CRISIS MANAGEMENT: CASE STUDY OF NYIRAGONGO VOLCANO ERUPTION 2021 IN DEMOCRATIC REPUBLIC OF CONGO

by

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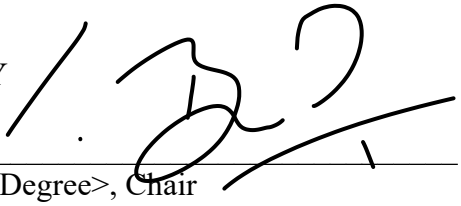

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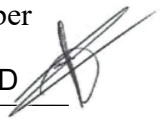

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DEDICATION

I dedicate this paper to my beloved parents Farida and Hocine who have always pushed me to follow my dreams and stand up, no matter what may happen in my life. To my brothers and sisters who mean so much to me: Nabila (Salima), Rachida, Mouna (Fethia), and our special sister Bouchra Abbad. To my beautiful nephews and nieces: Inès, Besma, Hiba, Nour, Youcef and Melissa.

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ABSTRACT

On 22nd May 2021, Nyiragongo volcano situated eastern Democratic Republic of Congo (DRC), erupted at 19:00 local time. Mount Nyiragongo, lies in the volcano region of Virunga National Park, near the border with Rwanda, 12 miles (19 km) north of Goma. Nyiragongo is known for its devastating eruptions (Rafferty, 2021). Increased volcanic activity earlier this year suggested an eruption was possible, but the Goma Volcano Observatory's functions were hampered by funding cuts (Salazar, 2021). Prior to the eruption, no public statement was made about a potential eruption of Nyiragongo volcano, the population was directly confronted to the disaster without any preparations. Driven by a general sense of fear and panic, people rushed away from lava flows in all directions, which created intense traffic jams.

32 people died as a direct result of the eruption (either burned by the lava or asphyxiated by fumes), including three children (UNICEF, 2021a). The Government Spokesperson, Mr. Patrick Muyaya declared that 9 persons were dead in traffic (Sengenya, 2021). 450,000 people were displaced and evacuated after the Nyiragongo volcano erupts. On 23rd May 2021, DRC Government activates contingency plan and set up a crisis cell, comprising local authorities, the UN and the RCRC (Red Cross and Red Crescent) Movement (IFRC, 2021). The volcanic eruption comes at a time of acute ancillary humanitarian need in North Kivu and Ituri. A State of Siege was declared by the Government to be in force in the two provinces since early May (2021). Some 44 per cent of the 5.04 million IDPs (Internally Displaced Persons) in DRC are currently located in North Kivu. 3.2 million people are already in dire need of food assistance in a province that has the highest protection incidences (5,856) in the country (OCHA, 2021).

To understand the circumstances and events that have influenced volcanic crisis management and emergency planning, the current research explored various aspects that have shaped the crisis management of the Nyiragongo volcano eruption 2021 in the Democratic Republic of Congo (DRC). To do that, a survey was conducted on 5000 people from Goma city including Nyiragongo. Eleven aspects were addressed in this survey: 1) facts about the Nyiragongo volcano environment and activity; 2) preparedness and early warning system; 3) contingency planning (emergency planning); 4) security and political context; 5) socio-economic realities; 6) health situation and COVID-19; 7) shelter, water, sanitation, and hygiene; 8) communication; 9) access and accessibility; 10) community and national engagement; and 11) international support. Although there is emergency planning for eventual volcano eruption in DRC; this research revealed that existing realities in the country made it so difficult to adapt and implement it in the field. Armed conflicts, poverty, malnutrition, COVID-19; all these complex facts have contributed to the volcano crisis management 2021 in DRC and much more. Therefore, this paper will be an important tool in developing effective preparedness and response planning for potential volcano eruptions. It will suggest also, an evidence-based source in volcano crisis management for tomorrow's workforce in DRC and worldwide.

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LIST OF ABBREVIATIONS AND ACRONYMS

ACAPS: Assessment Capacities Project

ArcGIS: Aeronautical Reconnaissance Coverage Geographic Information System

CCCM: Camp Coordination and Camp Management

DRC: Democratic Republic of Congo

ESA: European Space Agency

EVD: Ebola Virus Disease

FAO: Food and Agriculture Organization

GIS: Geographic Information System

GSNL: Geohazard Supersites and Natural Laboratory

HCT: Humanitarian Country Team

IDPs: Internally Displaced Persons

IFRC: International Federation of Red Cross and Red Crescent Societies

InSAR: Interferometric Synthetic Aperture Radar

IPC: Integrated Food Security Phase Classification

KPIs: Key Performance Indicators

MOUNSCO: United Nations Organization Stabilization Mission in the Democratic Republic of the Congo

N: Number

OCHA: UN Office for the Coordination of Humanitarian Affairs

OVG: In French "Observatoire Volcanologique de Goma" that refers to Goma Volcano Observatory

PMI: President's Malaria Initiative

RCRC Movement: Red Cross and Red Crescent Movement

UN: United Nations

UNDRO: United Nations Disaster Relief Organization

UNDRR: United Nations Office for Disaster Risk Reduction

UNFPA: United Nations Population Fund

UNHCHR: United Nations High Commissioner for Human Rights

UNHCR: United Nations High Commissioner for Refugees

UNICEF: United Nations Children's Fund

UNITAR/UNOSAT: United Nations Institute for Training and Research/ United Nations Satellite Centre

UPS: In French “Unité de Planification Spatiale” that refers to Urban Plan

USAID: United States Agency for International Development

WASH: Water, Sanitation, and Hygiene

WFP: World Food Programme

WHO: World Health Organization

CHAPTER I:

INTRODUCTION

This chapter will provide an outline of the research by first discussing the background and context of the study in the introduction. It will be followed by the research problem, the research objectives, and the significance of the study. Then finally, it will discuss the purpose and questions of the research.

1.1.Introduction

Mount Nyiragongo erupted on 22 May 2021 at 19:00 local time near the city of Goma (province of North Kivu), in the east of the Democratic Republic of Congo (DRC). Two lava streams emerged from the volcano at a height of 1,800 meters. One stream flowed east in the direction of Rwanda, while the other headed towards Goma, stopping 300 meters from Goma International Airport (UNICEF, 2021a). The Nyiragongo volcanic eruption is shown in Figure 1 and the lava flow is shown in Figure 2.

32 people died as a direct result of the eruption (either burned by the lava or asphyxiated by fumes), including three children (UNICEF, 2021a).450,000 people were displaced and evacuated after the Nyiragongo volcano erupts. The majority (over 80%) returned to their localities or neighbourhoods of origin. 4,051 households are currently living in collective centers and temporary sites (IFRC, 2021). 3 health centres and 7 schools (five primary and two secondary schools) are destroyed. Other health and education services are affected due to the interruption of basic services like destruction of access roads, disruption of electricity and supply to markets (ACT Alliance, 2021). The volcano eruption damaged a critical water pipeline in Goma, cutting off access to potable water for 500,000 people (USAID, 2021). The main damages caused by the Nyiragongo volcanic eruption of 22nd May 2021 are summarized in Appendix A.

Figure 1: Mount Nyiragongo erupting on Saturday 22 May 2021 Source: Kaliwavyo Raks-Brun, R. (2021). Mount Nyiragongo erupting on Saturday 22 May 2021, in Goma, DRC [online]. Available at: https://www.krqe.com/home/volcano-erupts-near-congolese-city-of-goma-crowds-flee/ (Accessed: 22 June 2021).

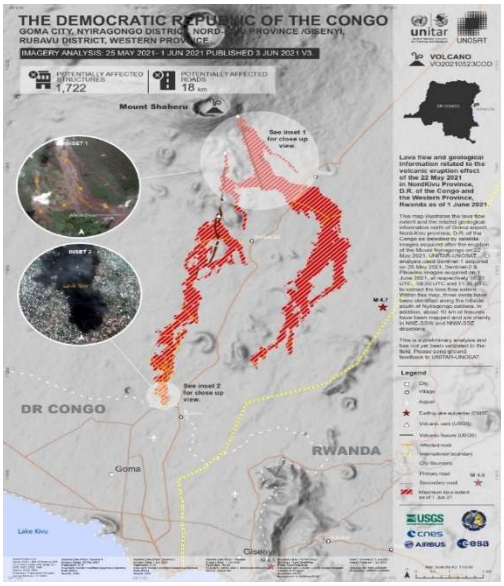

Figure 2: Lava flow of Nyiragongo volcanic eruption 22 May 2021, as of 1 June 2021
Source: UNITAR/UNOSAT (2021). *Lava flow and geological information in NordKivu Province, DR Congo and Western Province, Rwanda as of 01 June 202* [online]. Available at: https://unosat.org/products/3250 (Accessed: 24 June 2021).

Nyiragongo is associated with the East African Rift and is part of the Virunga Volcanic Chain. It is in the Congo (DRC), not far from the border with Rwanda. Nyiragongo is in Virunga National Park and is of Africa's most active volcanoes. Nyiragongo contained a lava lake in its deep summit crater that was active for half a century before draining catastrophically through its outer flanks in 1977. In contrast to the low profile of its neighbouring shield volcano, Nyamuragira, 3470-m-high Nyiragongo displays the steep slopes of a stratovolcano (Oregon Space Grant Consortium, 2011). Nyiragongo is known for its devastating eruptions. In 1977 some 2,000 people were killed, and in 2002 Goma was largely destroyed by lava, leaving more than 100,000 people

homeless and creating a refugee crisis. In 2021 lava stopped short of Goma's city limits, but the eruption killed more than 30 people and destroyed several villages (Britannica, 2022).

Although volcanoes studies involve identifying current or potential gaps within volcanic crisis management, to develop appropriate strategies to solve these gaps; however, relatively little has been written about Nyiragongo crisis management and the organizational aspects related to the response. Past studies have focused on Nyiragongo volcano activity, and its impact noticed on the ground for eruptions that took place in 1977 and 2002. Throughout the review of various academic and professional papers on the last Nyiragongo eruption 2021, it revealed that there are some technical reports and articles that were published on the event; but no academic study has undertaken research on crisis management of Nyiragongo volcano eruption in 2021.

As stated in the Urban Plan for Goma, which was published in July 2021, the population of Goma is estimated approximately at 1.039.966 individuals (Unité de Planification Spatiale (UPS), 2021). This population is living at risk of volcano hazards. Hence, to prevent life losses, casualties, major damages, and global impacts on economies, and services and minimize risks; it is vital to conduct research on these phenomena and prepare for appropriate interventions. Therefore, this subject of research was chosen to examine different aspects that have shaped the management of this crisis and attempts to find adequate solutions for better management. This research undertook a case study on crisis management of the Nyiragongo volcano eruption 2021 with a focus on the following eleven aspects:1) facts about the Nyiragongo volcano environment and activity; 2) preparedness and early warning system; 3) contingency planning (emergency planning); 4) security and political context; 5) socio-economic realities; 6) health situation and COVID-

19; 7) shelter, water, sanitation, and hygiene; 8) communication; 9) access and accessibility; 10) community and national engagement; and 11) international support.

1.2. Problem Statement

Volcanic eruptions are among the most awesome and most feared of natural phenomena. Myths, legends, and recorded history abound in testimonies to their destructive power, and the geological record shows that volcanic processes have been important throughout the earth's history. These processes continue at the present time, often with profound effects on human life and activity (UNDRO, 1985, p. 1). Regardless of sustained fascination with exploring volcanoes from different perspectives, few studies have exanimated aspects of volcano crisis management in DRC. Previous studies that reported on Nyiragongo activity and volcano eruptions in 1977 and 2002 like: Seach (1977), Hamaguchi et al (1991), Hernández et al (2013) and Burgi (2020) were focusing mainly on the volcano's geological setting, volcano's activity, lava flow and other technical volcano's characteristics. Monbiot (2002) has tackled the lessons learned from the response of 2002 eruption. Micheliers et al (2019) have evaluated population vulnerability to volcanic risk in a data scarcity context. Few other studies published by national authorities & institutions, and international organizations like MOUNSCO (2002), have covered emergency planning, inter-agency response, and the impact of a volcano eruption on Congolese society.

Regarding Nyiragongo volcano eruption 2021, it was widely covered in the media such as Actualite.cd, the Guardian, Africanews, UN News, Radio Okapi, and much more. Also, some technical reports related to emergency response and the evolution of the eruption were issued by "L'Observatoire Volcanologique de Goma (OVG)" which refers to Goma Volcano Observatory, as well as humanitarian agencies and national entities

involved in the response. However, there is a lack of academic research being conducted on the crisis management of the Nyiragongo volcano eruption 2021.

Crisis management has become an important challenge for DRC authorities, considering the growing complexity of chronic and recent emergencies. Consequently, they found themselves ill-equipped in terms of skills developed strategies, and approaches against the latest Nyiragongo volcano eruption 2021. Therefore, this research needs to be done to address undebated issues related to the crisis management of the Nyiragongo volcano eruption 2021 and draw attention to recommendations for operational preparedness and response actions before a crisis emerges.

1.3.Research Objectives

The overall purpose of this research focuses on exploring the multiple aspects and challenges that have formed the crisis management of the Nyiragongo volcano eruption 2021 in DRC. The research aims also, in studying possible solutions that can enhance the preparedness capacities of DRC in managing potential volcano eruption crisis. Hereafter, the objectives of this study:

1. To identify aspects that have shaped the crisis management of the Nyiragongo volcano eruption 2021.
2. To identify challenges and gaps in crisis management of the Nyiragongo volcano eruption 2021.
3. To explore measures that could be fixed for preparedness and response planning.
4. To recommend avenues of solution that can lead to better management of a volcanic crisis.

1.4.Significance of the Study

This study will contribute to the body of knowledge on skills development in volcanic crisis management by surfacing and evaluating aspects, strategies, and approaches that have shaped crisis management of Nyiragongo volcano eruptions 2021. The new findings can give empirical data as bases for suggestions on minimizing the risks of volcanic eruptions and developing constructive contingency planning. In an environment of rapidly and constantly changing, these accurate data would be an evidence-based source of information for policymakers, volcanologists, researchers, communities' representatives, humanitarian actors, and populations living at risk of volcanoes in DRC.

This study may provide managers and experts involved in volcanic emergency response with insight into the improvement of preparedness and response mechanism against volcanic crisis and go beyond recovery by building strong community resilience. It may also support the design of adaptive learning materials, and it can inspire different stakeholders to conduct training, seminars and awareness sessions that will foster a culture of disaster prevention among professionals as well as the general public in DRC. This paper can present to decision-makers the necessary evidence to issue policy instruments and appropriate assistance. It can be used also, in the development of prevention measures against volcanic eruptions and emergency management in all structures of the government, at local and national levels.

This paper will help to address the current shortage of research that explore volcanic crisis management in DRC, including the Nyiragongo volcanic eruption of 2021. It will provide real-world value to organizations operating in volcanic crisis management in such dynamic environments and the growing complexity of emergencies. In addition, this study

can be served as related literature for future researchers who plan to explore context and aspects of crisis management of the Nyiragongo volcano eruption 2021.

1.5.Research Purpose and Questions

Given the lack of research regarding the crisis management of the Nyiragongo volcano eruption 2021, this study aims to identify aspects that have influenced the management of Nyiragongo crisis 2021 and provide an avenue of solutions to overcome existing gaps. It looks also, to raise awareness for governments, institutions, local authorities, and communities globally, on the necessity of early engagement in preparedness and response mechanism to mitigate the risks of volcanic eruptions.

Furthermore, this study aims to provide an overview of different aspects that have contributed to the design of crisis management of the Nyiragongo eruption 2021, by exploring these main features: volcano environment and activity; preparedness and early warning system; contingency planning; security and political context; socio-economic realities; health and COVID-19; shelter, water, sanitation, and hygiene; communication; access and accessibility; community engagement; and international support.

This research attempts to answer the following questions: What are the aspects that have shaped the crisis management of the Nyiragongo volcano eruption 2021 in DRC? And how can DRC be better prepared for a potential Nyiragongo volcano eruption?

CHAPTER II:

REVIEW OF LITERATURE

This chapter will include relevant studies related to research questions. The existing literature will be reviewed to understand the concept of volcanic crisis management. In addition, it will identify factors, approaches, strategies, and gaps within papers that looked at the Nyiragongo crisis management dynamic.

2.1 Introduction

Volcanic eruptions can cause loss of life and livelihoods in exposed communities, damage critical infrastructure, displace populations, disrupt business, and add stress to already fragile environments (Blong, 1984). Voight (1996) published a study related to the eruption of Nevado del Ruizvolcanoin Armero (Colombia, South America) on 13 November 1985, whereby he stated, “The lessons from Armero are not lessons, they are old lessons forged in human behaviour that once again require the force of catastrophe to drive them home”. This example reminds us of the importance to conduct research on volcanic crisis management, but also to act against identified gaps before the next eruption.

Volcanic eruptions remain a serious threat to Goma town’s population and surrounding areas. It also constitutes an additional challenge for the government of DRC. In this part of the study, a literature review was carried out to illustrate various sources that focused on exploring volcano crisis management and more specifically Nyiragongo volcano eruption 2021. Different definitions have been captured to explain the following key concepts: crisis, crisis management, volcano, and volcano crisis management. Then, I reviewed documentation that have exanimated the Nyiragongo volcano’s background and its past eruptions that occurred in 1977 and 2002. Particular attention is given to fact-filled

information on major approaches and aspects that have characterized the current evolution of crisis management of the Nyiragongo volcano eruption 2021 in DRC.

2.2 Crisis and Crisis Management

To gain a deeper understanding of the thematic area of this research, the following definitions provide an overview of crisis and crisis management concepts. Tuor (2011) said that the word form "crisis" is nearly identical to the Greek word "krisis" from which it was borrowed into Latin, then into French, and finding its way eventually to the English tongue. Here is a list of the different senses of the Greek "krisis" found in the Oxford Classical Greek Dictionary:

> (i) Separation, discord, dispute.
>
> (ii) Choice, decision, judgment, sentence, issue, event, outcome.
>
> (iii) Trial, examination, lawsuit, court of justice, punishment.
>
> (iv) Issue, event, outcome.
>
> (iv) Medical: Sudden unlooked for change in a disease, leading to recovery or death (Tuor, 2011, pp.1-2).

In this definition, Tuor considered that the word ‘crisis’ in the English language is derived from the word ‘krisis’ in Greek classical terminology, and it has 5 different meanings: separation, choice, trial, issue, and sudden medical change. This definition looks old if we have to compare it with actual trending, as we use this word mostly to describe a specific concern like an economic crisis or environmental crisis.

In Oxford dictionary, the definition goes to show more modern statement, whereby the meaning of the word crisis is explained as “A time of great danger, difficulty or doubt when problems must be solved, or important decisions must be made” (Grasland et al, 2021, p.5). On the other hand, Drennan and McConnell (2007) have another explanation

with a focus on unexpected conditions that might create a crisis, as they have stated "Crisis is a set of circumstances in which individuals, institutions or societies face threats beyond the norms of routine day-to-day functioning, but the significance and impact of these circumstances will vary according to individual perceptions" (Drennan and McConnell, 2007, p.2).

Furthermore, Sakaki and Lukner (2013), have described a crisis by tackling the challenges and threads generated from a crisis; according to them, crises confront organizations, communities, and governments with extraordinary challenges to their operation, competence, responsiveness, and resilience. In general, a crisis can be defined as a situation in which a community of people perceives "a serious threat to the basic structures or the fundamental values and norms of a system, which under time pressure and highly uncertain circumstances necessitates making vital decisions." To be more specific, Farantos and Koutsoukis (2015) have provided a crisis definition with environmental context, they said that the environmental crisis, which involves the cases of environmental disasters, such as large-scale damage from emissions of radioactive or toxic gases from nuclear accidents or transportation accidents, of natural disaster or the crisis of endangered species, is linked to the deterioration of the natural environment and requires a high degree of organization and preparation for its treatment. The preparation for crisis treatment can make a difference when a crisis occurs.

Crisis management can be seen as a significant, often critical, part of strategic management within which potential threats should be identified. The following definition from Jia et al (2012), has provided in-depth clarification on this concept. According to them, Crisis management is a technique both for avoiding emergencies and planning for the unforeseen ones, as well as a method for dealing with them when they occur, so as to

mitigate their disastrous consequences. There are many different ideas or theories on how to best manage a crisis. These differing ideas, nonetheless, have some common elements: the need to anticipate potential crisis and prepare for them; the need to provide accurate information during a crisis; the need to react as quickly as possible to the situation; the need for a response that comes from the top and the need for long-term solutions.

Vašíčková, (2019) and Baubion (2013), have defined crisis management with an emphasize on the features and phases of crisis management. Vašíčková (2019) has stated that "In crisis management and strategy, we can see several common features, which include consistent analysis of the environment, cooperation with stakeholders and the top management activities". According to Baubion (2013), crisis management comprises various phases: preparedness before crisis, response to limit damages during the crisis and feedback after the crisis. After the crisis comes the time for in-depth analysis to review what has happened and how response actions were conducted. It is important to conduct this feedback process at the levels of each response institution as well as at the inter-agency and strategic levels.

2.3 Volcano and Volcano Crisis Management

To define a volcano, many definitions were found in literature about the term volcano. According to Volcano Discovery (2021a), the word "volcano" comes from the Roman God of Fire, "Vulcanus". Then, to descript the volcano, Habitat for Humanity (2021) stated "A volcano is a mountain that serves as a vent through which molten rock and other gases escape. When pressure from the gas and molten rock becomes too great, an eruption occurs. Volcanic eruptions may be subtle or explosive and can produce dangerous lava flows, poisonous gases, and flying rocks and ash. Many volcanic eruptions are also accompanied by other natural hazards, such as earthquakes, landslides, debris flows, flash

floods, fires, and tsunamis" (Habitat for Humanity, 2021). For more information on the number of active volcanoes around the world, Volcano Discovery (2021b) specified that there are probably millions of volcanoes that have been active during the whole lifespan of the earth. During the past 10,000 years, there are about 1500 volcanoes on land that are known to have been active, while the even larger number of submarine volcanoes is unknown.

The Holocene is the most recent geological epoch spanning from about 11700 years ago to the present day (Peppoloni and Di Capua, 2012). Hereafter, few statistics from the Smithsonian Institution's Global Volcanism Program database of 15 October 2021:

- Volcanoes erupting now: 48
- Volcanoes that erupted during 2021: 69
- Volcanoes that erupted during 2020: 68
- Volcanoes with confirmed historical eruptions: 560
- Volcanoes with confirmed Holocene eruptions: 866
- Volcanoes thought to have Holocene eruptions: 1,357 (Global Volcanism Program, 2021)

Regarding volcanic crisis management, this concept has been fully and clearly described in the following explanations: Volcanic crisis management is a framework whereby scientists, emergency managers (civil protection), and communities work together to develop and implement a set of preparedness and response measures aimed toward the mitigation of the effects of an eruption (Sigurdsson et al, 2015, pp.1188-1200). Additionally, crisis management broadly captures organizational leaders' actions and communication that attempt to reduce the likelihood of a crisis, work to minimize harm from a crisis, and endeavour to re-establish order following a crisis (Bundy et al, 2016, p.1661-1692). While

indicative of changes occurring in the volcanic edifice, they do not always lead to eruptions and may be unreliable as indicators of when an eruption may occur. They thus present a challenging environment for effective response, emergency management planning, and decision management (Doyle et al, 2014, p.62-72). This, together with the high social and economic cost of evacuation, makes volcanic crisis management extremely complex in areas of high risk (Marrero et al, 2012, p.33). A general methodology for management of eruptive crises is not available nor possible due to the great variety of situations deriving from differences in physical settings and, mainly, in social, cultural, economic, and political conditions. However, some basic components of the management plan can be identified, together with some steps necessary for its successful implementation. These steps result from the careful analysis of recent volcanic crises and the reasons for the success or failure of their management (Sigurdsson et al, 2015, pp.1188-1200).

2.4 Nyiragongo Volcano's Past Eruptions

Mount Nyiragongo, active volcano in the Virunga Mountains of east-central Africa. It lies in the volcano region of Virunga National Park, near the border with Rwanda, 12 miles (19 km) north of Goma. Nyiragongo rises 11,385 feet (3,470 meters) high and has a main crater 1.3 miles (2 km) wide and 820 feet (250 meters) deep containing a liquid lava pool. Some older craters on the mountain are noted for their plant life (Rafferty, 2021). It was discovered in 1894 by the German explorer Count G. A. von Götzen (Sahama, Meyer, 1958, p.1). Nyiragongo is known for its devastating eruptions (Rafferty, 2021). Prior to 2021, there were two major eruptions of Nyiragongo volcano that are depicted in the following chronicles:

2.4.1 Nyiragongo volcano eruption of 1977

The lava lake present in the summit crater of Nyiragongo from 1928 to 1977 completely disappeared after the short-lived eruption of January 10th, 1977 (Hamaguchi,

Nishimura and Zana, 1992). In 1977 some 2,000 people were killed (Rafferty, 2021). In fact, during the 1977 eruption; five fissures opened on the flanks of the volcano and the entire contents of the lake drained in less than an hour, producing a flood wave of rapidly flowing lava which covered an area of more than 20 km2, destroying over 400 houses and a section of highway over 10 km long. The largest of the five lava streams travelled at a speed of about 40 km/h, reaching a length of over 10 km and stopping only a short distance from the outskirts of the nearest town (UNDRO, 1985, p.22). About 100-150 hectares of land and 400 houses were destroyed by the flows (Squires, 1977a). Goma was plunged into semi-darkness and most of its residents fled to neighbouring Rwanda. Seven hours after the eruption began, lava effusion had completely ended, but fumarolic activity continued. At 15:00 on 16 January, a strong gas eruption from the main crater projected a cloud containing little or no solid material to about 1 km above the volcano. At 15:50, earthquakes felt on the crater rim preceded the collapse of what remained of the terraces, terminating major gas emission. Nowhere else in the world does such a steep-sided stratovolcano contain a lake of such fluid lava. Nyiragongo's proximity to heavily populated areas increase its potential for causing a natural disaster. The 1977 eruption raised awareness of the unique dangers posed by Nyiragongo (Squires, 1977b).

2.4.2 Nyiragongo volcano eruption of 2002

On the morning of January 17, the volcano Nyiragongo situated 10 Km north of Goma, in the eastern part of the Democratic Republic of the Congo, erupted. Shortly, three lava flows were reported, two moving south toward Goma town, and the third moving south-west in the direction of Sake (MONUSCO, 2002). In 2002, the UN reported 147 deaths (of whom 60-100 died in an explosion of the Goma central petrol station on 21 January), 30,000 people displaced, and 14,000 homes destroyed by the eruption. Around 470 injured people reportedly suffered burns, fractures, and gas intoxication (Wunderman, 2002). According to Papale (2021), before

and during the 2002 eruption the Goma Volcano Observatory did an excellent job with few resources, in terms of instruments and funds. Despite having only three very old seismometers recording on paper, they were able to raise the alarm that the volcano was about to re-awaken days before the eruption occurred on January 17. Unfortunately, the political situation at the time wasn't favourable. The alarms by the volcanologists remained unheard. The result was that hundreds of thousands of people fled across the Congo-Rwanda border and nearly as many found themselves homeless after the volcano erupted. The crisis was then managed by the United Nations. Days after the eruption it sent the first group of international scientists to the site. It then maintained a year-long programme of international cooperation involving Congolese volcanologists (Papale, 2021).

Through the review of literature on historical background of the Nyiragongo volcano and its past eruptions; the study report of Sahama and Meyer (1958) has given an overview of the volcano including its discovery, and it was one of the first studies that tackled the geological setting of Nyiragongo under Belgium colony. Hamaguchi, Nishimura and Zana (1992), have described 1977 eruption with a sequence of events that occurred during the eruption. UNDRO (1985) and Rafferty (2021) have highlighted the direct impact of the eruption on people and land with a summary of the 1977 eruption. Squires (1977) went into detail on each phase of the volcano eruption, earthquakes, and lava flows. However, all these studies focused on geological aspects and dangers of the 1977 eruption and did not consider covering the crisis management of such a devastating event. Regarding the 2002 eruption, Wunderman (2002) has underlined the results of this eruption against the population, land, and different activities. MONUSCO (2002) has offered a clear description of the ongoing eruption with a description of activities of the crisis management process and humanitarian response. Papale (2021) has paid special attention to volcano activity and the Goma Volcanology Observatory; and he has pointed up to

social and political conditions that influenced the crisis management of the 2002 Nyiragongo volcano eruption.

2.5 Aspects of Nyiragongo Volcano Crisis Management 2021

Most of the literature associated with aspects of the current volcano crisis management of Nyiragongo 2021, was extracted from technical and statistical reports issued by different bodies involved in the crisis response. In addition to analytic publications, journals, and scientific articles that have covered the event. Moreover, some information was gathered from press conferences conducted by national authorities' officials.

Since the beginning of the Nyiragongo crisis, OCHA (2021) has published regular situational reports in collaboration with humanitarian partners operating in DRC. These reports outlined the Nyiragongo eruption activity and the extent of damages. In addition to an overview of identified needs and response activities in shelter, water services, protection, food, non-food items (NFIs), coordination and other services. WFP (2021) has also issued several reports that have focused on needs assessments and relief assistance especially in terms of emergency food rations to people displaced from their homes in Goma, logistics and supply chain. In addition, it has conducted a market analysis to provide cash-based food assistance. IFRC (2021) has released a report whereby it has summarized the IFRC's operational strategy and responses' needs. In addition, it has launched an emergency appeal for 11.6m Swiss francs to support 80,000 people in DRC and Rwanda. Act Alliance (2021) has also raised a regional emergency appeal of USD 1,179,262. In this appeal, Act Alliance has provided a summary of its project that aimed to support affected populations in DRC and Rwanda; as well as build their resilience, from the impact of the volcanic eruption.

Following the Nyiragongo eruption, WHO (2021) has issued many publications that have provided an overview of the health situation in DRC as well as its emergency

strategy for vulnerable displaced persons and victims of volcano disaster. In these publications WHO has given particular attention to providing primary and secondary health services, mental health care, sexual and reproductive health care, prevention, and fight against epidemics. In the same context, IMA World Health (2021) has exposed the overall impact of Nyiragongo volcano eruption and the major needs among affected communities. On the other hand, UNICEF (2021) has closely monitored the progress of this crisis and released numerous situation reports, whereby it has raised the main populations' needs. In addition, it has covered the response strategy of the organization in water supply networks, sanitation, hygiene, family reunification, child protection, education, nutrition, and communication. USAID (2021) has summarized in its publication the impact of Nyiragongo eruption 2021 on society. In addition, it has revealed details on the contribution of USAID in the response through technical expertise and funding to different projects, especially in water, sanitation, and hygiene (WASH).

Martin (2021) focused in his article on the progress of Nyiragongo activity and monitoring of the volcano. Africanews (2021), has conducted several interviews with scientists and experts regarding the eruption with details on the lava flow and continued activity of Nyiragongo volcano. Salazar (2021) has provided a snapshot on the Nyiragongo eruption and basic needs of population. He has also emphasized on DRC context in terms of conflict and climate change. The Guardian (2021) has covered the Nyiragongo eruption and published several interviews with authorities' officials and different stakeholders on the event.

For a greater understanding of these various literature sources, they were classified into the following aspects:

2.5.1 Volcano environment and activity

Mount Nyiragongo, one of the world's most active volcanoes, located just north of Goma, Democratic Republic of Congo, erupted on 22 May 2021, destroying numerous homes, and causing thousands to flee to safety. A lava lake in Mount Nyiragongo began filling rapidly since the eruption (IMA World Health, 2021).

2.5.2 Direct impact on populations and infrastructures

32 people died as a direct result of the eruption (either burned by the lava or asphyxiated by fumes), including three children (UNICEF, 2021a). 450,000 people were displaced and evacuated after the Nyiragongo volcano erupts. The majority (over 80%) returned to their localities or neighbourhoods of origin. 4,051 households are currently living in collective centers and temporary sites. Over 2,400 residential buildings have been destroyed in Ngangi, Bushara, Bungerera, Mujoga, Mugerwa, Kisheke, and Kibati (IFRC, 2021). 3 health centres and 7 schools (five primary and two secondary schools) are destroyed. Other health and education services are affected due to the interruption of basic services like destruction of access roads, disruption of electricity and supply to markets (ACT Alliance, 2021). The volcano eruption damaged a critical water pipeline in Goma, cutting off access to potable water for 500,000 people (USAID, 2021).

2.5.3 Livelihood activities

Certain businesses and services such as banks are closed and certain markets partially or totally interrupted, which particularly affects the informal sector on which many very poor and poor households depend. The volcano eruption damaged a critical water pipeline in Goma, cutting off access to potable water for 500,000 people (USAID, 2021). Between 110 and 120 households may have lost their fields and crops and approximately 279 ha of the agricultural land was destroyed. Most of the crops and

livestock are gone due to lava as well as ashes (IFRC, 2021). Livelihood activities have also been impacted due to the disruption in agricultural activities, farming, fishing, and other commercial activities resulting in a shortage of basic food stuffs. In addition, the families that have fled are completely reliant on government and humanitarian aid agencies for basics needs like food, water, and shelter (ACT Alliance, 2021).

2.5.4 Health situation

Around 27 million people in the Democratic Republic of Congo (DRC) are experiencing high levels of acute food insecurity (IPC Phase 3 or above) between September and December 2021. The country has the largest number of highly food insecure people in the world (Integrated Food Security Phase Classification (IPC), 2021). Malaria is the principal cause of morbidity and mortality in the DRC (PMI, 2020). According to preliminary data from the quarterly bulletin of malaria surveillance, cases have reached 5 928 057 in the 2nd trimester of 2021 (Bulletin Épidémiologique Trimestrielle du Paludisme en RDC, 2021). Re-emergence of Ebola Virus Disease (EVD) is a major public health issue in the DRC and there are gaps in the country's capacity to prepare for and respond to outbreaks. Another challenge stretching the limited resources is the concurrent COVID-19 outbreak. The first confirmed COVID-19 case was registered in DRC on 14 March 2020 (WHO, 2021a). As of 22 May 2021, there have been 30 974 confirmed cases of COVID-19 (Reliefweb, 2021). The following year and more precisely on 22 December 2022, there have been 94 969 confirmed cases of COVID-19 with 1 461deaths, and as of 23 October 2022, a total of 6 185 534 vaccine doses have been administered (WHO, 2022). DRC has witnessed also up to 28 September 2021, several epidemics as follows: 6 817 suspected cholera cases including 125 deaths, 47 844 suspected measles cases with 694 deaths, 558 cases of meningitis including 202 deaths, 2790 cases of monkeypox with 72 deaths, 121

suspected pneumonic plague cases including 13 deaths, 1 121 104 suspected cases of typhoid fever including 411 deaths, and 2 yellow fever cases tested positive (WHO, 2021b).

2.5.5 Communication

The official declaration of the volcanic eruption was released by the Military Governor of the Province of North Kivu and the volcanological Observatory of Goma who have been coordinating the crisis response (ACT Alliance, 2021). The communications minister, Patrick Muyaya, had earlier tweeted: "The evacuation plan for the city of Goma has been activated … The government is discussing the urgent measures to take at present." Posted on 22nd May 2021 (The Guardian, 2021).

2.5.6 National response

Following the eruption of the Nyiragongo volcano on 22 May 2021, Congolese authorities ordered the evacuation of 10 of Goma's 18 neighbourhoods. On 06 June 2021, IOM counted more than 400,000 displaced people internally as well as to Rwanda, including 160,000 people who have already returned (USAID, 2021). The president of the Democratic Republic of Congo has announced the establishment of an agency for natural disaster management and prevention following a volcano eruption. Felix Tshisekedi announced in a news conference held on Sunday in Goma, the capital of eastern North Kivu province, where he explained that the decision came after the last volcanic eruption of Mt. Nyiragongo on May 22. From a press conference held in Goma, on 13th June 2021 (Forku, 2021).

2.5.7 Preparedness and early warning system

Increased volcanic activity earlier this year suggested an eruption was possible, but the Goma Volcano Observatory's functions were hampered by funding cuts (Salazar,

2021). According to a satellite image from 9 October 2021, the lava flows remain active and continue to fill the summit crater's lava lake. The lava returned to the crater 11 days ago and started to form the new lava lake (Martin, 2021). Celestin Kasereka Mahinda, the scientific director of the Goma Volcanology Observatory, said: "Today Nyiragongo found a way to breathe, which is a good sign," and he said also that "Fear would have persisted if the volcanic chimney remained blocked." from 18th September 2021, four months after the major eruption (Africanews, 2021a).

2.5.8 Security and political context

The DRC Prime Minister, together with 12 ministers, met on 24 May 2021 with the Humanitarian Coordinator and the Humanitarian Country Team (HCT). The Government activated its contingency plan which highlighted the following priorities: shelter, opening the Rutshuru-Goma Road, tracing children, and opening the Goma airport (OCHA, 2021).

2.5.9 Socio-economic realities

Between conflict, poverty, malnutrition and frequent disease outbreaks, humanitarian needs in the Democratic Republic of the Congo (DRC) are among the highest in the world. Such is their scale that the 2021 UN's Humanitarian Response Plan for the DRC requires more than €1.5 billion to meet the needs of vulnerable people (European Civil Protection and Humanitarian Aid Operations, 2021).

2.5.10 International support

Humanitarian actors have provided assistance areas of displacement, but this remains largely insufficient in view of the needs in WASH, shelter and food security in particular (OCHA, 2021). WFP aimed to reach 40,000 people in Sake, 65,000 in Minova and 60,000 in Rutshuru; while WFP in Rwanda was providing emergency food assistance to many others who have crossed the border (WFP, 2021a). Due to increasing need, by 9

June 2022, WFP had provided emergency food assistance to over 146,000 displaced people who had fled Goma (WFP, 2021b). In terms of funding humanitarian activities, OCHA has mobilized $1.2 million from the Central Emergency Relief Fund to supplement the $3.5 million from the DRC Humanitarian Fund, which were re-allocated to address urgent needs resulting from the eruption. However, a substantial gap in financing the relief efforts remains, as the UN estimates the total financial requirement at $15.6 million (Security Council Report, 2021).

2.6 Conclusion

The process of volcanic crisis management is too complex, as it can be influenced by the natural hazards of the volcano and the availability of response means in the field, as well as manmade decisions. Many studies as mentioned in this chapter have provided a clear definition of crisis, crisis management, volcano, and volcano crisis management. Meanwhile, the finding of the current review, revealed that few studies have been published on the background of Nyiragongo volcano and its activity. In addition, some research were conducted on Nyiragongo eruptions that occurred in 1977 and 2002. Regarding the latest Nyiragongo eruption 2021, relatively little has been written on the event, however, no study or academic research has tackled directly the crisis management of Nyiragongo volcano eruption 2021.

The limited literature related to the current crisis management of the Nyiragongo eruption 2021, was mostly found in different reports and articles issued by various institutions, journals, organisations, scientists, and national authorities' officials. These reports and articles have given an overview of Nyiragongo eruption 2021 and its continuous activity with special emphasis on damages noticed on the ground. It included also, population needs and emergency response actions in the following fields: health,

water, sanitation, hygiene, food, logistic, security, communication, protection, coordination, livelihoods, international support, and funding requirements. Moreover, there were some publications related to volcano surveillance and evacuation plans.

Although the above narratives have covered Nyiragongo eruption 2021 from several perspectives, but information concerning the crisis management of this disaster, remains largely unknown. Therefore, this research will pinpoint the aspects that have shaped crisis management of Nyiragongo volcano eruption 2021. Besides, it will underline different measures adopted by Congolese authorities during this crisis. It will also, provide some recommendations to mitigate the effects of the volcanic crisis and to improve the response to future eruptions.

CHAPTER III:

METHODOLOGY

This chapter will present the methodology of research together with data collection and analysis methods used to answer research questions. This chapter will include research aim, research design; area of research & sample size; research instrumentation; data collection procedures; methods of data analysis; research design limitations and challenges; and finally, conclusion.

3.1 Overview of Research Problem and Questions

An uptake in volcanic unrest and/or eruptive activity is always interesting to discuss from both technical and non-technical aspects. In a society that is densely populated and has vital and strategic assets, a change (increase) in volcanic activity can have a social and economic impact and, in some cases, political impact (Frontiers, 2022). Forecasting volcanic hazards and managing volcanic crises are extremely difficult endeavours, for reasons that span from the inherent complexity characterizing volcanic phenomena to the magnitude of the associated risks. Scientific developments as well as re-evaluations and new implementations are constantly ongoing, and the international debate on these difficult aspects is more alive than ever. A consensus on best practices concerning several aspects of the scientific approach, the role of scientists, and the most effective means of communication to stakeholders is slowly emerging. Still, many elements continue to be object of vivid discussion, and paradigms, views, and practices can differ significantly when managing real volcanic crises (Papale, 2020).

Many studies have investigated in volcanoes activities around the world, from scientific perspectives and socio-economic impacts. However, very few researchers have explored factors challenging and/or optimizing the success of volcanic crisis management. As mentioned in the literature review, relatively little has been written on Nyiragongo volcano,

and so far, no study or academic research has directly undertaken the crisis management of Nyiragongo volcano eruption 2021. Therefore, I have selected this topic of research to support scientists, decision-makers, and different stakeholders living at risk of volcanic eruption with evidence-based source of information related Nyiragongo volcano crisis management 2021.

Effective volcanic crisis management depends on various parameters, and this research is exploring the following aspects that have shaped the crisis management of Nyiragongo eruption 2021: volcano environment and activity; preparedness and early warning system; contingency planning; security and political context; socio-economic realities; health and COVID-19; shelter, water, sanitation, and hygiene; communication; access and accessibility; community engagement; and international support. This research will also provide, some recommendations to strengthen the preparedness and response approaches for future eruptions.

This research attempts to answer the following questions: What are the aspects that have shaped the crisis management of Nyiragongo volcano eruption 2021 in DRC? And how can DRC be better prepared for a potential Nyiragongo volcano eruption?

3.2 Research Design and Methods

The research design is intended to provide an appropriate framework for a study. A very significant decision in research design process is the choice to be made regarding research approach since it determines how relevant information for a study will be obtained; however, the research design process involves many interrelated decisions (Sileyew, 2019).

This research has adopted an exploratory approach with a mixed methods case study design. As emphasized by the University of Southern California Libraries (2022), an exploratory design is conducted about a research problem when there are few or no earlier studies to refer to or rely upon to predict an outcome. The focus is on gaining insights and

familiarity for later investigation or undertaken when research problems are in a preliminary stage of investigation. Exploratory research “tends to tackle new problems on which little or no previous research has been done” (Brown, 2006). While it may sound a little difficult to research something that has very little information about it, there are several methods which can help a researcher figure out the best research design, data collection methods and choice of subjects (Bhat, 2022a).

This design is based on the premise that an exploration is needed for one of the following several reasons: measures or instruments are not available, the variables are unknown, or there is no guiding framework or theory (Molina-Azorin et al, 2018, p.414).

A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident (Yin, 1994, p.13). Recognised as a tool in many social science studies, the role of case study method in research becomes more prominent (Zainal, 2007, p.1). Case Study is an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, programme, or system in a real-life context. It is research-based, inclusive of different methods and is evidence led. The primary purpose is to generate an in-depth understanding of a specific topic (Simons, 2009, p.10). A mixed methods case study design is a type of mixed methods study in which the quantitative and qualitative data collection, results, and integration are used to provide in-depth evidence for a case(s) or develop cases for comparative analysis (Creswell and Plano Clark, 2018, p.116). Both mixed methods research and case study research offer unique methodological advantages for researchers wanting to address the complexity of these research problems and issues (Plano Clark, Foote and Walton, 2018).

Therefore, the mixed methods case study was chosen, as little is known on the topic of the Nyiragongo volcanic crisis management 2021 and combining qualitative and quantitative methods is crucial to explore complex dynamics around crisis management of Nyiragongo volcano eruption. In addition, it allows an in-depth examination and understanding of aspects that have shaped crisis management of Nyiragongo volcano eruption 2021. The sub-methods used in mixed methods research are analysis of data, interviews, questionnaire surveys, and field research (Fuka et al, 2022, p.86). In practice, this involves tackling a question through more than one methodology, with the hopes that it'll provide you a fuller understanding (Wiedmaier, 2022). Moreover, using a mixed methods design enables to have a complementary outcome over all phases of the study with a qualitative component giving context to the quantitative results. Furthermore, mixed-methods can provide stronger evidence-based findings, that help to suggest appropriate recommendations for volcano crisis management in DRC. Then this study might be extended to countries that are affected by volcanic eruptions and further research related to this field.

Quantitative research methods emphasize objective measurements and the statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulating pre-existing statistical data using computational techniques (Babbie, 2010). The purpose of quantitative research is to generate knowledge and create understanding about the social world. Quantitative research is used by social scientists, including communication researchers, to observe phenomena or occurrences affecting individuals. Social scientists are concerned with the study of people. Quantitative research is a way to learn about a particular group of people, known as a sample population. Using scientific inquiry, quantitative research relies on data that

are observed or measured to examine questions about the sample population (Allen, 2017). Quantitative research is defined as an organized analysis of occurrences by collecting measurable data and applying statistical, mathematical, and computational methodologies. However, quantitative method reveals what and to what extent but often fails to answer more on why and how (WeeTech Solution, 2022).

Qualitative research is not concerned with numerical representativity, but with the deepening of understanding a given problem. In qualitative research, the researcher is both the subject and the object of his research. The objective of the qualitative methodology is to produce in-depth and illustrative information in order to understand the various dimensions of the problem under analysis (Queirós, Faria and Almeida, 2017, p.370). Qualitative research has the potential to complement quantitative data by providing depth and perspective to statistics (Naresh, 2021). Qualitative research is a process of naturalistic inquiry that seeks an in-depth understanding of social phenomena within their natural setting. It focuses on the "why" rather than the "what" of social phenomena and relies on the direct experiences of human beings as meaning-making agents in their everyday lives. Rather than by logical and statistical procedures, qualitative researchers use multiple systems of inquiry for the study of human phenomena including biography, case study, historical analysis, discourse analysis, ethnography, grounded theory, and phenomenology (University of Texas Arlington Libraries, 2022).

For a greater understanding of both methodologies, the following Table 1 provides a clear comparison of the strengths and weaknesses of qualitative and quantitative research.

	Qualitative Research	Quantitative Research
Strengths	*Results from sample surveys can be generalized for entire populations *Results can be aggregated and are comparable across population groups *Results can be broken down by socio-economic group for comparisons *Reliability of data and findings provides powerful indicators to guide policy *Replicability – publication of questionnaires and dataset permits scrutiny of findings *Transferability of dataset to other analysts means that analysis is not dependent on availability of an individual *Precise professional or disciplinary minimum standards exist for much survey work	*Open-ended questioning reveals new or unanticipated phenomena *Provides a rich picture of social phenomena in their specific contexts – reveals critical incidents *Provides a holistic interpretation of the detailed processes that have and are shaping people's lives *Provides insights into intra-household relations & processes *Provides deeper insights into causes and direction of causal processes *Permits researchers to access data on 'difficult issues' e.g., domestic violence *Data on marginal groups that surveys often cannot locate can be collected e.g., illegal migrants, the homeless, child-headed households *Encourages creativity and innovative explanatory frameworks *Data analyst is usually heavily involved in data collection and knows its strengths/ weaknesses *Participatory methodologies empower, rather than objectify, respondents
Weaknesses	*Sacrifices potentially useful information through process of aggregation *Sacrifices potentially useful data by placing households or events in discrete categories	*Difficult to demonstrate the scientific rigor of the data collection exercise *Low levels of standardization and definitions/criteria etc. vary from researcher to researcher

	*Neglects intra-household processes and outcomes *Commonly under-reports on difficult issues, e.g., domestic violence *Commonly under-reports on marginal/difficult to access individuals and households *Often wasteful in that large amounts of the dataset are never used *Relatively expensive in terms of money. *Poorly trained enumerators can make mistakes and inadvertently influence responses *Enumerators may falsify/ invent data.	*Analytical methods are poorly specified and vary from researcher to researcher *Completion of research is often dependent on a single individual *Often results cannot be generalized as it is unclear 'whom' they represent *Findings less likely to influence policy as they lack the legitimacy of science and the precision of numbers *Datasets are rarely made publicly available so that findings cannot be tested and other researchers cannot use the dataset.

Table 1: The Strengths and Weaknesses of Quantitative and Qualitative Approaches

Source: Hulme, D. (2007). *Integrating Quantitative and Qualitative Research for Country Case Studies of Development*. Manchester, University of Manchester, p.13.

While quantitative and qualitative research approaches each have their strengths and weaknesses, they can be extremely effective in combination with one another (Madrigal and McClain, 2012). Instead of approaching a research question using the binary lens of quantitative or qualitative research, the mixed methods research approach has the ability to advance the scholarly conversation by drawing on the strengths of both methodologies (Berman, 2017, pp.5-6).

Mixed methods research integrates qualitative and quantitative research approaches in many or all phases of a study to comprehensively address a research problem by collecting quantitative and qualitative data concurrently or in phases with the aim to

maximizing their inherent advantages while minimizing their disadvantages. (Ngulube, 2020, pp.425). According to Jennifer Greene (2006) "Mixed method inquiry is an approach to investigating the social world that ideally involves more than one methodological tradition and thus more than one way of knowing, along with more than one kind of technique for gathering, analysing, and representing human phenomena, all for the purpose of better understanding" (cited in Johnson et al., 2007, p.119). Mixed methods research is "practical" in the sense that the researcher is free to use all methods possible to address a research problem. It is also "practical" because individuals tend to solve problems using both numbers and words, they combine inductive and deductive thinking, and they (e.g., therapists) employ skills in observing people as well as recording behaviour (Creswell and Plano Clark, 2007, p.10). The overall goal of mixed methods research, of combining qualitative and quantitative research components, is to expand and strengthen a study's conclusions and, therefore, contribute to the published literature. In all studies, the use of mixed methods should contribute to answering one's research questions (Schoonenboom and Johnson, 2017, p.110). According to Manjengwa (2020), the advantages of employing mixed research methods in impact evaluation are as follows:

- Synergy: Quantitative methods achieve objectivity whilst qualitative methods provide the explanation to a given research phenomenon. The basic premise is that integration of quantitative and qualitative approaches permits a more complete and synergistic utilization of data in providing a better understanding of research problems and complex phenomena than either approach alone (Fetters & Freshwater, 2015). Better understanding can be obtained by triangulating one set of results with another and thereby enhancing the validity of inferences.

- Complementarity: The evaluators can elaborate, clarify, or validate the results from one method with the findings from the other method. Findings from qualitative and quantitative data sources can be compared after collecting both types of data simultaneously. The data can be analysed, and results compared through side-by-side discussions, or transforming the qualitative data set into quantitative scores, or jointly displaying both forms of data. Quantitative and qualitative data can validate each other and create a solid foundation for drawing conclusions on evaluations.
- Development: The results from one method can be used to help develop the use of the other method. This explanatory sequential design typically involves two phases: (1) an initial quantitative instrument phase, followed by (2) a qualitative data collection phase, in which the qualitative phase builds directly on the results from the quantitative phase. In this way, the quantitative results are explained in more detail through the qualitative data.
- Expansion: The evaluators can seek to extend the breadth and range of inquiry by using different methods for different inquiry components. For instance, use of qualitative data to augment a quantitative outcomes study. Within an outcomes study, the researcher collects and analyses both quantitative and qualitative data. The qualitative data can be incorporated into the study at the outset to help design the intervention; during the intervention to explore how participants experience a certain programme intervention; and after the intervention to help explain the results (Palinkas, et al., 2011).
- Participatory: Mixed methods also mirror the way individuals naturally collect information by integrating quantitative and qualitative data. This stakeholder participatory approach in the research process brings about change by providing

input about their needs, ways to address them, and ways to implement changes (Mertens, 2009). A reflection of participants' point of view in mixed methods give a voice to study participants and ensure that study findings are grounded in participants' experiences.

3.3 Area of Study and Sample Size

The area of study in this research is Goma city, the city includes Nyiragongo territory and the main localities that have been directly affected by the Nyiragongo volcano eruption 2021. The study area was selected since no studies have been conducted in this area on Nyiragongo volcanic crisis management 2021, and because of the severity of the problem in this study area. City of Goma, situated on the northern shore of Lake Kivu about 12 miles (19 km) south of Nyiragongo (Earth Observatory, 2001). Goma is the administrative capital of North Kivu province and a major urban centre in the Great Lakes Region. The city serves as an important economic and transportation hub that links eastern Congo to the broader East African sub-region. Goma shares a border with the Rwandan city of Gisenyi, and thousands of people cross each day. The city of Goma is divided into two communes, the Commune of Goma to the south and the Commune of Karisimbi to the north. It has 18 neighbourhoods, and each has its own chief. Neighbourhoods' chiefs (chefs de quartier) are important partners for local-level response efforts in resource-poor neighbourhoods and are well placed to provide access and information (Peyton, Gercama and Bedfor, 2019). The area of research was categorized based on the population of interest matrix model of ICRC (2017) illustrated in the following Figure 3.

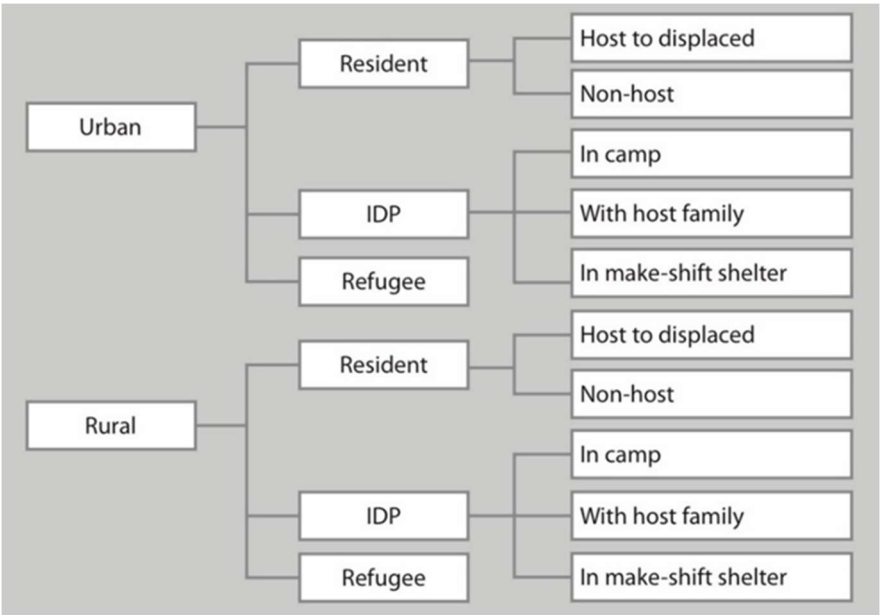

Figure 3: A population-of-interest matrix

Source: ICRC (2017). *Acquiring and Analysing Data in Support of Evidence-Based Decisions: A Guide for Humanitarian Work*. Geneva: ICRC, p.37.

Since the study area is Goma city, any participant from that area would be relevant to the study. According to Unité de Planification Spatiale (UPS) (2021), which stands for Urban Plan for Goma, the population of Goma is estimated at 1.039.966 individuals. As it is difficult to administrate questionnaires and carry out interviews with the population of Goma; the researcher had to conduct sampling and determine sample size. Sampling a large population is often an underlying challenge in conducting statistical surveys. A more feasible approach to save time and money would be to pick a smaller group or sample size that would be used instead to represent the entire population (Corporate Finance Institute, 2022). In the other hand, the sample size is a research term used for defining the number of individuals included in a research study to represent a population. The sample size references the total number of respondents included in a study, and the number is often

broken down into sub-groups by demographics such as age, gender, and location so that the total sample achieves represents the entire population (Kibuacha, 2021).

The target population in this study consisted of 5000 persons from Goma city and the researcher has selected this number to represent the population of Goma, because it is considered the minimum sample size in a survey for academic research in DRC. As one of the research objectives is to provide avenues of solution that can lead to better management of the volcanic crisis in DRC, it was crucial to align the sample size with national standards. In addition, this sample size is large enough to discover accurate data; and it is appropriate to generate realistic conclusions from research findings. To get a wide range and variety of people including persons involved in the Nyiragongo volcano crisis response 2021; the researcher has divided the survey into two categories: 1) population of Goma and 2) actors involved in the response. Consequently, 2500 people in each category responded to the questionnaire survey. To reach the research target, the survey covered different stakeholders and entities living in the 18 neighbourhoods of Goma. Among these entities: National Institutions, UN Agencies, National and International NGOs, United Nations Organization Stabilization Mission in the Democratic Republic of the Congo (MONUSCO), and donors operating in Goma. Stratified random sampling and snowball sampling methods were used to select the representative from two groups, whereby 50% were from Goma's population affected by Nyiragongo volcano eruption 2021 and the other 50% were actors involved in the response.

Stratified sampling is where the population is divided into strata (or subgroups) and a random sample is taken from each subgroup. A subgroup is a natural set of items. Subgroups might be based on company size, gender, or occupation (to name but a few). Stratified sampling is often used where there is a great deal of variation within a population.

Its purpose is to ensure that every stratum is adequately represented (Ackoff, 1953 cited in Taherdoost, 2016, p.21). The stratified random sampling ensures that members from each group are chosen randomly, whether the population of Goma that was affected by the volcano eruption or people participating in the Nyiragongo crisis response 2021. Snowball sampling is effective at reaching populations that are hard-to-reach or hard-to-ask, allowing members of the hidden population to conduct the recruiting on the researcher's behalf. Snowball sampling is accomplished by the identification of one or more individuals that represent the population of interest. These individuals are then asked to seek participation from others that are like them. The snowball (or chain) continues as the second-generation participant recruits a third tier of participants meeting the criteria, and so forth until data collection is complete (Casteel and Bridier, 2021, pp. 349-350).

3.4 Research Instrumentation

3.4.1 Questionnaire for survey

Invented by Sir Francis Galton, a questionnaire is a research instrument consisting of a set of questions (items) intended to capture responses from respondents in a standardized manner. Questions may be unstructured or structured. Unstructured questions ask respondents to provide a response in their own words, while structured questions ask respondents to select an answer from a given set of choices. Subjects' responses to individual questions (items) on a structured questionnaire may be aggregated into a composite scale or index for statistical analysis (Bhattacherjee, 2012, p.74). A questionnaire is the term used to describe the set of questions you're asking an individual. A survey is the process of collecting, analysing, and interpreting data from many individuals. It aims to determine insights about a group of people. A survey goes much deeper than a questionnaire and often involves more than one form of data collection (Smart Survey, 2022) A

questionnaire is a set of questions typically used for research purposes which can be both qualitative as well as quantitative in nature. A questionnaire may or may not be delivered in the form of a survey, but a survey always consists of questionnaire (Bhat, 2022b).

The questionnaire used in this study combined qualitative and quantitative questions. It contained 12 sections, and each section has 4 questions with multi-choice answers, except for section (1) related to personal information which has 8 questions. To ensure that respondents can read, understand, and answer the questions properly; clear and specific questions were formulated. In addition, I have purposely started with the least sensitive to the most sensitive questions to get feedback for all questions. I preferred to use a structured questionnaire, to gather actual information concerning perception of the local population and actors involved in crisis response regarding factors that have influenced the crisis management of Nyiragongo volcano eruption 2021.

The draft questionnaire was subjected to testing for 30 volunteers through focus group discussions. In respect of COVID-19 prevention measures, the testing was conducted for two separate groups of 15 adults from different backgrounds (students, housewives, journalists, guards, cleaners, farmers, shopkeepers, and humanitarian actors). The questionnaire was tested in French as it's the most commonly used language in DRC jointly with 4 other national languages. As a result of the testing, several points were taken into consideration and modified accordingly in the questionnaire. The final questionnaire contained the following 12 sections: 1) personal information 2) facts about the Nyiragongo volcano environment and activity; 3) preparedness and early warning system; 4) contingency planning (emergency planning); 5) security and political context; 6) socio-economic realities; 7) health situation and COVID-19; 8) shelter, water, sanitation, and

hygiene; 9) communication; 10) access and accessibility; 11) community and national engagement; and 12) international support.

3.4.2 Survey with one-to-one interview, emailing, and phone call

A survey is a method of collecting data in a consistent way. Survey research is useful for documenting existing community conditions, characteristics of a population, and community opinion (Guyette, 1983, p.47). According to Isaac and Michael (1997), survey is used «to answer questions that have been raised, to solve problems that have been posed or observed, to assess needs and set goals, to determine whether or not specific objectives have been met, to establish baselines against which future comparisons can be made, to analyze trends across time, and generally, to describe what exists, in what amount, and in what context." Most large surveys are based around a form (often called a questionnaire or a script) containing a number of closed questions. Interviewers are then appointed to ask questions exactly as outlined on the form, and record the answers, often by ticking the relevant boxes (INTRAC, 2017). Surveys can be administered in various forms, including in-person interviews, through telephone interviews, through the Internet, or a paper questionnaire that requires participants to write their answers (Lecce, 2021).

As indicated above in section 3.2 Area of Study and Sample Size, the aim was to reach 5000 individuals in Goma city, from the affected population and the actors involved in crisis response of the Nyiragongo volcano eruption 2021. Three different survey methods in this study, which was helpful to get access to the target population with less cost, faster, and to ensure response completion. These surveys methods are one-to-one interviews, emailing surveys, and phone call surveys; and they are defined as follows:

One-to-one interview (also called face-to-face surveys)**:** One-to-one interviews are usually conducted face to face. This offers the researcher the opportunity to interpret non-

verbal cues through observation of body language, facial expression and eye contact and thus may be seen to enhance the interviewers understanding of what is being said. To this end it permits the researcher to probe and explore hidden meanings and understanding (Mannion, 2009, p.310). Face-to-face surveys are characterised by the fact that an interviewer calls on, or meets with, the respondent and conducts the interview. The interviewer reads out the questions and records the respondent's answers. This can be done either in the form of a paper-and-pencil interview (PAPI) or a computer-assisted personal interview (CAPI). In the latter case, the questions have been recorded in a CAPI software programme; the interviewer reads them out from a computer screen and enters the respondent's answers directly into the computer – usually, a laptop. This enables automatic filtering (Groves et al., 2009; Loosveldt, 2008; cited in Schröder, 2016, p.1).

Emailing survey: an email survey is one that sends the survey instrument (e.g., questionnaire) to a respondent via email and most often samples respondents via email. These electronic mail surveys first came into use in the late 1980s, and many scholars at the time thought that they represented the future of survey research. (Lavrakas, 2008). Email survey research is the systematic data collection of information on a specific topic using computer questionnaires delivered to an online sample or population. Respondents receive, complete, and return their questionnaires via email. With the growth of online networks around the world, it is feasible to see an increase in the use of email survey research. (Thach, 1995, p.27). E-mail can provide a good opportunity for those researchers who have a limited research budget or who are interested in fast data gathering. E-mail is cheap, fast, and its asynchronous nature can lead to better response quality. Because e-mail obliterates time and zone constraints, surveying with e-mail can prove to be very beneficial when the sample is scattered and mobile (Simsek, 1999, p.83)

Phone call survey: Or the telephone survey is a method of inquiry in which data are collected from a sample of telephone numbers for the purpose of learning about a population that has been targeted for study in the survey (Kalsbeek and Agans, 2006, p.13). An interviewer assists the respondent to complete the questionnaire over the telephone. When paper based, this method is called Paper and Pencil Interviewing (PAPI), when computer-based, it is called Computer-Assisted Telephone Interviewing (CATI). Telephone interviews are usually cheaper than personal interviews since there is no travelling cost for interviewers and collection is usually faster than for personal interviews or self-enumeration. This method of collection is safer than personal interviews since the interviewer does not need to travel to dangerous or isolated areas (Statistics Canada, 2010). A growing number of mobile phone users have substituted their residential landline telephone for a mobile phone (Kühne and Häder, 2011). Therefore, mobile phone surveys are progressively playing an important role in data collection.

3.5 Data Collection Process

Data collection is the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes. The data collection component of research is common to all fields of study including physical and social sciences, humanities, business, etc. While methods vary by discipline, the emphasis on ensuring accurate and honest collection remains the same. The goal for all data collection is to capture quality evidence that then translates to rich data analysis and allows the building of a convincing and credible answer to questions that have been posed (Kabir, 2016). To obtain high-quality data that is relevant to the research problem, two workshops were conducred about the data collection process for 30 volunteers. These workshops were held

for two days on June/July 2021, whereby volunteers were separated into two groups of 15 persons, in respect of COVID-19 prevention measures. The participants to the workshops are the same persons that have volunteered in the draft of the questionnaire, and they are composed of 16 males and 14 females. During the workshop, participants had an overview of the research aim and objectives. In addition, they had a presentation and open discussion about the approach and methodology of the study. As mentioned earlier in this chapter, mixed methods case study is the approach used in this study and three methods of data collection can be utilized: one-to-one interviews, emailing, and phone calls. After that, we walked through each question from the questionnaire as a refresh session. Then, we focused on data collection protocols with a presentation of protocols, open discussion (Q &A), exercises and role plays.

The data collection protocols consisted of explaining procedures for collecting and recording data properly, and they are summarised in the following points:

- Mapping of the selected zone of research in Goma city to identify interested persons on the topic of Nyiragongo crisis management 2021.
- Describe the aim of the research and answer all questions raised by potential participants in the survey.
- Be always polite and thankful to the people that you have asked for an interview whether they have accepted or not to participate in the survey.
- Clarify that survey can be completed depending on the preference of the participant through one-to-one interview, or phone call, or email, and without any costs.
- Explain to participants that their participation will remain confidential, and they can provide their names or keep it anonymous.

- Inform participations to the survey that their participation is voluntary and confidential, and that they can stop the discussions at any time.
- Conducted surveys individually, in French, with limited background noise especially if it was a phone call method.
- Agree with participants to the survey on a suitable time and place to conduct the survey (home, garden, university, office after working hours, etc.).
- Take notes during the interview in response to each question, either by hand or directly on the computer.
- Build a good relationship with the participants and make them feel comfortable during the survey. Answer questions and concerns and express your gratitude for their contributions.

In addition to the above protocols, together with volunteers were defined all details related to the distribution zone of study (commune/neighbourhood), data collection schedule, provided tools (hard copies of questionnaires, consent forms, pens, new sim cards), regular contact with researcher and other volunteers in case of any challenges, weekly meetings to submit data that was collected and provide additional tools to volunteers. The survey was conducted from August to October 2021, and aimed at exploring two groups, it started first with institutions and organizations whereby were found actors involved in the response, then the population of Goma.

Two additional briefings were conducted on the 30 volunteers prior to data collection and immediately before the survey was launched. The hard copies of questionnaires were provided before the beginning of the survey. Households, individuals, and entities were selected based on stratified random sampling and snowball sampling from Goma city. The people interviewed were given the option to choose the way of completing

the interview, whether directly in person, by phone, or via email. Most of the households have chosen one-to-one interviews and some others phone calls. On the other hand, people who worked for the volcano response have opted for emailing by keeping an anonymous profile.

3.6 Methods of Data Analysis

Data analysis is defined as a process of cleaning, transforming, and modelling data to discover useful information for business decision-making. The purpose of Data Analysis is to extract useful information from data and taking the decision based upon the data analysis (Johnson, 2022). To obtain the needed conclusions from data analysis, there are some preparations that were undertaken before the analysis, and are outlined below:

- The analysis methods need to be directly connected to the research questions; therefore, it is important to identify clear research questions. As mentioned at the beginning of this paper, this study is meant to examine aspects that have shaped the crisis management of the Nyiragongo volcano eruption 2021. Then, based on the findings, draw attention to recommendations for better volcanic crisis management. In this study, the following research questions were addressed: What are the aspects that have shaped the crisis management of Nyiragongo volcano eruption 2021 in DRC? And how can DRC be better prepared for a potential Nyiragongo volcano eruption?
- The data collection is a crucial stage in any study and might determine the value of the whole research. Therefore, it is highly important to define the right methods and tools for data collection. Then eventually, research questions could be answered through these data findings. In order to get

reliable data, a mixed methods case study design was adopted for this study, and a survey was conducted to 5000 people from Goma city including the Nyiragongo area. To complete the survey, I used a questionnaire for one-to-one interviews, emailing, and phone calls. As mentioned above, the survey aimed to reach two categories 1) population of Goma; and 2) actors involved in the crisis response.

- The cleaning of primary data that was gathered from the survey should be done prior to data analysis. For that reason, since the first week of data collection in August 2021, I was exanimating if the information was properly recorded in Excel. However, some mistakes were noticed. Responses that appeared to be entered in error, duplicated, or missing have been flagged. Then, data was reviewed more closely, and fortunately, the correct responses were available and replaced accordingly. After completing data collection, the data was reviewed and compiled in electronic files.

There are several techniques and software for data analysis, depending on the type of data that was collected and the type of data visualization that we want to project. As this study has used a mixed methods design, in the data analysis process I have had to deal with qualitative and quantitative data. Therefore, content analysis and coding were used for qualitative data and descriptive statistics for quantitative data. Then triangulation to combine both qualitative and quantitative data. In addition to this, Power BI software was used, for data analysis and visualisation. Power BI was selected because it has the capacity to handle large amounts of data that could be extracted from different forms and sources like Excel, PDF, Text/CSV (comma-separated values), Share Point and the Web. Power BI

can be configured to automatically refresh its data to reflect the changes made to the file. Power BI will query the folder and detect any changes made to the file and refresh its data accordingly (Hopkins, 2023). As stated by Data Flair (2022), we can use the datasets imported in Power BI for data visualization and analysis by making sharable reports, dashboards, and apps. It has a range of custom visualizations includes KPIs (key performance indicators), maps, charts, graphs, R script visuals, etc. Power BI's capability of Excel integration helps users to view and work with the raw data behind a Power BI visualization.

Regarding methods of data analysis used in this study, they are described in the next paragraphs:

As mentioned above, content analysis was used for qualitative data. Content analysis is a research method that provides a systematic and objective means to make valid inferences from verbal, visual, or written data in order to describe and quantify specific phenomena (Downe-Wamboldt, 1992, p. 314). Qualitative content analysis involves a process designed to condense raw data into categories or themes based on valid inferences and interpretations. The process uses inductive reasoning, by which themes and categories emerge from the data through the researcher's careful examination and constant comparison (Shava et al, 2021, p.554).

In addition to content analysis, coding was used further for qualitative data. Coding is a way of indexing or categorizing the text in order to establish a framework of thematic ideas about it (Gibbs, 2007, p.132). According to Medelyan (2015), coding is the process of labelling and organizing your qualitative data to identify themes. After you code your qualitative data, you can analyze it just like numerical data. A code in qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient,

essence-capturing, and/or evocative attribute for a portion of language-based or visual data (Saldaña, 2013, p.3).

The application of qualitative content analysis presupposes that it is only important *what* was said, not *how* it was said. If at any later stage of the investigation, the actual phrasing of a significant part of the information is important, coding and retrieval procedures are better suited because they offer better access to the original text (Gläser and Laudel, 2013, pp.31-32). Consequently, using these both techniques would be suitable for analysing the qualitative data of this study.

After cleaning and carefully studying the transcripts of the survey, the first phase was extracting content by selecting relevant from irrelevant information and summarised it. This phase will reduce the volume of data, which aimed to improve the quality of information and be ready for additional structuration. Then in second phase, the extracted information was evaluated over again for further corrections if needed and to be largely free of repetitions. During the evaluation exercise, information with the same meaning was gathered, and a list of themes has emerged.

To undertake the coding, a hybrid approach that combined deductive and inductive methods was used. It started with a set of 11 priori codes (deductive codes) related to aspects that have shaped the crisis management of the Nyiragongo eruption 2021. Then new codes (inductive codes) were added based on the data findings. Because each list of coded data was lengthy and messy; it was essential to read it several times to identify linked topics and to associate it with answers provided by participants to the survey. After that, they have been grouped into comprehensive pieces and created categories (Mbangwa Mafuwane, 2011, pp.67-88).

Then to refine these categories and/or themes, they were compared and defined with a label for each category and subcategory that reflect respondents' perspectives. Besides, connections between these categories were described, and at the final stage, qualitative data has been converted into numerical codes that can be represented statistically and classified accordingly.

Regarding quantitative data, the descriptive statistics method was used. Descriptive statistics are used to describe the basic features of the data in a study. They provide simple summaries about the sample and the measures. Together with simple graphics analysis, they form the basis of virtually every quantitative analysis of data. With descriptive statistics you are simply describing what is or what the data shows (Trochim, 2001). Descriptive statistics include types of variables (nominal, ordinal, interval, and ratio) as well as measures of frequency, central tendency, dispersion/variation, and position (Kaur, Stoltzfus, and Yellapu, 2018, pp.60-63). There are three major types of descriptive statistics: Measures of frequency (frequency, percent), measures of central tendency (mean, median and mode), and measures of dispersion or variation (variance, SD, standard error, quartile, interquartile range, percentile, range, and coefficient of variation [CV]) provide simple summaries about the sample and the measures. A measure of frequency is usually used for the categorical data while others are used for quantitative data (Mishra et al, 2019, pp. 67–72).

The application of descriptive statistics is a powerful technique in analysing quantitative data. It has permitted in this study to double-check the data, summarise it, organise it, and present it in a wide range of outlines. By using the different types of descriptive statistics, we were able to get finer details on point of view of respondents. In addition, it has offered the overall perception of the participant about various aspects of

Nyiragongo crisis management 2021; and provided greater insight into their knowledge and understanding of the conditions that surrounded volcano crisis management before and after the eruption of 2021. Moreover, it has facilitated the analysis process and transformation of results in a distribution of frequency, percentages, and overall averages.

To combine analyses (qualitative & quantitative data), and enhance the certainty of the research findings, the triangulation was used. Triangulation is process of using more than one method, theory, researcher, and data collection method & technique to make the research findings more valid, reliable, and generalizable Johnson (2017, pp. 91-95). There are four types of triangulation according to Denzin (1978); (1) data triangulation, which includes matters such as periods of time, space and people; (2) investigator triangulation, which includes the use of several researchers in a study; (3) theory triangulation, which encourages several theoretical schemes to enable interpretation of a phenomenon and (4) methodological triangulation, which promotes the use of several data collection methods such as interviews and observations. As stated by Sarantakos (1998) triangulation allows the researcher:

- to obtain a variety of information on the same issue;
- to use the strength of each method to overcome the deficiencies of the other;
- to achieve a higher degree of validity and reliability; and
- to overcome the deficiencies of single-method studies.

As a mixed methods case study design was used in this research, the methodological triangulation was the most practical type of triangulation to combine qualitative and quantitative data. Once the analyses for qualitative and quantitative data were separately completed, the final phase was to review both analyses and integrate them. This process consisted of the following steps:

1. The survey data were entered into Excel (spreadsheet 1). This process was conducted at the beginning of the data analysis.
2. The qualitative data were analysed into qualitative response categories that were entered into a second Excel (spreadsheet 2).
3. These two Excel sheets were linked by key informant identification numbers. This approach will allow to keep records linked to both the survey and detailed responses.
4. The coded qualitative data were then quantified into variables based on each coded response.
5. The combinations were analysed by using Power BI.

The final product represented triangulation in that each final theme represented analysis of data from at least two data sources, and literature was used to further support these conclusions (Noble and Heale, 2019, p.68).

3.7 Validity of Research Design

The word validity is primarily a measurement term, having to do with the relevance of a measuring instrument for a particular purpose, but it has been broadened to apply to an entire study. A research investigation is said to have internal validity if there are valid causal implications and is said to have external validity if the results are generalizable (Lavrakas, 2008). The differences between paradigms mean there is no one way or specific set of standards to ensure validation in mixed methods research. Rather there is a need to understand what is being mixed, so as to decide whether or not more than one set of validation strategies should be applied (Andrew and Halcomb, 2009, p.123).

To ensure the validity of the mixed methods case study design that was applied in this study, the triangulation was the most appropriate process to utilize. By combining

multiple observers, theories, methods, and empirical materials, researchers can hope to overcome the weakness or intrinsic biases and the problems that come from single-method, single-observer, single-theory studies. Often the purpose of triangulation in specific contexts is to obtain confirmation of findings through convergence of different perspectives. The point at which the perspectives converge is seen to represent reality (Jakob, 2001, pp.1-29).

Triangulation is a powerful technique that facilitates validation of data through cross verification from two or more sources Johnson (2017, pp.91-95). Triangulation was employed in this study through several methodologies. By engaging in mixed methods case study design, qualitative and quantitative data helped to get an accurate representation of aspects that have shaped the crisis management of Nyiragongo eruption 2021. Both methods contributed to get a comprehensive data finding, which involved cross-checking data from two complementing methods, and it provided valuable insight that could not be obtained by using a single method.

Furthermore, the survey was conducted in three different methods: 1) one-to-one interview, 2) emailing, and 3) phone call; all these methods have provided first-hand, lived experiences. 5000 individuals completed questionnaires for the survey from different backgrounds of the community, including males and females. These individuals were identified from two groups; 2500 people from Goma town and 2500 actors involved in crisis response related to the Nyiragongo volcano eruption 2021. Thus, offering multiple sources of information, in addition to a literature review. Altogether they form validation.

3.8 Research Design Limitations and Challenges

Due to the lack of previous academic research on the crisis management of the Nyiragongo volcano eruption 2021, it was difficult to find relevant information on this

topic. In addition, the survey was conducted from August to October 2021, during that period preventing measures against COVID-19 were still in place. Hence, it was not possible to conduct a focus group discussion for more than 20 people in the same place. Therefore, various means were used to complete the survey like one-to-one interviews, emailing, and phone calls. As some parallel roads were affected by volcano eruption, and people were moving to safer locations; it was difficult to have access directly to persons of concern in some districts. Despite briefings and instructions given to interviewers, some questionnaires were filled in incorrectly at the beginning of the survey. Having observed this problem, more detailed instructions were given to them, and then they returned to responders to fill the gaps, which was time-consuming.

3.9 Conclusion

Various methods and techniques were employed to meet the objectives of this research, which focused on identifying aspects of Nyiragongo crisis management 2021 and providing avenues of solution for better volcanic crisis management. An exploratory approach with a mixed methods case study design was used to provide relevant data at different stages of the study. The first stage was meant to explore past studies through a literature review. In second stage, a questionnaire was developed and tested against 30 volunteers to conduct a survey. In third stage, data collection using a survey was carried out to 5000 individuals in Goma town through one-to-one interview, emailing and phone call. In fourth stage, results from qualitative and quantitative data were reviewed, analysed, then combined by using triangulation and Power BI.

CHAPTER IV:

RESULTS

This chapter will present and describe the main results of the study. It will consist of thirteen sections that will start with an introduction and demographic information of participants. Then, it will be followed by eleven sections that will provide an overview of the data findings of the survey obtained from one-to-one interview, emailing, and phone call. It will also include a text-based narrative with tables, charts, and graphs.

4.1 Introduction

An investigation is being performed in this research on the crisis management of Nyiragongo volcano eruption 2021. The main objective of executing the investigation is to identify aspects that have shaped the crisis management of the Nyiragongo volcano eruption 2021; and to recommend avenues of solution that can lead to better management of volcanic crisis. To reach this objective, an exploratory approach with a mixed methods case study design was used in this study. A questionnaire was developed and tested among thirty volunteers, then it was used by same volunteers to conduct a survey for 5000 individuals in Goma town. These individuals are composed of two groups, and they are: 1) population of Goma; and 2) actors involved in crisis response.

The survey was held for three months, from August to September 2021. In this survey different methods were used for data collection, whereby participants replied to the questionnaire in following techniques: 3225(64.5%) participants through one-to-one interview, 1175(23.5%) participants through emailing, and 600(12%) participants through phone calls. Although, different ways were employed to complete the questionnaire, the time spent in each interview was alike, between 35 to 55 minutes long.

It's worth mentioning that response rates are one of the toughest aspects of a study. Throughout my experience in conducting surveys, reaching 100% of participation was kind of a myth and impossible to obtain, but this study proves me wrong. The populations of Goma town were willing and enthusiastic to answer the questionnaire for the survey because they wanted to raise their voices to the national and international community about their actual situation. In addition, they wanted to shed light on their different experiences in facing the eruption and their living conditions before and after the Nyiragongo volcano eruption 2021. Therefore, all participants have completed questionnaires for the survey.

The results from both groups, the population of Goma and actors involved in crisis response, were combined to give a general overview of the sample. The main findings are summarised in the following sections:

4.2 Demographic Information of Participants

4.2.1 Name or anonymous

The participants in the study were afforded the possibility to provide their names or remain anonymous in respect of their rights to privacy and confidentiality. According to their responses, 99% (4970) of the respondents preferred to keep an anonymous profile and only 1% (30) have given their names (Figure 4, p.150).

4.2.2 Age

Respondents of all ages (18 through to over 60) were represented. A larger number was noticed in two categories of people aged between 36-60 and 26-35 years, accounting for 42% (2106) and 36% (1776) of the respondents, respectively. The lowest age bracket was 18-25 years with 14% (708). The oldest age bracket was 60 years, and above which accounted for 8% (410) of the respondents (Figure 5).

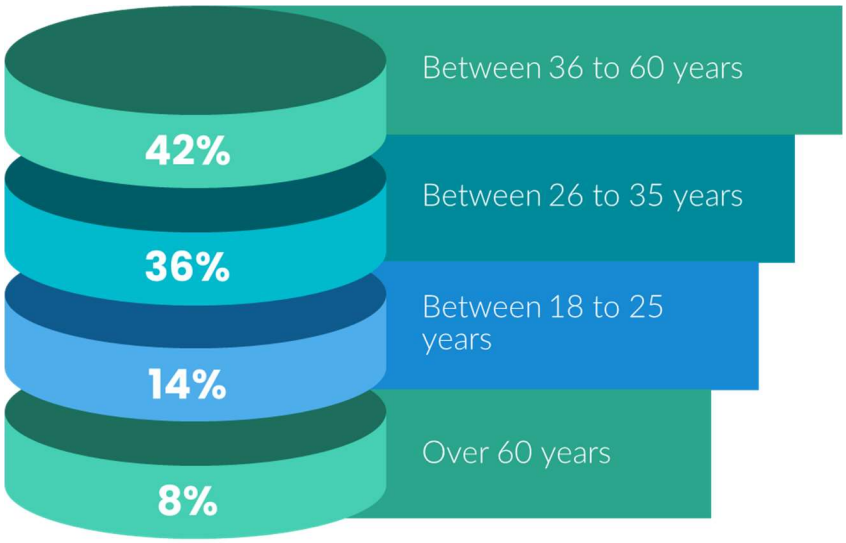

Figure 5: Age distribution of respondents

Source: Generated by author

4.2.3 Gender

To ensure that the gender dimension is adequately incorporated in this research, it was essential to investigate on the number of women and men as well as other genders that participated in the study. The gender composition of the respondents from males was 54% (2678) and 46% (2322) females, and no other genders were reported (Figure 6).

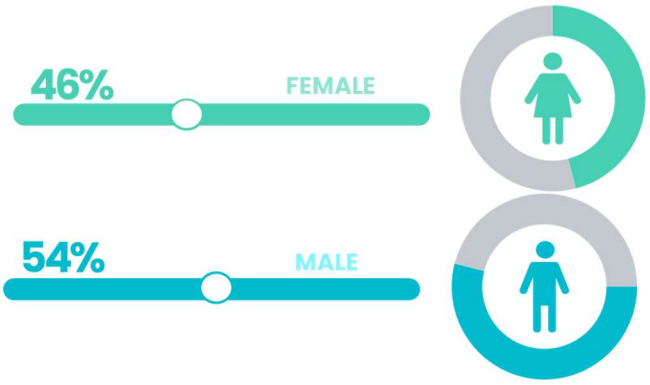

Figure 6: Gender of respondents

Source: Generated by author

4.2.4 Marital status

The findings of this study showed that the majority of respondents 41% (2025) reported they were married at the time of the survey, and 39% (1940) reported they were single. A small percentage reported they were in cohabitation (common-law relationship) with 9% (457), divorced 8% (409), or widow(er) 3% (169) (Figure 7).

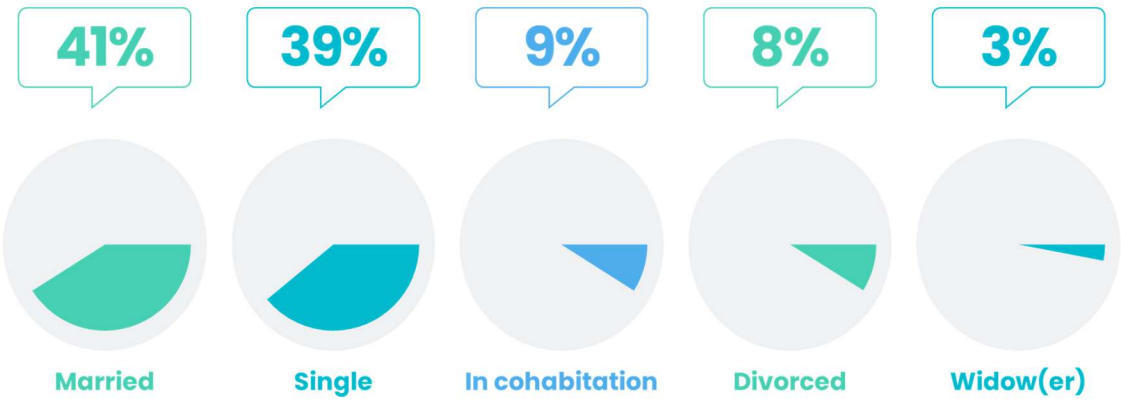

Figure 7: Marital status of respondents

Source: Generated by author

4.2.5 Function

As mentioned at the beginning of this paper, this study targeted two groups: 1) population of Goma, and 2) actors involved in the response. Hence, 50% of respondents were actors involved in crisis response, and the other 50% were people residing in Goma town. This study indicated that among respondents of 1st group related to the population of Goma town, a large proportion were small-scale traders with 19% (482), 15% (383) unemployed, and 13% (326) farmers. A small proportion with 11% (274) consisted of transporters, 9% (224) were cleaners, 7% (163) were fishers. A minor proportion of respondents with 5% each were students (136), security guards (122), and breeders (121).

Followed by journalists 4% (92), pupils 3% (82), and health staff 2% (48). The remaining respondents were salaried employees 1% (26), and "other" category 1% (21) (Figure 8).

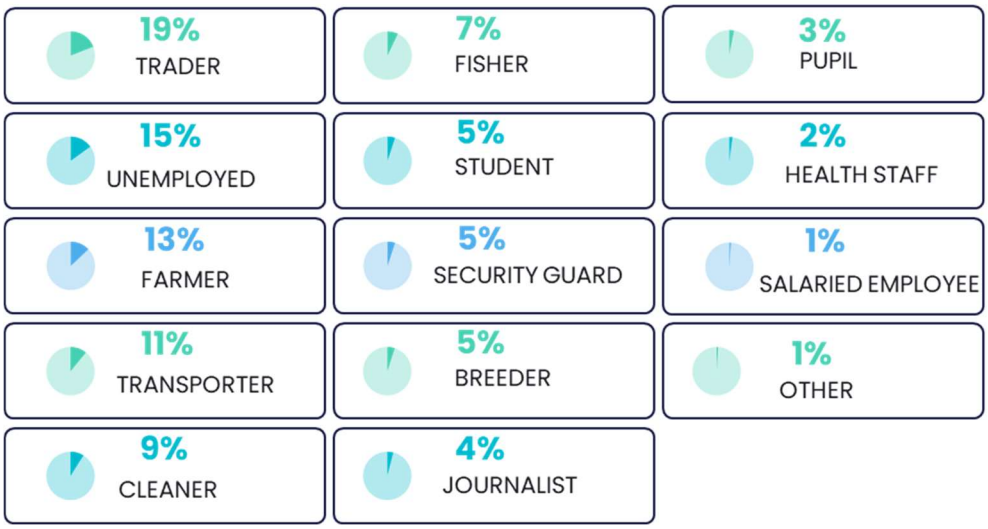

Figure 8: Function of respondents from Goma town populations

Source: Generated by author

4.3 Nyiragongo Volcano Environment and Activity

4.3.1 Knowledge of the activity of Nyiragongo volcano

Results showed that a high proportion of 86% (4308) of persons interviewed reported that they were aware that Nyiragongo volcano was an active volcano. A smaller proportion of the respondents 14% (692) reported that they were not aware of the activity of Nyiragongo volcano (Figure 9, p.150).

4.3.2 Background on Nyiragongo volcanic eruptions

Findings of the study revealed that overall, 84% (4186) of the respondents stated that they did know about the eruptive history of Nyiragongo that occurred in 1977, 2002, and 2021. The remaining 16% (814) stated that they are only aware of the 2021 eruption (Figure 10, p.151).

4.3.3 Live experience of Nyiragongo volcanic eruption 2021

Respondents were requested to report if they have witnessed or not the eruption of the Nyiragongo volcano in 2021. Results from the study indicated that a huge proportion 92% (4599) of respondents reported that they experienced personally the 2021 Nyiragongo eruption. A mere 8% (401) of respondents did not witness the event (Figure 11, p.151).

4.3.4 Perception of Nyiragongo volcano environment

Concerning the perception of the volcanic environment, a majority of 52% (2601) of respondents considered the Nyiragongo environment as a source of income. 28% (1401) perceived it as a family and cultural heritage, and 12% (613) believed that it's a good place to live. While 5% (227) considered that due to the risk of eruptions, we must leave this location. A small proportion of 3% (158), considered Nyiragongo environment as exploitation of natural resources (minerals) (Figure 12).

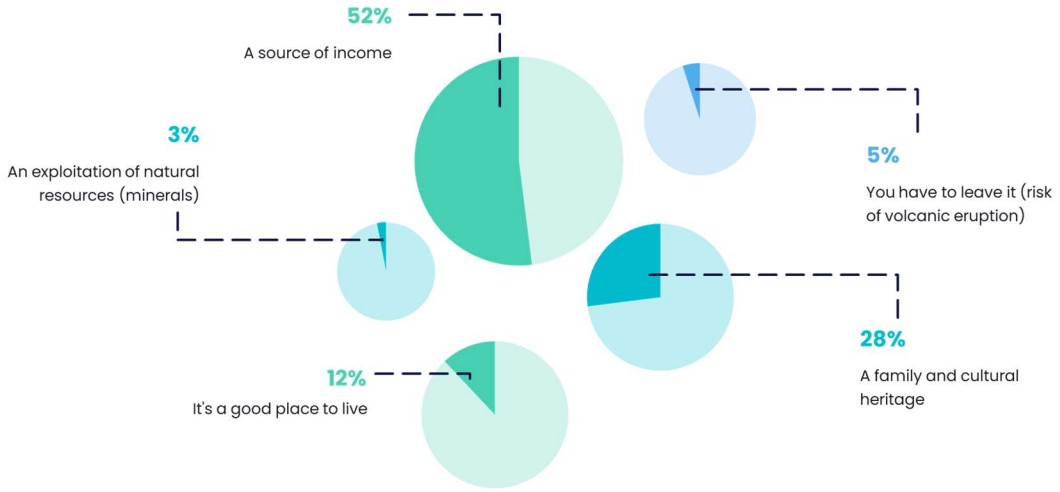

Figure 12: Response to question: What does the natural environment around Nyiragongo volcano represent for you?

Source: Generated by author

4.4 Preparedness and Early Warning System

4.4.1 Preparation for potential Nyiragongo volcanic eruption

The respondents were further asked whether they were prepared or not for a potential eruption of the Nyiragongo volcano. Then, results from the study indicated that about 100% (4989) stated that they were not prepared. Just 11 persons representing 0% stated that they felt prepared to deal with volcanic eruption (Figure 13).

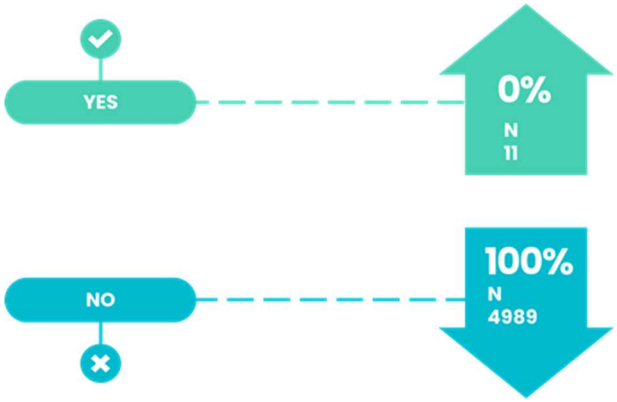

Figure 13: Response to question: Were you prepared for a potential eruption of the Nyiragongo volcano?

Source: Generated by author

4.4.2 Training in case of volcanic eruption

A considerable gap was noticed in volcanic risk and response education, through this study. The findings showed that 100% (4993) did not receive any training on what to do in case of a volcanic eruption. Only 7 persons representing 0% revealed that had a sufficient level of training to face a volcanic eruption (Figure 14**,** p.152).

4.4.3 Alert of Nyiragongo volcanic eruption 2021

A huge proportion of 99% (4932) of the interviewees in the study reported that they were not alerted on time about the eruption of the Nyiragongo volcano in order to protect

themselves. Whilst the rest 1% (68) reported that they were timely alerted to run away from the eruption and protect their families and belongings (Figure 15).

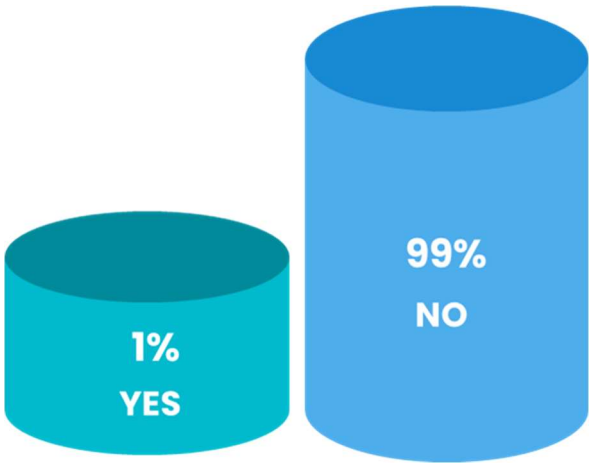

Figure 15: Response to question: Were you alerted on time about the eruption of Nyiragongo volcano to protect yourself?

Source: Generated by author

4.4.4 Monitoring of Nyiragongo volcano

In the survey, an average of 67% (3339) of the respondents stated that Nyiragongo volcano was not monitored by OVG or any other institution. A smaller proportion 33% (1648) of respondents stated that they did not know, and 0% (13) stated that OVG was operating (Figure 16, p.152).

4.5 Contingency Planning (emergency planning)

4.5.1 Knowledge of existing contingency planning

Results from the study indicated that 66% (3289) of the respondents appeared to have a lack of knowledge about the Contingency Plan in anticipation of volcanic eruptions in the DRC (2018-2022) for North Kivu in the DRC. Besides, 34% (1711) of respondents indicated that they have heard about it (Figure 17, p.153).

4.5.2 Knowledge of risks of 2nd eruption of Nyiragongo volcano after the eruption of May 2021

After the Nyiragongo eruption on 22nd May 2021, the local authorities warned officially about the risk of second eruption. When we requested participants to the survey if they were aware of that, 91% (4544) of the respondents confirmed that they were informed about that. The remaining 9% (456) revealed that they did not know about the risk of a second eruption. Regarding people who were aware of the potential second eruption, 76% (3822) stated that they respected instructions related to the evacuation plan, and 24% (1178) stated that they were not concerned about the evacuation plan **(**Figure 18, p.153).

4.5.3 Transport used in evacuation

When asked about transport means used during the evacuation from the volcanic eruption, an average of 39% (1931) of respondents declared that they moved on foot towards displacements sites, host families, or neighbouring country Rwanda. 32% (1596) of respondents declared that they used buses provided by local authorities, and 20% (1006) declared that they used their cars. Lastly, 8% (409) declared that they rented cars, and 1% (58) used taxis (Figure 19, p.154).

4.5.4 Availability of means of subsistence

To determine if disaster victims received or not basic assistance, interviewees were asked in separate questions about provided services. The results showed that 53% (2672) received shelter, 71% (3533) received food, 62% (3079) received drinking water, 47% (2354) received hygienic kits, 64% (3197) received health care services, 29% (1431) received psychological support. On the other hand, 15% (770) declared that they did not receive any assistance (Figure 20).

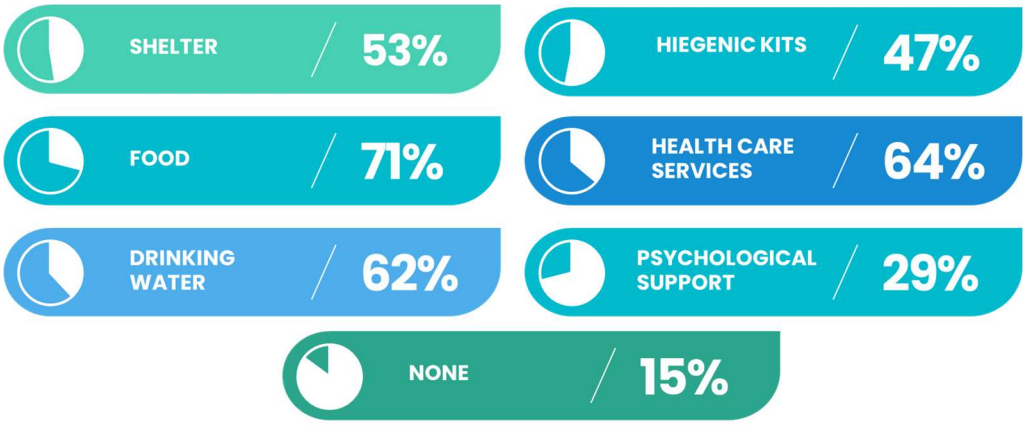

Figure 20: Response to question: Did you receive any means of subsistence at host sites?

Source: Generated by author

4.6 Security and Political Context

4.6.1 Familiarity with state of siege

To face insecurity and rebels armed groups in Eastern DRC, a "State of Siege" was put in place by the Government for two provinces North Kivu and Ituri since 6 May 2021. The majority 99% (4959) of those interviewed declared that they were fully aware of state of siege process and only 1% (41) declared that they were not familiar with it and did not know anything about its application (Figure 21, p.154).

4.6.2 Existing conflicts

To understand the security situation and existing conflicts during and after the Nyiragongo eruption, participants to the survey were asked if any conflicts occurred between the population and the rebels, or the national army and the rebels. An average of 40% (2010) of the respondents reported that there were no conflicts, and another 40%

(2020) reported that they do not know. The remaining 20% (970) reported that there were some conflicts in the area (Figure 22, p.155).

4.6.3 Protection impressions

A high proportion of 85% (4270) of interviewees revealed that they felt unprotected during and after the Nyiragongo eruption. A smaller proportion 11% (567) revealed that they felt protected. A mere 4% (163) believed that they did not know if they were protected or not (Figure 23, p.155).

4.6.4 Protection issues

The results of the study showed that 81% (4034) of the respondents stated that they did not face any protection issues related to assaults, theft, rape, menaces, or other abuse during and after the evacuation. On the other hand, 19% (966) of the respondents stated that they were a victim of theft (Figure 24).

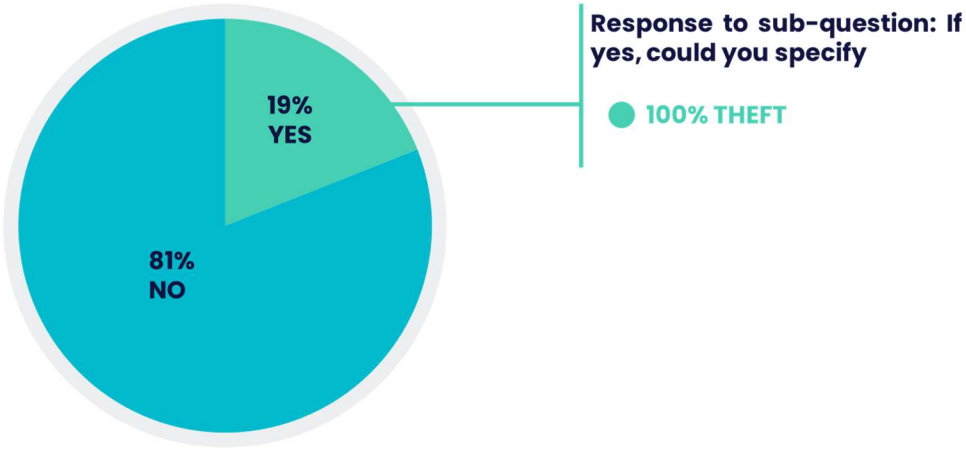

Figure 24: Response to question: Have you found any assaults, theft, rape, menaces, or other abuse during and after the evacuation?

Source: Generated by author

4.7 Socio-Economic Realities

4.7.1 Commercial activities around Nyiragongo volcano

To identify commercial activities surrounding the Nyiragongo area before the eruption, interviewees were asked in separate questions about existing activities. 96% (4783) of interviewees mentioned the existence of natural parks, 73% (3645) street vendors, and 72% (3609) agriculture. Results further indicated that 53% (2662) stated about the existence of restaurants, 37% (1838) handicrafts activities, 32% (1597) hotels, and another 32% (1585) stores. Only, 1% (27) declared that they did not know about the existence of any commercial activities (Table 2).

Activity	Numbers	Percentages
Stores	1585	32%
Hotels	1597	32%
Restaurants	2662	53%
Natural Park	4783	96%
Street vendors	3645	73%
Agricultures	3609	72%
Handicrafts	1838	37%
I don't know	27	1%

Table 2: Response to question: Was there any commercial activity around Nyiragongo volcano?

Source: Generated by author

4.7.2 Mining exploitations around Nyiragongo volcano

A majority of 90% (4490) of respondents revealed that there were no mining exploitations around Nyiragongo volcano. While 10% (498) of respondents stated that they

did not know if there were any mining activities in that area. Only 12 persons representing 0% reported the existence of such exploitations around Nyiragongo (Figure 25, p.156).

4.7.3 Impact of Nyiragongo volcanic eruption 2021 on populations' professional life

Results from the study indicated an important rate of 32% (1610) of the respondents revealed that they have lost their jobs after the Nyiragongo eruption, and only 1% (67) revealed that they got new job opportunities. Moreover, 2% (76) of the respondents stated that they have difficulties accessing their jobs. Regarding the salary, the majority 65% (3247) of respondents indicated that their salaries remained the same; and no salary decreases, or increases were reported. In addition, no support was provided by the Government related to salaries according to interviews (Figure 26).

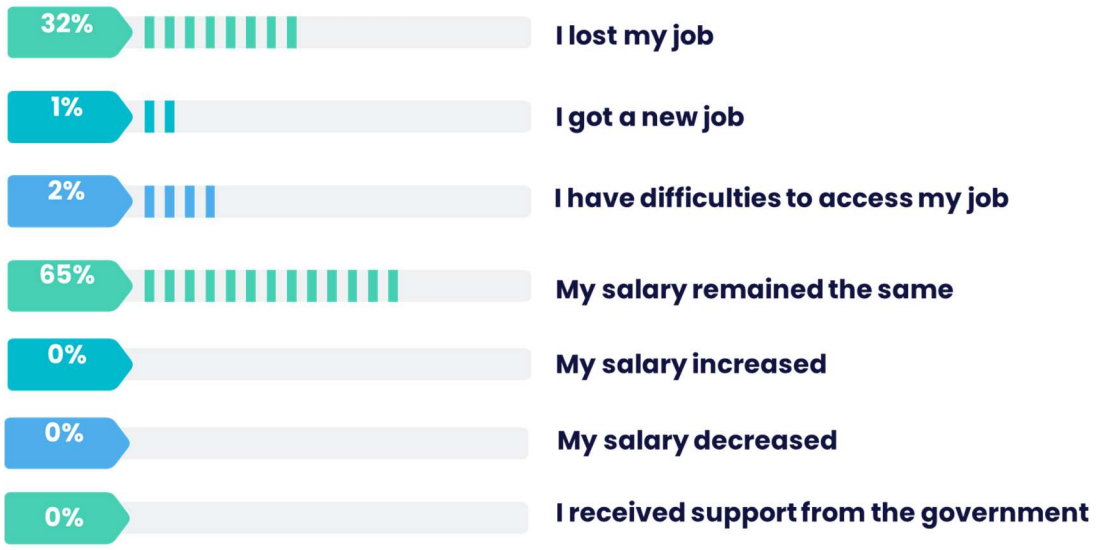

Figure 26: Response to question: How has the eruption of Nyiragongo volcano impacted your professional life?

Source: Generated by author

4.7.4 Impact of Nyiragongo volcanic eruption 2021 on populations' personal life

To measure further the impact of the eruption on personal life of the population, interviewees were asked in separated questions about the effect of the eruption on the personal side. No one of the interviewees reported deaths among their family members, and 1% (58) reported that they were injured. Besides, serious damages were noticed on housing, whereby 30% (1509) of interviewees reported that they have lost their houses, and 48% (2398) reported that their houses were partially damaged. On the other hand, 22% (1079) stated that they were living far away from their families. Under these complex conditions, 35% (1754) of interviewees revealed that they were still feeling fear against the eruption, and 84% (4197) stated that since the Nyiragongo eruption they were feeling stressed (Figure 27, p.156).

4.8 Health Situation and COVID-19

4.8.1 Common diseases among population

Malaria was the most widely recorded disease mentioned by an important proportion of 42% (2093) of respondents; then fever with 25% (1233), followed by malnutrition with 17% (843). Less proportions of responses were observed in the other diseases, 5% (235) in EVD, 3% (163) in Measles, 3% (168) in Diabetes, and 2% (97) in COVID-19. Only 1% was respectively noticed in the following diseases: Blood pressure (54), Psychical illnesses (50), and Motor illnesses (disability) (41). Whilst just 23 persons representing 0% reported about Cholera (Table 3, p.158).

4.8.2 Type of medical treatment used during Nyiragongo volcanic eruption 2021

An average of 44% (2183) of respondents revealed that they took the sick and/or injured persons to private health services, and a smaller proportion 17% (850) took them to public health services. A common practice noted amongst populations, whereby 27% (1349) of the respondents were self-medicated. Also, 7% (372) of the respondents acknowledged using traditional family methods for treatment. Then, 5% (246) of the respondents revealed that they were treated by a traditional healer (Figure 28).

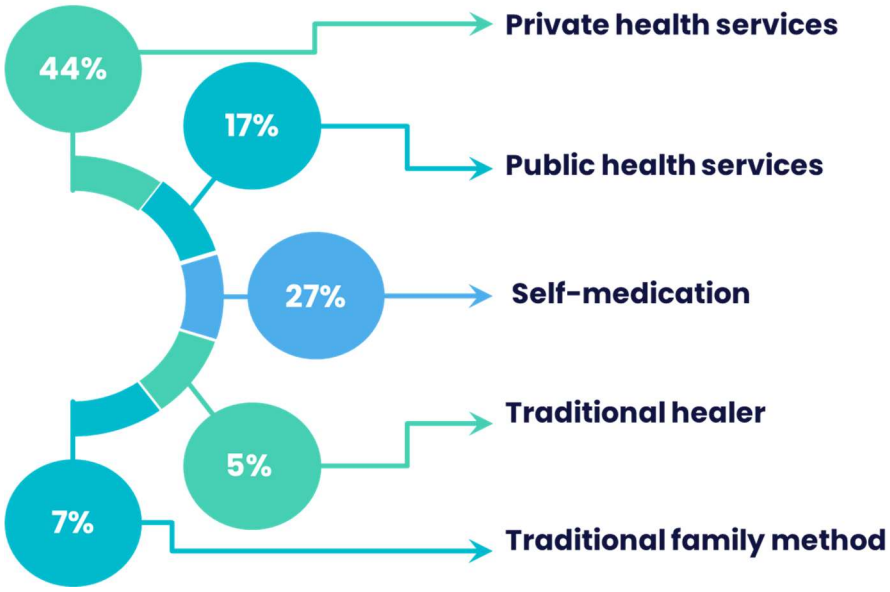

Figure 28: Response to question: What type of medical treatment would you have chosen during the eruption of the Nyiragongo volcano?

Source: Generated by author

4.8.3 Knowledge of prevention measures on COVID-19

To tackle the COVID-19 pandemic, prevention measures were imposed in DRC and worldwide to prevent disease transmission including lockdowns and social distancing.

The findings in this study revealed that a majority 84% (4203) were aware of these measures. On the other hand, 16% (797) of respondents stated that they were not aware of prevention measures against COVID-19 (Figure 29, p.157).

4.8.4 Escaping health services due to COVID-19

The results showed that 33% (1627) of respondents were avoiding health services driven by fears of COVID-19 transmission in health care facilities. Meanwhile, 67% (3373) of respondents stated that despite the COVID-19 pandemic, they were going to different health centres for treatment if needed (Figure 30).

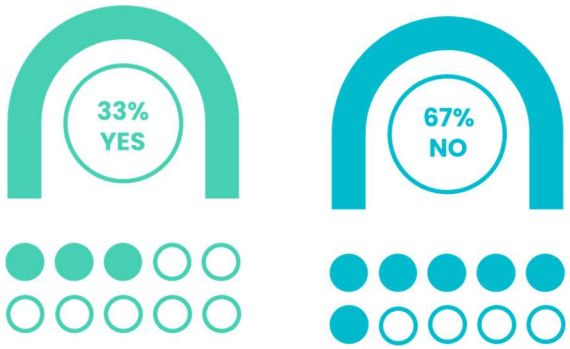

Figure 30: Response to question: Were you avoiding health services because of COVID-19?

Source: Generated by author

4.9 Shelter, Water, Sanitation, and Hygiene

4.9.1 Availability of shelter

A high proportion 73% (3625) of interviewees revealed that they returned to their old houses. A small proportion 14% (675) of interviewees reported that they were living in another town or province, 6% (323) reported that they were received by host families, and 5% (248) reported that they were living at neighbour's house. A mere 2% (110) reported

that they were lodging at the reception centre. While 19 persons representing 0% stated that they were staying in other places, and were homeless (Figure 31, p.158).

4.9.2 Access to safe drinking water

One of the most serious and direct effects of the Nyiragongo eruption was access to drinking water. A significant proportion 44% (2186) of respondents reported that they were using natural sources (the lake) to get drinking water. Slightly below natural sources, the piped water taps were used by 43% (2160) of respondents. Results further indicated that 9% (435) of respondents were using water tanks, followed by 4% (201) that were purchasing mineral water. Only 18 persons representing 0% reported that they were using boreholes to get safe water (Figure 32).

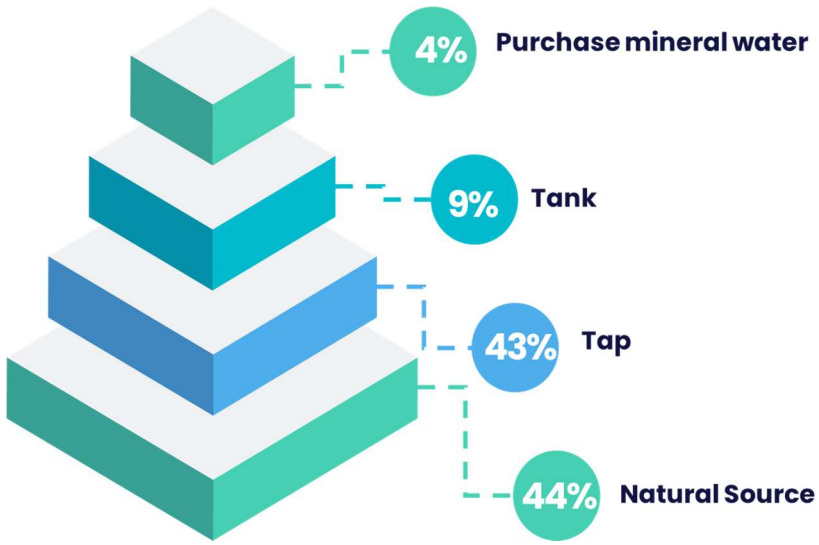

Figure 32: Response to question: How do you get access to safe drinking water?

Source: Generated by author

4.9.3 Access to sanitation

To understand the sanitation conditions at the place of living, participants in the study were asked if they had access to toilets and how many persons were using the same toilet. The results showed that 99% (4972) of respondents had toilets, and the remaining 1% (28) revealed that they did not have a toilet at their place of living (Figure 33, p.158).

Regarding the number of persons that were using the same sanitation facility, an average of 38% (1885) of interviewees revealed that the toilet was used by 5 to 10 persons. Then, 32% (1586) revealed that toilet was used by 10 to 15 persons. A small proportion of 15% (753) of respondents stated that the toilet was used by 15 to 20 persons, followed by 10% (513) of respondents revealed that the toilet was used by over 20 persons. The remaining 5% (263) of respondents stated that the toilet was used by 1 to 5 persons (Figure 34, p.159).

4.9.4 Access to handwashing facility

Respondents were requested further to state if they had basic handwashing facilities at their place of living, and how many persons were using the same facility. Results from the study indicated that 99% (4948) of respondents stated that they had a sink or other handwashing facility, and 1% (52) of respondents indicated that they did not have access to any type of handwashing facility (Figure 35, p.159).

Regarding the number of persons that were using the same handwashing facility, an average of 40% (2013) of interviewees stated that 5 to 10 persons were using the same bathroom sink. A small proportion 27% (1332) of respondents stated that the handwashing facility was used by 15 to 20 persons, and 19% (950) of respondents stated that washbasin was used by 10 to 15 persons. The results further showed that less proportion 7% (373) of

respondents stated that they were over 20 persons sharing the washbasin and the remaining 7% (332) stated that 1 to 5 persons were using a common handwashing facility (Figure 36).

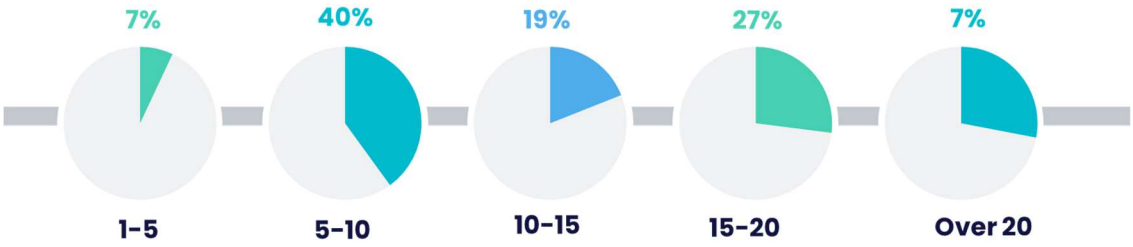

Figure 36: Response to sub-question: Number of users per one handwashing facility

Source: Generated by author

4.10 Communication

4.10.1 How was the population of Goma informed about Nyiragongo volcanic eruption 2021?

A majority 42% (2080) of the interviewees in the study, reported getting information about the Nyiragongo eruption mainly through personal observation of lava flow. An average of 30% (1492) of the interviewees reported that they learned about the eruption from social networks (social interactions and social media). Whilst 24% (1220) of interviewees revealed that they realised that Nyiragongo volcano was erupting when they saw the sky turning red. A smaller proportion of 2% (104) of the respondents watched the event on TV, 1% (54) revealed that they knew about it when several earthquakes occurred, and another 1% (27) revealed that they heard about the eruption on the radio. Only 23 persons representing 0% reported that they were informed about the Nyiragongo eruption through a publication from Goma Volcano Observatory (Figure 37, p.160).

4.10.2 Identification of contradiction in information released against Nyiragongo volcanic eruption 2021

When interviewees were asked if they found any contradiction in communications released about the Nyiragongo eruption, a majority 77% (3841) of the respondents acknowledged that they identified contradictions in data communicated to the public. A small proportion of 21% (1045) of the respondents stated that they did not find any paradox in information linked to the Nyiragongo eruption. Then, only 2% (114) of the respondents stated that they did not know if there was a contradiction in diverse communications (Figure 38, p.161).

4.10.3 Most trusted means of communication

The flow of information during the Nyiragongo eruption from different sources divided the public opinion on the most trusted means of communication. A high proportion of 83% (4172) of the interviewees trusted data released by private media, and a small proportion of 17% (828) of the interviewees had more faith in data communicated by public media (Figure 39, p.161).

For more details about the most trusted means of communication, the findings of this study revealed that an average proportion of 35% (1774) of the interviewees believed in information communicated by social media. A small proportion 18% (911) of the interviewees were more confident in texting or phone calls from their networks, 16% (786) of the interviewees trusted messages released on the radio, and 12% (619) of the interviewees had faith in communications that were transmitted on TV. A minor proportion of 7% (373) of the interviewees believed in posting in public spaces, and 5% (240) of the interviewees had more confidence in YouTube channels. The remaining proportions were 3% (130) in websites, 3% (129) in emailing, and 1% (38) in newspapers (Table 4).

Means of Communication	Numbers	Percentages
Radio	786	16%
TV	619	12%
YouTube Channels	240	5%
Social medias	1774	35%
Newspapers	38	1%
Web Sites	130	3%
E-mailing	129	3%
Posting in public spaces	373	7%
Texting or phone calls	911	18%

Table 4: Response to sub-question: Details on the most trusted means of communication about the volcano eruption and safety measures?

Source: Generated by author

4.10.4 Favourite language of communication

Respondents were requested to choose their favoured language of communication to receive information about the Nyiragongo eruption, then a significant proportion of 76% (3805) of the respondents reported that they preferred the Swahili language. A modest proportion 23% (1149) of the respondents opted for the French language. Only 1% (30) of respondents stated that they were more comfortable in Lingala language. The remaining 16 persons representing 0% preferred other languages (Figure 40, p.162).

4.11 Access and Accessibility

4.11.1 Existing transport routes before Nyiragongo volcanic eruption 2021

Results from the study indicated that all available means of transport were operational before the Nyiragongo eruption. About 100% (4994) of the respondents stated that roadway transports were running as usual. 97% (4851) of the respondents indicated that air transports were also serving. 93% (4637) of the respondents indicated that waterway movements were functioning, and only 1% (31) of the respondents revealed that

they did not have any information about transport means prior to the Nyiragongo eruption (Figure 41, p.162).

4.11.2 Operational transport routes during Nyiragongo volcanic eruption 2021

Results from separate questions showed that during the Nyiragongo eruption, waterway transports continued their activities through lake Kivu with 97% (4827), and roadways with 86% (4279). Merely 3% (139) of respondents revealed that the air network was operational, and just 1% (57) of respondents stated that they were not aware of transport activities throughout the Nyiragongo eruption (Figure 42).

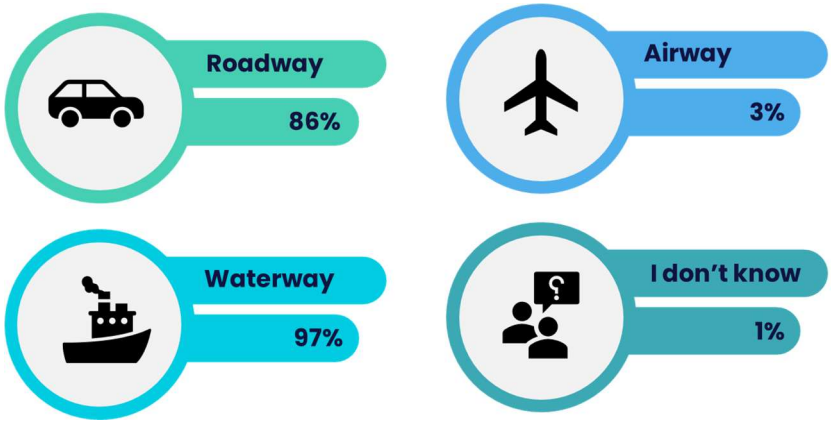

Figure 42: Response to question: What are the transportation routes that were operational during the eruption of the Nyiragongo volcano in 2021? Source: Generated by author

4.11.3 Access to affected population

Respondents were requested to state whether the affected population had access to relief assistance or not. About half of the interviewees 52% (2600) estimated that humanitarian aid reached partially affected people. Then followed by 39% (1951) of the interviewees who acknowledged that emergency services were accessible to impacted

individuals. Only 7% (361) of the interviewees considered that there was no possibility to access persons of concern. The remaining 2% (88) of the interviewees stated that they did not know whether there was access to the affected population or not (Figure 43).

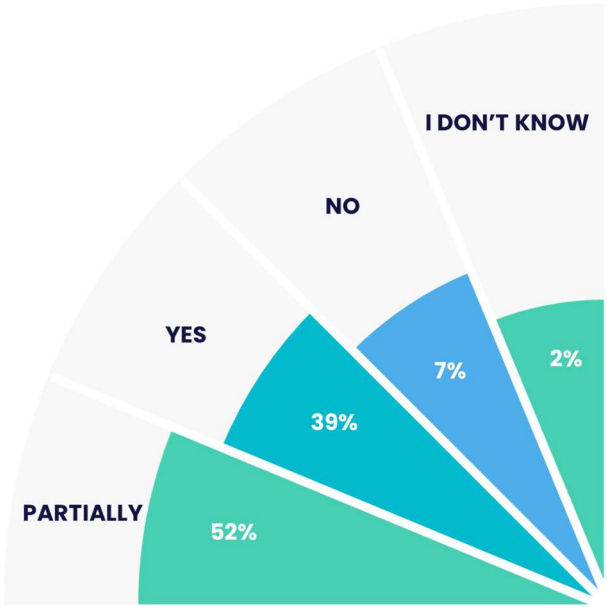

Figure 43: Response to question: Have the emergency services or humanitarian aid been able to access the affected population?

Source: Generated by author

4.11.4 Operational transport routes after Nyiragongo volcanic eruption 2021

To examine the available means of transport after the Nyiragongo eruption, interviewees were asked in separate questions about operational transport routes following the eruption. Based on the findings 95% (4735) of the interviewees stated that airway routes were operational. The roadways were used according to 87% (4347) of the interviewees. Regarding waterway routes related to lake Kivu, 85% (4230) of the interviewees stated that

they were functioning. Only 1% (59) of interviewees stated that they were not aware of operational transport routes after the eruption (Figure 44, p.163).

4.12 Community Engagement and National Response

4.12.1 Community support following Nyiragongo volcanic eruption 2021

A high proportion of 72% (3609) of respondents revealed that they did not receive any support from the community following the Nyiragongo eruption. A small proportion of 25% (1259) of respondents recognised that they received help and guidance from their community members and residents. A minor proportion of 3% (132) of respondents reported that they did not know if they obtained any kind of assistance from the community. (Figure 45).

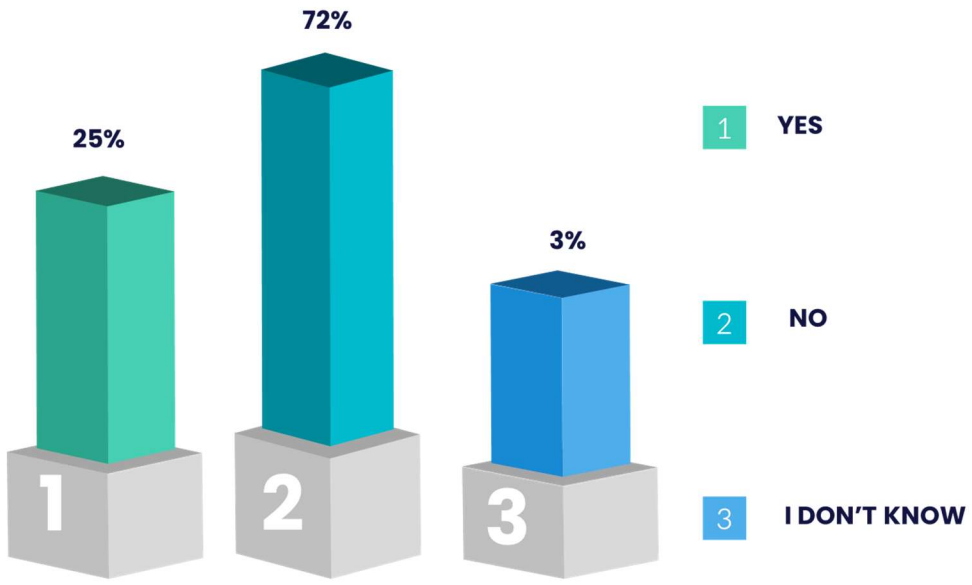

Figure 45: Response to question: Have you received any support from the community following the volcanic eruption?

Source: Generated by author

4.12.2 Volunteering following Nyiragongo volcanic eruption 2021

To assess the commitment of the population to volunteerism after the Nyiragongo eruption, interviewees were asked if they were involved in volunteer-based actions. The results from the study indicated that volunteerism acts were held by 35% (1768) of respondents. On the other hand, an important proportion of 65% (3232) of respondents stated that they did not volunteer (Figure 46, p.163).

4.12.3 Assistance from state services

This study revealed that state services and facilities were almost equally presented, to help affected populations at times of the Nyiragongo crisis. 31% (1553) of interviewees reported that they received support from the police, 24% (1209) from civil protection, 24% (1195) from the gendarmerie, and 20% (1007) from health services. The remaining 1% (36) of interviewees reported that they did not receive any assistance from state services (Figure 47, p.164).

4.12.4 Leadership of Nyiragongo volcano crisis management 2021

The findings of the study revealed that a significant proportion 51% (2571) of respondents, did not know who was responsible for leading Nyiragongo volcano crisis management in 2021. A modest proportion of 25% (1234) of the respondents believed that the governor of Goma was leading the crisis response, followed by 11% (530) who stated that the president was the leader. A small proportion 7% (359) of the respondents stated that the prime minister took the responsibility of leading the response strategy, and 6% (289) of the respondents stated that the Goma volcano observatory was leading the response against the Nyiragongo eruption. Only 17 persons representing 0% believed that The Agency for the Prevention and Management of Natural Disasters was the leader throughout the Nyiragongo crisis (Figure 48).

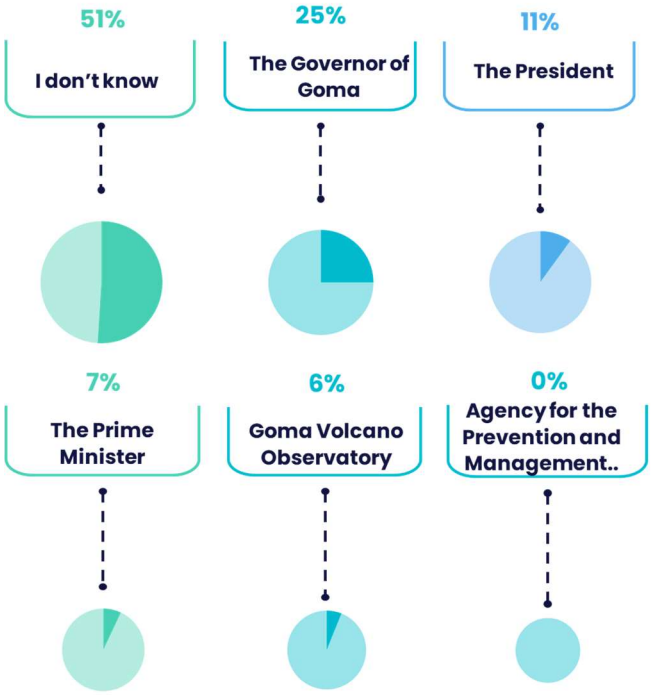

Figure 48: Response to question: Who was taking the lead in the crisis management of the Nyiragongo volcano eruption 2021?

Source: Generated by author

4.13 International Support

4.13.1 Support of different countries

The findings indicated that many countries were also concerned by the impact of the Nyiragongo eruption in DRC. It indicated that an average of 43% (2129) of the respondents received support from foreign countries, mainly from Rwanda, Europe, and the USA. Slightly more than half 56% (2801) of the respondents indicated that they did not receive any kind of support from foreign countries. Only 1% (70) of the respondents indicated that they did not know whether they received or not external support from abroad (Figure 49, p.164).

4.13.2 Support of International Organizations in DRC

The results revealed that some international organizations already operating in DRC were supporting the government's response against Nyiragongo eruption. A majority of 68% (3412) of the respondents stated that they did not receive support from international organizations. An average of 20% (994) of the respondents acknowledge that they were assisted by international organizations. Merely 12% (594) of the respondents stated that they did not know if they received support from international organizations operating in DRC or not (Figure 50, p.165).

4.13.3 Support of Congolese diaspora

A considerable disparity was found regarding the support of the Congolese diaspora. A huge majority 99% (4968) of the respondents indicated that they did not receive any kind of support from the Congolese community living abroad. Only 1% (32) of the respondents indicated that they received support from the Congolese diaspora (Figure 51, p.165).

4.13.4 Perception of international mobilization

Respondents were requested to provide their opinion on international mobilization. Results from the study indicated that international mobilization was perceived by 42% (2100) of respondents as Average, followed by 29% (1455) as Poor. Whilst 13% (634) of respondents perceived it as Inexistent, and 16% (811) stated that they did not have any idea about international mobilization (Figure 52).

Figure 52: Response to question: What do you think of the international mobilization?

Source: Generated by author

CHAPTER V:

DISCUSSION

This chapter will discuss the research findings of the study. It will offer in the beginning an introduction to the discussion of results. Then it will be followed by eight sections, whereby each section will develop a discussion based on the following major findings: 1) leadership, political context, and security; 2) communication; 3) contingency planning, preparedness, and early warning system; 4) emergency assistance and community engagement; 5) health situation and COVID-19; 6) socio-economic realities and livelihoods; 7) Nyiragongo volcano environment, activity, access, and accessibility; 8) international support. The last section will outline the limitations of the research.

5.1 Introduction to Discussion of Results

Exploring Nyiragongo volcano crisis management 2021, was a fascinating concept in a complex context. Many approaches and plans were designed by authorities to protect the populations and their belongings against potential volcanic eruptions. However, the implementation of different strategies was confronted with various aspects that have impacted the management and the response to such a crisis. To identify these aspects, a survey was carried out to 5000 individuals from people of Goma town and people involved in the response.

The data provided by participants in this study has demonstrated that Nyiragongo volcanic crisis management was determined by various factors. While some strategies were already defined in case of a volcanic eruption in DRC, they did not take into consideration the evolution of different systems in place and field-based conditions of inhabitants and infrastructures. The data demonstrated also, the capacity of populations and leaders to adapt to new situations despite limited means.

Based on the findings from this study, the aspects that have shaped the crisis management of Nyiragongo volcano eruptions 2021, are outlined below with a summary of discussions as well as a comparison of findings against the literature review.

5.1.1 Discussion on leadership, political context, and security

This study has shown that 51% of participants in the survey don't know who is leading the response to Nyiragongo volcano eruption of 22nd May 2021. Meanwhile, the majority (99%) are aware of the state of siege that aims to end conflicts in the region. According to United Nations High Commissioner for Human Rights (2021), the President of the Republic declared a state of siege in the provinces of North Kivu and Ituri on 30 April 2021. For an initial period of 30 days starting on 6 May 2021, civilian authorities were replaced by military personnel in those two provinces. As stated by Act Alliance (2021), due to lack of funding, the Goma Volcano Observatory which is known in French as "L'Observatoire Volcanologique de Goma (OVG)" was not operational at the time of the Nyiragongo volcanic eruption 2021. Then right after the volcanic eruption 2021, the OVG founded financial and technical support to coordinate the crisis response. According to OCHA (2021), the DRC government is leading the response. Conducted by the Minister of Defence, a delegation of eight ministers travelled to Goma to lead the humanitarian response. The UN News reported that five days after the eruption, the Governor of North Kivu ordered people in ten districts of Goma – a city of some 670,000 inhabitants – to evacuate as a precautionary measure, at risk by further volcanic eruptions of Mount Nyiragongo (UN News, 2021a). The president of the Democratic Republic of Congo has announced on 13th June 2021, the establishment of "Agency for Natural Disaster Management and Prevention" following the volcanic eruption (Forku, 2021). The

complexity of this official arrangements implied some unclear areas of responsibility and a fragmentation of authority.

Regarding the safety of people and their property over volcanic eruptions in DRC, Ramazani (2021, pp.5-6), has emphasized that the protection of the population and property remains a critical preoccupation to be dealt with before, during and after the eruption of the volcano. As such, this research revealed that 19% of respondents said that they were victims of theft and 85% felt insecure during and after the volcano eruption. At the end of May 2021, the UN reported that "At least 55 people were killed, and many others wounded, in the overnight assaults […] which targeted camps hosting internally displaced people near the towns of […] Tchabi, North Kivu province. They were carried out by suspected members of the Allied Democratic Forces (ADF) armed group" (UN News, 2021b). As reported by MONUSCO's radio called "Radio Okapi" on 7th July 2021, the province of North Kivu has at least 40 local armed groups distributed in all six territories of this province. Moreover, some of these armed groups occupy large regions, even two to three territories, where they exert a great disturbance on the population. The Congolese government has been clear that the state of siege will be maintained until the insecurity in the eastern provinces is adequately addressed (Security Council Report, 2021). The overall security situation in North Kivu deteriorated amid increased armed group activity, fuelling demonstrations by citizens' movements and pressure groups against the local authorities, humanitarian actors and the United Nations for the perceived inadequacy of their response. These developments hindered protection activities and heightened intercommunal tensions (Asylum Research Centre, 2021, pp.78-158).

5.1.2 Discussion on communication

As stated in the literature review by Salazar (2021), increased volcanic activity earlier this year suggested an eruption was possible, but the Goma Volcano Observatory's (OVG) functions were hampered by funding cuts. Hence, the eruption was not predicted by OVG. As a result, the population has learned about the volcanic eruption from diverse sources or personnel deduction. This research revealed that 42% of respondents were alerted about volcanic eruption when they saw the lava flow, 30% were informed through social media, 24% noticed the eruption when they saw the sky turning red, and 4% from other sources. Then, 77% of respondents identified that there is a contradiction in information released from different channels, and 76% prefer to follow the news in the Swahili language which is mostly used in Goma. This situation increased the sense of mistrust in public media and 81% of respondents asserted that they have confidence in private media and only 19% confirmed that they still believe in public media. In addition, 35% of respondents said that they trust information coming from social media, 16% from Radio, 12% from TV, 18% from messages and calls received by phone, and 19% from other media forms.

In the absence of any official communication about the ongoing disaster, Mboni (2021) reported that civil society activists turned into expert journalists, overturning the social networks' "truths" about the event. Facts emerged from rumours:

- The volcanic eruption was unfortunately real;
- It was the Nyiragongo volcano and not the less dangerous Nyamulagira;
- The lava flow springing from one of the fractures on the northeast flank was relatively "slow";

- The first flow was heading toward the city of Kibumba in Congo and toward Rwanda;
- The power line of the Matebe power plant was cut, plunging a large part of Goma, Congo, into darkness;
- Reconnaissance helicopter overflights organized by MONUSCO (United Nations Organization Stabilization Mission in the DR Congo) were monitoring the direction of the lava flow.

The warning for a potential second eruption, rumours, and misinformation about the evacuation mechanism that was put in place, have pushed the population to flee in various directions to save their lives. Subsequently, a large traffic jams have been observed on the main exit roads, creating situation of chaos. Afterward, Mr. Patrick Muyaya (Government spokesperson) declared that 9 persons were dead in this traffic as reported by the Congolese online news platform Actualite.cd.

5.1.3 Discussion on contingency planning, preparedness, and early warning system

The contingency planning for a potential volcanic eruption in North Kivu Province, was already developed by the Government of DRC which is officially called "Plan National de Contingence en Prévision des Eventuelles Eruptions Volcaniques en République Démocratique du Congo: Cas spécifique de la Province du Nord-Kivu. Préparation et réponses aux urgences (2018-2022). " (Ministry of Interior and Security of DRC, 2018). Right after the Nyiragongo volcano eruption 2021; the Government activated its contingency planning. However, the Government was faced by many challenges that were not taken in consideration during the elaboration of this planning such as: COVID-19 pandemic, conflicts, and state of siege. Furthermore, the existing resources and funds were

very limited to managing and additional crisis. Therefore, ad hoc resolutions were adopted to adjust the planning with realistic parameters.

This research has shown that 99% of respondents did not receive timely alerts on the Nyiragongo eruption for better preparedness. Moreover, 67% believe that Nyiragongo volcano was not monitored by OVG or any other institution, and 33% don't know if it was monitored or not. According to Ramazani (2021, pp.5-6), the Scientific Director of the Observatoire Volcanologique de Goma (OVG) revealed that his agency in charge of alerting and monitoring volcanic activity had stopped monitoring Nyiragongo for the past seven months, from October 2020 until April 2021, due to lack of financial resources and surveillance equipment. Meanwhile, Dujarric (2021) reported that the United Nations Organization Stabilization Mission in the Democratic Republic of the Congo (MONUSCO) has also mobilized its air assets to monitor the situation and is working with the authorities to ensure that the population is kept informed of all related developments. According to the Global Volcanic Hazards and Risk report, only 35% of permanent observatories have adequate technical and scientific capacity to monitor volcanoes (Sucasas and Yanes, 2021)

After receiving funds and technical expertise, OVG has exceptionally improved and ensured regular surveillance and data on the progress of Nyiragongo eruption. Although most participants in the survey are living around the volcano area, this research revealed that 100% of respondents did not receive any training on actions to undertake in case of a volcanic eruption.

5.1.4 Discussion on relief assistance and community engagement

The participants in the survey have expressed their frustration against the relief assistance so far provided. Their answers indicated that 53% of respondents have had

shelter, 71% have received food, 62% have had safe drinking water, 47% have had hygienic kits, 64% have had access to health services, and 29% have had psychological support. Meanwhile, 15% revealed that they did not receive any assistance. On the other hand, the population of Goma has shown its solidarity in such circumstances, whereby 26% of respondents said that they have received support from their community, and 35% said that they have volunteered during this specific emergency context. However, these outcomes have shown that despite efforts made to provide basic services to persons directly affected by the Nyiragongo volcano eruption, the assistance was in fact very limited and did not meet the needs of population. In these conditions, the Government of DRC has requested support from the international community in the response to this crisis.

UNHCR reported on its official website on 1st June 2021 that an estimated 450,000 people have fled Goma - around 120,000 of those have arrived in the neighbouring town of Sake in the eastern province of North Kivu. Around 8,000 also crossed the border into Rwanda, though the majority have since returned. Most of the displaced are currently being sheltered by host families, while others are staying in overcrowded churches and schools. As mentioned in the literature review, WFP aimed to reach a total of 40,000 people (WFP, 2021a). Due to increasing needs by 9 June 2022, WFP had provided emergency food assistance to over 146,000 displaced people who had fled Goma (WFP, 2021b).

The results of this study have demonstrated that 44% of respondents are using natural sources (Lake Kivu) that enable them to drink water, 43% are using drinking water taps, 9% are collecting potable water from water tanks and 4% are buying mineral water. According to UNICEF, as of 7th June 2021, the eruption melted mains water pipes and damaged a huge 5,000m³ reservoir. In the past, cholera epidemics have started when residents of Goma collected dirty contaminated water from Lake Kivu to drink or wash

pans. Therefore, UNICEF has provided water trucking, and has installed 15 emergency station chlorination points close to the lake. A task force coordinated by Regideso (Régie de Distribution d'Eau, which is the state-owned water company) and consisting of CICR, Mercy Corps and UNICEF are supporting Virunga Energy to install 1,500 meters of pipe on top of the lava to replace pipework that melted (UNICEF, 2021b).

The Prime Minister Jean-Michel Sama Lunkonde told a news conference in Goma on Monday 7th June 2021 that today, we decided on the progressive return of displaced people in line with a plan which will be issued by the military governor, and that the government would provide buses and trucks beginning on Tuesday to help people return (Aljazeera, 2021). As of 23rd August 2021, and according to the Camp Coordination and Camp Management (CCCM) working group and INTERSOS, 7,891 persons are still displaced in Masisi, and Rutshuru Territories, most of them accommodated in host families who have extremely limited resources. In Nyiragongo Territory, 31,904 displaced individuals are still staying in five spontaneous sites (Bujari, Mujoga, Kanyaruchinya, Kayembe and Kanyanja) according to local authorities. As stated by OCHA (2021), humanitarian actors have provided assistance areas of displacement, but this remains largely insufficient in view of the needs in WASH, shelter and food security in particular

5.1.5 Discussion on the health situation and COVID-19

According to research participants, the common diseases in Goma town are respectively: malaria 42%, fever 25%, malnutrition 17%, Ebola Virus Disease (EVD) 5%, diabetes 3%, measles 3%, blood pressure 1%, psychological illness 1%, motor illness (handicap) 1%. These diseases are widely known by the community, because the population of DRC and more specifically of North Kivu province is frequently exposed to several epidemics as listed in Appendix C. The health care in DRC as highlighted by Bersch

(2021) exists in a pyramid structure. The DRC government, aided by several NGOs, funds and controls the public health care system in a four-level model. The first level of health care in the DRC is community health centers. These are open for basic treatment and utilizes nurses for care. The next level contains centers where general physicians practice. The third level pertains to regional hospitals, where citizens can receive more specialized treatment. The fourth and highest level is university hospitals. The context of recurrent epidemics, high levels of acute food insecurity (IPC Phase 3 or above), in addition to diseases from unknown origin i.e., Cerebrospinal disease, has weakened the health system despite all efforts put in place.

Regarding the COVID-19 pandemic in DRC, the first confirmed COVID-19 case was registered in DRC on 14 March 2020 and as of 22 May 2021, there have been 30 974 confirmed cases of COVID-19 (Reliefweb, 2021). On 22 December 2022, there have been 94 969 confirmed cases of COVID-19 with 1 461deaths, and as of 23 October 2022, a total of 6 185 534 vaccine doses have been administered (WHO, 2022).84% of respondents in this study said that they are aware of prevention measures against this virus. However, 33% of respondents said that they are avoiding health care services because they are afraid to catch the disease from there. It's worth mentioning that DRC has had a distinctive experience in fighting Ebola Virus Disease (EVD) and other outbreaks in last 10 years. This experience has led the government to develop and implement appropriate interventions against COVID-19 in a short period. In 2017, following the 2014–16 Ebola outbreak in West Africa, the African Union launched the Africa Centres for Disease Control and Prevention (Africa CDC) to help prepare the continent for epidemics and pandemics (Happi and Nkengasong, 2022). According to UNDRR (2022) video published on LinkedIn, Ebola prepared Africa for the COVID-19 outbreak because: 1) stocks of

medical equipment were available; 2) there was a strong awareness of infectious disease; 3) many countries had public health measures in place; 4) countries recognised importance of community engagement; 5) a network of trained contact tracers was already in place.

Based on the results found in this study, the type of medical treatment that respondents would prefer to use during the Nyiragongo volcano eruption are the following: private health services 44%, self-medication 27%, public health services 17%, traditional family method 7% and traditional healer 5%. Following the eruption of the volcano, Mount Nyiragongo, also destroyed were three health facilities, causing health system disruptions affecting access to critical sexual and reproductive health services, including critical maternal health services (UNFPA, 2021). Ten people were poisoned by lava gas in Kibati, and occupancy rates in open health centres have increased from 65% before the eruption to 100%. There has also been an increase in patients needing gynaecological and obstetric services (ACAPS, 2021). It has also been reported that 38 health centers (including ten in Goma Health Zone, 19 in Karisimbi Health Zone and nine in Nyiragongo Health Zone) have been affected by the volcanic eruption (UNICEF, 2021a)

Due to this new emergency “Cluster Santé” which refers to the health cluster in DRC, has aligned its strategy to foresee an immediate response targeting 5 concentration areas: Saké, Rutshuru, Minova, Bukavu, and Goma based on 2 priorities: i) immediate response to the needs of the displaced persons with possibility of their return to areas of origin starting from June 2021; ii) Continuation of the response to humanitarian needs in Goma. In this perspective, the health cluster has prioritized the following 5 sectorial axes: Axis 1: Offer quality primary and secondary health care services to vulnerable displaced persons and victims of the disaster.

Axis 2: Provision of quality sexual and reproductive health care services to displaced persons and disaster-stricken pregnant and breastfeeding women, including care adapted to young people and adolescents, as well as clinical care for survivors of sexual violence.

Axis 3: Offer mental health care and psychosocial support (primary and secondary prevention) to people affected by the crisis.

Axis 4: Prevention and fight against epidemics (Cholera, Covid-19, measles, malaria, diarrhoea, typhoid fever, and Ebola virus disease by strengthening surveillance, early detection, isolation of cases and their management

Axis 5: Coordination, partnership, and complementarity: harmonization of coordination bodies of different axes, mapping of partners to avoid duplication, waste of resources, and lack of response where the gaps were identified.

According to a recent study published on 5 June 2020, on the effects of continuous exposure to sulphur dioxide among people living in Goma. The data covered a 10-year period and was collected from health centres around the Nyiragongo and Nyamuragira volcanoes. We found clear evidence between the increased incidence of acute respiratory symptoms following eruptions, particularly in areas near volcanoes (26km) up to six months following the eruption. This shows that ongoing exposure to harmful gas and particles in the air could continue to affect residents, months after the event (Michellier et al, 2020).

5.1.6 Discussion on socio-economic realities and livelihoods

This research revealed that before the Nyiragongo volcano eruption of 2021, some business activities from very basic to a high level, have created an economic dynamic in the region. When the participants to the survey were asked if there was any commercial activity around Nyiragongo volcano, 96% said yes about activities in the natural park, 73%

said yes for street vendors, 72% said yes for agriculture, 53% said yes for restaurants, 37% said yes for handicrafts,32% said yes for different activities in hotels, and 32% said yes for stores. Regarding mining exploitations, 90% of respondents said that there are no mining activities around Nyiragongo and 10% said that they don't know.

As pointed out by Monica Mellon (2021), prior to the 2021 volcanic eruption in the DRC, the nation was already struggling with a humanitarian crisis, following years of political violence and conflict. At the beginning of 2021, the United Nations predicted that 19.6 million people in the DRC were in need of humanitarian assistance. With more than five million displaced persons and the highest recorded levels of food insecurity before the eruption even took place, the humanitarian crisis in the DRC has only grown. In 2020 DR Congo experienced its first recession in 18 years because of COVID-19 and GDP (Gross Domestic Product) contracted by 1.7%. The COVID-19-containment restrictions have had a significant impact on livelihoods and income-generating opportunities. In 2018, approximately three-quarters of Congolese lived in poverty (less than $1.90 a day). Hence DR Congo has the third-largest population of poor worldwide. COVID-19 has likely exacerbated this situation (Danish Refugee Council, 2021).

Due to COVID-19 pandemic, in March [2020], the Congolese Government declared a state of emergency and closed all land and air borders, excluding food cargo, and enforced a nationwide curfew. In a country where approximately 70 percent of the population is employed in the informal sector, confinement measures constrained households' livelihoods and revenues, while driving food prices up and eroding household purchasing power (Asylum Research Centre, 2021, pp.78-158). In a televised address late on Tuesday (20 July 2021), President Felix Tshisekedi announced an end to the Covid-19 health emergency enforced since 24 March. Tshisekedi said that, from Wednesday 22 July,

all shops, banks, restaurants, cafes, firms and bars would be allowed to reopen. Public transport can resume, and large gatherings will be permitted. Schools and universities can now reopen on 3 August. Airports, ports, borders, and places of worship will follow on 15 August. Night clubs, stadiums and entertainment venues will also resume business as from 15 August. People in DRC will then be able to move freely across provincial borders. The president said that the recession brought by the Covid-19 pandemic has worsened the economic crisis in DRC (RFI, 2020)

In the aftermath of May's 2021 Nyiragongo eruption, the hot and viscous lava destroys everything in its path including building, roads, agriculture, and vegetation (Burke, 2021). Moreover, the land that has been buried by lava can no longer be used, thus it loses its value for sale. Those pyroclastic materials can change the landscape of the area after cooling creating new slopes and structures on Earth's surface (U.S. Geological Survey, 2021). Since over 300,000 people have lost their homes, lands and business, the town is calling for aids since many can't afford to rebuild what was distorted (Lonsdorf, 2021). The economic impact of volcanism is usually poorly documented and consequently under-estimated (Goujon, El Hadri and Paris, 2021, p.7). The economic impact of the Nyiragongo volcano eruption 2021 was devastating for Goma town. This study has shown that 32% of respondents have lost their jobs, 65% have kept the same salary scale, 2% have difficulties reaching their work, and 1% have had a new job position. It has been reported that prices have risen in the markets around Goma as recovery begins. The road between Goma and Rutshuru, which is one of the three main trade routes and facilitates the delivery of humanitarian aid to other locations, was blocked for six days while the lava was too hot to be removed. Thankfully, the lava has stopped flowing and rebuilding efforts have begun. However, Government officials have estimated costs of up to $20 million to rebuild the

city (Byrne, 2021). With the lack of development plans to tackle economic effects in case of a volcanic eruption, the Government of DRC found challenges to meeting emerging livelihood needs due to the Nyiragongo volcano eruption 2021. Addressing urgent emergency requirements whilst taking into account longer-term needs is widely recognised as a difficult. There is potentially a sharp trade-off between making a timely response to emergency requirements and durability or reusability. Costs also escalate (Clay et al, 1999, pp.62-63).

5.1.7 Discussion on Nyiragongo volcano environment, activity, access & accessibility

This study has demonstrated that the population of Goma is strongly connected to the Nyiragongo environment from different perspectives. 52% of respondents perceive the Nyiragongo environment as a source of income, 28% perceive it as a family heritage, 12% perceive it as a good place where to live, 5% perceive it as a dangerous place due to volcano eruptions' hazards, and 3% consider it as an exploitation of natural resources. According to Balagizi et al (2019), Nyiragongo and Nyamuragira, only ~ 14 km apart, are the Africa's most active volcanoes. The two volcanoes are located in the Virunga volcanic field, western branch of the East African Rift System, in the eastern Democratic Republic of the Congo. As stated by the GEO Geohazard Supersites and Natural Laboratory Initiative (GSNL) (2017), on the border of Democratic Republic of the Congo (RDC), Uganda and Rwanda; the Virunga is characterized with very fertile mountainous lands under a tropical climate were live millions of people grouped in cities and villages and is additionally home for several unique wild animals such as the famous mountain gorillas.

In terms of Nyiragongo volcano's activity, it is clear that respondents are aware of previous volcanic eruptions that occurred in 1977, 2002, and 2021. Based on the research's results, 86% of respondents do know that Nyiragongo is an active volcano, and only 14%

don’t know about its activity. Moreover, 92% of respondents have witnessed the latest Nyiragongo eruption of May 2021. As mentioned by Burgi et al (2014), mount Nyiragongo’s steep-walled, 1200m wide summit crater has contained a semipermanent but highly fluctuating lava lake that has experienced several overflows and major eruptions The European Space Agency (ESA) (2014) stated that, the extremely fluid 1977 lava flows caused many fatalities, as did lava flows that inundated portions of the major city of Goma in January 2002. Nyiragongo’s 1977 caused the death of 70 to 100 people, whereas in 2002 Nyiragongo’s lava flows destroyed the houses of ~120,000 people (10 to 15% of Goma city), forced a mass self-evacuation of ~300,000 people of Goma (corresponding to ~75 % of inhabitants) and killed ~140 people (The GEO Geohazard Supersites and Natural Laboratory initiative (GSNL), 2017, p.1). The last eruption of Nyiragongo, with lava flowing through cracks in the volcano's flanks, killed 32 people and destroyed several hundred homes on May 22 (2021). Less than four months later, lava had reappeared in the crater, which, for the scientific director of the OVG, was rather good news, as the volcano had found "a way to breathe" (Africanews, 2021b).

Before the Nyiragongo volcano eruption 2021, the existing transportation routes were very active as stated by most of the participants in this study. According to respondents, 100% of roadways were used, 97% of airways were used, and 93% of the waterway was used. In the case of Nyiragongo territory, the area is accessible through different types of transportation and entry points as pointed out below by Peyton, Gercama, and Bedfor (2019):

- Domestic overland routes – Overland traffic arrives in Goma daily from the Route Nationale 4, which runs through Nyiragongo, Rutshuru and Lubero territories.

- Lake Kivu traffic – Goma is a port city that is linked to destinations on Idjwi Island and Bukavu, a city with an estimated population of over one million people that is the capital of South Kivu province.
- Air Travel – Goma has an international airport with direct flights throughout East Africa that connect to Europe, the Middle East, and beyond. There are also domestic flights to large urban centres including Kinshasa, Kisangani, Lubumbashi, and others.
- Border Crossings – Goma shares a border with the Rwandan city of Gisenyi, and thousands of people cross each day. The Grande Barrière and Petite Barrière are critical Points of entry.

In the event of volcanic eruption, the logistic arrangements are very critical for an effective response, and particularly for evacuations and aid distributions. As expressed by Van Wassenhove (2006) "Logistic is the most important element in any disaster relief effort, and it is the one that makes the difference between a successful and a failed operation. Yet, the logistic operation becomes the most expensive part of any disaster relief. Logistics accounts for about 80% of the total costs in disaster relief.''

During the Nyiragongo volcano eruption 2021, the respondents revealed that 97% of the waterway was operational, 86% of roadways were operational, and only 3% of airways were operational. Regarding the accessibility to the population affected by the Nyiragongo volcano eruption 2021, this study has shown that emergency services and/or humanitarian aid found difficulties to reach victims of volcanic eruption 2021. 52%of respondents believe that assistance has partially reached the affected population, 39% of respondents believe that assistance has fully reached the affected population, 7% believe

that assistance has not reached the affected population, and 2% don't know if assistance has reached the affected population or not.

The sudden eruption of Mount Nyiragongo on 22nd May 2021 led to two lava flows towards Kibumba park as well as Buhene and Kibati in the North-East of Goma, DRC (Act Alliance, 2021). As of 26 May 2021, 1,400 meters of roads were potentially affected by the lava. The road between Goma and Rutshuru, which is the main route for food and humanitarian assistance into Goma, is blocked by lava. Alternative routes through Uganda and Rwanda are possible but complicated by COVID-19 restrictions. The roads leading to northern parts of North Kivu are damaged, preventing the delivery of goods in Beni territory, where 280,000 people have been displaced since January 2021 as a result of conflict and insecurity. Congolese construction company Société Congolaise de Construction has started works on 25 May to reopen the road. Goma and Bukavu airports are closed, with repercussions on the delivery of humanitarian assistance by air (ACAPS, 2021). Exemption granted to humanitarian helicopter flights for Goma and Bukavu (Nyembue, 2021). In early June 2021, the prime minister of the DRC spearheaded the phased return of thousands of people as seismic activity reduced considerably. The government provided buses to help people return to Goma. The government also declared the airport safe for landing, which further facilitated the delivery of international humanitarian aid (Odhiambo, 2021).

5.1.8 Discussion on international support

After one of Africa's most dangerous volcanoes – Mount Nyiragongo – sent fast-moving lava towards Goma, the largest city in eastern Democratic Republic of Congo in May (2021), international aid groups rushed supplies to half a million people who had been displaced. But nearly four months on, an estimated 30,000 people remain in makeshift

camps, with some pointing to what they see as long delays in receiving aid in a tightly controlled, government-led relief effort (Kleinfeld, 2021). If no humanitarian assistance is provided, host communities in these areas will face difficulties for the next harvest (January, February 2022) and will be forced to further deplete their productive assets. The volcanic eruption is worsening an already critical humanitarian crisis in the Democratic Republic of the Congo (FAO, 2021).

According to this study, 42% of respondents considered international support as average, 29% considered it as poor,16% said that they don't know, and 13% considered it as non-existent. In addition, 56% of respondents have indicated that they did not receive any international support, 43% confirmed that they have received international support, and 1% said that they don't know. Regarding the respondents who confirmed that they have received international assistance, they believe it was coming from Rwanda, European Union, and the USA. In terms of international organizations already operating in DRC, 68% of respondents revealed that they did not receive any support from them, 20% confirmed that they have received assistance from these international organizations, and 12% said that they don't know. The Humanitarian Coordinator (HC) assured Congolese authorities of the humanitarian community's support to respond to emergency priority needs following the eruption of the Nyiragongo volcano. Priority needs are being assessed by multiple Humanitarian Country Teams (HCT), including the Red Cross and INGOs (OCHA, 2021). However, a substantial gap in financing the relief efforts remains, as the UN estimates the total financial requirement at $15.6 million (Security Council Report, 2021).

After Tshisekedi's (President of DRC) visit to Goma, the government pledged to provide 1,000 temporary shelters, to be constructed by the military at a camp called

Kanyarucinya. The International Federation of the Red Cross agreed to contribute 500 additional structures at another site, Kibati (Kleinfeld, 2021). According to the Division des Affaires Humanitaires (DIVAH), 3,276 people are living in spontaneous sites and almost 1500 households in the formal sites of Kanyaruchinya and Kibati. The site of Bujari is still under construction, with a planned capacity of 130 households. Military and police around the camps control movements in the vicinity to avoid intruders and security issues.

After benefitting from rental assistance between December (2021) and January (2022), a total of 2,092 displaced families moved on from the spontaneous sites of Mujioga, Kanyania and the Kahembe, which are Primary Schools being used by the local populations as makeshift shelter, to more sustainable housing (UNHCR, 2022).

Under this emergency context, many countries have expressed their sympathy to families affected by this disaster and ensured their support to DRC Government in facing this new crisis. The Rwandan authorities have opened their borders to receive thousands of people fleeing the volcanic eruption of Nyiragongo 2021. Vincent Karega, the Rwandan ambassador to DRC who is stationed in Kinshasa, confirmed that his country had welcomed those fleeing the volcanic eruption. "The Rwandan borders are open and the reception of our neighbours is taking place peacefully. There was no blockage whatsoever but rather the organisation of coordinated entries," he said. The United States serves as the largest donor to the DRC, providing more than $130 million worth of humanitarian assistance in 2021 alone. The U.S. commitment of $100,000 for water security initiatives in the DRC (Mellon, 2021); and the European Commission has allocated emergency humanitarian funding of €2 million for those affected by the eruption of Mount Nyiragongo in the North Kivu province of the Democratic Republic of the Congo (DRC) (ECHO, 2021), just to name a few.

5.2 Limitations of Research

The findings of this study have to be seen in light of some limitations as emphasized below:

- The lack of prior studies that have analysed crisis management of the Nyiragongo volcano eruption 2021; has had implications on the literature review. Most of the findings relied on studies that looked at Nyiragongo background, previous volcanic eruptions, and emergency interventions in 1977 & 2002. Evidence on the Nyiragongo eruption and response 2021, where found online through data published by official institutions.
- The study focused on exploring aspects that have shaped the crisis management of the Nyiragongo volcano eruption 2021. These aspects were selected based on national contingency planning and in-depth discussions with scientists from different institutions related to volcanic crisis management.
- The prevention measures against the COVID-19 pandemic, have limited gathering to 20 persons with respect to physical distancing and hygiene recommendations. Therefore, focus group discussions were not included in the research's instrument.

CHAPTER VI:

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

This chapter will conclude the study by summarising the key research findings and their implications to the research aims, research questions, and literature review. It will also propose recommendations for actions to governments and communities for better volcanic crisis management, as well as opportunities for future research. Then, it will provide a general conclusion of the thesis.

6.1 Summary of Main Findings and Implications

This thesis is a mixed methods case study that was designed to determine aspects that have contributed to defining the crisis management of Nyiragongo volcano eruption 2021. This has included an overview of the existing environment, mechanisms, and services around the Nyiragongo area. In addition, it has taken into consideration the analyses of preparations, organisation, and delivery of emergency aid in response to this crisis. The main findings have reflected the assets and gaps identified in the volcanic crisis management of Nyiragongo. This study aimed also to draw up recommendations that could be used in the development of appropriate interventions in such phenomena. To complete this research, data collection was conducted on 5000 people from Goma city by answering a questionnaire through one-to-one interview, emailing or phone calls. The main outcomes of this study and their implications are described below:

a) Preparedness and Early Warning System:

The Nyiragongo volcano erupted suddenly without any prior alerts from relevant institutions. The volcano was supposed to be monitored by “Observatoire Volcanologique de Goma (OVG)” which refers to Goma Volcano Observatory. However, OVG was not

operating since few months due to a lack of funding. As a result, OVG couldn't provide early warnings on the eruption. Then, the population of Goma town couldn't have access to timely information and were living in fear and dread of an uncertain future towards the overall progress of the still ongoing eruption. With total confusion, populations were attempting to run away from the eruption in different directions, which generated to complete chaos in the city, where the citizens were no longer safe.

b) Contingency Planning:

A contingency planning was previously developed in 2018 in case of the eruption of the Nyiragongo and/or Nyamulagira volcanoes, and it was covering the period from 2018 to 2022. Then it was activated right after the Nyiragongo eruption by the government of DRC. Meanwhile, this planning was not updated with accurate data, especially with regard to security issues, budget allocation & financial resources, and COVID-19. Therefore, authorities have had to improvise and adapt the planning to these new realities. OVG was progressively involved in the response after receiving adequate assistance. In addition, long-term recovery projects were not taken into consideration in the planning.

c) Communication:

Communication during May's 2021 Nyiragongo volcano eruption failed to provide timely and accurate information so that the vulnerable population can undertake appropriate actions to protect their lives and belongings. First of all, the eruption was not predicted, and people were exposed directly to the disaster. Residents of Goma town have noticed the activity of the volcano from a personal perspective through the lava flow, earthquakes, the sky turning a fiery red, and social network. Although national authorities have made considerable progress in releasing news on eruption development and evacuation mechanism, however, rumours and fake news have emerged in society, due to

initial poor communications and warnings about a potential second eruption. This situation has further increased doubts and mistrust in official messages. A general sense of fear and panic has driven people to escape and get into the jammed-up roads where the traffic was crazy, resulting in nine deaths in traffic.

d) Political Leadership and Security:

Although areas of responsibilities and accountabilities were clearly defined in the contingency planning in case of volcanic eruption, however, the government who was leading the emergency operations, had to set up ad hoc arrangements for rapid onset response. As mentioned above OVG was not operating, then found solutions to be active again. In addition, North Kivu province including Goma town was under a state of siege, and a Military Governor was assigned accordingly. The Military Governor has officially declared volcanic eruption and ordered the evacuation of some neighbourhoods at risk of a second eruption. Then, the President created "Agency for Natural Disaster Management and Prevention" to manage the issues of volcano eruption and other future disasters. These different institutional mechanisms have made the response more complex because there was unclarity in the leadership, as well as the role and responsibilities of each institution during this crisis.

e) Relief Assistance and Community Engagement:

Throughout the emergency response, the government of DRC and humanitarian aid agencies were struggling with immediate actions and finding financial resources to provide appropriate assistance for victims of the Nyiragongo eruption. Therefore, very basic services were provided to displaced persons and returnees. Besides, for more than four months after the eruption, families are still in crowded living conditions in public settings and/or temporary housing. Rebuilding the city and construction of new sites for

stakeholders are far behind schedule. Communities have shown solidarity to each other by receiving some displaced families and sharing their food despite limited resources. Water, electricity, and health services are slowly getting back to normal. These conditions have affected the wellbeing of people in need and created a large frustration among them. Moreover, it has put their life at risk of different hazards of communicable diseases, malnutrition, conflicts, mental health concerns, sex & gender-based violence, and social disorder. All these facts demonstrated that recovery and reconstruction measures were not effectively addressed. For that reason, the government encountered enormous difficulties to redeploy its efforts from emergency to restoration activities.

f) Livelihoods:

This study revealed that residents of Goma town are associated with Nyiragongo background and more especially for their daily income. The rich soil, natural park, tourism activities, farming, small business, and informal functions have made an economic dynamic in the area. Following the Nyiragongo volcano eruption, stakeholders have lost all these advantages, as the lava flow has destroyed buildings, roads, agriculture, livestock, and vegetation. This eruption occurred while the region was suffering from protracted states of poverty, conflicts, food insecurity, frequent epidemics including COVID-19, and poor public insurance scheme. All these elements have had a significant impact on livelihoods and income-generating opportunities. As a result, families relied completely on the assistance provided by the Government and humanitarian aid agencies. However, these entities were mainly focusing on emergency response and less priority was dedicated to reducing the economic impact and implementation of income-generating projects that can secure regular revenues for people affected by the Nyiragongo volcano eruption.

g) Health & COVID-19:

Goma town has endured several health chokes in the recent decades, and results have shown that malaria, is still the most common disease. Stakeholders have also raised their concerns about widespread of fever and malnutrition. Added to that, recurrent epidemics (Ebola Virus Disease, measles, and cholera) and other diseases of known or unknown origins, have reduced the efficiency of the health system. COVID-19 has been another challenge faced by health workers, as well as the population. Previous experiences in epidemics have helped the Government to implement appropriate interventions against COVID-19 in a short period. Besides, prevention measures were widely known. However, some people (33%) were avoiding health services because they were afraid of having the disease in these services. The sudden volcanic eruption destroyed three health facilities, then a health cluster was quickly put together in serving victims &vulnerable people in place and displaced persons. Thanks to coordination efforts and awareness promotions, no epidemics were officially recorded by authorities. However, as stated by Michellier et al (2020) ongoing exposure to harmful gas and particles in the air could continue to affect residents' months after the event. Sub-consequently, the fragile health care framework associated with long-term health effects, have complicated initiatives aiming to ensure access to health services in emergency and long-term context.

h) Public Guidance and Awareness Sessions:

Although surrounded by two active volcanoes (Nyiragongo and Nyamuragira), the inhabitants of Goma ignored what to do in case of a volcanic eruption. Individuals from different spheres of society like students, traders, cleaners, security guards, health care workers, farmers, humanitarian aid workers, volunteers, and actors involved in the Nyiragongo volcano response; all of them revealed in this study that they did not receive

any training on measures to apply in case of a volcanic eruption. Most staff of volcanic crisis response found themselves in the middle of this force major event without prior knowledge or preparations. Some received guidance or orders from their seniors on rescue procedures and evacuations mechanism. But the majority, were trying to save lives and make some order based on their basic skills and available means. The lack of capacities and limited knowledge has resulted in delays in the response, especially for activities that needed immediate actions. As there were delays in the response and without clear guidance, populations were in direct contact with lava, smokes, and harmful gas, which have put their lives in danger. It has also impacted the movement of population and traffic congestion.

i) Logistics (access & accessibility):

In preliminary phases of the emergency, the overall logistics coordination was considered as fragile and failed to provide timely assistance to mitigate the suffering of vulnerable people. The lava flow, tremors, breaking up of volcanic materials into ashes, smokes, gases, and flying rocks have posed a considerable challenge in logistic arrangements. According to Olouch (2021), a section of the tarmac on Road Number 4 that goes from Goma to Kisangani, was cut off by the lava and motorists are now forced to manoeuvre around the rocks and mounds of black and grey lava. As of 26 May (2021), 1,400 metres of roads were potentially affected by the lava (ACAPS, 2021). Except airflights, all transport means cars, buses, ferries, motorcycles, and even on foot, people have employed to leave Nyiragongo eruption. As the majority were using the main road to city of Saké (around 20km west of Goma), and the other road leading to border city of Gisenyiin Rwanda (around 8km east Goma). This situation has created a large volume of traffic, that has affected the evacuation process put in place by the authorities and provision of relief aid goods & services. The Minister of Transport, Communication and Access

announced on 05 June the reopening of air traffic at Goma International Airport, which had been closed since 23 May (OCHA, 2021). The reopening of air traffic accompanied by parallel measures to promote the use of alternative roads and mobilization of resources has simplified cargo movements as well as passengers. Afterward, the logistic support has made an important growth through optimizing cooperation between all actors involved in logistics and supply chain systems at national and international levels.

j) Coordination:

When the Nyiragongo volcano eruption occurred, the province of North Kivu was under a state of siege and facing armed conflicts. The province was headed by Military Governor. Following the eruption, the president of DRC with the government's delegation moved from Kinshasa to Goma to present his support to affected families, check damages on the ground and reinforce coordination with Goma's officials. Other coordination meetings have been held between the government and humanitarian coordinator, as well as the humanitarian country team (HCT) to organise together the humanitarian response. Furthermore, the Government has had regular discussions with scientists and OVG regarding the updates on current volcanic eruptions, to support policymakers with accurate data and technical expertise. However, community representatives were not fully engaged in discussions. Therefore, significant delays and gaps were noticed on the ground during the implementation of the emergency response. The effectiveness of this ordination mechanism is at times limited, due to the centralisation of decision-making at the higher levels of the state in Kinshasa.

k) Environment:

The population of Goma town has always been attached to the Nyiragongo volcano environment despite their knowledge about its activity. It has been mostly perceived as a

source of income, family heritage, and a good place of living. After Nyiragongo eruption 2021, little was known about environmental impacts of this disaster at short and long-term levels. Lava flow and volcanic particles have caused considerable damages on forest, vegetations, domestic and wild animals. IFRC (2021) reported that most of the crops and livestock are gone due to lava as well as ashes, and according to the preliminary results of FAO remote sensing study, 279 ha of agricultural land and crops were highly affected, 1,252 ha moderately affected and 727 ha slightly affected, for a total of 2,261 ha. According to Peckyno (2010), eruptions can influence bird migration, roosting, flying ability, and feeding activity; it can also affect aquatic life by an increase in acidity, increased turbidity, change in temperature, and/or change in food supply. Moreover, Balagizi et al (2019) stated that volcanic emissions impact water quality as they are the primary source of the dissolved loads in both rain and surface waters.

l) International Support:

Due to the COVID-19 world economic impact, the international community has shown a timid engagement to support DRC's government in facing Nyiragongo volcanic crisis. Nevertheless, many countries, donors, UN agencies, non-governmental organizations (NGOs), experts and volunteers have assisted DRC by different means in emergency response. As such, during volcanic eruption, thousands of people fled the eruption to neighbouring country Rwanda. Then, this country opened its borders without any restriction for this mass movement of the population and implemented temporary shelters with basic services for them. MONUSCO, UN agencies, NGO's already operating in the DRC; have immediately allocated funds & expertise to help authorities in the response. Other countries and donors have provided DRC with financial support i.e., USA and European Commission. On the other hand, except for some individual initiatives taken

by locals, there was no financial support so far reported from the Congolese private sector and/or diaspora. It's worth mentioning that the UN estimates the total financial requirement at $15.6 million to rebuild the city of Goma according to Security Council Report, (2021).

6.2 Recommendations

The findings of this research have demonstrated distinctive aspects that have driven the crisis management of the Nyiragongo volcano eruption 2021. It has showed also that responding to emergencies like volcano eruptions, is still an important challenge in DRC. In line with the above results, the following recommendations might bring some useful guidelines for the volcanic crisis management approach, and an evidence-based source for further research.

6.2.1 Recommendations for action

- Preparedness and early warning system: Ensure continuous support to OVG, by allocating a specific budget for the observatory, which will allow scientists to monitor volcanoes and provide timely & accurate data on hazards. In addition, more attention should be directed to volcano studies and risk assessments.
- Contingency planning: Provide regular updates in the contingency planning with newfound actualities like effects of COVID-19 and conflicts. Then, adapt the planning by realistic measures especially regarding the budget and resources. Furthermore, find an equitable schemes between immediate relief and development projects.
- Communication: Build a relationship of trust and information sharing amongst government's officials, scientists, and the population. This approach forms the basis for effective communication in a crisis. In addition, improve communication strategy by offering real-time information on the eruption and response mechanism.

- Political leadership and security: Clearly demonstrate the leadership strategy adopted by the Government. Moreover, issue disaster laws that define the mandate of each institution involved in volcanic crisis management. Also, consider backup measures in case these institutions are not in service. Then, make sure that stakeholders assume their roles and responsibilities as specified in contingency planning.
- Relief assistance: Implement broader frameworks to meet the urgent needs of the population and promote durable solutions in water & sanitation, health, shelter, power, logistics, and social assistance. Invest immediately in building permanent solid housing and infrastructures, along with the employment of local resources and labour.
- Livelihoods: Design short-term and long-term strategies to reduce the economic impact of a volcanic eruption. Improve social safety net programmes and facilitate adherence toward this system for vulnerable people. Prospect for attracting private investment and creation of income-generating projects for local communities with tax reductions. Take advantage of Nyiragongo volcano eruption to promote for adventure tourism in respect of safety procedures.
- Health & COVID-19: Upgrade the quantity and quality of health facilities. Ensure the timely and uninterrupted provision of first aid services and emergency supplies in affected areas and relocation sites for free. In addition to the referral system, deploy ambulances and/or helicopters with intensive care materials. Maintain regular surveillance and analysis for the potential impact of volcanic particles and gas on the population's health. Provide frequent exercises on emergency care for the health workforce. Ensure community-based awareness approach to eliminate misperception on COVID-19 transmission at health care bodies despite prevention measures.

- Public guidance and awareness sessions: Deliver regular trainings and simulation exercises to institutions involved in volcanic response. Produce learning materials and conduct public awareness and preparedness sessions; whereby we should demonstrate safety methods and how to put them into action in case of a volcanic eruption. Integrate prevention measures against volcanic eruptions into school curricula.
- Logistics (access & accessibility): Construct new supply routes to allow food, medical supplies, and other humanitarian assistance to reach vulnerable people in remote areas. Then, separate road activities during emergencies by keeping some roads exclusively for population movement; and other roads for relief provisions and rescue vehicles. These arrangements could prevent traffic jams and ensure a smoother response. In addition, improve information exchange between public and private transportation networks. Furthermore, optimize logistics performance of national institutions, and be open to including local volunteers and new devices (like drones) in the process to facilitate and maintain the flow of goods.
- Coordination: Put in place a multi-disciplinary team at the national or local level with sufficient delegated authority to coordinate and reinforce crisis management of such phenomenon. This team must include experts from different areas and communities' representatives together with NGOs and relevant institutions.
- Environment: Address the impact of the Nyiragongo volcano eruption on fauna and flora by conducting in-depth assessments of the event. Also, include animal health as well as forests and plantations safeguarding in the response strategy. Invest in reforestation and public planting campaigns to rehabilitate degraded lands.
- International support: Explore collaborative opportunities with countries affected by volcanic eruptions to set up regional and/or an international system of surveillance and

rapid response. Reinforce cooperation mechanisms with neighbouring countries & globally to facilitate movement of population and cargo and address financial needs.

- Capacity building: Strengthen societies' resilience to volcanic eruption by enhancing their abilities to face such phenomena within all sectors in water and sanitation, health, communication, and early warning system, just to name a few. Test the effectiveness and efficiency of contingency planning by providing updated operational exercises for different disasters and emergencies. These exercises should be surprising, creative, and cover unexpected events to motivate and boost stakeholders to the best of their capacities. Then based on the analysis of these exercises, make necessary corrective measures to participants and the planning as well, to be better prepared for the next emergency context.
- Post-crisis and recovery: Tailor reconstruction and recovery strategies by taking into consideration priorities raised by communities to avoid being in "crisis after crisis"; given that tensions could be increased between the population and authorities, then it might lead to public disorder. Design post-crisis planning with more systematic schemes on reconstruction that focus on housing, basic services, and economic recovery, within a known budgetary framework.
- Fundraising: Foster fundraising strategy by targeting the private sector at local, national, and international levels. Simplify and expedite the administrative procedures for private and public investments. Encourage the Congolese diaspora to contribute to rebuilding territories affected by a volcano eruption and invest in their home country. Report on the progress of activities in the field and challenges that might occur by using check lists, clear & simple templates, pictures, and small narratives if required.
- Technology investment: Invest in new technologies and use active multi-thematic data for volcano surveillance, livelihoods, communication, logistics, awareness sessions,

community engagement, and environmental studies. Apply geospatial information technologies like: Interferometric Synthetic Aperture Radar (InSAR), Geographic Information System (GIS), Aeronautical Reconnaissance Coverage Geographic Information System (ArcGIS), satellite monitoring, remote sensing, and other systems to provide fast data collection & analysis. Therefore, technological investment would be of a great help in predicting volcanic eruptions and covering landscape and biodiversity indicators. Integrate appropriate solutions for smart agriculture, food security, forestry, resilience projects, and other fields to empower local development. Initiate creative resolutions by establishing a centre for "Environment Information System" that includes volcano, flood, earthquake, landslide, and coastal inundation hazards. This centre could be open for other research and extended at both regional and international levels.

6.2.2 Recommendation for future research

This research focused on the identification of aspects that have shaped the crisis management of the Nyiragongo volcano eruption 2021, and suggested avenues of solutions for better management. Meanwhile, further studies could be conducted about each aspect separately and provide additional analysis on features that could have influenced the management of this volcanic crisis. The survey was carried out over Goma town for 5000 participants, but more studies could be conducted for a larger number. Also, case studies could be extended to other provinces of DRC and Rwanda. The latter, shares its border with DRC and was directly impacted by the Nyiragongo eruption through volcanic materials that reached some neighbouring towns as well as the reception of refugees fleeing the volcano eruption. Although this study has employed mixed methods qualitative and quantitative, researchers may choose to apply only one method. To gain the trust and engagement of participants, and due to COVID-19 restrictions, the most popular tools were

used for data collection (one two one interviews, emailing, and phone calls). Excel and Power BI were deployed for data analysis to demonstrate the results in multi-ranging formats. Nevertheless, researchers may use different tools and systems for data collection and analysis, such as focus group discussions and KoBoToolbox.

6.3 General Conclusion

As stated by Andy Gilman "The secret of crisis management is not good vs bad; it's preventing the bad from getting worse", therefore, in this case study, I have attempted to demonstrate aspects that have shaped the current crisis management of the Nyiragongo volcano eruption 2021 and provide useful recommendations for the management of future volcano emergencies. As there was no academic research that has investigated in crisis management of Nyiragongo volcano eruption of 2021, the main resources covering this event were found through technical reports and articles published by scientists, official institutions, and organizations like Paolo Papale (volcanologist), UN News, and Assessment Capacities Project (ACAPS). The methodology was based on an exploratory approach with a mixed methods case study design. The data collection was conducted to 5000 people from Goma city and people involved in the response, by answering a questionnaire through one-to-one interview, emailing, or phone calls. Then, I used Excel and Power BI to analyse results.

This research revealed that crisis management projection was developed through contingency planning for a potential volcanic eruption in DRC over 2018-2022. This projection is meant to be successful in protecting lives, properties, and supporting communities; as it has defined a strategic organisation with a precision of roles and responsibilities of every institution. But in practice, with modest financial investment and field dynamics, the response to Nyiragongo volcanic crisis 2021 has been more complex

and challenging. The populations of Goma town and surrounding areas were hit by a sudden Nyiragongo volcano eruption on 22nd May 2021, without prior alert from OVG because it was not operational at that time due to lack of funding. As OVG couldn't provide early warnings of the volcano eruption, people did not have access to timely information and a general sense of panic and confusion emerged in town. Moreover, the country was confronted to unprecedented humanitarian needs, armed conflicts, COVID-19, economic shocks, and other aspects that have had a major effect on the response to the Nyiragongo volcano eruption 2021.

Although, we cannot predict volcanoes' activities, but we can anticipate crisis management and reduce the risks of volcanoes by promoting preparedness and response actions. Based on the results mentioned above, this thesis has presented some avenues of solutions to volcanic crisis management in DRC through the following main recommendations: (1) Provide financial and technical support to OVG to develop quantitative and qualitative risk assessments & analysis that would be important information basis for decision makers.(2)Strengthen the capacity of institutions and services in all sectors involved in the response.(3) Consolidate and update evidence-based analysis from these sectors to get a rational vision against future interventions.(4) Invest in technologies that could support volcano monitoring, relief assistance and sustainable development.(5) Deliver regular training to institutions involved in volcanic response and raise public awareness on prevention measures against volcanic eruption.(6) Foster a participatory approach between scientists, communities, local services, and national authorities to better understand uncertainties and build resilience to volcanic risks.(7) Addressing particular attention to the impact of such crisis on livelihoods and the environment. (8) Tailor post-crisis planning based on a community-based approach. (9)

Develop strong fundraising plans targeting the private sector, local, national, and international investors, as well as the Congolese diaspora. (10) Design proactive strategies and initiate planning for adaptation rather than planning for scaling up.

The experience gained from the crisis management of the Nyiragongo volcano eruption 2021, showed us that positive changes can be made to emerge stronger from a crisis and be better prepared for the next volcanic eruption.

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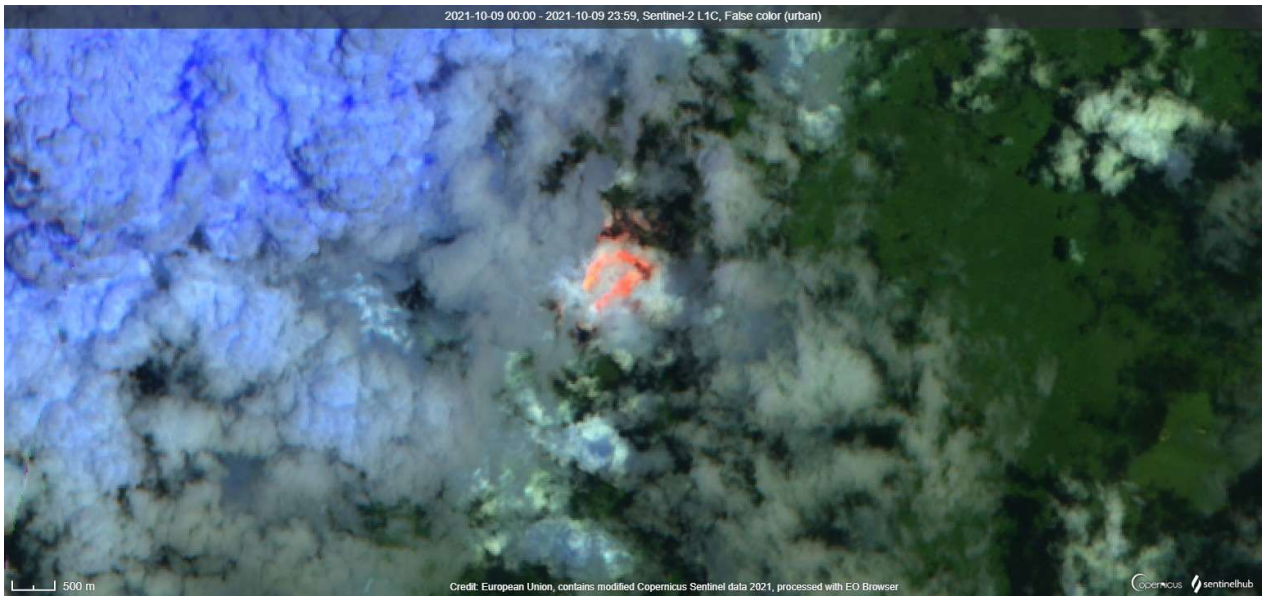
APPENDIX A

SUMMARY OF MAIN DAMAGES CAUSED BY THE NYIRAGONGO VOLCANIC ERUPTION OF 22 MAY 2021

Source: Designed by author and consolidated figures from various sources: UNICEF (2021a), IFRC (2021), Act Alliance (2021), and FAO (2021).

APPENDIX B

SATELLITE IMAGE FROM 9 OCTOBER 2021 CONFIRMS HIGH ACTIVITY IN THE INNER SUMMIT CRATER (SENTINEL 2, 2021)



Source: (SENTINEL 2, 2021)

APPENDIX C

HEALTH EMERGENCY INFORMATION AND RISK ASSESSMENT: ALL EVENTS CURRENTLY BEING MONITORED BY WHO AFRO (SEPTEMBER-2021)
SOURCE: WHO (2021) WEEKLY BULLETIN ON OUTBREAKS AND OTHER EMERGENCIES

Country	Event	Grade	Date notified to WCO	Start of reporting period	End of reporting period	Total cases	Cases Confirmed	Deaths	CFR
Democratic Republic of the Congo	Humanitarian crisis	Protracted 3	20-Dec-2016	17-Apr-2017	7-Nov-21	-	-	-	-
As of 7 Nov 2021, there are an estimated 5.7 million people internally displaced and 19.6 million are in need of emergency food assistance in the entire country. On 11 Nov 2021 one of the biggest attacks all year happened in the Kisunga village of North Kivu province causing the death of 35 people and forcing 4K people to displace. Health centre workers were kidnapped and facilities were looted and destroyed depriving nearly 12K of health services. In Ituri another attack occurred on 7 Nov 2021 causing 10 deaths, kidnappings, looting and burning of property. Nearly 25K people have relocated to the Beni territory in North Kivu as a result.									
Democratic Republic of the Congo	Cholera	Grade 3	16-Jan-15	1-Jan-20	7-Nov-21	6 817	-	125	1.8%
In 2021, from epidemiological week 1 to 44 (ending 7 November 2021), 6 817 suspected cholera cases including 125 deaths (case-fatality rate 1.8%) were recorded in 80 health zones across 16 provinces of the Democratic Republic of the Congo. In 2020, a total of 30 304 suspected cholera cases including 514 deaths (case fatality 1.7%) were reported in 179 health zones across 23 provinces.									
Democratic Republic of the Congo	COVID-19	Grade 3	10-Mar-20	10-Mar-20	25-Nov-21	58 235	58 233	1 107	1.9%
Since the start of the COVID-19 outbreak, declared on 10 March 2020, a total of 58 233 confirmed cases and two probable case, including 1 107 deaths have been reported. A total of 51 443 people have recovered.									
Democratic Republic of the Congo	Ebola virus disease	Grade 2	8-Oct-21	8-Oct-21	6-Nov-21	11	8	9	81.8%
On 8 October 2021, a case of Ebola virus disease (EVD) was confirmed by PCR in a 29-month-old male child living in the Butsili health area in the Beni health zone, North Kivu province in the Democratic Republic of the Congo. The patient, treated in turn in three health facilities in the Beni health zone since 27 September 2021, died on 6 October 2021 in a local health facility in a hemorrhagic event. This case follows three suspected clustered deaths of EVD in the same family in the Butsili health area on 14, 19 and 29 September 2021 respectively. These three deaths were not sampled or given a dignified and safe burial. By 6 November 2021, 11 cases, of which 8 confirmed and 3 probable, and nine deaths have been reported.									
Democratic Republic of the Congo	Measles	Ungraded	12-Oct-21	1-Jun-2021	17-Oct-21	47 844	1 193	694	1.5%
From week 1 through week 41 of 2021 (ending 17 October) 47 844 suspected measles cases and 694 deaths (CFR 1.5%) have been reported. The outbreak has been confirmed in 92 health districts across 23 affected provinces including the capital city of Kinshasa. A total of 1 193 cases are IgM + for measles among which 65% are children under five and 29% known to be vaccinated, half of them have an unknown vaccination status. A total of 436 cases are IgM+ of rubeola among which 5.5% are more than 14 years old.									
Democratic Republic of the Congo	Meningitis	Grade 2	30-Jul-2021	1-Jun-2021	31-Oct-21	2 558	29	202	7.9%
On 28 July 2021, an alert was reported in the locality of Panga, Banalia territory, in Kisangani disctrict in DRC as a result of an illness with signs similar to those of meningitis. As of 31 October 2021, 2 558 cases have been reported including 202 deaths (CFR= 7.9%). Twenty nine samples have been confirmed on the 181 analysed samples including 27 for Neisseria meningitidis serogroup W, 1 Hemophilus influenzae and 1 Sp)									
Democratic Republic of the Congo	Monkeypox	Ungraded	n/a	1-Jan-20	7-Nov-21	9 047	39	301	3.3%
Since epidemiological week 1 up to week 44 in 2021, 2 790 cases have been reported with 72 deaths (CFR 2.5%). Between epidemiological week 1 and week 53 of 2020, a total of 6 257 suspected cases including 229 deaths (CFR 3.7%) were reported in 133 health zones from 17 out of 26 provinces in the country. During the same period in 2019, 5 288 suspected cases and 107 deaths (CFR 2.0%) were reported in 132 health zones from 18 provinces. Overall, there was a regressive trend from epidemiological week 33 to 53 of 2020 (276 cases vs 76 cases).									
Democratic Republic of the Congo	Plague	Ungraded	12-Mar-19	1-Jan-20	7-Nov-21	582	-	44	7.6%
From 22 April 2021, a cluster of deaths due to suspected pneumonic plague were recorded in the health zone of Fataki, Ituri province, Democratic Republic of the Congo. An investigation was conducted during which suspected cases were identified and samples taken for confirmatory testing. From epidemiological week 1 to 44, 2021 (ending on 7 Nov), 121 suspected pneumonic plague cases including 13 deaths were reported in eight health zones in Ituri province. From January to December 2020, 461 suspected plague cases of which 31 deaths were reported in eight health zones of Ituri. The health zones of Biringi, Rethy, and Aru reported the most cases.									
Democratic Republic of the Congo	Poliomyelitis (cVDPV2)	Grade 2	15-Feb-2018	1-Jan-18	26-Nov-21	201	201	0	0.0%
No case of circulating vaccine-derived poliovirus type 2 (cVDPV2) was reported this week. There are 11 cases reported in 2021 so far. The total number of 2020 cases remains at 81.									
Democratic Republic of the Congo	Typhoid fever	Ungraded	1-Jul-2021	1-Jan-21	3-Oct-21	1 121 104	19 734	411	0.0%
In 2021, from Epi week 1 to 39, 1 121 104 suspected cases of typhoid fever have been reported including 411 deaths (CFR 0.0%) and 19 734 confirmed cases in the epi week 39. In 2020, a total of 715 920 suspected cases of typhoid fever were reported, including 178 deaths (CFR 0.0%).									

APPENDIX D

QUESTIONNAIRE IN FRENCH

QUESTIONNAIRE DE RECHERCHE SUR :
LA GESTION DE CRISE : ÉTUDE DE CAS DE L'ÉRUPRTION DU VOLCAN NYIRAGONGO EN 2021 EN RÉPUBLIQUE DÉMOCRATIQUE DU CONGO (RDC)

Province du Nord Kivu, Ville de Goma,

Août, Septembre, Octobre2021

Cher (e) Madame/Monsieur,

Je vous invite à participer à un projet d'étude intitulée : Étude de Cas sur la Gestion de Crise de l'Éruption du Volcan Nyiragongo 2021. Le questionnaire ci-dessous a été conçu pour collecter des informations dans le cadre d'un projet d'étude universitaire visant à identifier les aspects qui ont formé la gestion de crise actuelle de l'éruption du volcan Nyiragongo 2021.

Votre participation à ce projet de recherche est entièrement volontaire. Si vous avez le temps, veuillez prendre quelques instants pour remplir le questionnaire. Vous pouvez choisir entre un entretien individuel, un e-mail ou un appel téléphonique. Pour répondre, veuillez cocher la réponse que vous jugez appropriée pour chaque question. Il n'y a pas de bonnes ou de mauvaises réponses et il s'agit de vos propres expériences rencontrées dans la vie de tous les jours. Vos réponses resteront confidentielles et anonymes. Si vous ne vous sentez pas à l'aise avec tout ce que nous demandons, vous pouvez annuler votre participation et arrêter cet exercice à tout moment.

Merci beaucoup pour votre participation !

I. INFORMATION PERSONNEL :

1. Nom & Prénom :
2. Anonyme :
3. Âge : 18-25 ☐ 26-35 ☐ 36-60 ☐ >60 ☐
4. Genre : Homme ☐ Femme ☐ Autre ☐
5. Statut matrimonial : Célibataire ☐ Marié(e) ☐ Divorcé(e)☐ Veuf(ve) ☐ En concubinage☐

   Autre ☐
6. Commune : Goma☐ Karisimbi ☐
7. Quartiers par commune :
   7.1 Goma : Les Volcans☐ Mikeno☐ Mapendo☐ Katindo☐ Himbi☐ Keshero☐ Lac Vert☐

   7.2 Karismbi: Kahembe☐ Katoyi☐ Majengo☐ Mabanga-Nord☐ Mabanga-Sud☐

   Kasika ☐ Murara ☐ Virunga ☐ Ndosho☐ Mugunga Bujovu ☐
8. Fonction :
   Commerçant☐ Agriculteur ☐ Agent de Nettoyage☐ Pêcheur☐ Élève☐ Étudiant ☐
   Sans emploi☐ Salarié☐ Personnel de Santé☐ Éleveur ☐ Transporteur ☐ Journaliste ☐
   Agent de sécurité☐ Acteur dans la réponse lié à l'éruption du volcan Nyiragongo ☐ Autre☐

II. FAITS SUR L'ENVIRONNEMENT ET L'ACTIVITÉ DU VOLCAN NYIRAGONGO :

1. Saviez-vous que le volcan Nyiragongo est un volcan actif ? Oui☐ Non☐
2. En quelle année il y a eu éruption du volcan Nyiragongo ?
   1977☐ 2002☐ 2021☐ Toutes ces années☐ Aucune de ces années☐ Je ne sais pas☐
3. Aviez-vous vécu l'éruption du volcan Nyiragongo en 2021 ? Oui☐ Non☐
4. Que représente pour vous l'environnent naturel autour du volcan Nyiragongo ?
   Il fait bon à vivre☐ Il faut le quitter (risque d'éruption)☐ Une source de revenus ☐

Un héritage familial et culturel☐ Une exploitation de ressources naturelles (minéraux) ☐
Rien ☐ Autre préciser ☐

III. PRÉPARATION ET SYSTÈME D'ALERTE PRÉCOCE :

1. Etiez-vous préparé pour une éventuelle éruption du volcan Nyiragongo ? Oui☐ Non☐

2. Aviez-vous reçu une formation sur les actions à prendre en cas d'éruption du volcan Nyiragongo ?
   Oui☐ Non☐

3. Est-ce que vous étiez alerté au temps opportun sur l'éruption du volcan Nyiragongo pour vous protéger ?
   Oui☐ Non☐

4. À votre avis, est-ce qu'il y avait une surveillance du volcan Nyiragongo avant son éruption en Mai 2021, par L'Observatoire Volcanologique de Goma (OVG) ou une autre institution ?
   Oui ☐ Non☐ Je ne sais pas☐

IV. PLAN DE CONTINGENCE (PLANIFICATION D'URGENCE) :

1. Saviez-vous qu'il y a un Plan National de Contingence en prévision des éruptions volcaniques en RDC (2018-2022) pour le Nord Kivu en RDC ? (Plan d'Urgence)
   Oui ☐ Non ☐

2. Est-ce que vous étiez au courant des risques d'une 2ème éruption du volcan Nyiragongo (après l'éruption du 22 Mai 2021) ?
   Oui☐ Non☐
   2.2 Si oui, est-ce que vous aviez suivi les consignes des autorités locales pour évacuer les zones à risque ?
   Oui ☐ Non ☐ Je n'étais pas concerner☐

3. Quel moyen de transport vous aviez utilisé pour fuir l'éruption du volcan Nyiragongo ?
   À pied☐ Voiture personnel☐ Voiture de location☐ Taxi☐ Bus☐ Autre préciser☐

4. Aviez-vous reçu des moyens de subsistance aux lieux d'accueil ?
   Abri ☐ Nourriture☐ Eau potable☐ Kits Hygiénique☐ Services de soins et de santé☐
   Support Psychologique☐ Aucun☐ Autre préciser☐

V. SÉCURITÉ ET CONTEXTE POLITIQUE :

1. Saviez-vous qu'il y a Etat de Siège au Nord Kivu y compris Goma ?
   Oui ☐ Non☐

2. Est-ce qu'il y a eu des conflits entre la population et les rebelles ou l'armé avec les rebelles durant et après l'éruption du volcan Nyiragongo ?
   Oui☐ Non☐ Je ne sais pas☐

3. Est-ce que vous vous sentiez protéger pendant et après l'éruption du volcan Nyiragongo ?
   Oui☐ Non☐ Je ne sais pas☐

4. Est- ce que vous aviez subis des agressions vols viols menaces ou autres abus pendant et après l'évacuation ?
   Oui☐ Non☐
   4.1 Si oui, préciser si c'est possible (date, lieu, personne/acteur)

VI. RÉALITÉS SOCIO-ÉCONOMIQUES :

1. Est-ce qu'il existait des activités commerciales autour du volcan Nyiragongo ?
   Magasins☐ Hôtels☐ Restaurants☐ Parc Naturel☐ Marchands Ambulants☐
   Agricultures☐ Artisanats☐ Rien☐ Je ne sais pas☐ Autre Préciser☐

2. Est-ce qu'il y avait des exploitations minières autour du volcan Nyiragongo ?
   Oui ☐ Non☐ Je ne sais pas☐

3. Comment l'éruption du volcan Nyiragongo à impacter sur votre vie professionnelle ?
   J'ai perdu mon poste de travail ☐ J'ai eu un nouveau poste de travail☐ Je rencontre des difficultés à accéder à mon travail ☐ Mon salaire a augmenté☐ Mon salaire a baissé☐ Mon salaire est resté le même☐ J'ai reçu un support de l'État ☐

4. Comment l'éruption du volcan Nyiragongo à impacter sur votre vie personnelle ?
   J'ai perdu un membre de ma famille☐ J'étais blessé ☐ J'ai perdu ma maison☐ Ma maison est à moitié endommagée☐ J'habite loin de ma famille☐ Je crains encore l'éruption☐ Je suis stressé

VII. SITUATION SANITAIRE ET COVID-19 :

1. À votre avis, quelles sont les maladies les plus répondues chez la population de Goma ?

Malnutrition☐ Malaria☐ Fièvre☐ Rougeole☐ Maladie à Virus Ebola☐ Choléra☐ COVID-19☐ Diabète☐ Tension artérielle☐ Maladies Psychiques☐ Maladies moteurs (handicap) ☐

2. Quelle méthode de soin vous auriez choisi durant l'éruption du volcan Nyiragongo ?
   Service de santé privé Service de santé public Automédication Tradipraticien Méthode traditionnelle familiale Aucune Autre préciser

3. Est-ce que vous connaissez les mesures barrières contre COVID-19 ? Oui☐ Non ☐

4. Est-ce que vous évitiez les services de santé à cause du COVID-19 ? Oui ☐ Non☐

VIII. HABITAT, EAU, ASSAINISSEMENT ET HYGIÈNE :

1. Où est ce que vous habitez actuellement ?
   Centre d'accueil ☐ Retour à l'ancienne maison☐ Chez une famille d'accueil ☐
   Chez un voisin☐ Autre commune/province☐ Autre préciser ☐

2. Quel est le moyen que vous utilisez pour avoir accès à l'eau potable ?
   Robinet ☐ Citerne☐ Puits☐ Achat d'eau minéral☐ Source Naturel ☐
   Autre préciser ☐

3. Est-ce que vous avez des toilettes dans votre lieu d'habitation ? Vous êtes combiens à utiliser ?
   Oui☐ Non☐ Autre préciser ☐
   3.1 Nombre d'utilisateur : entre 5-10☐ 10-15☐ 15-20☐ plus de 20 ☐

4. Est-ce que vous avez un lavabo ou autre installation pour se laver les mains dans votre lieu d'habitation ? vous êtes combien à l'utiliser ?
   Oui☐ Non☐ Autre préciser ☐
   4.1 Nombre d'utilisateur : entre 5-10 ☐ 10-15 ☐ 15-20 ☐ plus de 20 ☐

IX. COMMUNICATION :

1. Comment étiez-vous informé sur l'éruption du volcan Nyiragongo en Mai 2021 ?
   Radio☐ TV☐ Tremblements de terre☐ Ciel rougeâtre☐ Réseaux sociaux☐ Couler de lave☐ Publication du Centre Volcanologique de Goma☐ Autre préciser ☐

2. Est-ce qu'i y avait des informations contradictoires sur l'éruption du volcan Nyiragongo entre les différents moyens de communications ?

Oui ☐ Non☐ Je ne sais pas☐

3. Quel est le moyen de communication dont vous faites le plus confiance pour avoir des informations sur l'éruption du volcan et les moyens de se protéger ?
   3.1 Médias publics☐ Médias privés☐
   3.2 Radio☐ Télévision☐ Chaines YouTube☐ Réseaux sociaux☐ Journaux☐ Sites Web☐
   E-mailing☐ Affichage dans les espaces publics☐ Messages ou appels téléphoniques☐

4. Dans quelle langue vous auriez préféré recevoir l'information sur l'éruption du volcan Nyiragongo ?
   Swahili☐ Lingala☐ Français Autre préciser☐

X. ACCÈS ET ACCESSIBILITÉ :

1. Quelles sont les voies de transport qui existaient déjà à Goma avant l'éruption du volcan Nyiragongo en 2021 ?
   Voie aérienne☐ Voie fluviale☐ Voie routière☐ Aucune☐ Je ne sais pas☐

2. Quelles sont les voies de transport qui étaient opérationnelles durant l'éruption du volcan Nyiragongo en 2021 ?
   Voie aérienne☐ Voie fluviale☐ Voie routière☐ Aucune☐ Je ne sais pas☐

3. Est-ce que les services de secours ou les aides humanitaires ont pu accéder à la population sinistrée ?
   Oui☐ Non☐ Partiellement ☐ Je ne sais pas☐

4. Est-ce que tous les voies de transport qui existaient déjà avant l'éruption du volcan Nyiragongo en 2021 sont opérationnelles actuellement ?
   Voie aérienne☐ Voie fluviale☐ Voie routière☐ Aucune☐ Je ne sais pas☐

XI. ENGAGEMENT COMMUNAUTAIRE ET NATIONALE :

1. Est-ce que vous aviez reçu une aide de la communauté suite à l'éruption du volcan ?
   Oui☐ Non☐ Je ne sais pas☐

2. Est-ce que vous étiez volontaire pour aider la communauté suite à l'éruption du volcan ?
   Oui ☐ Non☐

3. Aviez-vous reçu une assistance des services de l'Etat ?
   Police☐ Gendarmerie☐ Protection Civile☐ Services de Santé☐ Aucune☐
   Autre préciser☐

4. Qui est le lead dans la gestion de crise de l'éruption du volcan Nyiragongo en 2021 ?
   Le Gouverneur de Goma☐ La Primature☐ L'Agence de Prévention et de Gestion des Catastrophes Naturelles☐ La Présidence☐ Observatoire Volcanologique de Goma☐
   Je ne sais pas☐

XII. APPUI INTERNATIONAL :

1. Est-ce que vous aviez reçu un soutien international suite à l'éruption du volcan ?
   Oui☐ Non☐ Je ne sais pas☐

   1.1 Si oui, de quel pays :

2. Est-ce que vous aviez reçu un support des organisations internationales exerçant en RDC ?
   Oui☐ Non☐ Je ne sais pas☐

3. Est-ce que vous aviez reçu un support de la diaspora congolaise ?
   Oui☐ Non☐ Je ne sais pas☐

4. Que pensez-vous de la mobilisation internationale ?
   Bonne☐ Moyenne☐ Faible☐ Inexistante☐ Je ne sais pas☐

APPENDIX E

QUESTIONNAIRE IN ENGLISH

QUESTIONNAIRE OF RESEARCH:
CRISIS MANAGEMENT: CASE STUDY OF NYIRAGONGO VOLCANO ERUPTION 2021 IN DEMOCRATIC REPUBLIC OF CONGO (DRC)

Province of North Kivu, City of Goma,

August, September, October2021

Dear Sir/Madam,

I invite you to participate in a research study entitled: Case Study on Crisis Management of Nyiragongo Volcano Eruption 2021. The enclosed questionnaire has been designed to collect information as part of academic project to identify aspects that have shaped the current crisis management of Nyiragongo volcano eruption 2021.

Your participation in this research project is completely voluntary. If you have the time, please take a moment to filling out the questionnaire. You may choose between one-to -one interview, emailing or phone call. To answer, please, put a tick to the answer you think appropriate for each question. There are no right, or wrong answers and it's about own experiences encountered in everyday life. Your responses will remain confidential and anonymous. If you do not feel comfortable with anything we ask, you may cancel your participation and stop this exercise at any time.

Thank you very much for your participation!

I. PERSONNEL INFORMATION:

1. Surname & First name:
2. Anonymous:
3. Age: 18-25☐ 26-35☐ 36-60☐ >60☐
4. Gender: Male☐ Female☐ Other☐
5. Marital Status: Single☐ Married☐ Divorced☐ Widow☐ In cohabitation☐ Other☐
6. Town/Commune: Goma☐ Karisimbi ☐
7. Neighborhoods per town:
   7.1 Goma: Les Volcans☐ Mikeno☐ Mapendo☐ Katindo☐ Himbi☐ Keshero☐ Lac Vert☐
   7.2 Karismbi: Kahembe☐ Katoyi☐ Majengo☐ Mabanga-Nord☐ Mabanga-Sud☐ Kasika☐ Murara☐ Virunga☐ Ndosho☐ Mugunga☐ Bujovu☐
8. Function:
   Trader☐ Farmer☐ Cleaner☐ Fisher☐ Pupil☐ Student☐ Unemployed☐ Salaried employee☐ Health Staff☐ Breeder☐ Transporter☐ Journalist☐ Security Guard☐ Actor at Nyiragongo volcano eruption response☐ Other☐

II. FACTS ABOUT NYIRAGONGO VOLCANO ENVIRONMENT AND ACTIVITY:

1. Did you know that Nyiragongo volcano is an active volcano? Yes☐ No☐
2. In which year did the Nyiragongo volcano erupt?
   1977☐ 2002☐ 2021☐ All of these years☐ None of these years☐ I don't know☐
3. Did you witness the eruption of Nyiragongo volcano in 2021? Yes☐ No☐
4. What does the natural environment around Nyiragongo volcano represent for you?
   It's good to live☐ You have to leave it (risk of eruption)☐ A source of income☐ A family and cultural heritage☐ An exploitation of natural resources (minerals)☐ Nothing☐ Other, specify☐

III. PREPARDNESS AND EARLY WARNING SYSTEM:

1. Were you prepared for a potential eruption of the Nyiragongo volcano?
   Yes☐ No☐

2. Did you receive any training on what to do in case of a volcanic eruption?
   Yes☐ No☐

3. Were you alerted on time about the eruption of Nyiragongo volcano to protect yourself?
   Yes☐ No☐

4. In your opinion, was there any monitoring of the Nyiragongo volcano before its eruption on 22nd May 2021, by L'Observatoire Volcanologique de Goma (Goma Volcano Observatory) or another institution?
   Yes☐ No☐ I don't know☐

IV. CONTINGENCY PLANNING (EMERGENCY PLANNING):

1. Did you know that there is a National Contingency Plan in anticipation of volcanic eruptions in the DRC (2018-2022) for North Kivu in the DRC? (Emergency Plan)
   Yes☐ No☐

2. Were you aware of the risks of a 2nd eruption of the Nyiragongo volcano (after the eruption of 22nd May 2021)? Yes☐ No☐

   2.2 If yes, have you followed the instructions of the local authorities to evacuate the areas at risk?
   Yes☐ No ☐ I wasn't concerned☐

3. What means of transport did you use to escape the eruption of Nyiragongo volcano?
   On foot☐ Personal car☐ Rental car☐ Taxi☐ Bus☐ Other, specify☐

4. Did you receive any means of subsistence at host sites?
   Shelter☐ Food☐ Drinking water☐ Hygienic kits☐ Health care services☐ Psychological support☐ None☐ Other, specify☐

V. SECURITY AND POLITICAL CONTEXT:

1. Did you know that there is a "state of siege" in North Kivu including Goma?
   Yes☐ No☐

2. Was there any conflict between the population and the rebels or the national army with the rebels during and after the eruption of the Nyiragongo volcano?
   Yes☐ No☐ I don't know☐

3. Did you feel protected during and after the eruption of Nyiragongo volcano?
   Yes☐ No☐ I don't know☐

4. Have you found any assaults theft rape menaces or other abuse during and after the evacuation? Yes☐ No☐
   4.1 If yes, could you specify if possible (date, place, person/actor)

VI. SOCIO-ECONOMIC REALITIES:

1. Was there any commercial activity around Nyiragongo volcano?
   Stores☐ Hotels☐ Restaurants☐ Natural Park☐ Street vendors☐ Agricultures☐ Handicrafts☐ None☐ I don't know☐ Other, specify☐

2. Were there any mining exploitations around Nyiragongo volcano?
   Yes☐ No☐ I don't know☐

3. How has the eruption of Nyiragongo volcano impacted your professional life?
   I lost my job☐ I got a new job☐ I have difficulties to access my job☐ My salary increased☐ My salary decreased☐ My salary remained the same☐ I received support from the government ☐

4. How has the eruption of Nyiragongo volcano impacted your personal life?
   I have lost a family member☐ I was injured☐ I lost my house☐ My house is partially damaged☐ I live far away from my family☐ I am still afraid from eruption☐ I am stressed☐

VII. HEALTH SITUATION AND COVID-19:

1. In your opinion, what are the most common diseases among the population of Goma?
   Malnutrition☐ Malaria☐ Fever☐ Measles☐ Ebola virus disease☐ Cholera☐

COVID-19☐ Diabetes☐ Blood pressure☐ Psychical illnesses☐ Motor illnesses (disability) ☐

2. What type of medical treatment would you have chosen during the eruption of the Nyiragongo volcano?
   Private health services☐ Public health services☐ Self-medication☐ Traditional healer☐
   Traditional family method☐ None☐ Other, specify☐

3. Do you know the prevention measures against COVID-19? Yes☐ No☐

4. Were you avoiding health services because of COVID-19? Yes☐ No☐

VIII. SHELTER, WATER, SANITATION AND HYGIENE:

1. Where do you live now?
   Reception Centre☐ Back to old house☐ Host family☐ Neighbor's house☐ Other Town or province☐ Other, specify☐

2. How do you get access to safe drinking water?
   Tap☐ Tank☐ Borehole☐ Purchase mineral water☐ Natural Source☐ Other, specify☐

3. Do you have a toilet at your place? How many people use it?
   Yes☐ No☐ Other, specify ☐
   3.1 Number of users: between 5-10☐ 10-15☐ 15-20☐ over 20☐

4. Do you have a bathroom sink or other handwashing facility at your place? How many people use it?
   Yes☐ No☐ Other, specify☐
   4.1 Number of users: between 5-10 ☐ 10-15 ☐ 15-20 ☐ over 20 ☐

IX. COMMUNICATION:

1. How were you informed about the eruption of the Nyiragongo volcano in May 2021?
   Radio☐ TV☐ Earthquakes☐ Red Sky☐ Social networks☐ Lava flow☐ Publication from Goma Volcano Observatory☐ Other, specify☐

2. Was there contradictory information about the eruption of Nyiragongo volcano between the different means of communication?
   Yes☐ No☐ I don't know☐

3. What is the most trusted means of communication about the volcano eruption? and safety measures?
   3.1 Public Media☐ Private Media☐
   3.2 Radio☐ TV☐ YouTube Channels☐ Social medias☐ Newspapers☐ Web Sites☐
   E-mailing☐ Posting in public spaces☐ Texting or phone calls☐

4. In which language would you prefer to receive information about the eruption of Nyiragongo volcano?
   Swahili☐ Lingala☐ French☐ Other☐

X. ACCESS AND ACCESSIBILITY:

1. What are the transport routes, that already existed in Goma, before the eruption of the Nyiragongo volcano in 2021?
   Airway☐ Waterway☐ Roadway☐ None☐ I don't know☐
2. What are the transportation routes that were operational during the eruption of the Nyiragongo volcano in 2021?
   Airway☐ Waterway☐ Roadway☐ None☐ I don't know☐

3. Have the emergency services or humanitarian aid been able to access the affected population?
   Yes☐ No☐ Partially☐ I don't know☐

4. Are the transport routes that already existed before the eruption of the Nyiragongo volcano in 2021 currently operational?
   Airway☐ Waterway☐ Roadway☐ None☐ I don't know☐

XI. COMMUNITY AND NATIONAL ENGAGEMENT:

1. Have you received any support from the community following the volcanic eruption?
   Yes☐ No☐ I don't know☐

2. Were you volunteering to help the community following the volcanic eruption?
   Yes☐ No☐

3. Have you received any assistance from State services?
   Police ☐ Gendarmerie ☐ Civil Protection☐ Health Services☐ None☐
   Other, specify☐

4. Who was taking the lead in the crisis management of Nyiragongo volcano eruption 2021?
   The Governor of Goma☐ The Prime Minister☐ The Agency for the Prevention and Management of Natural Disasters☐ The President ☐ Goma Volcano Observatory☐
   I don't know☐

XII. INTERNATIONAL SUPPORT:

1. Have you received international support following the volcanic eruption?
   Yes☐ No☐ I don't know☐
   1.1 If yes, from which country:

2. Have you received support from international organizations operating in the DRC?
   Yes☐ No☐ I don't know☐
3. Have you received support from the Congolese diaspora?
   Yes☐ No☐ I don't know☐

4. What do you think of the international mobilization?
   Good☐ Average☐ Poor☐ Inexistent☐ I don't know☐

APPENDIX F

RESULTS OF QUESTIONNAIRE IN FIGURES

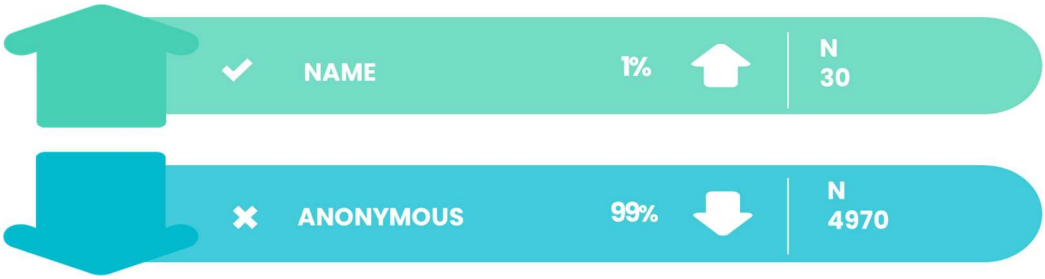


Figure 4: Rate of anonymity and name provided by respondents

Source: Generated by author

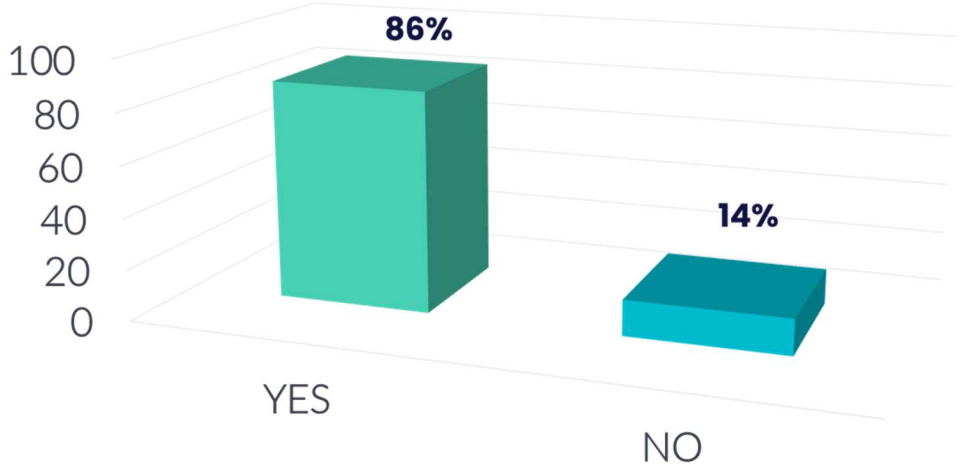


Figure 9: Response to question: Did you know that Nyiragongo volcano is an active volcano?

Source: Generated by author

Figure 10: Response to question: In which year did the Nyiragongo volcano erupt?

Source: Generated by author

Figure 11: Response to question: Did you witness the eruption of Nyiragongo volcano in 2021?

Source: Generated by author

Figure 14: Response to question: Did you receive any training on what to do in case of a volcanic eruption?

Source: Generated by author

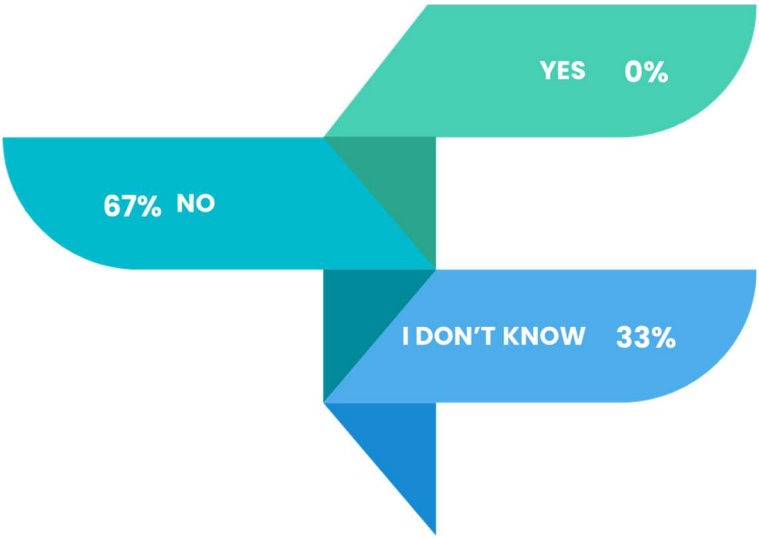


Figure 16: Response to question: In your opinion, was there any monitoring of the Nyiragongo volcano before its eruption in May 2021, by L'Observatoire Volcanologique de Goma (Goma Volcano Observatory) or another institution?

Source: Generated by author

Figure 17: Response to question: Did you know that there is a National Contingency Plan in anticipation of volcanic eruptions in the DRC (2018-2022) for North Kivu in the DRC? (Emergency Plan)

Source: Generated by author

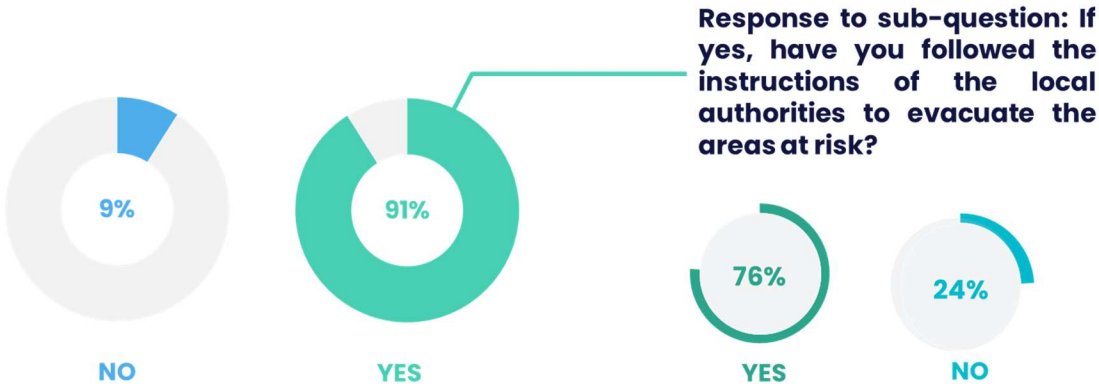


Figure 18: Response to question: Were you aware of the risks of a 2nd eruption of the Nyiragongo volcano (after the eruption of 22nd May 2021)

Source: Generated by author

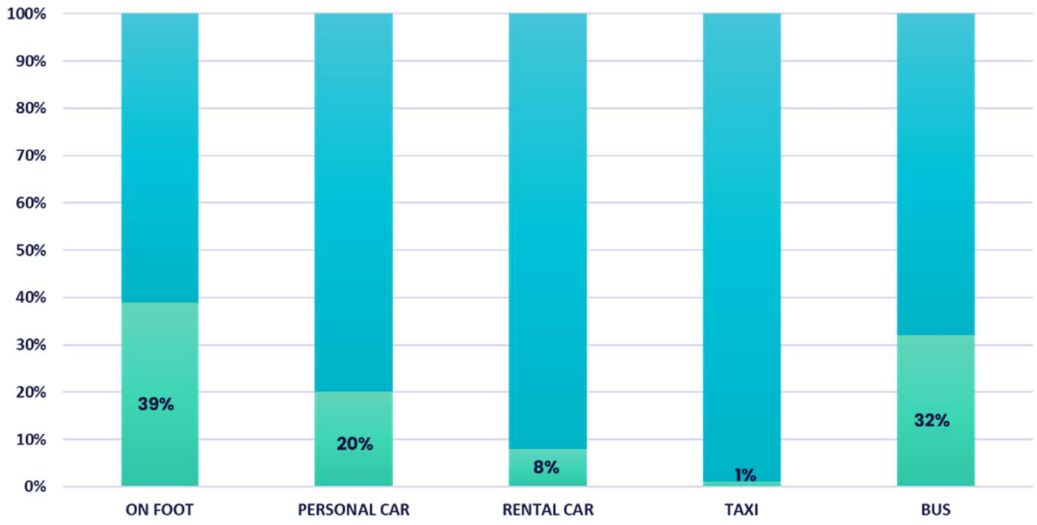


Figure 19: Response to question: What means of transport did you use to flee the eruption of the Nyiragongo volcano?

Source: Generated by author

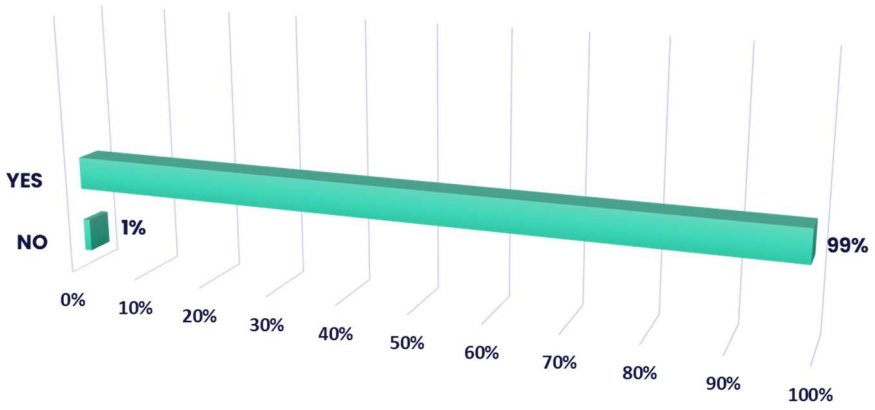


Figure 21: Response to question: Did you know that there is a "state of siege" in North Kivu including Goma?

Source: Generated by author

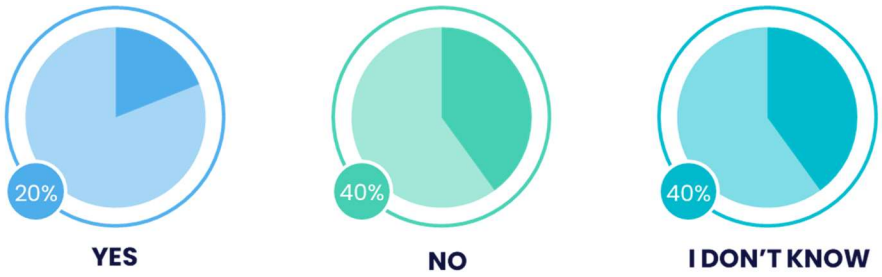


Figure 22: Response to question: Was there any conflict between the population and the rebels or the national army with the rebels during and after the eruption of the Nyiragongo volcano?

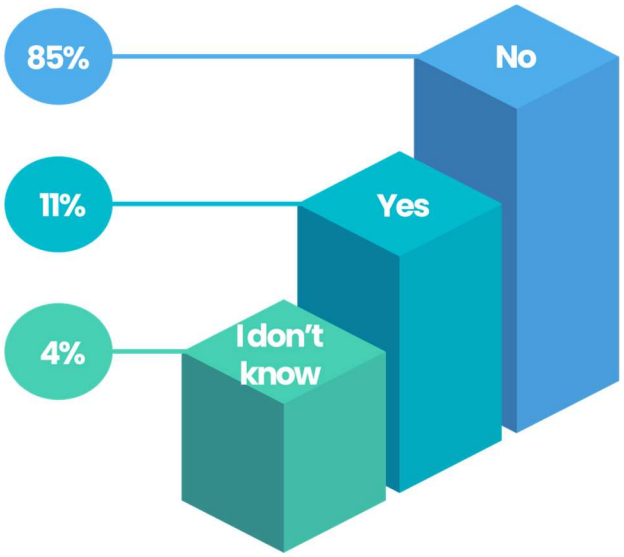


Figure 23: Response to question: Did you feel protected during and after the eruption of Nyiragongo volcano?

Source: Generated by author

Figure 25: Response to question: Were there any mining exploitations around Nyiragongo volcano?

Source: Generated by author

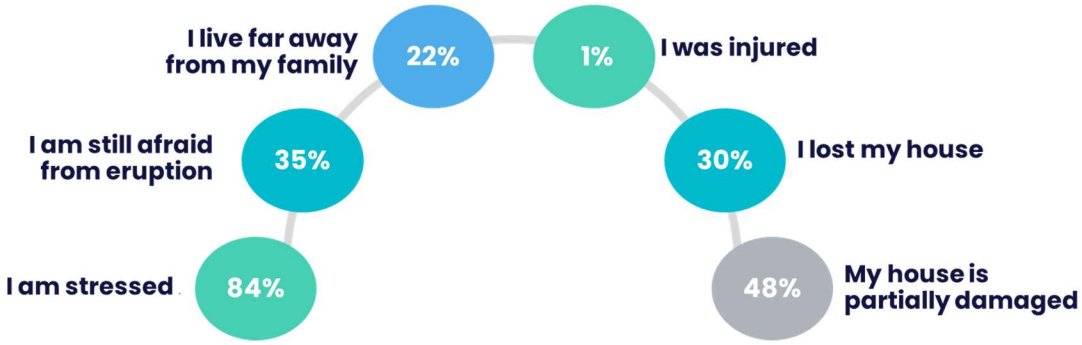


Figure 27: Response to question: How has the eruption of Nyiragongo volcano impacted your personal life?

Source: Generated by author

Disease	Numbers	Percentages
Malnutrition	843	17%
Malaria	2093	42%
Fever	1233	25%
Measles	163	3%
Ebola virus disease	235	5%
Cholera	23	0%
COVID-19	97	2%
Diabetes	168	3%
Blood pressure	54	1%
Psychical illnesses	50	1%
Motor illnesses (disability)	41	1%

Table 3: Response to question: In your opinion, what are the most common diseases among the population of Goma?

Source: Generated by author

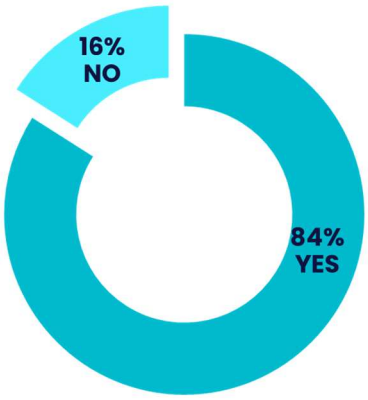


Figure 29: Response to question: Do you know the prevention measures against COVID-19?

Source: Generated by author

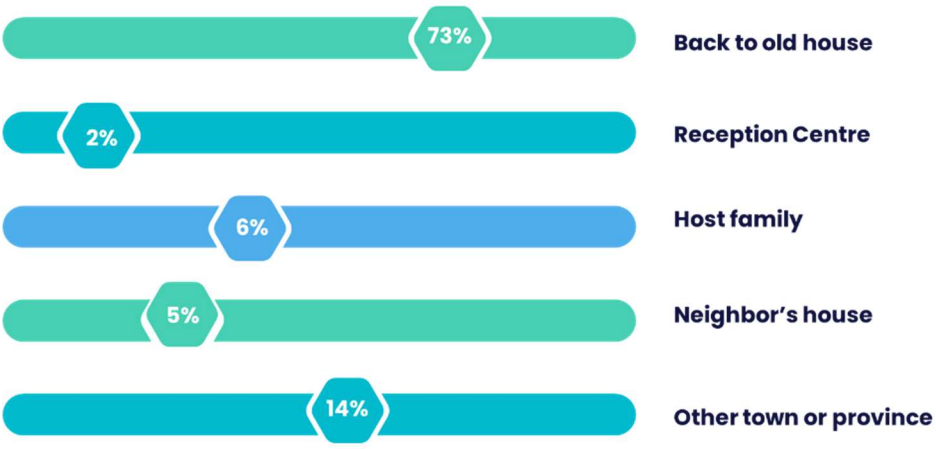


Figure 31: Response to question: Where do you live now?

Source: Generated by author

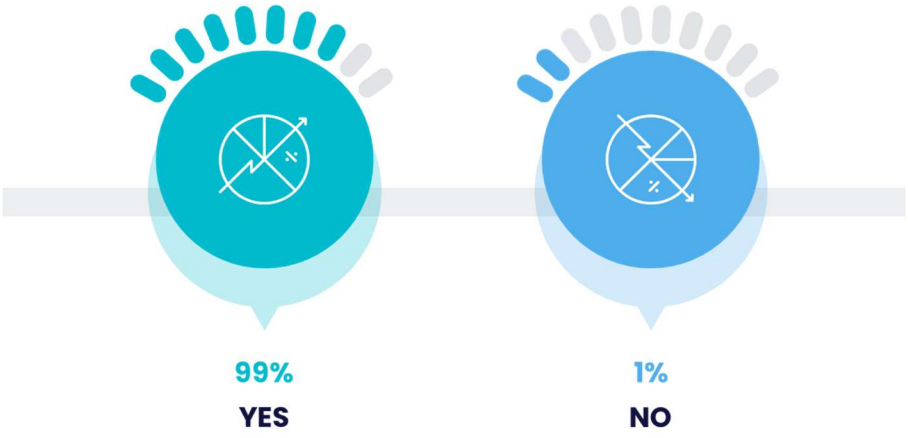


Figure 33: Response to question: Do you have a toilet at your place?

Source: Generated by author

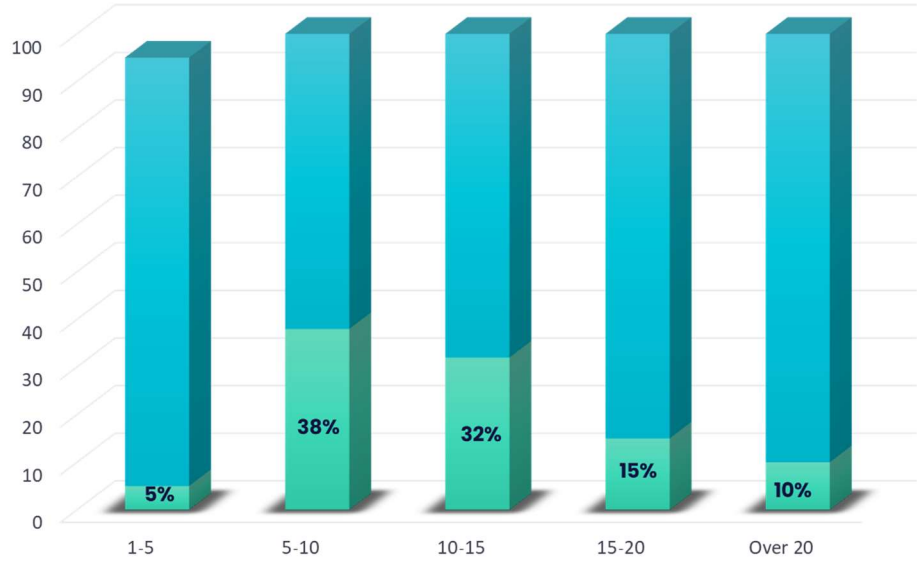


Figure 34: Response to sub-question: Number of users per one toilet

Source: Generated by author

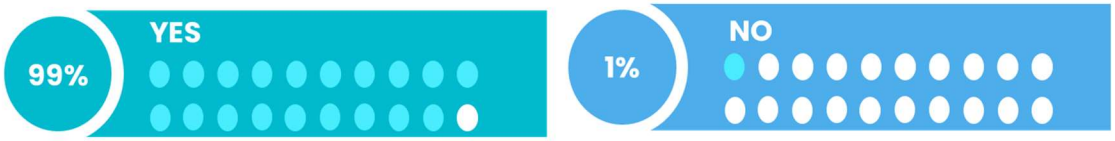


Figure 35: Response to question: Do you have a bathroom sink or other handwashing facility at your place?

Source: Generated by author

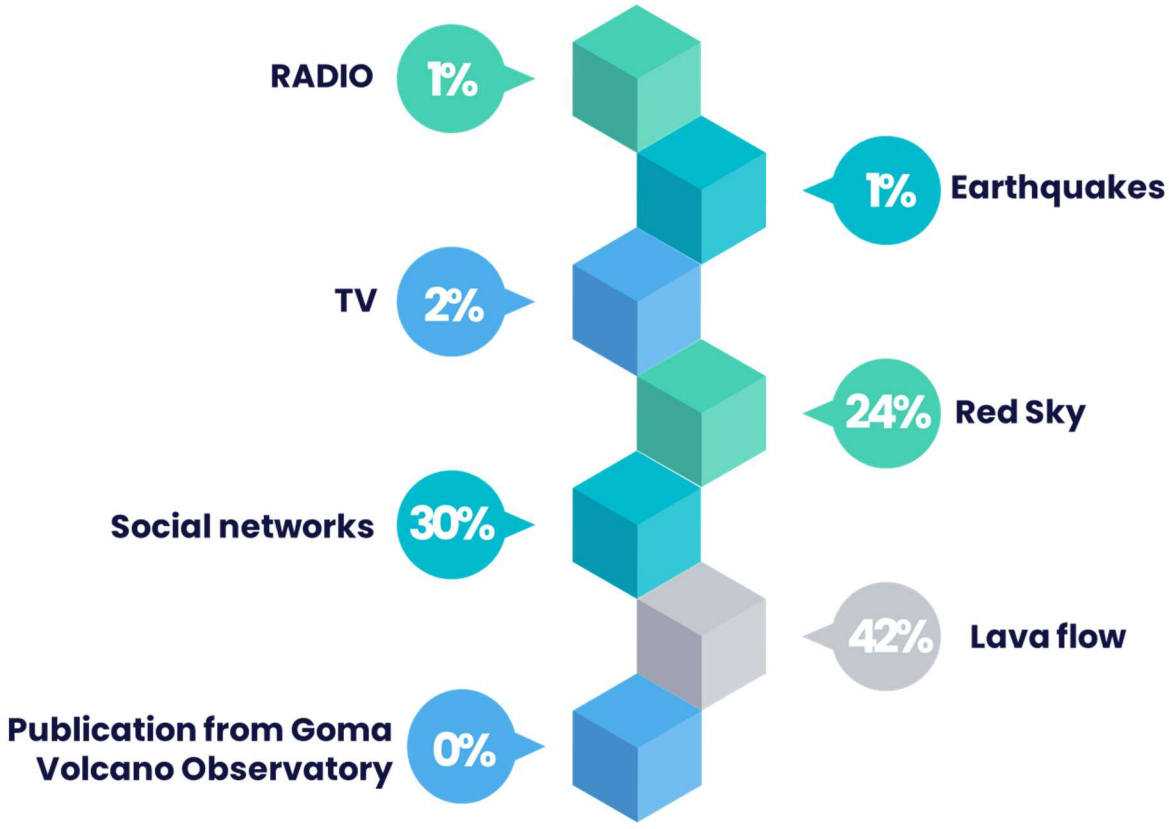


Figure 37: Response to question: How were you informed about the eruption of the Nyiragongo volcano in May 2021?

Source: Generated by author

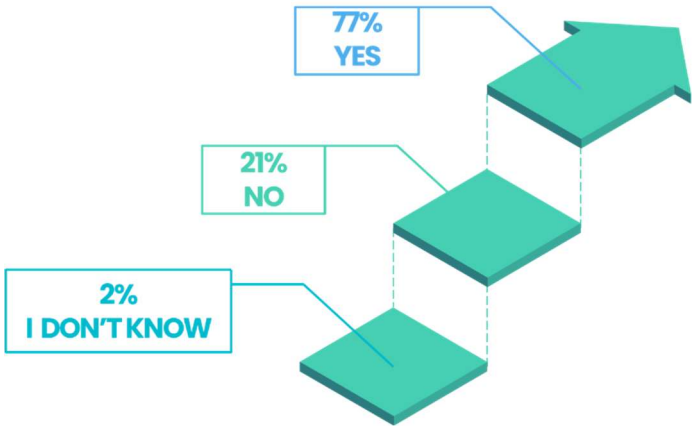


Figure 38: Response to question: Was there contradictory information about the eruption of Nyiragongo volcano between the different means of communication?

Source: Generated by author

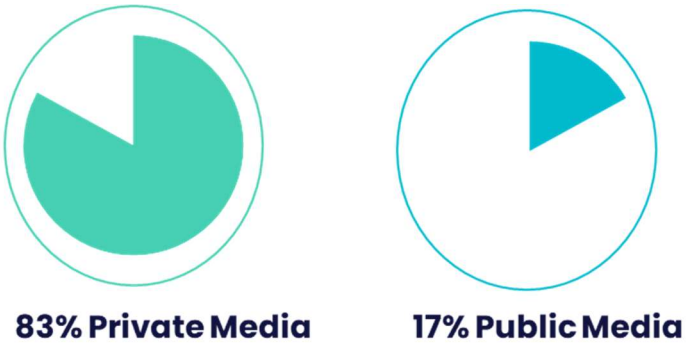


Figure 39: Response to question: What is the most trusted means of communication about the volcano eruption and safety measures?

Source: Generated by author

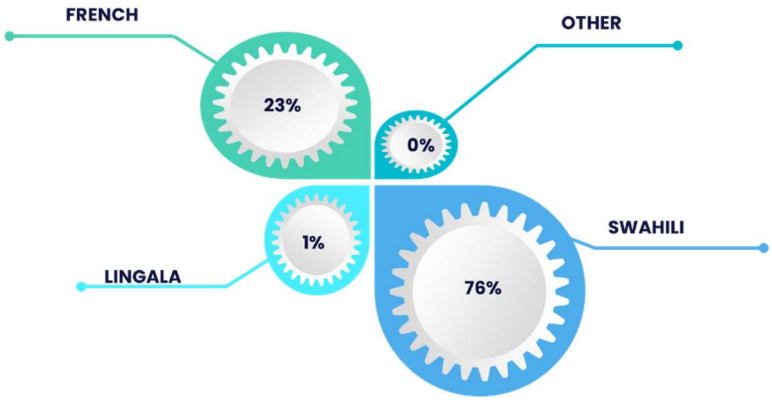


Figure 40: Response to question: In which language would you prefer to receive information about the eruption of Nyiragongo volcano?

Source: Generated by author

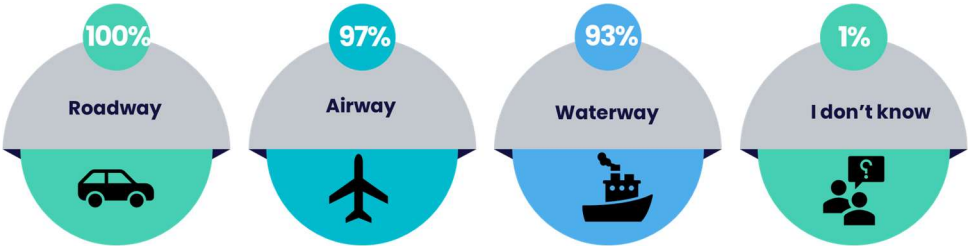


Figure 41: Response to question: What are the transport routes, that already existed in Goma, before the eruption of the Nyiragongo volcano in 2021?

Source: Generated by author

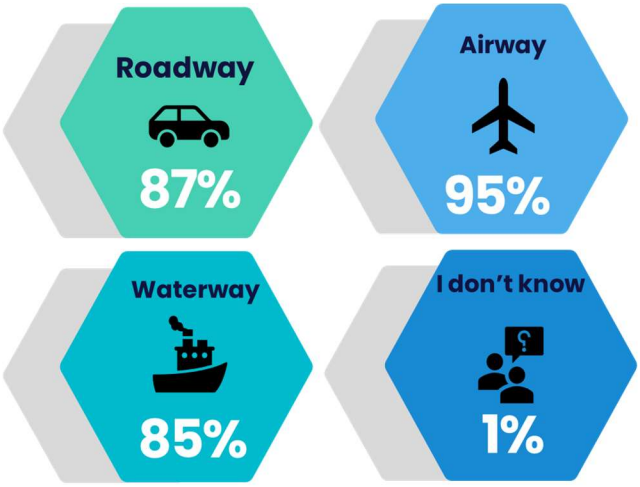


Figure 44: Response to question: Are the transport routes that already existed before the eruption of the Nyiragongo volcano in 2021 currently operational?

Source: Generated by author

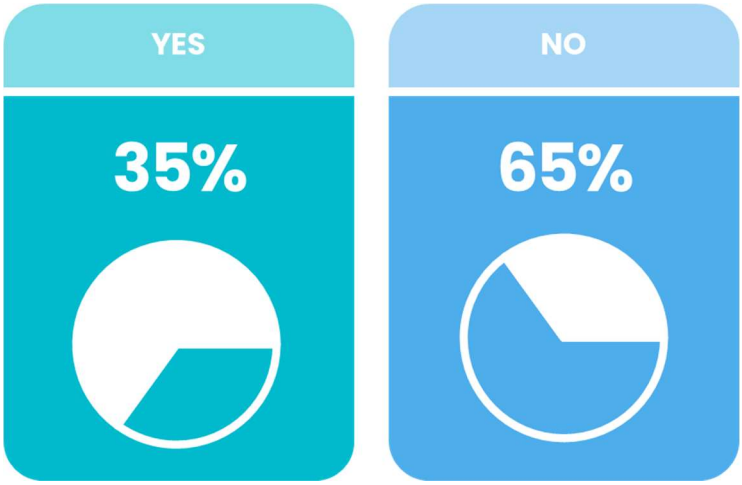


Figure 46: Response to question: Were you volunteering to help the community following the volcanic eruption?

Source: Generated by author

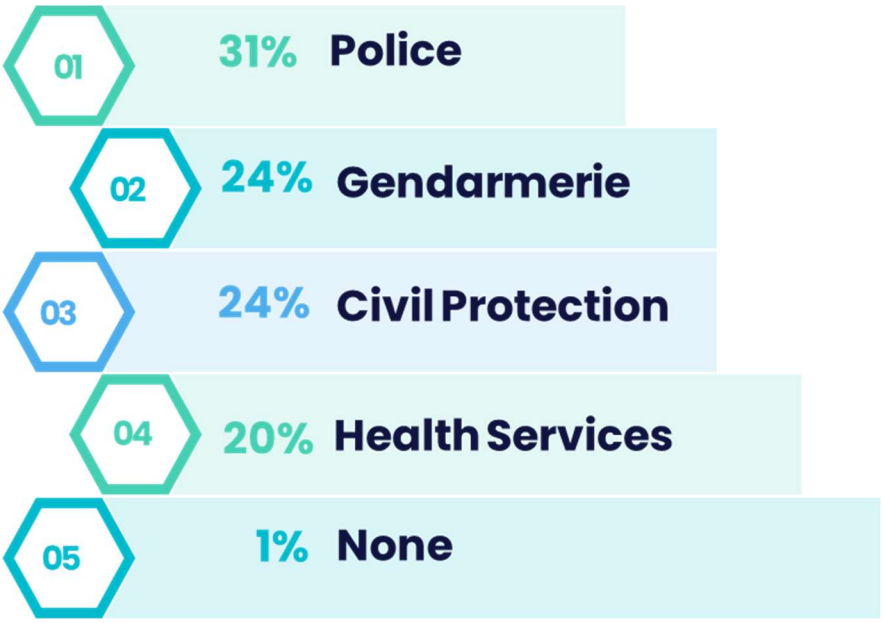


Figure 47: Response to question: Have you received any assistance from State services?

Source: Generated by author

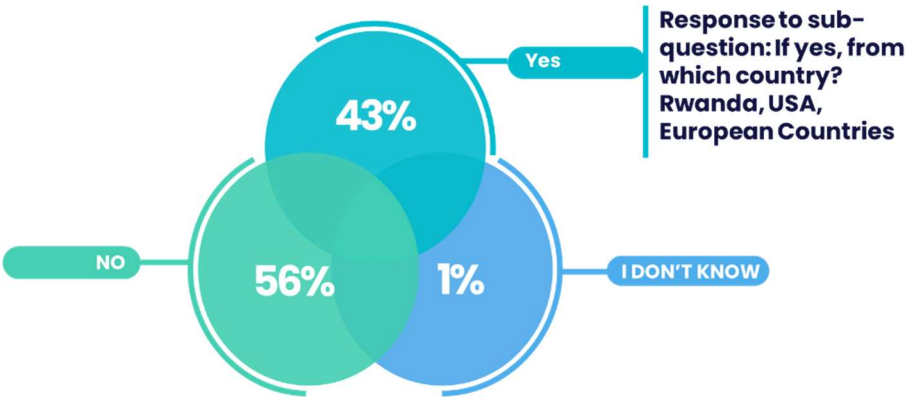


Figure 49: Response to question: Have you received international support following the volcanic eruption?

Source: Generated by author

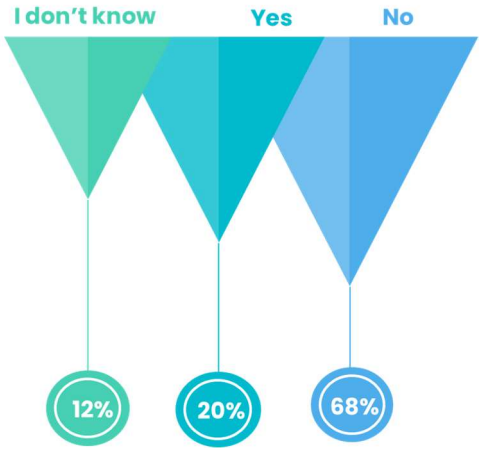


Figure 50: Response to question: Have you received support from international organizations operating in the DRC?

Source: Generated by author

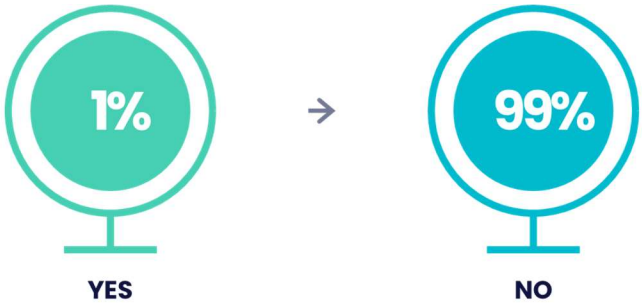


Figure 51: Response to question: Have you received support from the Congolese diaspora?

Source: Generated by author