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Title: The Impact of Technological Innovation on Disaster Response and Risk Reduction through Urban Planning: Case of Cyber City (Mt Hampden) Harare, Zimbabwe.

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APPROVAL FORM

The undersigned attests to having evaluated this project and authorized its submission for marking after making sure it complies with the requirements of the HBSc DMS, Faculty of Science, and Disaster Risk Reduction Department.

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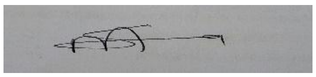
DECLARATION FORM

I, MACHESA MUFAROWASHE STELLA, with registration number B213146B, affirm that this dissertation results from my own efforts and has not been previously submitted to any institution other than Bindura University of Science Education. All sources used or quoted are cited and comprehensively referenced.

Signature:  **Date: 06/05/25**

DEDICATION

This dissertation is dedicated to my mother, Rachael Machesa and my sister Heather Chiveza. Thank you for your unwavering support and love. Without your love, prayers, care and support, I would not have come this far. I'm glad for my mother's faith in me. You have been a tower of support for me throughout, and I am grateful.

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May the Almighty bless you all!

ACRONYMS

AI	Artificial intelligence
CPU	Civil Protection Unit
DL	Deep Learning
DRR	Disaster Risk Reduction
EMA	Environmental Management Agency
GDP	Gross Domestic Product
GIS	Geographical Information System
IDP	Integrated Development Plan
IoT	Internet of Things
LRT	Light rail transit
ML	Machine Learning
NGO	non-governmental organizations
NUA	New Urban Agenda
TAM	Technology Acceptance Model
UDRI	Urban Disaster Reduction Index
VR	Virtual reality

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ABSTRACT

This chapter presents a comprehensive study and discussion of research findings on the application of technical breakthroughs in urban design to reduce disaster risk. The study took a mixed-methods approach, combining employee questionnaire responses (80% response rate) with case studies of Big Data and AI applications in crisis management. The findings show that Big Data technologies such as Hadoop, Spark, and NoSQL databases are critical for processing and analyzing large datasets to predict, monitor, and respond to disasters. Geographic Information Systems (GIS), Internet of Things (IoT) sensors, and social media platforms such as Twitter help to boost early warning systems and improve real-time situational awareness. Machine Learning (ML) and Deep Learning (DL) models achieve outstanding accuracy levels (ranging from 80% to 99%) across several disaster phases, with DL excelling in damage assessment and post-disaster response, while ML is more effective in risk assessment and early warning procedures. Nevertheless, obstacles like data integration issues, privacy concerns, and restricted access to critical datasets (e.g., satellite and social media data) limit the full promise of these technologies. Furthermore, security weaknesses in wireless communication networks pose hazards that must be addressed. The chapter finishes by emphasizing Big Data and AI's transformational potential in disaster management, and advocating for improved interoperability, data-sharing frameworks, and security measures to construct more resilient urban planning systems. These ideas provide a foundation for policymakers and practitioners to use technology successfully in disaster risk reduction.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Integrated ecosystems and resilient cities require purposeful planning; however, many sprawl cities, such as Harare in Zimbabwe, situated in developing nations, lack this feature. Insufficient planning leads to critical infrastructural breakdowns, safety hazards, and economic collapse. Consequently, citizens are plunged into extreme unemployment, homelessness, inadequate access to essential health services, and dispossession of shelter (Chirisa, 2014). Modern mobile phone applications, remote detection technologies, and Geographic Information Systems (GIS) have provided new possibilities for regional and urban planners. With these techniques, planners and managers are empowered to mitigate infrastructure risks, optimize resource allocation, engage the local populace, and participatively resolve urban problems. Suggested methods, if adopted, would profoundly enhance city living, greatly increasing adaptability and standards of living.

1.2 Background of the Study

Barcelona is a city that has implemented smart technologies around the globe to assist in urban living and resource management (Topic, 2015). The city built an entire ecosystem of the Internet of Things (IoT) that includes waste management, traffic control, and energy consumption integration. For example, smart waste containers inform systems requiring supervision and collection route optimization, which can be preemptively activated, minimizing operational costs. This method decreases vehicle emissions and improves environmental sustainability. Singapore is rather famed for technology use in urban planning and management, especially with the "Smart Nation" initiative (Leong et al., 2021). The city-state employs GIS and data analytics to develop a comprehensive blueprint for urban design. One of their important projects is the Virtual Singapore program, which offers urban planners a 3D computer model of the city for simulations and assessments of prospective development (Chen, 2021). This framework enhances the efficiency of the decision-making processes about the land use and infrastructure of the city, ensuring that developments obey the sustainable and accessible vision for the urban growth cycle.

The capital city of Ethiopia, Addis Ababa, has emerged as an outstanding example of excellent African urban development.

Rezvani et al. (2023) explains that the city has formulated an Integrated Development Plan (IDP) with the intention of dealing with the impacts of urbanization within a socially and economically inclusive sustainable framework. One of the urban planning priorities for Addis Ababa is Transit Oriented Development (TOD). It is also a prerequisite for public transportation. The introduction of Light Rail Transit (LRT) systems has transformed public transport for city residents by providing reliable and efficient transport services. Formerly the LRT was inaugurated in 2015 as the first in Sub-Saharan Africa, it now connects multiple regions with the city center. Ceder (2021) observes that the system has considerably reduced traffic congestion and travel times for residents which has increased public transport usage. Along with these benefits, the LRT expands access to strategic economic zones which enhances employment opportunities, increases economic mobility, and works for citizens.

Informal housing settlements have become a pressing issue in Ethiopia, and to tackle this issue, the government is planning to construct affordable housing units as the main component of the integrated development plan. The Ethiopian government is making attempts to fulfill the housing requirements for low-to-middle-income households with programs such as the "20/80 Housing Scheme" (Poshai et al., 2024). In addition to residential construction, informal settlements are being upgraded to extend water, sewage, and power facilities. Furthermore, Addis Ababa is undergoing directed urban planning where resource conservation techniques are incorporated into engineering works. Apart from these urban planning objectives, the government aims at improving the amount of parks and green spaces within the area which is also an important contributor to the government's life quality index. Regionally, there is a sharp improvement in air quality and biodiversity which is associated with increased access to leisure and recreational activities for the citizens. In line with the national climate change mitigation and deforestation strategy, the Addis Ababa government has also started tree planting campaigns (Temesgen, A., 2022).

The challenges confronting urban planning in Zimbabwe are intertwined, including rural-to-urban migration, insufficient funding for infrastructure, and advanced sustainable development (Matamanda, 2020). Nevertheless, some attempts have been made to address these issues technologically. Chronic drainage issues in the capital city of Harare have historically plagued the region. These problems are exacerbated by rainfall that floods, disrupts traffic, and deteriorates conditions even further. Citizens have grown frustrated with the apparent inaction by the Harare City Council regarding the upkeep of functional drainage systems (Chirisa, 2014). Citizens bear the burdens from urban planning absences where the safety and mobilities promised are, instead, trapped within the risks of floods. During the past week, persistent rains caused severe floods in the CBD of Harare and along key thoroughfares such as Chinhoyi Street, Rezende Street, and even Julius Nyerere Way. Flooding of critical routes rendered them impassable to vehicles and public transport. This not only impedes daily life but also stifles local businesses and regional economic activity.

Flooding poses challenges to people as they must navigate around deep waters which is particularly dangerous for the elderly and young children. In addition, there will be severe disruption to the economy due to businesses and services coming to a full stop, resulting in diminished consumer foot traffic and spending which will further hurt the economy.

Chitungwiza faces a set of challenges pertaining to water supply and management (Musemwa, 2021). For processes like urbanization to develop constructively, the topography and ecosystem balance must be factored in. The nearby water sources are already polluted due to poor industrial practices which access to clean water for residents. It is also important to acknowledge that in recent decades, population growth due to migration from rural areas to urban centers for better employment opportunities has been considerable. Basic water supply and sanitation services have been exceeded due to rapid urbanization, leading to overdependence (Ndaw, 2016). Due to the demand, residents face decreased water supply and interrupted service from the systems designed to provide water.

1.3 Problem Statement

The last few years have witnessed an increase in the occurrence of natural disasters which have systematically obliterated several towns and cities, as well as created new challenges for disaster management systems. These systems appear to be underdeveloped and poorly integrated, which exacerbates damages. The modern technologies that include mobile phone applications, geographic information systems (GIS), remote sensing, and artificial intelligence (AI) can vastly optimize response to disasters, urban planning, and mitigation of risks.

1.4 Aim

This study seeks to analyze the effects of technological innovations on the response to, and risk mitigation planning for, disasters in Mt Hampden, Harare.

1.5 Objectives

1. To examine innovative technologies that might aid urban planning for risk mitigation.

2. To assess the effects these technologies have had on the efficiency of disaster response.

3. To evaluate the impact of technological innovation on disaster response.

1.6 Research Questions

I. Which of the offending technology innovations can be employed in urban planning to assist in risk mitigation?

II. What is the effect of these technologies on the efficiency of disaster management operations in urban settings?

III. How does technological innovation assist in enabling response actions for a given disaster?

1.7 Significance of the Study

As far as Mt Hampden is concerned, this research will inform community collaborators and civic leaders as well as spatial planners. This research seeks to inform policies by advancing an urban planning model that incorporates multi-hazard planning to bolster community resilience. Additionally, it may serve other metropolitan areas facing similar issues by promoting technological solutions for disaster risk reduction aimed at greater ecological sustainability.

1.8 Scope

The current study covers the trends in technology pertaining to disaster management and urban planning in relation to Mt Hampden, Harare. It looks into the use of technology such as GIS, drones, and mobile applications in managing disaster risks. The research will explore the opportunities for some of the technologies to be incorporated into the local urban planning frameworks to mitigate the risks. Views will be collected via survey from the general community as well as local government stakeholder groups but no other towns and cities beyond Mt Hampden will be included. The study will explore community perception and technology use perception but will not explore the details of technology implementation. The findings of the study will contribute towards formulating and local policies and plans towards effective disaster management, urban resilience, and their operational strategies.

1.9 Definition of Key Terms

1.9.1 Technological innovation means activities that produce or modify an existing technology, device, system or process, which involves a significant shift in multiple domains. This involves use of information, knowledge and materials to develop new methods aimed at solving issues, enhancing productivity, promoting development, and creating value (Coccia, 2021).

1.9.2 Disaster response strategies seek to reduce the health and life-sustaining impacts of a disaster during the moments immediately before, during, and after the disaster (Siriwardhana et al., 2021).

1.9.3 Urban planning addresses the problem in a city which requires a policy that will govern these human phenomena and the relationships occurring within the spatial confines of a city so as to provide a structured approach for the distribution of land, transport, infrastructure, services and nature vis-a-vis equilibrium so that all users fairly share the advantages and disadvantages of using the constructed socio-economic facilities (Chirisa, 2014).

1.9.4 Risk Reduction is one of the risk control measures that aims at minimizing the economic losses that are likely to be incurred. This phrase covers an extremely broad range of factors, which may include some form of loss mitigation, reduction in the frequency of loss, or reducing the probability of the loss happening (Rezvani et al., 2023).

1.9.5 Disasters are described as disruptions to the functioning of a community or society on a local, regional, or national level paired with a hazardous event occurring alongside exposure, vulnerability, and capacity and along with impact loss, which can include human loss, material loss, economic loss, environmental loss, and more. Focus is placed on the socio-geographical scale and social dimensions of disaster analyzed in terms spatially, including the impacts extending from the epicenter to the periphery. This is particularly important concerning the difference between response to an emergency and recovery activities (UNISDR 2016).

1.10 Research Project Structure

Along with the chapter's conclusion, the outline includes background of the study; purposive statement, problem statement, research objectives, research questions, hypothesis, significance of the study, scope and delimitation, definition of major concepts which are anchored within the focus of the chapter. In chapter two, the theoretical framework as well as the literature review deepens the study within the scope of the previous chapter. Chapter three deals with methodology, which is a blended research design alongside the research instruments applied in the study. Other considerations addressed within the study include ethical considerations. The fourth chapter is dedicated to data presentation as well as analysis and discussion of findings in relation to interview and questionnaire results. Chapter five revolves around the summary and conclusion, providing final thoughts while also formulating a proposal for further research.

1.11 Chapter Summary

This chapter examines the planning function of cities, focusing on sustainable development in less economically developed countries (LEDCs) such as Harare. It considers the impacts of unchecked urban sprawl, informal settlements, and the lack of infrastructure and services which contribute to flooding, waterborne diseases, systemic failures, public safety risks, and financial burdens. Barcelona and Singapore demonstrate how smart technologies improve the living standards of residents and enhance service delivery on multiple levels. This chapter graples with the contours of Harare in particular; furthermore, the exacerbating problem of insufficient drainage to curb excessive flooding creates a greater need for advanced technology-based disaster managements, such as GIS and mobile applications. The research's central focus is the impact of these technologies on disaster management and planning response frameworks aimed at improving practice and community resilience. Along with some definitional clarifications, a technological shift is applied to the area of Hampden. It concludes by formulating the WIP framework that will be developed in the next chapters.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The innovative strategies of dealing with disasters and planning urban areas about population centers is becoming a very important concern given the scope and scale of the recurring disasters. This study aims to integrate technology in retrospective studies and frameworks to self-evaluate risk associated with development around Mt Hampden in the city of Harare.

2.1. Addressing Risks and Emergency Response: Integrating Technology into Urban Planning

Proper Land Use Planning techniques can eliminate accident-prone areas by designating and delineating safe construction regions using appropriate technology. Cities can restrict construction in hazardous areas through effective zoning policies as a way to minimize disaster risks. Infrastructural design ─ drainage systems, roadways, and other emergency facilities ─ contributes greatly to disaster mitigation (Saunders & Kilvington, 2016). Weather protective systems proposed by urban planners allow structures and systems to sustain severe damage. Community participation fosters resilience by collaborating with the local residents during the planning stages. Through active engagement, residents help address and prioritize their needs enabling planners to devise better local disaster management strategies.

2.1.1. Technological Advances in Urban Planning

As described by Xhafa (2015), urban planners have leveraged GIS technology because it allows them to visualize and analyze geospatial data. With GIS technology, planners are capable of creating sophisticated maps portraying vulnerabilities spatially, depicting the high-risk areas within urban zones. This information aids in making land use decisions as well as planning for various infrastructural facilities and even emergency services. Salazar and FdezArroyabe (2018) reported that remote sensing technologies such as satellite images and aerial photographs are invaluable for environmental monitoring, damage and disaster evaluation, as well as for planning for risks management. Urban planners can employ these tools to oversee the growth of cities, land use changes, and other climatic impacts and local hazards over time. Furthermore, mobile applications designed for communication and information dissemination regarding disasters are novel solutions. Such applications can relay timely information about alerts, evacuation routes, and assistance available so community members can remain alert, and disaster response efforts can be improved. The sophisticated analytics of big data on population density, structure, infrastructure, and disaster history is now possible with modern urban planning technologies.

Predictive modeling is one of the tools that can be used to foresee possible threats and to plan prevention initiatives. Drones, equipped with cameras and sensors, can conduct aerial surveys and evaluate the impact of disasters (Khan & Gupta, 2022). Urban planners can evaluate and enhance risk zone mapping, infrastructure monitoring, and damage assessment using drones. This technology improves the collection and analysis of data, thereby improving response time.

2.2. Disaster Risk and Its Causes

The United Nations Office for Disaster Risk Reduction (UNISDR) has defined disaster risk as follows. Risk = Hazard × Capacity \ Vulnerability. From this definition, we see three fundamental elements interacting. “Hazard” represents the potential injuries and destruction that could be caused by a natural or anthropogenic phenomenon. These include but are not limited to typhoons, earthquakes, floods, and even industrial accidents. These hazards have different intensity levels based on the geography and environment in which they are situated (Wannous & Velasquez, 2017). Vulnerability is the ability of individuals and populations, as well as systems, to sustain injuries when exposed to a hazard. This depends on several determining factors such as socioeconomic parameters, infrastructure development level, and public awareness.

Vulnerability can also stem from a lack of shelter, information, or resources for disaster preparedness. In the context of a given community or nation, capacity refers to the human skills and resources available at the individual, organizational, and institutional levels, including the technology and financial resources available, which enable disaster planning, response, and recovery. High capacity results in reduced risks and minimized disaster risk.

2.2.1 Impact of Climate Change, Urban Growth, and Poor Governance on Increasing Disaster Risks

The work of Zheng et al (2024) emphasize that the risk associated with climate change is worsened by the rest of natural disasters as a consequence of alterations in their frequency, severity, and geographical occurrence. The rise in global temperatures, as an example, is associated with an increase in heavy rainfall, droughts, and stronger winds. These changes exacerbate pre-existing vulnerabilities in disaster-affected regions. Climate change in Zimbabwe, for example, has shifted rainfall patterns, which increases the risk of flooding during the rainy season while also constraining agricultural productivity.

Rapid urbanization in less developed countries, and the informal settlements within them, pose a heightened risk due to a lack of basic infrastructure, sanitation, or emergency services, and inadequate resources to sustain the high population. Mursaleen and Bashir (2025) indicate such areas are especially prone to disaster. The uncontrolled expansion of Harare City is likely to increase flooding risk because the drainage systems are unable to keep pace with the rainfall. Also, the city's population and infrastructural concentration make disaster response difficult, compounding the risk.

Poor governance, together with weak institutional structures, increases the level of perilous disaster threats. Displays of insufficient political will, absence of policy alignment alongside weak investment into proactive planning, monitoring and evaluation frameworks expose communities to unnecessary danger. Insufficient governance may result in poor enforcement of building codes, ineffective zoning regulations, and underinvestment in critical facilities (Carrillo, 2016). The absence of integrated frameworks for disaster risk management in a resource-constrained and governance-challenged country like Zimbabwe compromises the attempts to enhance resilience and reduce vulnerability to disasters.

To conclude, the Zimbabwean people, like other nations, need to understand that disaster risks and changes in climate, urbanization, and poor governance are all interdependent. There is potential for efficiency in managing disaster risks through targeted interventions informed by sound policy frameworks aimed at addressing the identified gaps.

2.3 Technological Innovation in Disaster Response (Global Perspective)

Long-term sustainable growth and the development of a particular region is integrated in a knowledge-based economy. It is in a network society where an individual's and corporate socioeconomic class is stratified based on their capacity to enter into strategic collaborations that are partnerships based on knowledge and learning intensive (Clarke, 2001). The last two decades have been marked by profound changes in the business world with the advent of and the emergence of information and communication technologies (ICTs). It is the knowledge economy's backbone. It has a distinguishing feature of the need to manage an intangible asset; an asset as opposed to material resources, increases in value when utilized (Laszlo and Laszlo, 2006). An information-based economy emphasizes the generation of knowledge and creativity as core components of the mechanisms that drive economic and urban growth.

Additionally, more recent research indicates that there is an important correlation between regions that are creative and the growth of economies (Durmaz et al., 2008). In other words, the wealth of cities in the knowledge age is defined by their creativity. For the past three decades, these include and have encompassed regions of famous metropolitan areas which are now emerging as epicenters for clusters of knowledge regions around the globe. These are Silicon Valley, DNA Valley, and One-North.

In addition, Winden and Berg (2004) claim that knowledge cities not only need to provide the requisite resources and workforce to generate knowledge but also need to be proactive sponsors of creativity and innovation. A knowledge economy uses research, technology, and intellect to produce high-value-added goods. A knowledge city integrates the business and public sectors that value knowledge, invest in its creation and dissemination, and use it to produce goods and services (Carrillo, 2016).

The first two paragraphs comprise the analysis, and this phrase fits perfectly with the analysis. To begin, I will clearly define the issues from urbanization and agglomeration to socioeconomic barriers and more. Afterward, I will describe the depiction of the layouts and maps along with the use of floats and agitation as illustrative tools. Despite many local initiatives proudly branding themselves as 'knowledge cities,' only a few have earned that title, including Barcelona, Delft, Dublin, Montreal, Munich, and even Singapore. Following this analysis, other regions seeking the title of "knowledge city" through knowledge-based urban development strategies include

Bangalore, Brisbane, Copenhagen, Dubai, Kuala Lumpur, and Shanghai (Yigitcanlar, 2008). One of the most defining characteristics of a knowledge city is the sustained access to vast amounts of capital investment capable of stimulating economic growth.

This allows cities to exploit as motivation for controlling the economy the organizational capabilities, socio-cultural vibrancy, and even the more natural knowledge and physical monuments (Baum et al 2007). This discipline and practice, which stems from the entrepreneurial and scholarly activities that produce knowledge, offers a more constructive and hopeful outlook towards the creation of urban zones that are imaginative and inventive (Yigitcanlar and Velibeyoglu 2018). Arising as a major focal point feature of the alarming increase in the global struggle for economic advancement, KBUD, or knowledge-based urban development, calls for a radical reinterpretation of some of the most basic concepts of management value relationships, capital systems, controlling regions, and development planning. A KBUD's primary guarantee offers attaining a sustainable economy in human habitat, which is sustainable urban and economic development(Yigitcanlar et al., 2008). The interrelated set of three primary goals central for the socio-urban and economic policy framework are interlinked and provide almost all domains of socio-urban and economic policy.

Again, this focuses on a central aspect of economic growth, the Advancing a Development Strategy of Structured Economic Growth. The processes that lead to the creation of these areas, ‘settlements’, are a result of technology shifts as well as changes in the economy. Advancements such as the worldwide telecommunication systems have impacts on the structure and functioning of the global economy. This is illustrated in the new `International Division of Labor` where the production process is separated from the R&D and upper level management functions, but all portions of the manufacturing process are in instantaneous spatial communication with each other.

The idea of long economic waves, which denotes the recurring pattern of growth and reduction in the economic activity of a nation, illustrates the effect of technology shifts on the macroeconomy. The early cycles of innovation (known as Kondratieff cycles) were based on steam and water power mechanization. The current cycle, which is the most recent one, is still focused on microelectronics and digital telecommunication, robotics, and even biotechnology. As Konderatieff cycles pose numerous technical revolutions, there is a shift in the economy and it also affects the pace and nature of urban change as well as transformations. While cyclically driven processes continue to reshape the economy, the resulting alterations to a city's geography are most prominently observed during the high phase of the cycle. Some technologies developed for certain regions change the actual shape of the city. Examples of this include the suburbanization transport technologies and the construction of skyscrapers in New York, which were made possible due to high-speed elevators.

2.4 Innovation in Technology Applied to Urban Planning (A Regional View)

India leads the adoption of geospatial technology. This technology has been integrated into disaster risk reduction activities such as risk assessment, mapping, early warning systems, planning, preparedness, and ongoing monitoring and evaluation. Disaster management in India is made easier with the use of spatial technology because of its scalability, reach, and ability to replicate systems. Participation from industry leaders could further enhance these efforts and make them more attractive. The North-Eastern Region of India is considered one of the most disaster-prone areas in the world (Sandilya et al, 2024). The region is prone to numerous natural hazards which vary in intensity from one area to another and over time. Most parts of the region are afflicted with recurrent flooding, landslides, cyclones, thunderstorms, and riverbank erosion. The primary driver of these catastrophic calamities includes geographical features such as underlying geological attributes, relief, situational context, locational coordinates, etc. To mitigate these disasters and provide a comprehensive solution to the predominant disasters afflicting the region, the North Eastern Regional Node for Disaster Risk Reduction (NER DRR) was established at NESAC in Shillong.

NESAC has been trying to improve the use of space-based input technologies for preparing inputs related to floods, landslides, forest fires, thunderstorms, industrial accidents, and precursors to earthquakes, with a focus on the Northeastern states (NER) of India. As observed by Yigitcanlar et al. in 2008, the NER-DRR system is one of the systems that has substantially enhanced disaster management in the Northeast region of India, augmenting the government's disaster response capabilities. Northeast India NER-DRR aims to achieve disaster mitigation, disaster preparedness, and comprehensive disaster risk reduction by constructing a central server geospatial database for multiple disaster-prone regions in Northeast India. It is essential to develop simulation models and other automated geographic information systems decision-making support tools tailored to assist the Northern India NER resources using the geographic datasets stored in static data servers for advanced systems.

The setting up of National and State Emergency Operation Centers at the district level helps in the quicker and more efficient distribution of services that have been augmented with space technology and can be interfaced through satellite communication systems mounted over VPS/Space Technology Networks. Provide operational assistance to the area in conjunction with all interested parties, and with all stakeholders, design and develop products and services which meet the needs of the area. ISRO/NESAC is willing to undertake initiatives to expose potential users to how these sophisticated and reliable systems will work in communications design with built-in redundancy features. Conduct advocacy workshops for stakeholders on disaster risk reduction and the general community, showing them the application of geo-spatial technologies (Subashini and Sellamuthu, 2025). NER-DRR includes these domains of disaster: flood, landslide, earthquake information systems, crop damage assessment, forest fire, meteorological services, hazard and vulnerability assessment, epidemiological disasters, industrial hazards, and satellite communication. Systems for early warning are able to monitor floods, severe storms, lightning, and some epidemic disasters, as well as experimental monitoring of landslides and many other phenomena. Most of the activities of NER-DRR operate based on the requirements of the State Disaster Management Authorities (SDMAs) for the Northeast region.

2.5 Case Study: Zimbabwe's Struggles with Disaster Management

Planning is a prerequisite for sustainability. The zoning laws in Zimbabwe have adverse effects on most low-income families and marginalized builders, preventing them from constructing appropriate shelter (Tibaijuka 2005; Chaeruka and Munzwa 2009; Mubvami and Musandu Nyamayaro 1993). Such planning systems are rooted in a compulsion to enhance control, health, security, order and cleanliness, as quoted from the Regional, Town and Country Planning Act (Chapter 29:12) (Davison, 2002). There are acute increases in urbanization, poverty, unemployment, even homelessness, and at the same time enduring shifts in economic growth. To combat climbing poverty rates, entire families are squeezed into single dwellings, resulting in slum proliferation (Tevera and Chikanda, 2000). This is referred to as Development control or demolition and tight control of urban space (Toriro, 2007). There is also a disproportionate urgency in fulfilling construction and housing targets in Zimbabwe's planning of housing and urban development (Kamete, 2009), which eliminates the likelihood of providing affordable housing.

Christiansen and Winding claim that urban sprawl, land use zoning, systematized hierarchies, and low-income group exclusionary policy all work together to create a synergistic system, which the poor lack the resources to meet regulatory frameworks resulting in ineffective planning (2007). These inadequacies have been termed "planning failures," as proposed by Toriro (2007) which also explains the stagnated pace of construction in high-demand urbanized areas, in addition to the systematic omission of the poor from housing provision frameworks (Payne, 2005).

The construction policy from the perspective of housing development focuses on the supply perspective of capital, skilled labor, and training including policies, technology, legal frameworks, as well as demand in relation to preferences and sale prices of finances of the household in question. However, in Zimbabwe, construction must comply with urban planning requisites. Musandu states that RTCPA requirements often impose consolidation or subdivision of land post construction (1993). This is sometimes coupled with a change of land use. Bureaucratic procedures are known to raise other development costs other than transaction costs (Olsen, 2005; Natsios, 2010).

The planners stated their opposition to the socio-legal framework for 'choking' the growth of urban housing for which the backlog is currently estimated at over half a million units (Newsday, 2010). These concerns emerged during what was described as "Planning legislation, procedures and best practices" at the ZIRUP annual conference in Kariba. The decision came after an article in Newsday titled "Town planners blast legislation" dated August 24, 2010. Town planners supported an analysis of town planning laws and regulations, thus justifying the lack of urban housing construction.

There are policy barriers towards national housing construction, especially within strict period limits for processing applications and the slow rate of their approval, which greatly constrains the rate of growth of the housing stock. Such significant constraints result in a lag in the construction needed for infrastructure development of roads and water pipes necessary for housing construction within a particular region. A gradual population increase and settl

In solving multicriteria decision problems, the decision maker must evaluate multiple criteria, the utilities of which are integrated into a single mathematical expression referred to as the multi-attribute utility function. Criteria are hierarchically structured problems in which each criterion is associated with a utility function. This function is generated by normalizing scores onto a scale with best and worst predefined outcome boundaries of the criterion at each extreme. This shifting global environment has transformed the industry, changing customer preferences and bringing new competitors into the market. The year 2020 brought uncertainty, spotlighting the need for effective risk management within the textile sector. Firms are now focused on creating extremely resilient supply chains.

Nevertheless, responding to the aftermath of the pandemic requires much more than a quick reaction. It requires thinking differently, which means learning about the dangers one faces in their sector and developing long-lasting strategies (Naiwen et al., 2021). In the textile industry, financial payment risks can arise from several sources, such as negotiating poor contracts and receiving weak payment terms. You must be attentive regarding the numerous options available to ensure prompt receipt of payment for goods rendered.

2.7 Urban Risk Reduction in Zimbabwe

Urban risk reduction remains a compelling issue in Zimbabwe, especially in its capital city Harare, which suffers from persistent flooding problems. The city experiences severe floods as a result of its infrastructure being incapable of supporting heavy rainfall, flooding decimated neighborhoods, transportation systems, and causing extensive damage to property and infrastructure. To address this important need, numerous technical solutions have emerged to improve preparedness and reaction. One notable example is the use of drainage modelling software, which permits urban planners and engineers to model and analyze the city's drainage systems to identify critical chokepoints and optimize the design of the drainage infrastructure. According to Schmidt (2024), city planners are now able to determine more accurately the flood scenarios and take appropriate actions to reduce the impact through advanced modeling techniques which assists in proactive flood management, ultimately protecting vulnerable areas.

Notwithstanding the possible advantages of these technological solutions, their effective implementation in Harare is hindered by stark policy gaps. One primary concern is the lack of holistic policy approaches that integrate modern technology with disaster risk management, as well as urban planning. Outdated policies often overlook the fundamental functions that technology can serve in alleviating urban perils, which leads to lost opportunities for development. Moreover, limited funding and resources severely hinder the adoption of new approaches, creating barriers for local governments to spend on necessary technological upgrades and infrastructure improvements (Jiménez and García 2012). In addition, there is an urgent need to devise training programs to help planners and municipal officials acquire the requisite technological skills and knowledge. Filling these gaps would enable Harare to harness technological innovations for effective urban risk management, thus bolstering the city's resilience to flooding and other disaster-related challenges.

2.8 Theoretical Framework

2.8.1 Disaster Risk Reduction (DRR) Cycle

The Disaster Risk Reduction (DRR) Cycle is a comprehensive approach to efficiently managing disaster risks in a succession of discrete stages (Konecny, 2025). This cycle consists of four major phases which are mitigation or prevention, preparedness, reaction, and recovery.

DISASTER RISK REDUCTION CYCLE

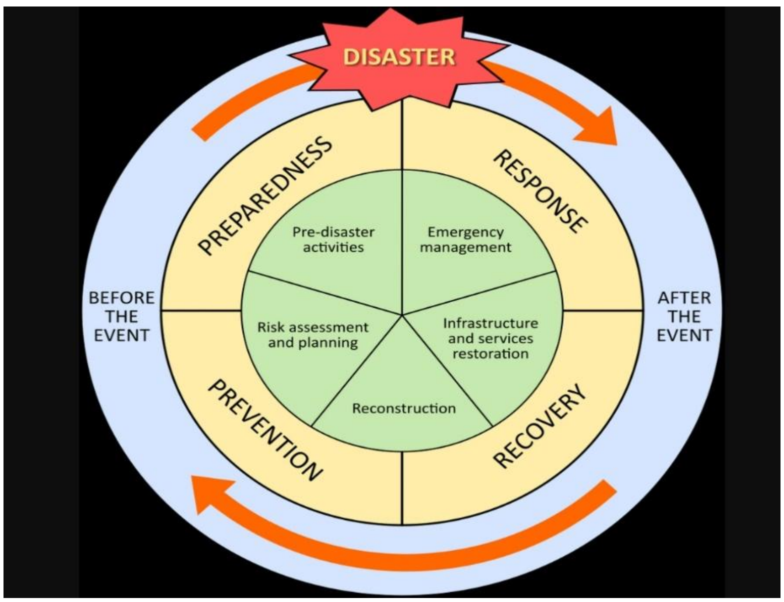

Figure 2.8 Disaster Management Cycle

- Mitigation or prevention of disaster risk reduction involves the implementation of spatial planning and flood defenses which incorporates the engineering design as well as the zoning techniques aimed at reducing or eliminating risks associated with urban disasters. Using sophisticated flood modelling simulation tools, the city's potential floods are simulated to improve its drainage system within the scope of mitigation works made in Harare.
- Preparedness a potential disaster can be mitigated with proper advanced planning and education and training of personnel on drills. National public education campaigns about the risk of untapped disasters and advanced flooding warning mobile technologies that

exist in Zimbabwe will actually prepare the community in advance to respond to flooding emergencies.

- Response refers to actions taken to contain the damage inflicted by the disaster. In this stage commences the emergency response action, protective action for the public, and relief goods dispatch to the affected areas. An integrated approach in dealing with the floods occurring in Harare is to make use of up-to-the-minute mobile computing and drone information, which will greatly improve the speed of rescue operations as soon as the resources required are determined.
- Recovery aims to either bring the damaged area to its original state or improve it. This step includes rebuilding important infrastructure, restoring services, and taking care of the people's needs. Recovery concerning urban design must structurally incorporate lessons from past disasters so that the flood mitigating infrastructure post development is more resilient.

These components of the DRR Cycle can enable urban planners and policymakers to design an advanced disaster risk management system which enhances the community resilience of Harare and other Zimbabwean cities.

2.8.2 Smart Cities Framework

This serves as a further example of a theoretical framework intended to demonstrate the role of modern technologies and current information systems in cities' governance for enhancing urban resilience. The Internet of Things (IoT), big data analytics, and intelligence-enabled infrastructures as part of smart systems create adaptive and flexible environments.

The Internet of Things (IoT) refers to a system of interrelated devices that communicates in real-time. From an overall risk prevention perspective, rainfall and river flow can be monitored. For example, in Harare, smart sensors could be used in sump pumps to monitor water level elevation from the basin during the rainy season. Data governance is defined as the practice of policy making and decision making of policies and governance frameworks based on analytics within the considered data (Poshai et al 2024). Through IoT, urban planners have access to data that allows them to understand and address the numerous vulnerabilities within the urban ecosystem. Concerning data driven approaches in Harare, it is feasible to assess areas that are flood prone and target those areas with anticipatory mitigation efforts (Rezvani et al 2023). Resilience in smart cities incorporates foresight and planning, response, and recovery from metropolitan adverse events, and constitutes one pillar of the smart cities framework.

The integration of monitoring and control technologies within urban planning enhances a city's resilience through efficient resource management, collaboration with other stakeholders, and real-time activity monitoring. Implementing smart city concepts in Zimbabwe could foster greater awareness for disaster risks and improve agile urbanism in the nation.

2.9. Barriers to Implementing Technological Solutions for Disaster Risk Management

As highlighted earlier, there is virtually no technology uptake for disaster risk management (DRM) in Zimbabwe or in more developed urban areas like Harare. One of the glaring problems is the dominant focus on the market price of these technological systems (Joerges, 2019). Internet of Things (IoT) devices, real-time analytics platforms, as well as advanced drainage modeling software pose a significant financial burden. In addition, underfunded countries such as Zimbabwe do not offer fiscal inflow opportunities. Consequently, local governments find it justifiable to restrict expenditures on sophisticated systems. This paradigm shift constricts local governments in Zimbabwe to meeting only basic immediate needs while ignoring the more important long-term mitigation strategies for potential disasters.

The gap between rural and urban areas is a critical concern, too. Compared to urban areas, the Internet and technological infrastructure gaps place remote areas at a disadvantage (Salemink & Bosworth, 2017). Semi-urban centers may have better access to technical infrastructures, but rural areas lack the necessary infrastructural support to avail modern technology. The absence of integrated modern technology in disaster risk management frameworks stifles adequate policy development. Existing frameworks primarily overlook the utilization of technology in the planning and mitigation phases of a disaster. Meda, as quoted in Komino (2019), suggests that in the absence of favorable technology policies, local governments are bound to face challenges in applying appropriate technologies for disaster risk reduction. In addition, a lack of governance may result in the disproportionate allocation of technology across different territories, leading to disparities in the responsiveness and efficiency of disaster preparedness and response strategies.

The integration of technology into disaster risk reduction in Zimbabwe holds a cautiously optimistic promise for enhancements. However, successful implementation is hindered by stubborn gaps such as infrastructural voids, legal barriers, burdensome overhead costs, and other complex socio-political challenges. Addressing these obstacles is essential to enable sophisticated urban systems, like those in Harare, to manage and mitigate disaster risks.

2.10 Problems Encountered in the Use of Technological Innovations for Disaster Response

In addition to the extreme organizational and structural constraints, self-contained unitary resource limitations impose extremely rigid limitations for individuals in Zimbabwe. Given the lack of adequate funding, skilled personnel, modern equipment, and technology, along with insufficient human capital, these circumstances severely constrain the application of SP Technologies for Preparedness and Response.

Acquiring capital for further development of any technology discipline is one of the most concerning challenges. Some communities and organizations do not have the requisite funding types that would enable them to channel resources towards critical technology investments. As noted by Chen et al., modern spending on some high-ticket items, such as drainage modeling software, IoT sensors, and data analytic platforms, can severely limit stakeholder participation due to high barriers to entry. Within extremely resource-constrained environments, insufficient financial support tends to be the primary obstacle to the adoption and implementation of novel disaster response systems, especially when funding priorities are centered on short-term operational necessities rather than strategic long-term objectives. In addition to any breakthrough technology, there has to be trained specialists available to operate and maintain such systems to enable effective technology cross-over.

Nonetheless, some communities and organizations still lack the appropriate training for employees and community members. Often accessible advanced local technological skills go to waste due to poor implementation, resulting in the underutilization of available resources Framework Capstone. Furthermore, the attempt to build capacity often wastes limited resources and time in resource-scarce environments. Many resource-scarce areas lack the foundational structures necessary for the effective application of contemporary technology. Disaster response technology can be severely hampered by sparse bandwidth, unreliable electricity, and poor infrastructure maintenance. These challenges, when combined with the inadequate urban infrastructure in Harare, greatly hinder the ability to keep pace with technological advancements in the modernization of disaster management.

There are various hindrances as to why individuals are unwilling to adopt new innovations for businesses and societies. Preexisting social perceptions of new technologies, gaps at certain levels of information and communications technology (ICT) related skills, and general distrust toward new technologies all pose hurdles to adoption. Furthermore, the notion that technological answers are either not required or far too simplistic serves to worsen stakeholder engagement, thus worsening situation in respect of disaster management (Oke & Arowoiya, 2022). These concerns which you raise are very serious in regard to the efficacy of disaster risk reduction in severely constrained contexts. These communities and organizations are not able to fully leverage sophisticated technologies which hinders their ability to gather data, situational awareness, and disaster communications. The lack of technological integration inadequately prepares and responsively exposes communities and organizations to disasters, thereby increasing their vulnerabilities to risks, particularly among economically disadvantaged populations.

In conclusion, there is an urgent need to resolve the technological issues in disaster response for improving disaster risk reduction in a resource constrained country like Zimbabwe. If financial, instructional, structural, and societal acceptance barriers were removed, communities and organizations could strategically deploy advanced technologies to enhance resilience and efficiently mitigate disaster risks.

2.11 Policy and Technological Solutions for Disaster Risk Reduction in Zimbabwe

A combination of low-cost technological policies coupled with some external collaboration seems to be the best approach for improving disaster response in Zimbabwe, particularly in Harare. Below are some noteworthy solutions that can be implemented.

2.11.1 Case Study: An Example of Low-Cost Innovation

Mobile technology serves as an invaluable asset during emergencies because information can be disseminated quickly. For example, mobile alert systems can transmit vital information to flood prone areas, enabling real-time SMS or application alerts. Citizens are informed of critical hazards and the actions that need to be taken. (White, 2011) This method enhances notification systems, facilitates awareness, and encourages community-level preparedness planning. A more recent unique innovation in disaster response is the use of cameras and sensor-equipped drones. (Ahmed et al, 2023) Community drones can fly over disaster regions to capture aerial images, providing critical situational information necessary for response measures. Drones can also monitor video footage of water levels, infrastructure damage, and populations during floods. This information permits optimal resource allocation, strategic planning, and timely emergency service provider rescue operations. Drones also replace traditional survey methods, making these more cost-effective.

2.11.2. Integrating Policies

Any technological intervention that aims to solve a problem is rendered useless if a comprehensive national policy framework exists. In Zimbabwe, technology is handled under the scope of the National Disaster Risk Reduction Strategy which includes configuration management techniques (Mavhura, 2018). The interface between technology and national policies allows local governments to adopt technology. The interface fosters standardization in the application of technology in disaster preparedness and response leading to uniform practice in diverse areas. Every government official and politician must prioritize the application of technology for disaster risk management on projects, and managed at all levels of government. This includes the use of remote sensing and geographical information systems which promotes public private partnerships, which needs to be led by local authorities. Adoption of the right policies will strengthen Zimbabwe's ability to manage and recover from disasters.

2.11.3 International Collaborations

Partnerships with foreign organizations can offer relevant knowledge, materials, and expertise that can improve disaster risk reduction in Zimbabwe. For example, the UN's "Early Warnings for All" initiative seeks to advance preparedness capacity through the use of aid benchmarks and technology transfer (Chatiza, 2019). Programs of this nature grant Zimbabwe the opportunity to modern technology, funding, and best practices that can strengthen the nation's disaster response planning. Such collaborations can foster intercountry information exchange for nations facing similar challenges in the management of disasters.

2.12. Summary of the Chapter

As highlighted in the review of the related bodies of literature, due to the increasing foreign disasters, innovation emerges as the foremost concern in the case of catastrophe management and urban planning for Cyber City, Mt Hampden, Harare. It focuses on the impact of the mobile and advanced phone technologies on urban governance, public involvement, and disaster administration alongside GIS based applications. It evaluates the impacts of climate change, poor governance, and Zimbabwe's risk profile in the context of internationally sponsored mid-scale smart city projects aimed at urban resiliency. Such concepts as the Disaster Risk Reduction (DRR) Cycle are formulated and funding implementation issues alongside the digital divide are discussed. Finally, it undermines the sound cost technology approach and forming coalitions for global supremacy in disaster mitigation and community resilient design planning.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, we attempt to provide a systematic way for the integration of technology innovations within the framework of disaster management and urban design for risk reduction. It also centres in the target population in the study, sample size and its determination, sampling procedures, research instruments, validity and reliability of the study, data collection techniques and procedures, ethical matters, data analysis and presentation and conclusion made in the study. The approach indeed achieves the purposes it is intended for [6] thanks to the focused, structured method of gathering, interpreting, and analysing the data in accordance with the study objectives.

3.2 Area of the Study

Mt Hampden is an area of strategic importance located just northwest of Harare, the capital city of Zimbabwe. It is about 15 kilometres from the city centre and accessible through major roads. The region has higher-than-average elevation which offers beautiful views as well as cooler temperatures relative to the surroundings. Currently, significant urban development is underway in Mt Hampden with the construction of Cyber City, a smart city project aimed at incorporating modern technologies into the urban planning framework. Together with the ongoing infrastructure developments, the proximity of Mt Hampden to Harare makes it a critical zone for economic development and innovation concerning urban planning, particularly in relation to disaster response and risk mitigation frameworks.

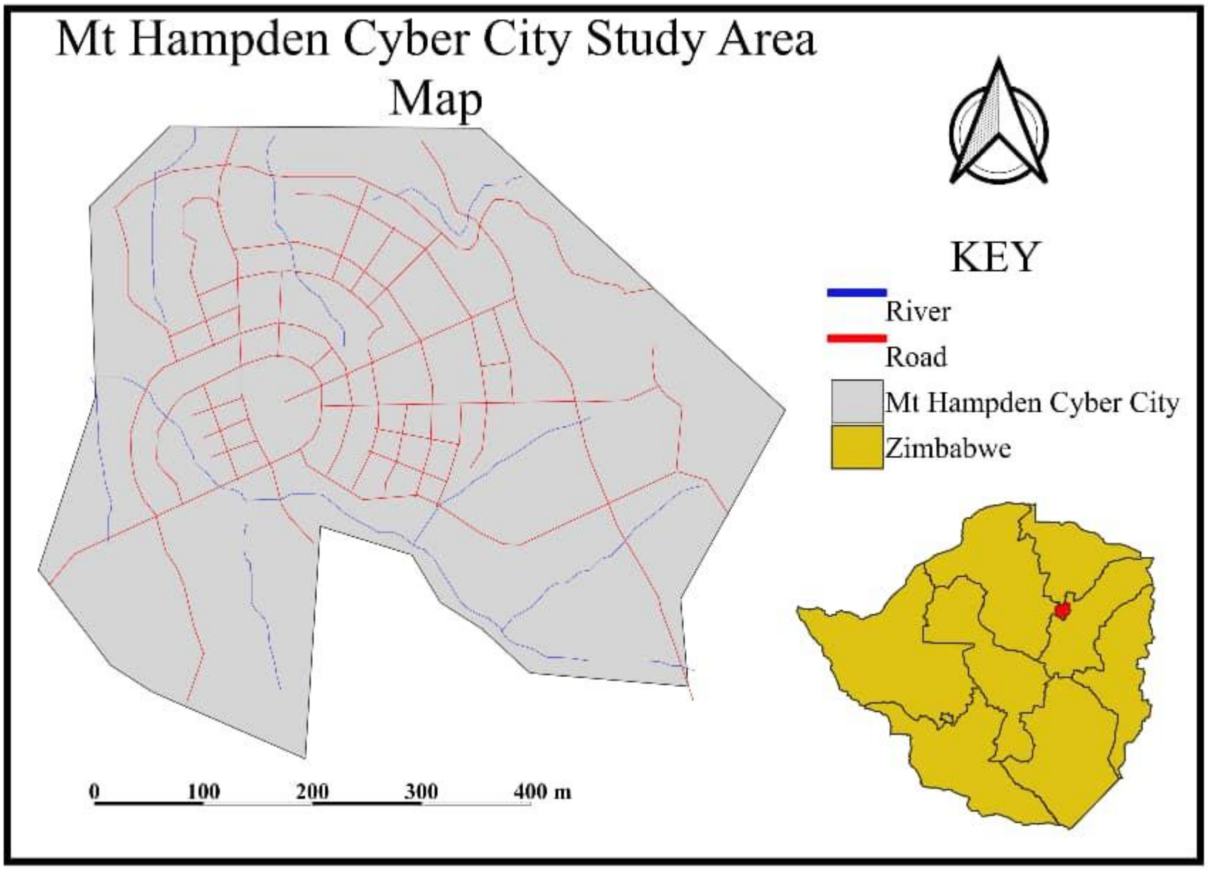

Figure 3.2 shows the area map of Mt Hampden, Harare in Zimbabwe

3.3 The research design

The study employed a mixed-methods design that incorporated both quantitative and qualitative research. This method facilitated the collection of quantitative data through surveys, as well as qualitative data through open-ended interviews, which enhanced understanding of the issue at hand. This method provided better evaluation of the effectiveness of modern improvements in technology in disaster management, which evaluated the results easier (Creswell & Plano Clark, 2018).

The quantitative aspect of the study derives from closed-ended questions that are part of structured questionnaires. This method allowed for capturing numerical information concerning various specific advances in the technology used for disaster management. The questionnaire is designed to ascertain the respondents' actual understanding of the technology, its efficacy, and their concern regarding its use. Respondents are selected through purposive sampling to ensure that participants possess adequate knowledge about disaster management, so that the information collected would be pertinent to the research focus. The study's descriptive quantitative data were computed and analyzed using descriptive statistics, which enabled the assessment of trends and patterns in the data (Bryman, 2016). In addition to the quantitative component, the study also included qualitative elements by incorporating open-ended questions into the structured survey. This design feature allowed participants to express some of their views as well as their experiences and thoughts on the recent changes in technology. Those data were analyzed qualitatively by coding the responses to identify themes and patterns. This thematic analysis greatly strengthened the findings by integrating the qualitative and quantitative data about the research question (Fetters, Curry, and Creswell, 2013).

3.4 Instruments of data collection

3.4.1 Questionnaires

In qualitative research, a questionnaire is an optional substitute for an interview in which the questions are pre-prepared (Mitchell, 2016). It is possible to consider a survey conducted as a questionnaire that measures perception, awareness, and experience with development in technology for disaster risk reduction within a given population. This approach is advantageous because researchers are not limited by geography in where data can be collected systematically. Questionnaires can be constructed for all populations including those with disabilities, thus increasing accessibility.

A case in point is the intellectually disabled population who, while facing challenges in expressing their thoughts, can be aided through the use of questionnaires. The same holds true for individuals with autism or other speech and language disorders. Nonverbal and individuals with restricted speech also benefit from closed-ended questions that require minimal effort to respond. These individuals would respond more readily to questions posed through a questionnaire rather than verbally, thus providing a means to study the effects of technological progress on disaster management and urban planning in Mt Hampden.

3.5 Population and sampling

3.5.1 Population

The personnel engaged in disaster management and those working in urban planning at Cyber City, Mt. Hampden, Harare, Zimbabwe constitute the study population. This market was estimated to include around 50 individuals, including professionals in disaster management, urban planners, and other stakeholders concerned with disaster preparedness, response, recovery, and resilience. It is logical to anticipate that these individuals would have the necessary knowledge and experience to elaborate extensively on the technological enhancements that could be integrated into the software systems utilized in disaster management operation.

3.5.2 Sampling

In this study, participants were selected using purposive sampling from a specific group of employees in charge of disaster management and urban planning at Cyber City, Mt, Hampden, Zimbabwe. This non-probability sampling technique was used so that all participants captured in the sample were experienced and knowledgeable regarding disaster management technological innovations. Employees of the Metropolitan Planning Organization who participated in the planning activities as either planners or planning supervisors were knowledgeable about the requisite technologies and provided informed consent to the study. Out of a population of about 50, a sample of 20 was drawn to ensure diversity in opinions while controlling for costs associated with data collection and analysis. This approach enhances researched based understanding of the role of technology in disaster management planning.

3.5.3 Sample Size

The participant sample in this study consisted of 20 from a total population of 50. There were multiple reasons why a sample size of twenty was pursued. First, having a sample size of twenty means this sample captures 40% of the total population which is optimal for perspective while remaining manageable for data collection and analysis. Also, while a larger sample size may provide data, the data collection process may overwhelm the available resources and prove counterproductive.

3.6 Data Collection Processes

Casual procedures were established for gathering qualitative and quantitative data from participants working in disaster management and urban planning at Cyber City located at Mt. Hampden in the city of Harare. This started with designing a set of questionnaires that incorporated both quantitative and qualitative elements. Before the large-scale data collection, the structured questionnaires were piloted to ensure their clarity and usefulness towards achieving the objectives of the study. Before the data collection began, informed consent was obtained from participants to guarantee their comprehension of the study aims and their rights regarding participation. In terms of the study, the questionnaires were administered either in person or remotely, depending on the participants' preferences, and participants were supported to ensure that they could complete the questionnaires without difficulty. After collection, the data was stored securely to maintain confidentiality and identifiable information which could link them to the data was removed to ensure anonymity. Additional validation mechanisms were developed to cross-check the data for consistency and accuracy which improved the reliability of the data.

3.7 Procedures for Presenting and Analyzing Data

Descriptive statistics outlining the respondents' profiles, as well as their responses to specific questions, including quantitative data from closed-ended questions, were summarised and presented in structured form. The main results were displayed in tables for ease of comparison. Response rates by participants, age distributions, and educational qualifications of the participants are some of the tables that were constructed to aid understanding of the quantitative data obtained. The data was also presented graphically with bar and pie charts illustrating important highlighted information. These graphics, aside from aiding comprehension, capture the audience's attention and render the data more engaging and memorable. Qualitative data obtained from open-ended questions was presented thematically. Thematic analysis involves distilling relevant issues which were graphically presented alongside respondents' quotes. This approach deepened understanding of participants' experiences and perspectives. Discourses were systematically articulated and described alongside supportive statements.

Both quantitative and qualitative approaches to achieve a complete understanding of the research problem the data were utilized. The quantitative data was processed with the statistical package SPSS, which provided descriptive statistics and performed inferential tests. This type of analysis allowed the researcher to detect key relationships and trends within the data, thus validating the conclusions drawn from the study. Conversely, qualitative data analysis centers on the determination of themes and patterns through thematic analysis. This process required classifying the data according to the identified themes and interpreting those themes vis-a-viz the questions of the study and the literature available on the subject. The use of qualitative research with quantitative research not only enriches a study, but also bolsters its credibility and trustworthiness.

3.8 Validation of the research instruments

Validity is the measure of how well an instrument achieves or measures what it was intended to measure. As Latham noted in 2007, validity is important, as it allows one to draw reasonable conclusions from correct results that have been verified. In this study, we have dealt primarily with face validity and content validity. To enhance validity, all possible ambiguously phrased questions should be eliminated. As Kristjansson et al. explain in 2013, to achieve face validity, each question must align with the objectives of the study. To achieve content validity, lines and questions must include all relevant particular concerns that need to be addressed. In 2012, Saunders et al. proposed a number of techniques, including surveys and interviews. The mixed method strategy addresses the limitations of a single approach. Walliman describes this in 2011 as triangulation: use of multiple tools and methodologies that strengthen each other.

Latham (2007) defines a test's reliability as the degree to which it can achieve consistent results when administered multiple times under the same conditions. In this case, the sample size in the study significantly improves the reliability of the outcomes. The larger the sample size, the more accurate the data is. Such well-crafted answers allow the asking of the same questions repeatedly, which enables a wider range of responses within the predetermined framework. This study sought to interpret the data gathered from the interview guide and the questionnaires. This was to improve validity, so that the elements which were meant to be captured by the guides were captured and all discrepancies were corrected before the study actually began. This resulted in reducing some of the certainty in some questions while also determining that some questions that were asked were unnecessary.

3.9 Ethical considerations

All research undertakings, including those that fall under the more specialized categories like disaster management and urban planning, which potentially put subjects under socio-economic or disaster-related risks, raise ethical issues (Munhall, 2018). Several pivotal ethical guidelines will be followed throughout the study regarding participants' welfare as well as the ethics of conducting the research. To begin with, offering informed consent to all eligible participants is essential before commencing the study. Wang et al., (2024) explain that this consists of explaining the objectives of the study, its procedures, risks involved, and benefits so participating individuals can make educated decisions. Additional measures to communicate to people with disabilities will be inclusive to ensure that the vulnerable group understands the protective measures taken regarding their information and the protective measures concerning their well-being and confidentiality. Participants' anonymity will be safeguarded, and all responses, including data collection and storage, will be conducted in a manner that participants' responses will remain confidential. No participants will be identifiable from the disseminated results as all details have been masked.

Furthermore, the privacy and dignity of participants will be upheld in the dissemination of the findings, although their opinions will be prioritized as long as their inclusion serves the purpose of enriching discourse on urban planning and disaster management. The incorporation of these ethical parameters is designed to help foster trust, ensure the integrity of the research, and capture insights that can strengthen resilience.

3.10 Summary

This chapter presented a comprehensive plan for the study examining the impact of technological developments on disaster management, as well as urban planning mitigation within Mt Hampden in Harare. The overarching research philosophy was pragmatic, utilizing a mixed-methods approach, both qualitative and quantitative, for data collection and analysis.

The primary case study selected was Mt Hampden in Harare, from which a singular case study was derived. The participants for this study included locally active government members and civic responders, yielding a population sample of around fifty. Data collection for this investigation included semi-structured interviews along with survey questionnaires, all of which underwent systematic analysis through thematic analysis, content analysis, and triangulation of reliability.

The researcher addressed ethical considerations of informed consent, the confidentiality of personally identifiable information and protected health information, as well as anonymity and ensured legal compliance with all relevant statutes and guidelines pertaining to the study.

CHAPTER 4

DATA ANALYSIS, FINDINGS AND DISCUSSION

4.1 Introduction

Research design, population size, sample size and sampling procedure, research instruments, validity, reliability, data collection, presentation, and analytical procedures, as well as ethical considerations, were all covered in the previous chapter on research technique. The presentation, analysis, and discussion of study findings are the main topics of this chapter.

4.2 Questionnaire Response Rate

The researcher used the questionnaires to find the response rate, which is shown in Table 1 below.

Table 4.1: Percentage distribution of questionnaires

Category	**No of respondents**	**No of questionnaires responded to**	**Response (%)**
Employees	20	**16**	**80%**

According to the results in table 4.1 above, 20 employees received questionnaires. A usable response rate of 80% was achieved by the completion and return of sixteen questionnaires.

4.3 Biographical data

4.3.1 Age Group

According to the results shown in Figure 4.1, 30% of the respondents were under the age of 25, 60% were between the ages of 32 and 50, and 10% were between the ages of 51 and 65. The vast majority of those surveyed are still of working age.

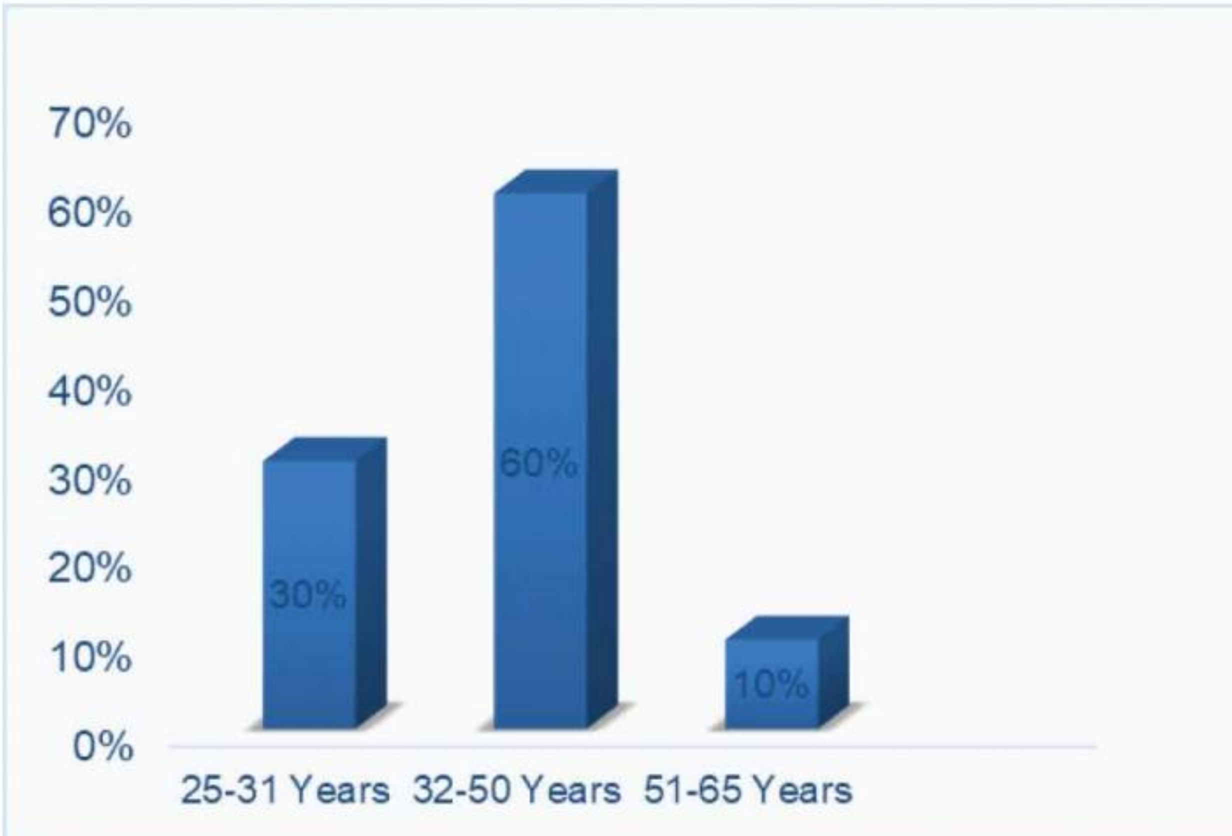

Figure 4.1 Age group

Source: Primary Data

4.3.2 Gender of Respondents

The results in Figure 4.2 indicated that 50% of the respondents were male and 50% were female. The results indicate that the respondents were equally represented.

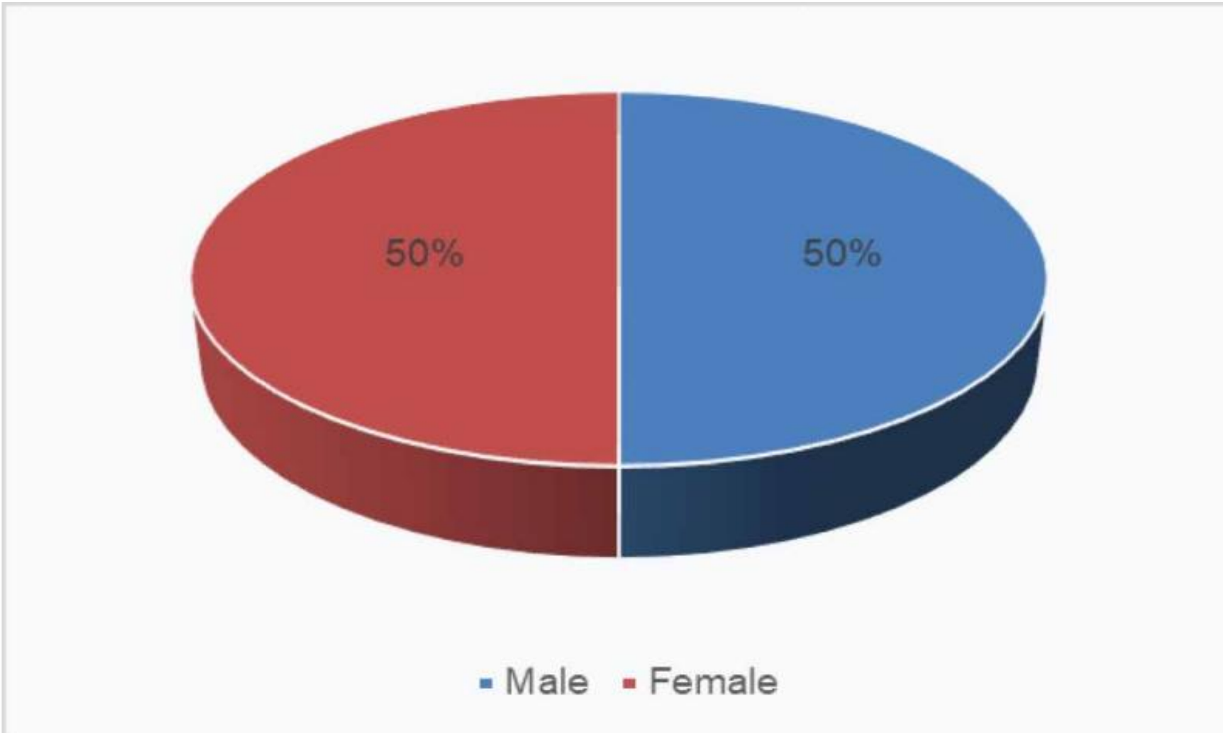

Figure 4.2 Gender

Source: Primary Data

4*.3.3 Academic Qualifications*

According to Figure 4.3, the respondents' educational backgrounds are as follows: Ten percent have master's degrees, twenty-five percent have apprenticeship diplomas, and sixty-five percent have bachelor's degrees. The findings demonstrate that the respondents possess the necessary education to carry out their responsibilities with effectiveness and efficiency.

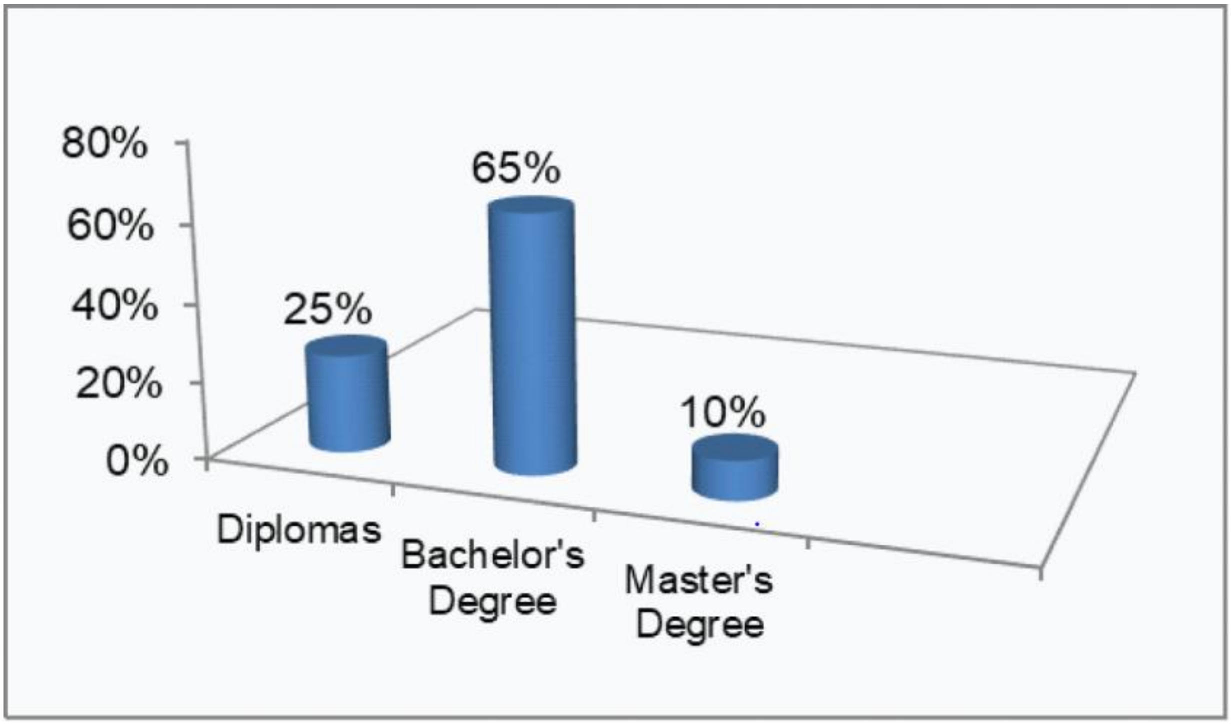

Figure 4.3 Academic qualifications

Source: Primary Data

4.4 Descriptive Statistics

4.4.1 The technological innovations applicable to urban planning for risk reduction

The data taken from Table 4.1 indicates that the big data paradigm can be separated into four applied science domains: (1) big data techniques, which gather data to reveal hidden patterns and trends; (2) big data storage, which offers databases for storage at a reduced cost; (3) big data processing, which offers data processing in the cloud; and (4) representation, which creates dashboard and visualization software based on real-time data. Ambari, Flume, Oozie, Pig, Mahout, Sqoop, and Zookeeper (Hadoop Database). Large sequential batch processing is best suited for the Hadoop system. Additionally, Spark, an open-source cluster computing framework, is effective in processing data in real-time, interactively, and in parallel. NoSQL databases have become much more popular as relational database substitutes in recent years. Document stores, column stores, and key-value stores are the three categories of NoSQL databases. These databases are very effective when using in-memory computing and are used for data analytics. The use of cloud computing technologies has grown recently, but there are still issues with hybrid cloud integration and the creation of unified integrated information management systems, claims Du (2023).

Table 4.2: Big Data Paradigm

Area	**Subarea**	**Description**
Methods	Data mining	A procedure to examine a lot of data in order to identify important trends and guidelines. For instance, Mahout is a framework for creating algorithms for data mining.
	Machine learning	a branch of artificial intelligence (AI) that helps with information discovery and decision-making. There are three types of machine learning algorithms: semi-supervised, unsupervised, and supervised. For instance, machine learning is done with Spark and Storm technologies.
	Statistical analysis	Focuses on gathering, analyzing, interpreting, presenting, and organizing data. For instance, statistics are performed using R Studio and SPSS software.
	Analytical tools	Investigate unprocessed data to find insights, correlations, and hidden patterns. For instance, Spark
Storage	Data warehouses	Large volumes of data are collected from many sources and used for decision-making in a business. An example of a Hadoop-based data warehouse system is Apache Tajo.
	NoSQL databases	a widely dispersed, non-relational database that facilitates quick, ad hoc organization and analysis. For instance, document stores (MongoDb) and column stores (Cassandra and HBase).

	In a memory database	Primarily relies on main memory for data storage.
Processing	Hadoop engines	Using open-source Java Framework technology, big data may be processed and stored more affordably while maintaining great scalability and fault tolerance.
	Real-time analytics	It describes the degree of responsiveness with which a system can digest information and derive valuable insights almost instantly after getting it. For instance, Informatica and Storm
	Cloud sourcing	IT resources are outsourced in order to cut expenses and gain access to technological know-how with less resources.
Representation	Visualizations	It offers quick overviews of critical performance metrics for a certain goal. For instance, dashboards based on real-time data, Google charts, etc., are created using Tableau software.

As illustrated in tables 4.3 and 4.4, there is an abundant number of models, frameworks, and systems which use different data sources to provide support covering all the stages of disaster management. Computation strategies are employed in catastrophe situations to support decision-making in disaster management that is based on databases, structured real-time data, and information processing techniques. Big data from geo-informatics platforms and remote sensing helps with disaster early warning systems. Forecasting natural disasters like earthquakes and floods is made possible by the use of Geographic Information Systems (GIS), Global Positioning Systems (GPS), and environmental monitoring equipment connected with cloud services. While social media sites like Twitter provide an instantaneous catastrophe awareness and information dissemination tool, geo-informatics and transport network data improve our understanding of human mobility during a disaster. The smooth integration of various data streams and processing paradigms, such as Hadoop, can lead to effective catastrophe preparedness.

ecosystem, which helps in the computation, storage, and processing of large datasets. Data from various social media platforms can help in tracking hurricanes (Liu, 2022).

Table 4.3: Big Data Applications in Disaster Management

Case	Application of an integrated information system for snowmelt flood early warnings.	Implementation of an autonomous emergency warning system using cloud servers and a messaging module	To design a simulator for human emergency mobility following disasters	Development of a generic Knowledge as a Service (KaaS) framework for disaster cloud data management	Real-time monitoring of social big data for disaster management	Creation of a disaster surveillance system using Zigbee and cloud services
Disaster type	Floods	Earthquakes and wild fires	Earthquakes	-	Floods, fires, and explosions	-
Disaster phases	Preparedness phase	Preparedness phase	Preparedness and response phase	Response phase	Response phase	Preparedness and response phase
Data	Geo-informatics, sensor data	Earthquake and gas sensor data.	From 1 August 2010 to 31 July 2013, GPS records were collected from 1.6 million users in Japan, together with news reporting and transportation network data.	Examples of data sources include social media (blogs and tweets), sensors, and incident reports.	Social media data (tweets).	Temperature data were obtained simultaneously from seven separate sensors 10 times.
Findings	offered a comprehensive strategy built on cloud services, the Internet of Things (IoT), and geo-informatics. .	Proposed prototype system gives a valuable awareness against disasters by autonomously distributing alerts through Twitter.	Using experimental results, we simulated and validated the general model of human emergency mobility to ensure its predictability.	Stored massive amounts of disaster-related data from many sources and eased searches by ensuring interoperability and integration.	The designed system scrapes Twitter data, analyzes disaster-related messages in real time, and presents disaster trends in a map.	The Zigbee-based congestion control concept is designed for both real-time monitoring and non-real-time prediction of disasters.

Key technology used	GIS, Global Positioning System (GPS).	GPS, cloud server, Arduino, and MySQL databases.	-	Integration of relational and NoSQL databases	GPS and document databases	Zigbee and Hadoop
Case	Applying statistical analysis to catastrophe management using data from multiple sources .	created a system for gathering and analyzing catastrophe data using beacon-based ad hoc routing and crowd sensing. .	Boost the effectiveness of queries on a geospatial semantic web for disaster relief. .	Analysis of smog disasters using online device data and social media	Big Data Cognition Conceptualization for City Emergency Rescue	utilizing big data analytics to develop an early warning system for flood informatio n manageme nt.
Disaster type	Hurricanes	-	-	Smog	Wild Fires	Floods
Disast er Phase s	Response phase	Preparedness phase	Response phase	Preventive phase	Response phase	Preparedness phase
Data	Geographical and social media data (Twitter) were collected from 38,224 tweets for analysis.	User-generated location data acquired from users' mobile devices	Geospatial data were obtained from 54 schools and 3,449 streets.	Social web data was randomly obtained from 100,000 geographically designated tweets.	Population distribution, geographical, video, and socioeconomic data.	Recorded daily rainfall and river level readings for three years (2022-2024).
Findings	A strategy is offered for mitigating potential effects, responding, and	A system is intended to collect real-time disaster data and create prompt local evacuation alerts for	The proposed approach minimizes individual spatial query execution	The proposed framework provides guidelines on people's behavior and government	To enhance emergenc y decision-	A system for predicting floods identifies a poor link between rainfall

	coordinating effectively during disasters.	consumers.	time in disaster response applications.	strategies for smog disaster mitigation.	making during disasters, large-scale event venues generate 3D simulation scenarios.	and river water levels.
Key technologies used	GIS, Mahout, Apache Hive, Hadoop, and R	HTML5, Hadoop	Map reduced	Hive and storm	-	Semantic networks and ontologies

Table 4.4: Disaster Management Phases with Major Data Sources and Application Fields

Disaster Management	**Phase Data Source**	**Reviewed Application Fields**
1. Mitigation or prevention		
Long-term risk assessment and reduction	Satellite, 33%	
	Crowdsourcing, 17%	General natural disaster
	Sensor web and IoT, 17%	Earthquake
	Social media, 13%	Oil spill
	Mobile GPS and CDR, 12%	Flood
	Simulation, 8%	
Forecasting and predicting	Simulation, 50%	Hurricane
	Satellite, 25%	Flood
	Sensor web and IoT, 13%	
	Social media, 12%	
2. Preparedness		

Monitoring and detection	Social media, 31%	
	Sensor web and IoT, 31%	
	Satellite, 13%	Wildfire
	Combination of various data types, 9%	Flood
	Spatial data, 4%	Earthquake
	Lidar, 4%	Landslide
	Mobile GPS with CDR: 4%	Volcano
	Crowdsourcing,4%	
Early warning	Social media with 29%	
	Sensor web and IoT (29%)	
	Simulation with 14%	Flood
	Crowdsourcing 14%	Tsunami
	Satellite (14%)	
3.Response		
Damage Assessment	Satellite: 53%	
	UAV, 21%	Earthquake
	Social media: 16%	Flood
	Sensor web and IoT: 5%	Typhoon
	Crowdsourcing: 5%	Hurricane
Post-disaster coordination and response	social media: 25%	
	Satellite, 16%.	
	Sensor web and IoT: 16%	
	Crowdsourcing: 10%	
	UAV, 9%	General natural disaster
	Simulation: 6%	Flood
	Spatial data: 6%	Earthquake
	Lidar: 6%	
	Mobile GPS and CDR: 3%	
	3% is a combination of different forms of data.	

4. Recovery		
	a combination of many data types, 60%.	Earthquake
	Crowdsourcing: 30%	Hurricane
	Satellite: 10%	Typhoon

Moreover, it is noted how critical big data analytic capabilities are for projecting flood events. The system's data collection capabilities are very basic; nevertheless, with the addition of more data sets and multiple considerations, it could serve as an effective preliminary alarm system for flood control. On the other hand, combining data sets, routing web-based information access to disaster management agencies, and enabling them to obtain a fully integrated disaster information management system is crucial for enhancing ease of use and streamlining decision-making processes. Every phase of the disaster management cycle interacts with a unique form of big data. The pervasive challenge is figuring out how to consolidate different datasets associated with various types of disasters. Integrating disaster datasets is claimed in literature as the most critical step toward solving the multifaceted problems of disaster management. All the gaps identified in Figure 4.3 suggest that the scope of available datasets is limited, further indicating that there is untapped potential in employing big data technologies for disaster management. Not all big data is publicly accessible. Data from Twitter comes at a steep price, while Facebook data is obtainable through its open API. A contractual arrangement with a telecom provider is necessary for obtaining mobile subscribers' call detail records. Moreover, some satellite data is free, like Landsat and SRTM, while others such as Lidar and GeoEye, charge fees.

Moreover, geospatial data analysis can integrate nadir aerial, thermal, and oblique imagery to assist in locating people within the region of concern. Behavioural responses and movement of people before or during a disaster can also be gleaned from available financial datasets containing transaction information, for instance, debit and credit cards. Additionally, transportation data from automobiles fitted with GPS can be used to evaluate the magnitude of the disaster's impact. Radio Identification (RFID) systems and user-installed wireless sensor networks are indispensable in the area of tracking people and acquiring environmental data. The ability to communicate over a wireless channel opens the possibility for mobile users to use unethical means to add, modify or erase information in such a way as to mislead the disaster system. Furthermore, these vulnerable and unsecured information technology components require attention since they do not yet exist in disaster management software.

In the context of recognizing risks and anticipating a wide range of disasters, information can be obtained from multi-sourced heterogeneous data. There are issues related to privacy, as well as protection of personal data within the big data framework. This is especially the case considering that big data contains a wealth of sensitive information. Such information is easier to identify when applying the big data framework. For these reasons, it is necessary to try as much as possible to protect the privacy of individuals and make sure that the data collected is anonymized. Data that has been aggregated and anonymized should be processed and stored using the appropriate big data technology, Capretz (2023) notes that open source and cloud-based solutions have eased some storage and processing constraints (Hadoop, Spark, etc.).

With regard to this scenario, big data system technologies enable understanding, exploration, and reasoning of disaster-related information procured over the Internet, mobile phones, sensors, RFID systems, and other platforms. They would support swift humanitarian responses to various types of disasters. Moreover, harmful geo- spatial event detection and geo- monitoring services can be improved with the fusion of geo-informatics acquired data and the big data approach. It will also enable the delineation of areas that require maximal attention by the government and other agencies concerned with the management of disaster. Analysing processed disaster data could help in developing plans for optimal responses to potential future disasters.

4.4.2 The impact of these technologies on the effectiveness of disaster response

4.4.2.1 Machine Learning /Deep Learning Methods in Disaster management case studies

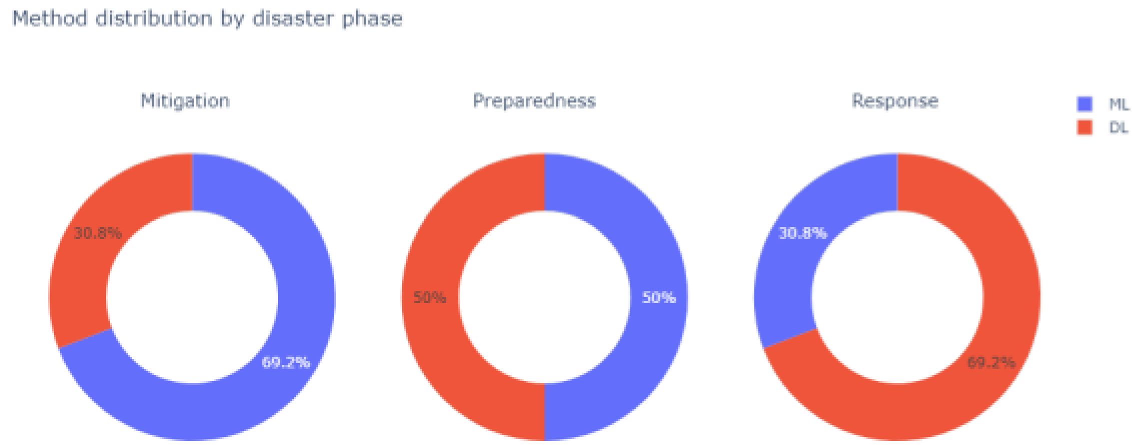

Figure 4.3 Distribution of the research studies in percentage form by disaster phase.

The percentage distribution of ML and DL-based research by disaster phase is displayed in Figure 4.3. There are more ML-focused research initiatives than DL-focused ones during the mitigation phase. Consequently, 69.2% of the research was developed using machine learning approaches, whereas 30.8% was generated using DL processes. Half as many studies (50%) concentrated on ML and DL methods for the phase of catastrophe preparation. Studies that used DL techniques did better than those that used ML techniques in terms of disaster response.

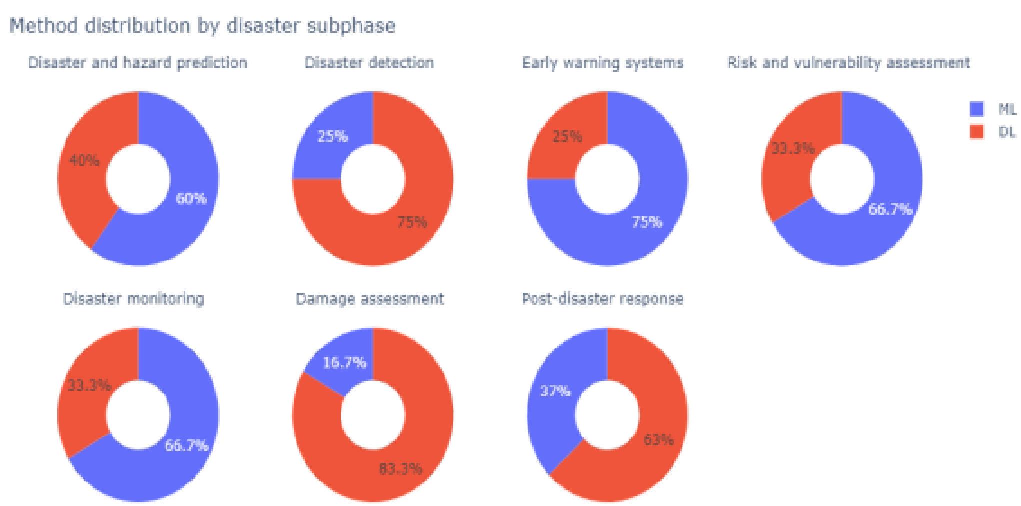

Figure 4.4 ML and DL's percentage distribution in studies based on subphases of disasters.

Based on research studies and questionnaires, Figure 4.4 displays the distribution of both ML and DL percentages across various subphases of a particular disaster. This demonstrates that deep learning-based methods have done better than machine learning-based methods in terms of detection (75%), damage assessment (83.3%), and post-disaster response (63%). Similarly, in early warning systems (75%), risk and vulnerability assessment (66.7%), disaster monitoring (66.7%), and disaster and hazard prediction, machine-learning-based methods outperformed deep learning-based methods.

Aerial photographs, sensor feeds for early warning systems and disaster and hazard prediction, satellite images, inventory maps for evaluating disaster risk and vulnerability, video footage for detection, online news services for disaster monitoring, and other image data such as that from Google and the AIDR platform for post-disaster damage assessment are more examples of data sources that are utilized. By enhancing data black boxing and the signal-to-noise ratio (false data labeling), crowdsourcing platforms have also been demonstrated to increase the efficacy of DL-based damage assessment systems.

4.4.3 The role of technological innovation in disaster response

Accuracy, F1 score, precision, recall, and AUC metrics were determined to be the most important performance indicators for assessing the efficacy of ML and DL approaches in disaster management. Figure 4.5 displays the accuracy of ML and DL-based algorithms created for different kinds of disaster subphases. Consequently, post-disaster response to storms, flood and wildfire detection, and tsunami and rainfall monitoring attained the highest accuracy levels. The accuracy performance outcomes of the used ML/DL based approach are shown for every stage of the disaster in Figure 4.6. Most of the studies done within this scope provide performance metrics with accuracy between 80% and 98%. After normalization, Figure 4.6 indicates that in 5.3 percent of the publications, the peak accuracy of catastrophe reaction achieved is 91%. Disaster mitigation has a more prominent presence with 5.1% of publications and 91% of total publications.

On the other hand, normalizing input data changes displayed in the displayed distribution of disaster preparation data. The distribution of the considered literature is more evenly spread, with 3.9% of publications claiming to reach a benchmark 95% accuracy.

Even throughout the different phases, this figure indicates that most, if not all, ML and DL models utilized in disaster management publications are performing optimally at 88.8% accuracy on average. Image-based models have an average accuracy value of 88.82%. Text-based models reach an average accuracy value of 88.17%. Structured data models achieve an average accuracy value of 88.65%. These conclusions point strongly toward frontier research that ML and DL algorithms provide accurate outcomes irrespective of the data form which is highly beneficial. Furthermore, every dataset can stand alone or be integrated with others.

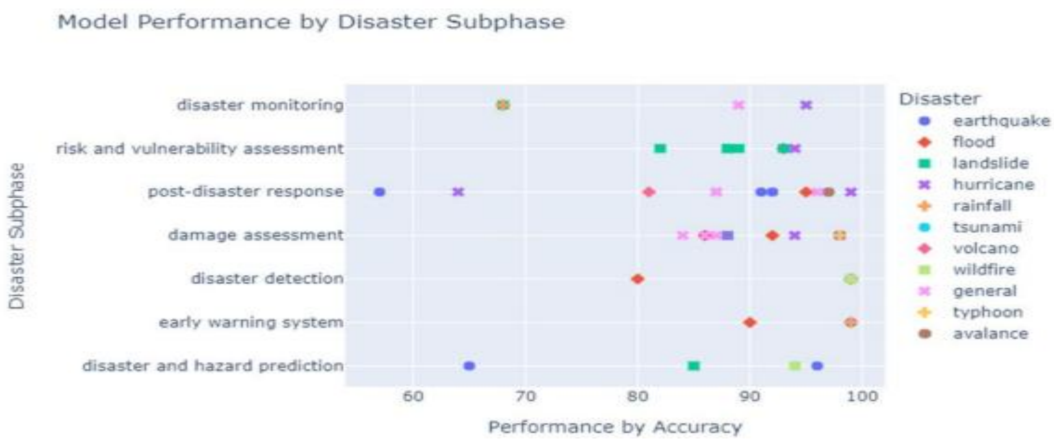

Figure 4.5 Performance of the developed approaches in terms of accuracy by disaster type and subphase.

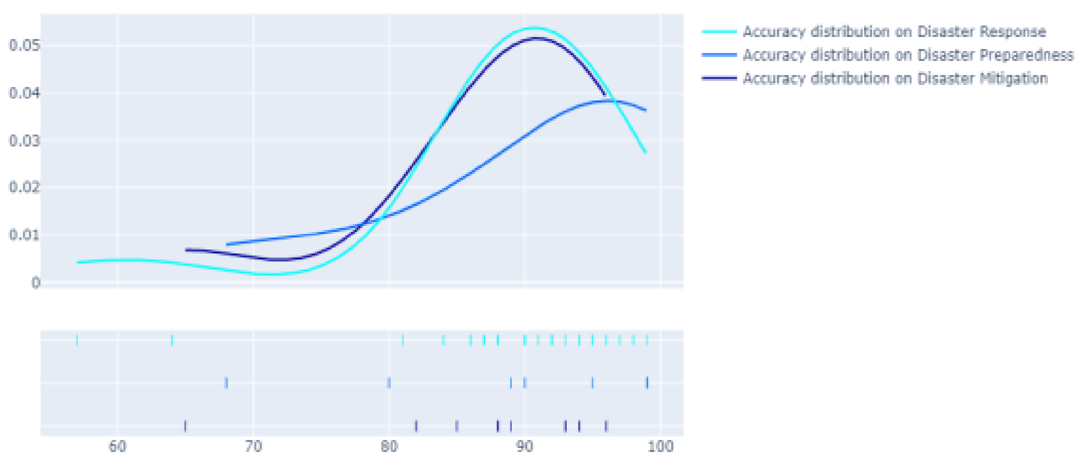

Figure 4.6 Performance of the developed approaches in terms of accuracy distribution over disaster phases.

Some methodologies in the reviewed sources are more accurate in terms of performance metrics related to different disaster stages. In disaster preparedness, the ML method of logistic regression (LR) achieved an accuracy of 99.93%, while DL with GANs achieved 99.2%. In disaster mitigation, DL with CNN had the highest accuracy at 96%, and KNN was the best performing machine learning technique at 92.74%. For the response phase, SVM ML achieved the highest accuracy of 99%. In the response to disaster phase, DL techniques performed better with CNN, achieving 98% accuracy.

4.5 Chapter summary

This chapter provided data visualization, analysis, and debate. It focused on analysing the response rates of the administered questionnaires, biographical information of the respondents, descriptive statistics, and analyses and discussions of the results of the case study on the technological innovations for urban planning toward risk mitigation, the effectiveness of these technologies concerning the responsiveness to disasters, and the impact of technological innovations. The next chapter presents the findings, conclusions, and recommendations of the study.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

In this chapter, I will outline the impact of technological innovation on disaster response and risk reduction through urban planning integration, drawing conclusions and making recommendations. In this paper, I will present the research conducted, evaluate the achievement of set research objectives, and provide conclusions about the findings that seem most important. The chapter also illustrates recommendations which relate to some findings deemed essential.

5.2 Summary of findings

The current research analysis biases the findings by concentrating on the function of machine learning/deep learning techniques and big data analytics in disaster management. Above all, these technologies improve disaster management capabilities, particularly prediction, early warning systems, and post-disaster damage assessment.Government organizations can make their disaster response activities more accurate and efficient by using big data analytics and machine learning. The fusion of satellite images, sensor data, sociological and social media info gives better insight into decision-making and resource allocation. The study also focuses on the ability of these technologies to strengthen the resilience of urban infrastructure and the people living in it. Urban planners can devise effective catastrophe mitigation plans by analysing large datasets to uncover specific trends and patterns. Besides, building the capacity and training them equips disaster management workers with the tools needed to use the technologies effectively. This includes training on data analysis and interpretation, as well as hands-on experience with big data tools and technologies. Furthermore, the results underscore important gaps in research into catastrophe management. Enhancing disaster management systems' accuracy necessitates the development of sophisticated machine learning algorithms capable of handling multifaceted disaster scenarios and the integration of diverse information streams, including social media, sensor networks, and satellite imagery. Future studies ought to develop new techniques for integrating and analyzing these disparate data sources and assess the actual utility of big data technology for disaster management. Following these lines of inquiry would make it possible for organizations to leverage technological advancements to bolster resilience to disasters and improve response, thereby reducing risks and potentially saving lives.

5.3 Conclusion

The focus of this paper is the influence of big data analytics and machine learning/deep learning technologies on disaster management regarding their impact on predicting disasters, setting up early warning systems, and damage assessment. Government agencies often respond to disasters by combining satellite images, sensors, and social media. This improves response accuracy and effectiveness. The analysis highlights the need to develop capacity and train disaster management personnel to effectively harness these technologies. It also identifies advanced research focuses, such as the creation of more sophisticated machine learning algorithms, the inclusion of multiple datasets, and other areas critical for enhancing disaster management systems and subsequently urban risk mitigation.

5.4 Recommendations

- To enhance disaster management, the government and agencies need to adopt big data analytics technologies along with machine learning and deep learning.
- Integrating disaster management systems encourages data and resource sharing among agencies and other stakeholders.
- Establish training courses for disaster management practitioners that will enable them to utilize big data analytics, machine learning and deep learning technologies.
- Utilize more sophisticated methods of data collection and analysis to improve multi-faceted disaster management models. Moreover, researchers and developers should shift their focus to more advanced machine learning or deep learning algorithms capable of deciphering intricate disaster frameworks.
- Expanded sources of social media, satellite imaging, and sensors can enhance the precision of disaster management models. Furthermore, the integration of social media alongside sensor data and satellite imagery can enhance the precision and effectiveness of disaster management models.
- Investment and sponsorship directed towards utilizing big data analytics, machine learning technologies, and deep learning in disaster management systems should be provided by policymakers.

5.5 Chapter Summary

This chapter investigates the major impact of technological improvements, particularly big data analytics and machine learning, on disaster response and urban design for risk reduction. It focuses on significant findings demonstrating how these technologies improve prediction, early warning systems, and damage assessments. The study emphasizes the importance of integrating several data sources, such as satellite imaging and social media, to improve decision-making and resource management. Finally, the chapter presents ideas for implementing advanced technologies, encouraging data sharing, and developing supportive policies to improve disaster management and community resilience.

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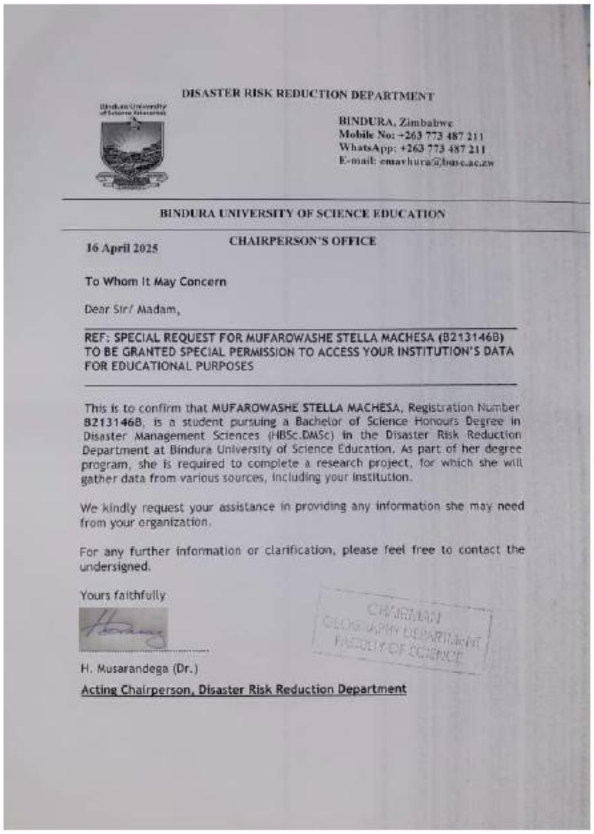
Appendix 1, BUSE APPROVAL LETTER



DISASTER RISK REDUCTION DEPARTMENT

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BINDURA UNIVERSITY OF SCIENCE EDUCATION

CHAIRPERSON'S OFFICE

16 April 2025

To Whom It May Concern

Dear Sir/ Madam,

REF: SPECIAL REQUEST FOR MUFAROWASHE STELLA MACHESA (B213146B) TO BE GRANTED SPECIAL PERMISSION TO ACCESS YOUR INSTITUTION'S DATA FOR EDUCATIONAL PURPOSES

This is to confirm that **MUFAROWASHE STELLA MACHESA**, Registration Number **B213146B**, is a student pursuing a Bachelor of Science Honours Degree in Disaster Management Sciences (HBSc.DMSc) in the Disaster Risk Reduction Department at Bindura University of Science Education. As part of her degree program, she is required to complete a research project, for which she will gather data from various sources, including your institution.

We kindly request your assistance in providing any information she may need from your organization.

For any further information or clarification, please feel free to contact the undersigned.

Yours faithfully

CHAIRMAN
GEOGRAPHY DEPARTMENT
FACULTY OF SCIENCE

H. Musarandega (Dr.)

Acting Chairperson, Disaster Risk Reduction Department

Appendix 2, Questionnaire

My name is Machesa Mufarowashe S, and I am a Bindura University of Science Education student. I am requesting your assistance to carry out my research, which reads The Impact of Technological Innovation on Disaster Response and Risk Reduction through Urban Planning : A Case Study of Mt Hampden, Harare. The main thrust of my research is hinged on the following objectives, To identify technological innovations applicable to urban planning for risk reduction. 2. To analyze the impact of these technologies on the effectiveness of disaster response. 3. To assess the role of technological innovation in disaster response.

Your cooperation is greatly appreciated.

Section 1: Respondent Information

a. Age Group:

    18-24

    25-31

    32-50

    51-65

    66 and above

b. Gender:

    Male

    Female

    Other

c. Academic Qualifications:

    High School Diploma

    Bachelor's Degree

    Master's Degree

    Doctorate

    Other: ___________

Section 2: Questionnaire Response Rate

a. How many questionnaires were distributed to employees?

10

20

30

Other: ___________

b. What was the response rate (%) of completed questionnaires?

50%

70%

80%

Other: ___________

Section 3: Technological Innovations in Disaster Management

a. Which big data application areas do you find most relevant for urban planning? (Select all that apply)

Data Mining

Machine Learning

Statistical Analysis

Analytical Tools

b. How effective do you think cloud computing technologies are in disaster management?

Very Effective

Effective

Neutral

Ineffective

Very Ineffective

c. In your opinion, what is the biggest challenge in utilizing big data for disaster management?

Data Privacy

Data Integration

Accessibility of Data

Other: ___________

Section 4: Impact of Technologies

a. How do you rate the impact of machine learning on disaster response effectiveness?

Very High

High

Moderate

Low

Very Low

b. Have you experienced or witnessed the use of technological innovations (like AI/ML) in disaster management?

Yes

No

If yes, please describe: ___________

Section 5: Overall Feedback

a. What improvements do you suggest for enhancing the effectiveness of technological innovations in disaster management?

……………………………………………………………………………………………

……………………………………………………………………………….………………