar of persons and sharing this in a tamper-proof way.” Participant, 23NG.

The BCT-enabled architecture could provide a coordination platform to manage beneficiary information and help other partners to **‘know your beneficiaries’ KYB**.

“Like for the CBOs, there was need to have a single registry of beneficiaries that will used by all partners to avoid duplication of efforts as currently through the cash and voucher system, someone is getting money from three different programs, and this platform is good.” Participant, 7SN.

Appendix XV: Transcripts on the Themes for Potential Barriers to adopting the Blockchain-enabled Architecture in Kenya HSC

a) Change resistance

The **resistance to change** was discussed in three dimensions. First, the **resistance from executives** who would want to control the transactions and information, and they don't want the accountability and transparency provided by BCT;

“If people are denied access to something, they will resist. The money comes in, you don't have control over it. You want money today; you won't have it! You have to put

in the system. And you know, they want some short cut, so anything which you know removes the control from these guys in power, they will say no.” Participant, 8JN.

Second, **employee resistance** who associate new technologies with making them redundant, and general resistance as new technological changes comes with lots of learning to do;

“There is resistance. It depends on the impact on the human capital, where the large number of people feel that their duties and responsibilities are going to be threatened by this new technology. We also get lots of resistance when we are trying to implement new technologies as it involves a lot of learning.” Participant, 15TG.

Third, **resistance from community** in cases where the beneficiaries refuse to give their data without having a ‘stipend in return’ and data is required to be fed and shared in the system amongst partners.

“There is lots of resistance to beneficiaries to give personal information, required to be put in the system, without giving them immediate stipend.” Participant, 14LN.

b) Coordination issues

The coordination of different disaster partners was said to presents a barrier to successful blockchain adoption, primarily **due to resource challenges**, and differing priorities among stakeholders as these entities may have different technological capabilities, data management practices.

“Some of these organisations are funded differently. You might find that for example where I work, money just comes maybe early enough, another organisation gets the money later, and we may have resources for such an intervention, but they wouldn’t, and this leads to confusion of the coordination structures.” Participant, 4SN.

Other issues arising from coordination **is establishing trust and consensus** among these diverse stakeholders regarding data sharing, governance, and decision-making processes which can be complex and time-consuming.

“When I have information, how do I even trust the people that I'm sharing the information? So that's why in this side, we have a lot of confidential information that we don't give out. So, whatever we give out is not much.” Participant, 17NG.

c) Corruption

Corruption was found to pose a significant barrier to successful blockchain adoption, primarily due to the technology's reliance on trust and transparency, and if any of the disaster partners are corrupt or engage in fraudulent activities, they may attempt to manipulate or distort the information to be recorded on the blockchain, or they can hinder fair governance in the consensus mechanism used thus distorting the trust that the technology provides. Respondents cited that the current internet parking fees are manipulated, or management insists on manual collection of fees and such fraudulent issues could be escalated in manipulating DRR information.

d) Few BCT applications in HSCs

The limited number of use cases for blockchain was cited as a barrier to its successful adoption limiting its perceived utility and uncertainty regarding its long-term viability.

“We may want to implement such a technology, but how many people out there are using a similar technology? Very few.” Participant, 12LN.

e) Governance challenges

Government control was mentioned to be a barrier to successful BCT adoption. State-controlled entities were said to reject the decentralisation, and transparency offered by blockchain, as it challenges their existing power structures and control over data or resources.

“I always say it's all about interest. Just because at the end of the day. We are in a society that's really controlled by the government. So, it's always about the interest of the government. If it will work, I know it can cause I know even first world countries are really struggling with it.” Participant, 20NC.

Government control could impede real time information sharing offered by BCT.

“For government, information is normally vetted. So that is one item that may cause delay, due to the control flow of information.” Participant, 19NG.

f) Conflicts of interests

There were struggles between professionals and government officials over technological implementations.

“Sometimes you know I'm talking about this country, where financial resources are controlled by the political class, implementations and responses, and the frameworks and the innovations are controlled by the professionals and when such don't match, what happens?” Participant, 19NG.

g) Policy and regulatory limitations

Lack of policies would inhibit BCT adoption in Kenya.

“I think we also have policy limitations. I would say we have policy limitations, and this limits what can be operationalised.” Participant, 11JC.

h) Digital divide and lack of digital literacy

High digital illiteracy levels were cited to potentially hinder blockchain adoption in some parts of the country as they may not understand instructions to input data successfully.

“Most people in Northern Kenya haven't gone to school, and they only understand their own language. They're not literate enough, to understand the basics required for digitising data.” Participant, 1SN.

i) Lack of BCT knowledge

Lack of knowledge about BCT could hinder its adoption and make malicious people misinform people against the blockchain.

“I will say there is lack of knowledge on how to utilise it. Your study also can try to help out, because once you expose something that is not known to people and they see how it can support them do their work better, why not? Because sometimes people don't adopt technology because they don't know it.” Participant, 5SG.

j) Lack of technical skills

There was a lack of skilled developers, who would build and maintain the blockchain systems in HOs.

“Our organisation does not have someone with possession of the knowledge and skills, to develop and maintain it, besides, not everybody is able to use technology as some guys are not always technology-wise competent.” Participant, 11JC.

k) Scalability issues

It was difficult to scale piloted blockchain projects and HOs also struggled with to scaling up new technologies due to their disruptive nature.

“The most technological companies are moving to the cloud, hence most of the on-premise solutions they had are being phased out, and with that comes an introduction of newer technologies which gives one a challenge to scale up.” Participant, 27NN.

l) High investment cost

Due to the high investment cost of BCT, decision makers would need to either buy or outsource it.

“The other thing is return on investment. It becomes a bit challenging to explain why you are using so much as compared to doing what the core function is, and then some people are already just outsourcing the services.” Participant, 27NN.

a) Infrastructure barrier

For the **infrastructure barrier** respondents mentioned the lack of a steady flow of electricity and hardware's required for BCT implementation. Other respondents from the ASAL regions expressed that communities' members lack smartphones, and this may hinder an effective information sharing. ASAL regions suffered from network coverage issues which would disrupt or delay information sharing amongst partners.

b) Technological risk

Lack of awareness of BCT posed technological risks.

“We are so scared when we hear about Bitcoin and all that. The eyeballs scan that’s happening right now in Kenya for the World Coin for instance, what will happen to that data?” Participant, 5SG.

Security concerns also posed risk on BCT.

“I would like to dig deep, and look at especially the risk factors with that system. Is it hackable? Can somebody hack into that system and the people who are managing the kind of information that I’m giving them. So that I might be giving information, while I’m selling my country. Somebody will know my vulnerable point, and then tomorrow they will eat me. “Where you think that information cannot be altered, you’ll be shocked at the way that information will be altered as they are experts in these kinds of things.” Participant, 18NG.

Similarly, HOs fear technological risk to safeguard their reputation.

“You’ll find that organisations fear the risk. Where is our reputation going to be destroyed? Let me tell you one thing, what we are normally very keen with is the system risk, especially in regard to data of the skeleton transmission. Otherwise, they may not be able to like, accept or even own it.” Participant, 1SN.