Beyond Disaster Coloniality and Towards Epistemic Justice: The Value of Local Knowledge in Madagascar's Disaster Risk Management

By

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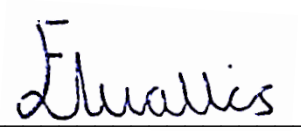

Abstract

ABSTRACT OF THESIS submitted by:

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Madagascar's disproportionate vulnerability to disasters, exacerbated by climate change, underscores the urgent need for enhanced, context-specific disaster risk management strategies. This thesis employs interviews and observational data as primary research methods to examine how field experts and technical experts define and perceive drought differently. Furthermore, it explores how epistemic injustice undermines the credibility of local knowledge and how this impacts disaster risk management strategies. Additionally, the paper investigates how disaster coloniality influences stakeholders' perceptions and responses to disasters, underscoring the importance of incorporating local perspectives.

The findings reveal emerging drought conditions in northern Madagascar, which are severely impacting local communities, particularly smallholder farmers. Given the North's typical characterisation as a "tropical" climate, the onset of drought in this region could have significant implications for the entire island. Unlike the semi-arid South, which has been experiencing severe drought for several decades, drought is a recent phenomenon for the North of Madagascar, leaving local populations unprepared and lacking effective disaster risk management strategies to deal with the rapidly changing climate. Key challenges include reduced water and sanitation access, increased food insecurity, and a rise in health concerns, exacerbating existing socio-economic vulnerabilities shaped by Madagascar's colonial history. This thesis emphasises that disasters are not "natural", but a result from the combination of hazards, vulnerability, exposure, and coloniality. Moreover, it highlights the importance of integrating local knowledge and addressing the coloniality of disasters in Madagascar's disaster risk management.

Keywords: drought, disasters, Madagascar, climate change, agriculture, precipitation, vulnerability, knowledge, coloniality, epistemic injustice

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1 INTRODUCTION

1.1 Background of Study

As an island nation and classed as one of the most "underdeveloped" nations globally (United Nations 2023), Madagascar faces disproportionate vulnerability to the effects of climate change. As temperatures and sea levels rise, this heightened susceptibility manifests in the increased occurrence and/or severity of disasters like cyclones, droughts and flooding (Intergovernmental Panel on Climate Change [IPCC] 2014). Disasters further compound and are exacerbated by existing challenges, including poverty, food and water insecurity, illnesses and diseases, limited infrastructure and political corruption. Despite this evident vulnerability, research on climate change and disaster risk management in Madagascar is limited. Solutions cannot be developed if the problem itself has not been identified, demonstrating the need for further research to enhance disaster risk management strategies in Madagascar.

Although droughts, cyclones and flooding are often labelled as "natural disasters" (Berlemann and Wenzel 2015, Alano and Lee 2016) I refer to them as "disasters", deliberately omitting the term "natural". This choice of terminology reflects the well-established argument that disasters are not natural phenomena but are instead the outcome of multiple inter-connected factors that compound and reinforce each other (Bonilla 2020). While a disaster may arise from a natural hazard such as drought, the disaster itself occurs when the hazard is combined with other social, economic, political and, I argue, colonial factors. Furthermore, as the effects of climate change become increasingly widespread, it raises the question of whether what were once considered "natural hazards" can still be deemed "natural". Scientific evidence attributes climate change as we know it to anthropogenic factors, suggesting that even the hazard component of a disaster is no

longer induced by natural processes alone (Intergovernmental Panel on Climate Change [IPCC] 2022). The following sub-sections will present my research aims and objectives, the corresponding research questions that will guide my research towards achieving them, and an overview of the thesis.

1.2 Research Aims and Objectives

The overarching aim of this thesis is to examine how the recognition and management of disasters in northern Madagascar are influenced by the differing perspectives of field experts and technical experts. The following objectives help to guide me towards this aim:

1. Compare and analyse how field experts and technical experts perceive and observe drought and its impacts in northern Madagascar.
2. Assess the influence of epistemic injustice on the authority of local knowledge in disaster risk management.
3. Investigate the historical and ongoing impacts of disaster coloniality on current responses to drought and climate change in northern Madagascar.

1.3 Research Questions

To help me in achieving these aims and objectives, the following questions guide my research:

How do the differing perspectives of field experts and technical experts influence the recognition and management of drought in northern Madagascar, and how is this affected by epistemic injustice and disaster coloniality?

Sub-Questions:

1. How do smallholder farmers and technical experts perceive and observe drought and its impacts differently, and what are the implications of these differences for drought recognition in northern Madagascar?
2. In what ways does epistemic injustice affect the perceived credibility and value of local smallholder farmers' knowledge compared to the expertise of technical experts?
3. How do the historical and ongoing impacts of disaster coloniality shape the current responses to drought, and what can be done to ensure more equitable and effective drought management strategies that incorporate local perspectives?

1.4 Thesis Overview

In Chapter 2, I demonstrate that, although there is existing research on drought in the southern regions of Madagascar and on disaster risk management more generally, the subject of drought in northern Madagascar has so far remained entirely unexplored. This is particularly true when viewed through the lenses of disaster coloniality and epistemic injustice, which provide the theoretical framework for my study and extend the relevance of my findings beyond the scope of disaster risk management, as I outline in Chapter 3. To address my research questions, I conducted qualitative fieldwork in northern Madagascar, as detailed in Chapter 4. The results of this analysis, presented in Chapter 5, reveal the onset of drought and its impacts on local populations in the North of Madagascar, particularly smallholder farmers. As I discuss in Chapter 6, these findings underscore the importance of incorporating local perspectives in disaster risk management. In Chapters 7 and 8, I present my conclusions and recommendations of this thesis, acknowledging the onset of drought in northern Madagascar and highlight the importance of incorporating local knowledge and qualitative research to enhance disaster risk management.

2 LITERATURE REVIEW

This chapter reviews the existing literature relevant to the research questions and identifies the research gap. The literature review is organised into several sub-sections. First, I introduce the concept of drought by identifying four commonly recognised types. Next, I provide an overview of Madagascar's environmental and climatic conditions and the island's historical and contemporary agriculture. This is followed by a discussion on the existing research on drought in Madagascar. I then examine the socio-economic and ecological impacts of drought and climate change, underscoring the particular vulnerability of smallholder farmers reliant on rain-fed agriculture.

Additionally, I introduce the concept of disaster risk management, detailing the four primary stages of the disaster cycle and the use of geospatial technology as a disaster risk strategy. This primarily refers to formal disaster risk management, as recognised by technical experts in the Global North. However, I also recognise the coping mechanisms and adaptive strategies utilised by local populations and smallholder farmers as informal (but equally valid and important) forms of disaster risk management. Finally, I outline the research gap concerning drought in northern Madagascar and conclude by highlighting how this thesis contributes to existing literature on climate change and disaster risk management.

2.1 Introduction to The Concept of Drought

An estimated 55 million people are impacted by droughts and associated water scarcity every year. Considered a natural hazard by definition, drought is typically characterised by a period of

"abnormally low precipitation and subtle onset" (Ekundayo, Abiodun, and Kalumba 2022, 2). However, as a concept it is difficult to define. Nhamo, Mabhaudi and Modi (2019) identify four different types of drought: meteorological, agricultural, hydrological and socio-economic drought.

The first, meteorological drought, refers to a "prolonged period of dry weather", which is characterised by temperature increase, a prolonged absence in rainfall and reduced humidity, increasing evapotranspiration. Agricultural drought is described as a phenomenon primarily impacting the agricultural sector, where crops become wilted due to prolonged moisture deficit, thus causing a decline in crop yields. Hydrological drought is considered to be a "slow process drought", which occurs when water supply from various sources of water drops beneath the typical level. Finally, socio-economic drought refers to economic losses and social impacts, causing increased product demand, which leads to socio-economic impacts and famine (Nhamo, Mabhaudhi, and Modi 2019, 76).

The distinct types and varying definitions of drought highlight its multifaceted and complex nature, making it challenging and arguably impossible to address with a single approach or solution. Consequently, understanding these nuances is crucial for developing effective, context-specific strategies to mitigate the impacts of drought across different regions and sectors.

2.2 Climate and Environmental Conditions in Madagascar

Described as having one of the most "unpredictable climates on the planet", Madagascar experiences highly varied environmental and climatic conditions. Rainfall is rare in the western and southern regions (Desbureaux and Damania 2018, 358), while the northern and eastern parts of the island have a more tropical climate. Nematchoua et al. (2018) identified five distinct types

of climate across 16 regions of Madagascar. These include *transition tropical,* primarily located in the northern regions; *humid tropical,* prevalent in the North and East; *hot and semi-arid,* predominant in the Southwest; *altitude tropical,* mainly observed in the Central Highlands; and *semi-arid tropical,* predominantly found in the eastern and central regions of the island (Ibid., 887). While the north and east experience the highest rainfall, partly due to heavy rain from tropical cyclones, (Barimalala et al. 2021, 4), in recent years, the dry season has been prolonged in areas with a humid climate (Nematchoua et al. 2018).

Madagascar's climate unpredictability may partially result from the combination of two phenomena: The El Niño Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). ENSO involves periodic sea surface temperature and air pressure fluctuations in the Pacific Ocean, affecting tropical atmospheric flow, while the IOD involves similar fluctuations in the Indian ocean. ENSO influences Madagascar's climate by causing warmer, drier conditions during austral summer-autumn if El Niño occurs, and wetter, cooler conditions if La Niña occurs. Additionally, IOD events affect local convection near Madagascar, leading to warmer, wetter conditions during positive IOD events, and the opposite during negative events (Kreppel et al. 2014).

Impacts of climate change are especially severe on islands, where important sectors are interconnected and thus highly vulnerable to climate-related threats (Weiskopf et al. 2021). An estimated five million people in Madagascar are "vulnerable to natural disasters such as cyclones, droughts and flooding" (Rakotobe et al. 2016). Climate change is causing such disasters to increase in both frequency and intensity, as well as reducing the reliability of seasons (IPCC 2023, Chapter 11, Working Group I, Sixth Assesment Report: The Physical Science Basis).

2.3 Historical and Contemporary Agriculture in Madagascar

During the precolonial period, the Malagasy population cultivated rice and owned small kitchen gardens, alongside growing manioc, sweet potatoes and corn on non-irrigated land. They also dug and maintained their own canals through a common law system (Gezon 2012, 128). For approximately three generations, Madagascar underwent a transformation driven by the "French dream of shaping the island and its people" according to French ideas and values. This period began with conquest and, between the First and Second World Wars, evolved into a process of integrating Madagascar into '*la plus grande France*'. Throughout the decades during and following the Second World War, the policies of the Malagasy government resembled those of other French colonies in an effort to fulfil the centralising vision of French policymakers (Randrianja and Ellis 2009, 155).

After the establishment of formal control by the French over Madagascar in 1986, the French government aimed to transform Madagascar into a settler colony by granting land concessions to French farmers. One objective was to increase the self-sufficiency of Diego Suarez, where a major military base was located (Gezon 2012, 128) and many French settlers had established themselves (Jackson 1971, 74). To achieve this, concessions were intended for the production of cash crops for export and others for a vegetable market to meet the needs of the French population in the region. Consequently, "exotic vegetables" such as carrots, cabbage, green peppers, green beans, aubergines, beetroots and potatoes were cultivated (Gezon 2012, 128). During this colonial period, Madagascar served as a source of raw agricultural and industrial materials for France (Jackson 1971, 70) and the majority of Madagascar's cash crop development was concentrated in the North of the island (Ibid, 74). Madagascar's annexation as a French colony in 1896 was characterised by war, resistance and famine, driving many people to flee to the forests

to live as shifting cultivators. This period led to the devastation and abandonment of irrigated, marsh, and rainfed rice fields (Jarosz 1993, 370).

Therefore, from the onset of colonial rule, Madagascar faced chronic rice shortages. Agricultural production became primarily geared towards exports, as the colonial state aimed to boost revenues and export goods to France and other markets in Europe and Africa, whilst also creating new markets for French products within the colony (Jarosz 1993, 370). During the colonial period, Madagascar's economy was therefore heavily reliant on imports, and the system of colonial preference abolished any form of competition for the French industry. Conversely, Malagasy coffee farmers were under constant pressure to increase production to sustain their income, while taxes paid to the state by Malagasy taxpayers subsidised French settlers. Additionally, Madagascar was obligated to receive imports primarily from France rather than potentially lower-cost options closer to the island, such as from South Africa or India (Randrianja and Ellis 2009, 170).

One technique used by colonial settlers to do business with smallholder farmers involved lending money to farmers at very high interest rates at the beginning of the growing season, leaving the recipient in debt after making his repayment following the harvest. Such methods prevented farmers from saving money or investing in new technology, "trapping them in a near-subsistence economy" (Randrianja and Ellis 2009, 168). This historical context underscores the complex relationship between colonial politics and agricultural practices, which has significantly shaped Madagascar's agricultural landscape (Jarosz 1993, 370).

Since the colonial era, European vegetables have been grown on Amber Mountain. This created a market for vegetables, which suffered a decline in the mid-1970s when most of the French left Madagascar (Gezon 2012). The diminished market for vegetables created risks for

those producing them, as "exotic vegetables" do not form an integral part of the northern Malagasy diet and that there is a correlation between higher income and vegetable consumption. This led to khat, "a shrub or tree whose leaves have been chewed for centuries" (Balint, Falkay, and Balint 2009, 604) for their stimulant effects, being welcomed as a substitute for farmers who were suffering from decreasing profits from vegetable farming (Gezon 2012, 130).

Khat was brought to Madagascar by Yemeni dock workers during the French colonial era at the turn of the 20th century and was initially cultivated as a cash crop by French-descended farmers who had settled in Madagascar (Gezon 2012, 127). As a crop, khat adapts well to local environmental conditions with an ability to withstand, to a certain extent, drought and frost, as well as having a root system useful for erosion prevention (Ibid, 132). Consequently, not only does khat provide an income for a much longer period than vegetables, which only provide an income every three to six months, but khat is also much less vulnerable to rainfall fluctuations, as well as less susceptible to infestations of pests (Ibid, 130).

Today, Madagascar stands out as a rice-based economy, with rice consumption per capita consistently ranking among the highest globally, with a majority of arable land dedicated to rice cultivation. Moreover, rice holds significant symbolic importance in Malagasy culture and politics (Minten and Barrett 2008). Rainfed agriculture, relying on rainfall as the primary water source for crop cultivation, serves as the main activity for over 80% of the Malagasy population (Desbureaux and Damania 2018, 358). Additionally, livestock, particularly zebu cattle, are of social, cultural and economic significance, as well as both a risk management and self-insurance coping strategy in the face of agricultural and climatic shocks (Hänke and Barkmann 2017).

Malagasy farmers typically prepare for the upcoming agricultural season by clearing new lands during the dry period from August to October, with agricultural activity peaking in

September. The primary crop planting season begins in December, with farmers harvesting in May and June, after which they typically plant a second crop that they then harvest between February and March (Desbureaux and Damania 2018, 361). Given the direct dependence on agriculture for their livelihoods, smallholder farmers are especially vulnerable to climatic shocks, with even slight reductions in agricultural productivity leading to significant impacts on food security and income. Farming constitutes the livelihood of approximately 70% of the Malagasy population, making it crucial to understand the vulnerability of farmers to climate-related risks (Harvey et al. 2014, 2).

2.4 Existing Research on Drought and Climate Change in Madagascar

Madagascar has been identified as one of the countries most affected by drought, given its frequent occurrence of approximately once every three years (Nhamo, Mabhaudhi, and Modi 2019, 79). There are several papers confirming the existence of drought in the South of Madagascar (Rigden et al. 2024, Makoni 2021, Harrington et al. 2022, Serele, Pérez-Hoyos, and Kayitakire 2020), which has the lowest water supply coverage in the country and faces significant vulnerability to drought, having experienced the first climate-driven famine (Rigden et al. 2024).

Indicators such as rainfall, soil moisture and vegetation greenness measured by metrics like Normalised Difference Vegetation Index (NDVI) reveal "long-term trends culminating in recent drought conditions in Southern Madagascar". This quantitative research is further supported by observations indicating changing patterns in the availability of water, which align with "climate change model simulations" (Rigden et al. 2024, 6). According to Rigden et al., (2024, 6) this evidence suggests that the seasonal hydroclimatology of southern Madagascar is being altered by anthropogenic climate change. Regional climate model outputs assessing the impacts of warming levels of 1.5 ºC and 2 ºC project a deficit in overall rainfall and wet spell days in the northern and

eastern regions of Madagascar, alongside an increase in the maximum number of dry spells (Barimalala et al. 2021, 1). The decline in rainfall is shown to be more pronounced in the eastern and northern regions of the island compared to the western and southern areas (Ibid, 4).

2.5 Impacts of Drought and Climate Change in Madagascar

Global climate change is expected to have significant impacts on populations, particularly those in "developing" countries, known as "smallholder farmers" (Morton 2007). This vulnerability is largely due to their typical location in tropical regions and limited adaptive capacity (Morton 2007). However, predicting such impacts is challenging due to the lack of standardised definitions for these farming systems, the complexity and specificity of their locations, and their susceptibility to various climate-related and other stressors (Morton 2007). While there is no single, universal definition of "smallholder agriculture", this is defined by Morton as "rural producers, predominantly in developing countries, who farm using mainly family labor and for whom the farm provides the principal source of income" (Morton, 2007, 1).

Chesney and Moran (2016) used the Climate Security Vulnerability Mapping (CSVM) 3.1 tool to highlight Madagascar's vulnerability to climate-related hazards. The island has been identified as highly exposed to climate related risks alongside other regions in Africa, such as parts of Somalia, Ethiopia and South Sudan. However, Sani and Chalchisa (2016) highlight the difficulty of predicting the impacts of climate change suffered by smallholder and subsistence farmers, given the unique nature of each local context. Despite the increase in quantitative studies of future impacts through methods like predictive modelling, such efforts risk concealing important climatic variability.

Climate change and agriculture are mutually influencing, with the effects of climate change on agriculture intensifying, particularly in "developing" countries. Rising temperatures and shifting precipitation patterns driven by climate change are increasingly leading to decreased crop yields (Sani and Chalchisa 2016). This threatens livelihoods and food security, leading to severe socio-economic and ecological impacts. Conversely, agriculture also exacerbates climate change, as droughts contribute to increased deforestation (Desbureaux and Damania 2018). Consequent tree cover loss not only diminishes Madagascar's natural resilience, but also contributes to rising greenhouse gas emissions and the loss of microclimates. The relationship between drought and deforestation will be further addressed in Section 2.5.2 on Ecological Impacts.

2.5.1 Socio-Economic Impacts

The vulnerability of Madagascar to drought and other disasters is increased by the significant poverty facing the population, with the island standing out as having one of the most severe poverty rates in Africa, with 81% of its population living below the international poverty threshold of $1.25 per day (PPP), while the per capita gross national income barely surpasses $430 (Harvey et al. 2014). Moreover, approximately 70% of the Malagasy population is living below the national poverty threshold, while around 50% are entirely reliant on natural resources for their subsistence (Cochrane et al. 2019). Due to their reliance on agricultural activities for their livelihoods, coupled with food insecurity and limited access to formal safety nets, Malagasy farmers face heightened vulnerability to "any shocks to their agricultural system". Pest outbreaks and extreme weather lead to significant losses in crop production and income, exacerbating food insecurity (Harvey et al. 2014, 1).

Several other factors contribute to the heightened vulnerability of Malagasy farmers to even slight declines in crop productivity (Ibid, 7), particularly because cultivation takes place on very small plots of land, predominantly used for subsistence farming and limited income generation. The low crop yields can be attributed to a variety of factors, including the limited use of fertilisers, pesticides, and improved seed varieties, coupled with the reliance on low-technology farming practices (Ibid, 7). In some areas, between 2012 and 2014, rice production had dropped by 75% (Nematchoua et al. 2018).

2.5.2 Ecological Impacts

Madagascar's geographic isolation and diverse climates make it a biodiversity hotspot, home to unique fauna and flora (Nematchoua et al. 2018), with approximately 90% of its species endemic to the island. Such exceptional levels of endemism and species diversity make Madagascar a critical priority for international conservation efforts (Goodman and Benstead 2005). However, this rich biodiversity and ecological significance are increasingly under threat, with the IUCN Red List assessments showing that overexploitation and unsustainable agricultural practices affect approximately 60% of vertebrate species and almost 90% of all plant species (Ralimanana et al. 2022).

Compounding these threats, Desbureaux and Damania (2018) have linked Madagascar's drought to deforestation, finding that droughts have led to a significant increase in deforestation, particularly in areas with a high baseline of water stress. They found that droughts resulted in an increase in deforestation by 7.6% on a national scale and 17% in the semi-arid South. Rainfall during the growing seasons directly affects yields and may influence deforestation rates in the subsequent growing season (Ibid, 361).

According to the study conducted by Desbureaux and Damania (2018), insufficient rainfall during February and March, characterised by the peak in the traditional rainy season and the growing period of primary crops, was followed by notably more forest clearing in subsequent months. Similarly, rainfall shocks during June and July (the beginning of the secondary planting season) were also linked to increased deforestation. This demonstrates how reduced yields driven by drought during the growing season led farmers to expand cropland through deforestation during the following agricultural season to compensate for diminished production (Desbureaux and Damania 2018, 361). Deforestation-induced habitat loss remains high, with studies suggesting that there may have been a forest cover loss of 50% between 1950 and 2005 across Madagascar (Ibid, 358).

Not only do deforestation and consequent habitat fragmentation threaten important biodiversity and ecosystems, but they also reduce the island's natural resilience to climate change and related disasters (Hannah et al. 2008, 590). Furthermore, given that forest biomass has a higher resilience to "short-term rainfall fluctuations" than crop production, forest resources can offer a "crucial safety net for poor rural households" during disasters such as droughts and floods (Desbureaux and Damania 2018, 357). This illustrates a troubling paradox: as the need for safety nets increases amid more frequent droughts, the occurrence of deforestation rises, further threatening their availability.

2.6 Disaster Risk Management

Disasters are defined by the IPCC as "severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects

that require immediate emergency response" (Intergovernmental Panel on Climate Change [IPCC] 2012, 5). Importantly, this definition underscores the interplay between physical hazards and social vulnerability. As highlighted in the introduction, there is a well-established argument that disasters are not "natural" but "socially produced" (Bonilla 2020, 1), which will be further addressed in Section 3 on the Theoretical Framework. It is crucial to recognise that disasters arise not solely from physical hazards, but from their interaction with pre-existing vulnerabilities and exposure within a society, leading to diverse impacts across different sectors.

Yekeen et al. (2020) identified four phases of disaster management: preparedness, prediction, damage assessment and rehabilitation, which are in turn divided into primary and secondary forms of management. Primary disaster management phases include mitigation and introducing corrective action, while secondary phases include mitigation and preparedness, as well as response and recovery. The forecasting of disasters usually works in tandem with an Early Warning System, which constitutes an information tool used for disaster prediction and to promptly communicate warning information regarding severe events or disasters. Early Warning Systems tend to consist of several key elements, including "risk knowledge, monitoring and warning, dissemination of information, and response capabilities" (Ibid, 4).

The slow onset and complex characteristics of drought, coupled with its varied origins and occurrence across "different temporal and spatial scales" (Nhamo, Mabhaudhi, and Modi 2019, 75), render it challenging to detect its duration or termination (Ekundayo, Abiodun, and Kalumba 2022). Consequently, it is especially difficult to forecast, monitor and manage (Nhamo, Mabhaudhi, and Modi 2019). Alerting affected communities via Early Warning Systems can significantly contribute to minimising the impact of disasters. For instance, Rakotobe et al. (2016, 117) conducted a study to investigate preparatory actions taken by smallholder farmers in the case

of cyclone Giovanna. Such actions included storing clean water and food, moving livestock to secure locations, moving rice seeds to avoid flood damage and using sandbags to secure the roof, demonstrating disaster risk reduction at the household level.

The use of geospatial technology is a key element of disaster management through its provision of "risk modelling and vulnerability analysis", enabling "effective early warning and damage assessment (Yekeen, Balogun, and Aina 2020). The three common categories of drought monitoring indicators include rainfall-based indicators, vegetation index-based indicators and model-based indicators (Senay et al. 2015). Geospatial methods typically used for the monitoring of meteorological drought include "Water Requirement Satisfactory Index (WRSI), Standardised Precipitation Index (SPI), Normalised Difference Vegetation Index (NDVI), and Weather/Seasonal Rainfall Forecasts" (Nhamo, Mabhaudhi, and Modi 2019, 82).

2.6.1 Existing Coping Mechanisms and Risk Management Strategies

Alderman and Paxson (1992) distinguish between *risk management* and *risk coping* strategies. *Risk management* entails taking proactive measures to mitigate the impact of risks. An illustrative example they provide is crop and field diversification (Alderman and Paxson 1992), where farmers have alternative income sources in the case of crop failure. In contrast, *risk coping* strategies involve dealing with risks after they occur. This might involve balancing consumption over time to mitigate the impact of future income shocks or distributing the burden of risks across households (Alderman and Paxson 1992). This could manifest through communal resource sharing or mutual aid within communities during times of crisis. However, the distinction between the two types of strategies can often become blurred, given that initial coping strategies may evolve into adaptions or risk management strategies for households or entire communities (Morton 2007).

Sani and Chalchisa (2016) outline several adaptation strategies and coping mechanisms adopted by farmers in sub-Saharan Africa. In drought-sensitive regions, this includes replacing water-intensive crops with low water-requirement crops, while in flood-prone areas, farmers typically plant short-duration crops and adjust planting and harvesting times to avoid peak rainfall periods. Additional strategies include crop diversification, adjusting planting dates to align with changing precipitation patterns, engaging in alternative income-generating activities, employing various water conservation methods, and digging boreholes. However, it is important to acknowledge that this is not an exhaustive list of strategies and that there is significant variability both between and within countries across sub-Saharan Africa.

Where there are severe water shortages, groundwater becomes a necessary alternative and in some areas is the only reliable fresh water source. However, this can be difficult to access, with the success rate of drilling productive wells remaining at 30-50% due to hydrogeological complexity, high salinity of groundwater and lack of information and capacity within the drilling sector (Serele, Pérez-Hoyos, and Kayitakire 2020, 1404). Therefore, not only is it expensive to drill wells, but it is necessary to drill two wells, on average, to have one that is productive. This exacerbates the scarcity of an already limited resource, highlighting the urgent need for improved technology, capacity-building, and information transfer. Such projects are already underway, as UNICEF and the European Union delegation in Madagascar have collaborated on a project employing satellite imagery to enhance sector knowledge and ensure access to safe, clean water for communities in southern Madagascar (Ibid).

Alongside these more informal risk management and coping strategies, there are several formal safety nets such as cash transfers and weather-index insurance programs, which have been shown to significantly enhance development and the resilience of farmers to droughts (Desbureaux

and Damania 2018, 363). However, drought management efforts are complex and typically rely on post-disaster relief aid as opposed to "proactive resilience building" (Nhamo, Mabhaudhi, and Modi 2019, 76). While there are several risk-coping strategies used by farmers, these are insufficient to protect them from food insecurity (Harvey et al. 2014). Limited resources and capacity have prevented farmers from adapting their farming strategies in response to climate change. Harvey et al. (2014) highlight the urgent need for technical, financial and institutional support to enhance the resilience of Malagasy farmers to disasters and climate change.

2.7 The Research Gap: Drought in Northern Madagascar

While numerous studies have investigated drought conditions in southern Madagascar, as established above, the topic remains largely unexplored in the northern regions of the island. To date and to the best of my knowledge, there is a complete absence of research addressing the existence and specific impacts of drought in northern Madagascar, despite its critical importance. There are several possible reasons for this research gap. Firstly, drought is a complex disaster with varying definitions and perceptions, making it difficult to identify. Secondly, southern Madagascar has been experiencing severe and prolonged drought conditions for many years, making it a more obvious and urgent focus for researchers.

However, as a region with a tropical climate that traditionally receives reliable and abundant rainfall, the impacts of climate change on northern Madagascar hold particular significance for the island's overall vulnerability to disasters. In contrast to the southern regions, populations in the North are facing these challenges for the first time and at a rapid pace, hindering their ability to develop adaptive strategies and coping mechanisms. This represents a critical research gap, as

understanding the unique challenges faced by northern Malagasy communities can inform more effective and region-specific adaptation strategies.

2.8 Conclusion

This literature review has explored the multifaceted problem of drought in Madagascar, identifying the various types of drought and their socio-economic and ecological implications. It has underscored the Madagascar's vulnerability to climate change and disasters, with drought research predominantly concentrated on southern regions and a critical research gap on the topic in the North. Furthermore, this review has highlighted how the island's colonial history has shaped contemporary agricultural practices. Finally, it has outlined the various formal and informal disaster risk management strategies used to mitigate the impacts of disasters, while also acknowledging their limitations.

This thesis contributes to the literature on the socio-economic impacts of disasters on the Malagasy population, with a specific focus on smallholder farmers in northern Madagascar. The findings are also highly relevant to climate change literature, highlighting how the changing Malagasy climate appears to be largely driven by climate change. Moreover, common coping mechanisms like deforestation for charcoal production exacerbate greenhouse gas emissions and biodiversity loss, as well as contributing to the loss of microclimates. This underscores the urgent need for improved disaster risk management and emphasises the critical importance of addressing regional disparities in research on disasters and climate change. Integrating historical contexts into contemporary strategies and developing an understanding of existing disaster risk management strategies is essential to enhancing Madagascar's resilience to disasters.

3 THEORETICAL FRAMEWORK

This chapter introduces the theoretical framework underpinning the thesis, which is grounded in decolonial theory using two primary theoretical lenses: disaster coloniality and epistemic injustice. These perspectives provide the theoretical framework guiding my research questions, which aim to examine how power relations and colonial legacies influence who is granted the epistemic authority to identify disasters and their impacts in Madagascar and how this affects the identification and management of disasters. Disaster coloniality addresses the notion that disasters are not "natural", but rooted in colonial histories, which shape contemporary disaster management practices, particularly in the context of a former colony like Madagascar. Epistemic injustice, on the other hand, addresses the question of whose knowledge is considered valid and who has the authority to make decisions, which is influenced by the coloniality of knowledge. Such a framework, I argue, is also crucial to an ethical research practice. As a Western researcher, adopting a decolonial approach is essential when engaging with marginalised communities in a former colony. Disregarding the inherent coloniality of Western research and knowledge systems would risk perpetuating the very injustices I aim to deconstruct.

The following section is structured into several subsections. It begins with an introduction to coloniality, followed by an explanation of the concept of epistemic injustice. Next, it briefly introduces the "banking" and "problem-posing" concepts of education as proposed by Freire (2012) and presents a decolonial perspective on remote sensing. Finally, I propose a novel perspective on what constitutes disaster risk and provide an introduction to the concepts of disaster coloniality and disaster colonialism.

3.1 Understanding Coloniality

Before delving into decolonial theory, it is useful to establish the meaning of coloniality and differentiate it from colonialism. This distinction is well articulated by Nelson Maldonado-Torres, who defines colonialism as a "political and economic relation in which the sovereignty of a nation or a people rests on the power of another nation" (Maldonado-Torres 2007, 243). This formed part of the modernist project, which involved the European exploration and "discovery" of other worlds, expanding trade, establishing colonies, and systematically colonizing indigenous peoples during the eighteenth and nineteenth centuries. How knowledge was produced, alongside ideas about the nature and validity of specific forms of knowledge, became commodities of colonial exploitation, much like other natural resources (Smith 1999, 59). Thus, colonialism encompasses not only how Western authority is imposed over indigenous lands, modes of production, law and government, but also over all aspects of indigenous knowledges, languages and cultures (Ibid, 64).

In contrast to colonialism, coloniality refers to enduring power structures that originated from colonialism but continue to shape contemporary culture, labour, intersubjective relations and knowledge production far beyond the formal end of colonial administrations (Maldonado-Torres 2007, 243). Aníbal Quijano emphasises that, while the "racial axis" (hierarchy) of subordination was established within the matrix of colonialism and has a colonial origin and character, it proves to be more enduring than colonialism itself (Quijano and Ennis 2000, 533). Colonialism is thus outlived by coloniality, which manifests as the present-day traces of colonialism deeply embedded in knowledge systems, social hierarchies and power relations (Maldonado Torres 2007).

Maldonado-Torres (2007) introduces the concept of the "coloniality of Being", which he posits as primarily concerning the normalisation of "extraordinary events that take place in war". In essence, he contends that within modernity, the unethical and perverse acts of war are

legitimised through the colonial framework and the construct of race. A contemporary example of this would be how the disproportionate impact of disasters on marginalised communities is normalised through the term "natural disaster", which conceals the underlying injustices and coloniality that transform a "natural hazard" into a disaster. Grounding his conceptualisation in Martin Heidegger's exploration of ontology and Being (Heidegger, 1962), Maldonado-Torres (2007, 252) adapts the Cartesian formulation of "cogito ergo sum" ("I think, therefore I am") to: "I think (others do not think, or do not think properly), therefore I am (others are-not, lack being, should not exist or are dispensable)".

Here, he establishes an important link between the coloniality of knowledge and the coloniality of being, arguing how the Cartesian formulation could be construed as "the coloniality of knowledge (others do not think) and the coloniality of Being (others are not)" (Maldonado-Torres 2007). One alleged trait of "primitive" peoples was thus their presumed lack of intellectual capacity and creativity, rendering them incapable of inventing or producing anything of value. This perception not only excluded them from civilisation, but also from humanity itself, as they were not regarded as "fully human", while some were even viewed as less than partially human (Smith 1999, 25). Grounding this thesis in decolonial theory helps to reveal how historical injustices continue to shape present-day research and politics, manifesting in contemporary knowledge systems, environmental injustices and power relations, which frame marginalised groups as both intellectually and existentially inferior.

3.2 Epistemic Injustice

The coloniality of knowledge is inextricably tied to the concept of *epistemic injustice*, whereby the knowledge of individuals is undermined or perceived as inferior on the basis of their

identity. This sub-section will primarily be concerned with epistemic injustice theory developed by two leading scholars in the field: Miranda Fricker (2007), who coined the term *epistemic injustice* and José Medina (2013), who introduced the *epistemic vices* and *virtues.*

Miranda Fricker introduces two forms of *epistemic injustice*: *testimonial injustice* and *hermeneutical injustice*. This thesis will focus on *testimonial injustice*, which is characterised by a speaker's credibility being unfairly diminished due to prejudice (Fricker 2007, 1) and how individuals are "wronged in their capacity" as knowledge givers (Ibid, 7). Marginalised and "systematically disadvantaged" people often face unfair depictions as intellectually inferior, being misrepresented as lacking particular cognitive abilities, or simply being granted less authority and credibility compared to members of other groups (Medina 2013, 27-28). Marginalised peoples face multiple epistemic disadvantages, including limited access to information and educational institutions, as well as diminished credibility and authority (Medina 2013, 29).

In contrast, privileged groups benefit from greater access to information and educational institutions and enjoy enhanced epistemic authority and credibility (Medina 2013). Western researchers, myself included, tend to belong to this privileged group. Conversely, marginalised communities are perceived as voiceless and devoid of life force, humanity or spirit, rendering them unable to contribute to the production of research or science. Instead, they are viewed as mere objects of research (Smith 1999, 61). Smith (1999, 1) emphasises that the very concept of "research" is deeply intertwined with European imperialism and colonialism, as the globalisation of knowledge and Western culture constantly reinforces the West's self-perception as the centre of legitimate knowledge and the authority on what counts as knowledge (Ibid, 61).

While it is true that privileged elites typically enjoy epistemic advantages and oppressed subjects generally face epistemic disadvantages, the situation is often more nuanced. Privileged elites also encounter certain epistemic disadvantages or "blind spots", which are characterised by Medina (2013) as "epistemic flaws" embedded in the character of individuals belonging to the privileged elite. He refers to such flaws as "epistemic vices", which he defines as a "set of corrupted attitudes and dispositions" that obstruct the acquisition of knowledge. Conversely, an "epistemic virtue" involves attitudes and dispositions that "facilitate the acquisition and dissemination of knowledge" (Medina 2013, 30).

Medina questions whether cognitive benefits enjoyed by elite members of society, such as "the privilege of knowing", "always being heard as a credible speaker" or possessing "cognitive authority", could lead to some individuals becoming "epistemically spoiled" (Ibid). He highlights that the "epistemically spoiled" often find it more difficult to learn from their mistakes and biases, which are shaped by their perspective and position in the world (Ibid). This can result in a "credibility excess" (Fricker 2007), leading some individuals to consider themselves "cognitively superior" (Medina 2013, 31). This exaggerated self-perception leads to the first "epistemic vice", which Medina terms "*epistemic arrogance"*(Ibid).

Another epistemic disadvantage of the privileged elite is their lack of necessity to know, which leads to ignorance. For instance, individuals possessing significant power can sometimes be unaware of the "violence committed to maintain their privilege" (Ibid, 33). The second epistemic vice, which results from this privilege of "not needing to know", is an absence of curiosity about certain aspects of life they have "learned to avoid" or not concern themselves with. This is referred to by Medina as "*epistemic laziness*" (Ibid). The epistemic vices of laziness and arrogance together undermine an individual's potential to learn and contribute to knowledge (Ibid,

34). This not only negatively impacts the cognitive perspective of the individual, but also affects those around them and "the social knowledge that becomes available or unavailable to the relevant communities". Arrogance and laziness both support and reinforce each other, "individually contributing to the deterioration of the epistemic character of the subject and jointly producing epistemic injustices that ultimately affect all members of society" (Ibid).

In addition to the epistemic ignorance resulting from luxury, there is also "ignorance out of necessity", which Medina describes as a need "not to know". This type of ignorance functions as a "defense mechanism […] used to preserve privilege", leading to "closed-mindedness" (Ibid). Blindness to social violence can be produced by epistemic laziness, but also by a deliberate effort not to see, a common trait among the privileged who tend to be ignorant to the oppression sustaining their privilege (Ibid, 35). This is exemplified by the perception of disasters as "natural" rather than "socially produced" (Bonilla 2020, 1), as this enables the privileged to evade responsibility for how the oppression upholding their privilege contributes to the creation of the disasters that they label as "natural". The three epistemic vices of arrogance, laziness, and closed-mindedness contribute to producing "*active ignorance"* (Medina 2013, 39).

Actively ignorant subjects are responsible not only for their lack of specific knowledge, but also for their epistemic attitudes and behaviours that perpetuate and sustain ignorance. These individuals are either unconsciously or deliberately at fault for their complicity with epistemic injustices that uphold and contribute to oppression. It is worth noting that belonging to the socially privileged does not immediately cause an individual to possess these vices, and such vices can also be found among the oppressed (Ibid, 40).

While it is important to avoid romanticising the epistemic situation of the oppressed, who face many epistemic disadvantages that reinforce their oppression, they may also possess certain epistemic advantages or "virtues" (Ibid, 41). Medina highlights three epistemic virtues: humility, curiosity and open-mindedness, which constitute the exact opposite of the epistemic vices of the privileged (Ibid, 42). First, epistemic humility enables an individual to recognise their cognitive gaps and how to fill them, thereby enhancing learning processes and overall cognitive improvement (Ibid, 43). Second, "epistemic curiosity" or diligence may arise out of the need for certain types of knowledge in order to escape stigmatisation or even to survive (Ibid, 44). This enables oppressed subjects to extend beyond the confines of their own perspective, leading to the third epistemic virtue of "open-mindedness". Oppressed subjects typically feel the need to be more attentive to other perspectives, often being encouraged or even obligated to observe reality not only through their own eyes, but also through those of whose perspectives and social positions "matter more" (Ibid, 44).

When writing about the epistemic virtues and vices of the oppressed and the privileged, it is essential to acknowledge the intersectionality of oppression, where individuals in different social positions experience oppression in unique ways, often accumulating diverse sets of experiences and collectively developing a unique combination of cognitive strengths and weaknesses (Ibid, 45). Consequently, oppression should be understood not as a dichotomy between the oppressed and the oppressor, but as a spectrum, where an individual can simultaneously be oppressed and an oppressor (Freire 2012, 45). Therefore, we cannot and should not generalise about a single epistemic perspective for the oppressed or the oppressors (Medina 2013, 45), as oppression has distinct impacts on differently situated subjects.

Epistemic injustice theory sheds light on the devaluation of knowledge from marginalised groups and questions the perceived superiority of Western knowledge. Recognising and integrating local perspectives through ethical research practices is essential to identifying disaster risk and enhancing adaptation strategies. By addressing testimonial injustice and prioritising the knowledge of marginalised groups through qualitative methods, this thesis underscores the importance of valuing local knowledge in disaster risk management.

3.3 The Banking Concept vs Problem-Solving Education

The "banking concept" of education is introduced by Paulo Freire as an "instrument of oppression" (Freire 2012, 7), typical in Western educational systems. In this model, the teacher acts as the "narrating Subject" while the student is merely a "listening object". The teacher's role is to deposit information, effectively transforming students into passive "containers" to be "filled" with the knowledge of the teacher. Freire highlights: "In the banking concept of education, knowledge is a gift bestowed by those who consider themselves knowledgeable upon those whom they consider to know nothing" (Ibid, 72). The "banking concept" of education demonstrates how epistemic arrogance manifests in the Western educational system, where knowledge is regarded as a one-way transfer to be memorised, stored and repeated. Conversely, the "problem-posing" concept of education is a dialogical approach, where the teacher-student roles are dissolved, and they become co-producers of knowledge rather than depositors and recipients of information (Freire 2012).

3.4 A Decolonial Perspective on Remote Sensing

As established in the literature review, remote sensing and the use of satellite imagery can be crucial to developing effective Disaster Risk Management strategies. Climate change and the rising occurrence and frequency of disasters is making such technology increasingly important, particularly in terms of monitoring and forecasting disasters. However, the rising prominence of GIS technologies in disaster risk management also means it is more important to critically examine and reflect on how we use them. For instance, when examining the use of satellite mapping from a decolonial perspective, it is useful to acknowledge the historical role of maps. As highlighted by Penelope Anthias, maps were used in imperial cultures to establish racialised boundaries between the colonised and coloniser (Kent and Specht 2023, 110), converting a "potential world of human relations into one of permanent forms of conquest, colonialism, and war" (Maldonado Torres, 2016, 12). The colonial history of maps raises questions about the coloniality behind remote sensing, a research method using satellite imagery that makes it possible to map the Earth from space.

Although remote sensing data is often presented as objective, Bennett et al. (2022, 730) highlight how this conceals the "wider subjectivities and situatedness of all remotely sensed data", raising questions of who has access to and control over the data, as well as for what purposes and for whom the data is utilised. This is further questioned by Turner and Taylor (2003), who underscore how our increased reliance on GIS technologies may "obstruct our understandings of the material and nonmaterial relationship of human societies with their environments" (177-178). It is important to recognise that relying solely on GIS and remote sensing technologies can distance us from the realities on the ground. While highly useful, they only offer a snapshot or "bird's eye perspective" of complex environmental processes, often overlooking the interconnected social,

economic and political dynamics. Although these methods can greatly enhance disaster risk management practices, it is crucial to supplement them with qualitative, in-situ data from the perspective of the affected communities. While they might provide us with data and figures, "quantifying the damage is not the same as understanding what survivors need, which is where our focus should be" (Montano 2021, Location No. 355).

3.5 Disaster Risk

Figure 1 below, adapted from (de Brito, Evers, and Höllermann 2017), provides a visual representation of what constitutes disaster risk through the lens of disaster coloniality. This diagram emphasises that disasters are not "natural" or random occurrences. Instead, they result from the combination of a hazard with other factors, namely vulnerability, exposure and coloniality. Bonilla (2020, 1) underscores that social and environmental vulnerability is not natural, but rather a "product of racio-colonial governance". To further clarify this and to avoid downplaying the role of coloniality in producing disasters, I introduce coloniality as a distinct factor.

This does not imply, however, that coloniality is separate from the other three factors, but rather that it is too significant to be considered just a "type" of vulnerability or exposure and constitutes a factor in its own right. Nonetheless, it is crucial to recognise that these four factors are interconnected and mutually exacerbating. This diagram demonstrates that a hazard, such as drought, is not inherently a disaster but rather one of several factors that contribute to the occurrence of a disaster. This diagram highlights the multi-faceted dimensions of disaster risk by illustrating that, while a hazard may be induced by natural processes, the disaster itself is shaped by human factors.

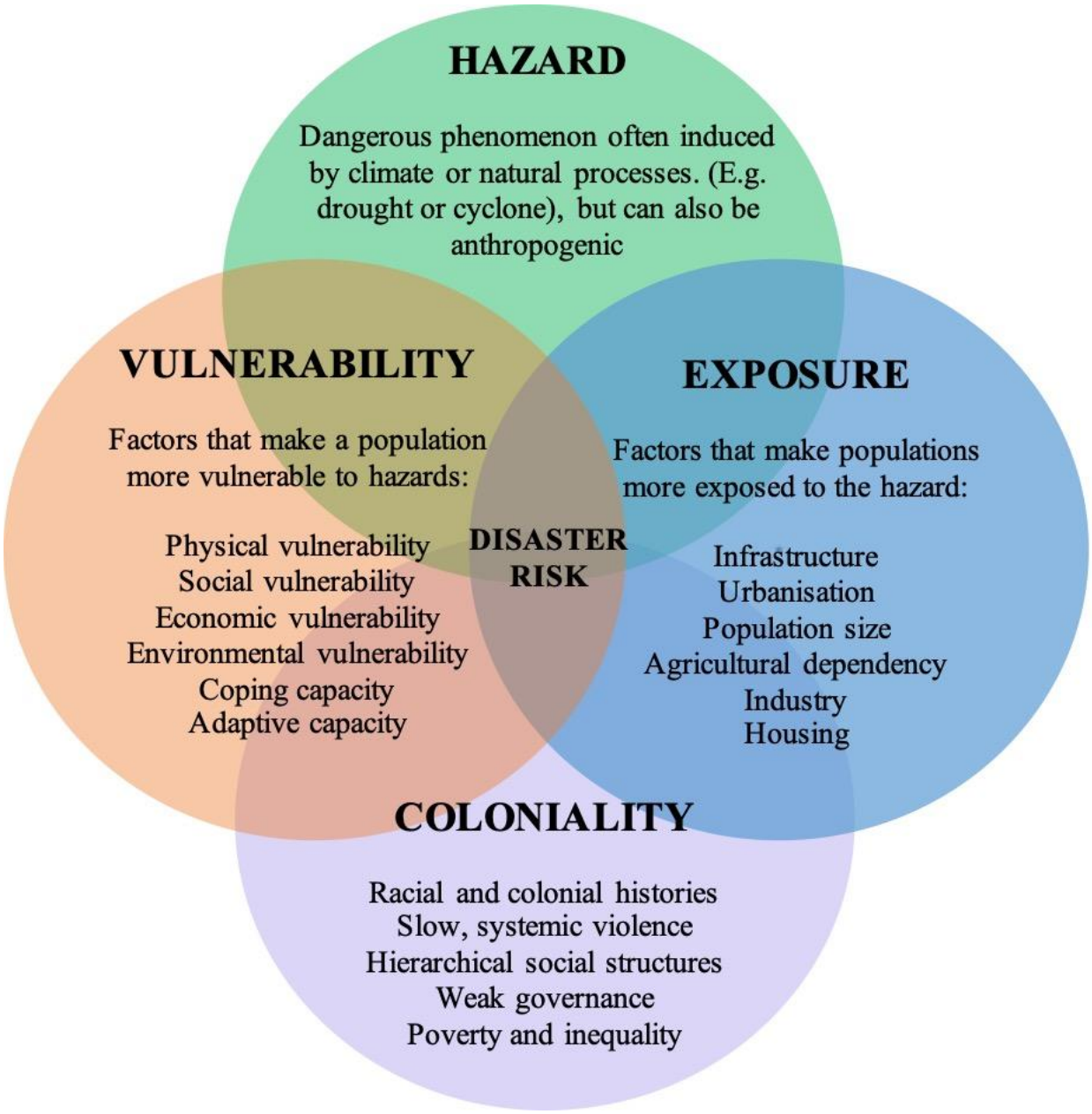

Figure 1: Disaster Risk Diagram (adapted from de Brito et al. [2017])

3.6 The Coloniality of Disaster

Malcom Ferdinand, in his book *Decolonial Ecology* (2022), uses Noah's ark as a "political metaphor" that reflects humanity's response to the ecological crisis. Here, he introduces the concept of a "*politics of boarding*", raising the fundamental question of who is rescued and who is abandoned (Ferdinand 2022) in the face of this crisis. However, the ecological crisis is neither singular nor purely ecological. It is a complex series of interconnected crises that expose deeply rooted injustices, revealing how centuries of oppression, inequality and colonial exploitation culminate in the form of (non)natural disasters. Disasters are not random acts of nature; they unmask systemic biases. This is vividly portrayed by Samantha Montano (2021, Location No. 394) through the narrative of Hurricane Katrina as one of "racism, classism, incompetence, corruption, and indifference spun around in a hurricane that left lifeless bodies floating down Main Street". Failing to acknowledge that disasters are "socially produced" (Bonilla 2020, 1) and viewing them as isolated events overlooks the systemic racial violence and dispossession perpetuated across multiple disasters (Rivera 2022).

Rivera (2022) introduces the concept of "*disaster colonialism"*, which concentrates on how disasters and vulnerability are exploited as tools to deepen coloniality by reinforcing existing colonial power structures through systemic vulnerabilities and inadequate responses. García López (2020, 1) describes the colony as a space of neglect, disposability, intentional exploitation, killing and *letting die*. This structural neglect and necropolitics are inherent in contemporary disaster management. As underscored by Montano (2021), the creation and management of disasters constitute political decisions. Rivera (2022, 126) further highlights the political dimensions of disaster management, emphasising that inadequate disaster planning is often used as a tool to displace and disenfranchise marginalised communities. Therefore, the conventional disaster

discourse that frames disasters as “acts of God”, “twists of fate”, or “freaks of nature,” obscures their deliberately orchestrated nature (Montano 2021, Location No. 394). It is neither accidental nor coincidental that those who suffer the most severe consequences of disasters are often the most marginalised.

While “*disaster colonialism”* focuses on how disasters are deliberately orchestrated to deepen coloniality, the “*coloniality of disasters*” (Bonilla 2020) concentrates on how disasters amplify existing inequities rooted in colonial and racial histories. This concept aligns with Maldonado-Torres’ (2007) definition of coloniality as enduring power structures that originated from colonialism and continue to shape society, culture and knowledge systems. The concept of disaster coloniality thus illustrates how disasters exacerbate the inequalities perpetuated by these enduring colonial structures that originated from colonialism. García López (2020, 1) highlights how the coloniality of disasters transforms colonial zones into necropolises— “spaces-regimes governing life and death where life is expendable”. He characterises these dynamics as foundational to the structures that exacerbate the damage inflicted by disasters on “colonized-racialized subjects”. The coloniality of disasters recognises how disasters reveal the enduring power relations and colonial structures that were established during the colonial era. Such colonial structures dictate whose voices are heard and whose are silenced, ultimately determining who survives and who is deemed expendable.

This thesis is primarily concerned with how disaster coloniality is exacerbated by the coloniality of knowledge and epistemic injustice inherent in disaster risk management. The exclusion of local knowledge from the design and decision-making processes of disaster management practices constitutes a form of disaster coloniality, undermining empowerment and reducing affected communities to “victims” devoid of agency. Returning to Ferdinand’s metaphor

of Noah's Ark, moving beyond disaster coloniality is not just a question of who is rescued or abandoned, but also who is granted the authority to determine who needs rescuing, from what, and how. It is more than repairing roofs and bridges in the aftermath of a cyclone. It is a matter of addressing the "deep inequities and long histories of dispossession that had already left certain populations disproportionately vulnerable to disaster" (Bonilla 2020, 10).

3.7 Conclusion

Through the lens of disaster coloniality and epistemic injustice, this thesis aims to uncover the influence of power relations and colonial legacies on the identification and management of disasters in Madagascar. The combination of decolonial and epistemic justice theory demonstrates how the devaluation of local knowledge systems and perceived superiority of Western knowledge is rooted in present-day coloniality. Therefore, this thesis seeks to uncover how epistemic injustice and disaster coloniality are mutually perpetuating and how they impact disaster risk management practices in Madagascar. More broadly, this approach emphasises the importance of qualitative research and the incorporation of local perspectives in the identification and management of disasters, whilst illuminating how coloniality persists in contemporary research methodologies and disaster risk management strategies.

4 METHODOLOGY

4.1 Introduction

This thesis initially set out to critically examine the efficacy of top-down versus local disaster risk reduction strategies in Madagascar, with a particular emphasis on drought and water scarcity in the Diana region. As the research progressed, it became apparent that drought in northern Madagascar is more of a contentious topic than anticipated. Many disaster risk experts denied the existence of drought in the North, indicating that it is solely present in the South. That the South of Madagascar undeniably faces severe drought and water scarcity is a well-documented and ongoing issue (Rigden et al. 2024, Makoni 2021, Harrington et al. 2022, Serele, Pérez-Hoyos, and Kayitakire 2020).

What emerged as particularly concerning, and thus became the primary focus of this thesis, is the transforming situation in the North. Previously recognised for its abundance of water and precipitation, the North of Madagascar is now experiencing significant local concerns about water access and observed changes in climate. This discrepancy in perceptions about water issues in northern Madagascar became my central interest in an attempt to explore varying perspectives and critically examine whose viewpoints are considered most valid and granted most authority. Therefore, this thesis primarily relies on qualitative research methods in order to capture a diverse range of perspectives. The data analysed was collected through 17 interviews, multiple informal conversations, and participant observations conducted over a period of 10 days in Diego Suarez, situated within the Diana region of northern Madagascar, as well as five days in the capital city, Antananarivo.

4.2 Selection of Research Site

Several compelling motivations influenced my choice of Madagascar as the research location. Firstly, Madagascar is recognised as one of the world's least developed countries (United Nations 2023), making it disproportionately vulnerable to disasters exacerbated by climate change. Despite this heightened vulnerability and the island's minimal historical contribution to global emissions, research on Madagascar, particularly concerning climate change adaptation, remains scarce. This lack of research hinders the nation's ability to effectively address and mitigate these worsening challenges.

Diego Suarez was specifically selected as the primary research location due to my collaboration with a local NGO, Azimut, which focuses on critical issues such as water, sanitation, and education - areas which are closely aligned with my research interests. After sharing my research proposal and expressing my desire to conduct the study in Madagascar, the director of Azimut enthusiastically supported the collaboration. They offered invaluable assistance in tailoring my interview questions to the local context and facilitated connections with relevant contacts, significantly enhancing the research process.

Moreover, due to its proximity to the equator, northern Madagascar experiences significantly higher levels of precipitation compared to the South, making it considerably "wealthier" in terms of both economic and natural capital (Minten and Barrett 2008, 18). However, despite this relative wealth, a questionnaire conducted in collaboration with Azimut prior to my travel to Madagascar revealed that the primary struggle of local populations in the Diana region is drought and the lack of access to water. This alarming finding raises concerns about the broader implications for the entire country, particularly given that one of the supposedly "tropical" regions is beginning to experience drought.

Another notable aspect of Diego Suarez, relevant to the theoretical framework of this thesis, is its historical significance as a French naval base during the colonial era, owing to its strategic port location. Consequently, the city still bears strong influence from French colonialism, with traces of this era highly visible today. This colonial legacy is evident in various aspects of the city's infrastructure, culture, language and relative wealth in comparison to other regions.

4.3 Data Collection

Although I had prepared research questions, as well as specific aims and objectives before entering the field, I approached the fieldwork with an open mind in order to truly understand the most prominent issues affecting the local population. This approach aimed to minimise initial biases or subjectivities. Therefore, my interviews were semi-structured and flexible, incorporating open-ended questions that allowed participants to speak freely and openly about the matters most pertinent to them. This method enabled me to gain a deeper understanding of the local situation. The open-ended questions were designed to guide the interviews, whilst ensuring that participants did not feel obligated to discuss specific concepts or themes, encouraging a more authentic and comprehensive dialogue.

My primary data was collected through a total of 17 semi-structured interviews, informal in-depth conversations, and participant observations during 15 days of fieldwork in April 2024, supplemented by a collaborative questionnaire conducted prior to my departure. Interviews typically lasted between 60-90 minutes, with some lasting longer. To ensure participants felt comfortable and able to speak freely, all interviews were conducted in familiar surroundings.

Participant observation included a field mission with the NGO to the municipality of Andranovondronina, where I conducted two of the 17 interviews with four local smallholder farmers. This combination of methods provided a comprehensive understanding of the issues faced by the local population. Another significant component of my research was attending the 2024 UN-SPIDER Conference in Bonn, focused on "Early Warnings for All." Held over a period of three days from 12th-14th March 2024, the conference featured presentations from various organisations and institutions. During the conference, I took extensive notes and engaged in multiple informal conversations about the role of remote sensing and its practical applications in implementing the Sustainable Development Goals, with a specific focus on forecasting and Early Warning Systems.

4.4 Question Design and Interview Structure

I developed three sets of questions for the semi-structured interviews (see Appendices), designed specifically for local smallholder farmers and community members, NGO experts, and experts working in government agencies with a focus on disaster risk. For local smallholder farmers, the questions aimed to uncover the main problems facing the local population from their perspective, as well as how they perceive, prepare for, and respond to these issues. For experts from NGOs and government agencies, the questions were also designed to identify the primary challenges facing local population from their professional viewpoints. Additional questions sought to investigate observed changes, particularly in relation to climate and their perceived impacts. Furthermore, experts were asked about the most prominent challenges they encounter in their work, any resistance they face, the response of their organisations or agencies to disasters, and the

existence and effectiveness of Early Warning Systems. Moreover, experts were asked what they believe would be most helpful in facilitating their work or the situation of the Malagasy population.

The interviews conducted in English were recorded and subsequently transcribed. For interviews conducted in Malagasy, I collaborated with a local researcher who translated the questions from English into Malagasy and acted as an interpreter during the interviews themselves, translating responses in real-time and facilitating follow-up questions. To ensure the comfort of the research participants, the responses during Malagasy interviews were recorded manually in a notebook rather than using a voice recorder, as the context did not always feel appropriate for audio recording.

4.5 Description of the sample

The research aimed to explore the disparity between local and top-down perspectives on the contentious issues of drought and water scarcity in Northern Madagascar, with a focus on the Diana region and specifically the port city of Diego Suarez. To achieve this, I conducted interviews with local smallholder farmers and experts in environmental and disaster risk management. Throughout this thesis, I refer to the smallholder farmers as "field experts" and professionals working in disaster risk management, NGOs, academia etc as "technical experts". This terminology aims to recognise the local knowledge of farmers as a legitimate form of expertise, thereby avoiding hierarchical categorisations among participants. In the same vein, the adaptive strategies and coping mechanisms used by the field experts in response to disasters can be understood to constitute informal disaster risk management.

Some of the interviews took place in groups, resulting in a total of 29 participants. The sample comprised 17 men and 12 women. Among the participants, nine were experts or affiliated with NGOs, 16 were local field experts (smallholder farmers), and four were environmental science students from Université Nord Antsiranana. Although most interviews took place in Northern Madagascar, two were conducted in the capital, Antananarivo. The rest of the interviews were conducted in Diego Suarez itself, nearby municipality Andranovondronina, local village Namakia and online. Most participants had lived in the region since their childhood, while others had resided there for several years.

In addition to the formal interviews, I engaged in multiple informal conversations, which helped to enhance my understanding of the local context. I was also invited to join a field mission with the NGO Azimut in Andranovondronina, where I attended a meeting with local representatives and experts from the water, health, and education sectors. This experience provided valuable insights into the participatory nature of Azimut's projects, stakeholder perceptions and interactions. Furthermore, it offered a deeper understanding of local governance structures and local associations. Table 1 provides an overview of the number of participants, their categorisation into expert, local farmer or student, and their respective interview locations.

Table 1 - Data Collection Participants

Interview Location	Technical Experts	Field Experts (Smallholder Farmers)	University Students	Total Participants
Antananarivo	2	-	-	2
Andranovondronina	-	4	-	4
Namakia	-	12	-	12
Diego Suarez/Antsiranana	4	-	4	8
Online	3	-	-	3
Total	9	16	4	29

4.6 Data Analysis

The data gathered from semi-structured interviews, informal conversations and fieldnotes were analysed using an open coding method (Strauss and Corbin 1990). Initially, I identified relevant concepts and themes within the data, which enabled me to recognise recurring themes and sub-themes. Subsequently, I created several tables categorising the interviews and responses to key questions, separating data from field and technical experts due to the distinct nature of the interviews and questions. This approach allowed me to compare and contrast the data, highlighting commonalities and differences between the perspectives of the research participants.

4.7 Limitations

The primary limitations of this research were related to the limited time available to conduct the study. This constraint was especially pronounced during my time in the capital, where the tight schedules of experts, coupled with city traffic and general delays, made it difficult to complete all planned interviews.

The language barrier also posed a significant challenge due to my limited proficiency in French and inability to speak or understand Malagasy. To mitigate this, a friend and local researcher from the Azimut network assisted by acting as an interpreter during interviews with local farmers. While this support was instrumental to my research and enabled me to interview participants who spoke neither French nor English, there is a possibility that some nuances of the conversation may have been lost in translation. Additionally, despite my trust in the interpreter's objectivity, some degree of subjectivity is inevitable in any translation process. Furthermore, interviews conducted in English may have also been slightly affected by imperfect English proficiency, potentially impacting the quality of the data. While I believe this impact to be minimal, it did pose significant obstacles to the extraction of direct quotes and their inclusion in the Results and Discussion. This is not only due to the language barrier, but it would have also led to the uneven representation of those interviews conducted in English. For this reason, most of the information from interviews is paraphrased.

Moreover, it is important to acknowledge that there are certain situations where recording interviews is either not possible or inappropriate for the setting. Consequently, not all of the interviews and conversations were recorded using the voice recorder, but instead were recorded manually in a notebook, to ensure that participants felt comfortable and able to speak freely. This

approach may have led to the loss of some information, but I deemed it necessary to maintain an environment conducive to open and transparent communication.

4.8 Research Ethics

This study adheres to the CEU Research Ethics Policy and Guidelines, ensuring that ethical standards are upheld throughout the entire research process. In line with my theoretical framework (see Section 3), the ethics of my research methodology were further guided by the principles of a "decolonising research methodology" approach designed by Keikelame and Swartz (2019) to challenge Eurocentric research methods that devalue the local knowledges and experiences of marginalised populations. In line with this, throughout the entire research process, I have remained mindful of my own positionality as a white, British researcher operating within the framework of the Western educational system. This required continuous self-reflection to recognise and acknowledge the influence of my perspective on observations and interpretations.

Conducting qualitative fieldwork from this positionality poses the risk of becoming implicit in the very system I aim to critique through my research and theoretical framework. To mitigate this, I was guided by the principles outlined by Keikelame and Swartz (2019), who identify five central tensions and structures deemed essential in a "decolonising research methodology". The first structure, power, is addressed through the concept of "*power with*" rather than "*power over*", emphasising equal power relations between researchers and research participants (Keikelame and Swartz 2019). To ensure this, all participants provided informed consent both before and after the interviews took place. All interviews were conducted in a safe environment familiar and comfortable to the participants, ensuring they felt at ease and in control. When interviews were recorded, participants granted explicit consent for the recording of the conversation. Similarly,

informed consent was solicited and obtained for any observational photographs taken, including those without human subjects.

To further ensure the concept of "*power with*", interviews and questions were framed to empower the participants, positioning them as the experts rather than research "objects". This approach avoided the use of Western academic terminology as much as possible, focusing only on what the participants felt comfortable sharing. The second principle underscored by Keikelame and Swartz (2019) was "trust", emphasising the importance of the cultivation of trust between the researcher and participants through a respectful and collaborative research practice. Consequently, interviews were framed in alignment with Freire's concept of "problem-posing" education (Freire 2012), where the research process is based on mutual respect, trust, and collaboration, shaped by common goals and values through the co-production of knowledge. This approach also reinforces the first principle of "*power with*" by focusing on equal power relations between the researcher and participants.

Additionally, recruitment procedures were collaborative and facilitated by the voluntary support of the NGO and local friends. Participants were never coerced into participation, and only those who demonstrated genuine willingness were included in the study". While the friend providing translation assistance volunteered out of enthusiasm and kindness as a fellow researcher and was unaware of any form of renumeration, she was thanked with an electronic tablet gifted from the researcher's mother-in-law's company. Spontaneous interviews were also conducted upon the willingness of research participants who had observed other ongoing interviews. No incompetent adults or children were involved in the research, and group interview participants were fully informed about the research beforehand and provided their consent. To mitigate any

potential risks, all participants remain anonymous, and any critical remarks made by participants about certain organisations were handled discreetly to avoid any consequences.

The third principle outlined by Keikelame and Swartz (2019, 4) is culture and cultural competence. In practice, this involved creating space for critical reflection through the interview questions, as well as analysing the responses of participants with careful attention to the cultural context. Additionally, participants may benefit from the research by shedding light on their struggles and potentially accessing findings that could improve their situation. This approach aims to address the epistemic injustice of disseminating knowledge in ways that lack relevance for the "original knowledge holders" (Keane, Khupe and Seehawer 2017, 13), aligning with the fourth principle of conducting a respectful and legitimate research practice (Keikelame and Swartz 2019, 4). This principle emphasises integrating ethical principles and ensuring research practices are "culturally appropriate." By adopting this approach, the research seeks to prevent knowledge outcomes from being confined to an elite community of Western researchers and aims to be beneficial to those who took the time to share their knowledge.

The final principle outlined by Keikelame and Swartz (2019, 5) is the recognition of individual and community assets. This involves a reorientation towards focusing on the strengths, capacities and resilience of marginalised communities rather than problematising them (Sweet et al. 2014). To achieve this, I designed my questions in a way that aimed to capture both the struggles faced by communities and the strategies they use to deal with and adapt to the changes in climate. However, it is also important not to over-idealise or romanticise traditional knowledge and local strategies (Chalmers and Fabricius 2007), which can transform certain terms like "resilience" into buzzwords. To avoid this, I aimed to create space for participants to freely express their perspective on their situation, acknowledging that there might not always be solutions.

An additional consideration throughout the duration of fieldwork was my personal safety. Madagascar is a country with a high poverty index and thus crime rates remain high. As a female researcher, gender-related risks were also taken into consideration. Interviews were conducted in safe spaces and I was mostly accompanied by a trusted local friend, who assisted with translation. Furthermore, general safety precautions were always considered, and I never entered any situations I felt were risky or had the potential to become unsafe.

5 RESULTS

The following chapter presents the results of my fieldwork in Madagascar, beginning with an overview of the study location, Madagascar's political structure, disaster risk management framework, and water management legislation. For purposes of clarity and to facilitate comparison, it is then divided into two sub-sections, initially focusing on the perspectives of field experts, followed by those of the technical experts. In the first sub-section, I discuss the changes observed by the field experts, including the recent phenomenon of drought, shifting rainfall patterns, water access and sanitation issues, agricultural impacts and cyclones, along with a timeline of these changes according to the participants. It is important to acknowledge that, although I present the different types of impacts separately, they are all deeply interconnected and mutually reinforcing. Subsequently, I examine the responses of the field experts to these changes, detailing their primary and secondary activities, strategies for dealing with water management and access issues, as well as agricultural and economic adaptations. Following this, I address the challenges faced by smallholder farmers concerning support and infrastructure, concluding with the primary needs they emphasised during the interviews.

In the second sub-section, I present the perspectives of the technical experts. First, I outline the changes they have observed, including the onset of drought, shifting precipitation and rainfall patterns, cyclones and climate change as a global phenomenon. Then, I examine the impacts and responses observed by the technical experts, including agricultural impacts, water access and sanitation, infrastructure, health issues, biodiversity and alternative income-generating activities undertaken by local populations, including smallholder farmers. Subsequently, I address the current disaster risk management strategies in both preparedness and response. Finally, I present

the responses of the technical experts in relation to the greatest challenges they face in their work, the most pressing issues facing the Malagasy population, and the improvements needed to mitigate these challenges.

The structure of this results section, starting with the perspectives of the field experts followed by those of the technical experts, contrasts the immediate realities of those directly impacted by climatic changes against the more technical perspectives of those working in relevant fields. Consequently, this section integrates two different kinds of expertise, whilst allowing the identification of similarities and disparities between the diverse types of knowledge.

5.1 Primary Study Location: Diego Suarez/Antsiranana, Diana Region of Madagascar

Formerly known as Diego Suarez, now officially named Antsiranana, the port city in the North of Madagascar is located in the Diana region, as shown below in Figure 2. Despite the official name change, it continues to be referred to by locals as “Diego”. The city was a popular location for the French during the colonial period, reflecting its historical significance and enduring colonial influence. Also situated in the Diana region is the Montagne D’Ambre (Amber Mountain) National Park, from which Diego Suarez sources the majority of its water.

Figure 2: Map of Study Area (Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community[2024])

5.2 Madagascar's Political Structure

Madagascar is divided into 22 regions (Interview 17). Each region contains multiple districts, which are further divided into communes (Interview 17). For instance, the Diana region has five districts, including one that consists of just one commune, which is Diego Suarez (Interview 17). Communes are governed by elected mayors, while district chiefs are appointed by the government (Interview 17). This can lead to potential tension if the mayor and district chief belong to different political parties (Interview 17). Typically, each district consists of one urban commune and several rural communes (Interview 17). Communes are then further divided into villages (fokontany), which also have their own chief, who have little power. It was highlighted by one technical expert that there is a significant lack of coordination across the different levels of governance (Interview 17).

5.3 Background of disaster risk management in Madagascar: The BNGRC

The Bureau National de Gestion des Risques et des Catastrophes (BNGRC)[1] serves as the central authority overseeing disaster risk management in Madagascar. This governmental organisation is responsible for all aspects of disaster risk, working across all stages of the disaster cycle, including forecasting, monitoring and response. BNGRC's mandate includes the coordination of various stakeholders, including government bodies, ministries, associations, and international agencies such as the United Nations (Interview 14).

Supporting BNGRC are four hierarchical committees operating at different administrative levels: regional, district, commune, and village. The regional committee, known as Comité de

[1] The National Office of Disaster Risk Management

Region de Gestion des Risques et des Catastrophes (CRGRC)[2], oversees regional disaster management efforts. The district-level committee, Comité de District de Gestion des Risques et des Catastrophes (CDGRC)[3], manages district-specific activities. At the commune level, the Comité Communal de Gestion des Risques et des Catastrophes (CCGRC)[4] takes charge, while the Équipe Locale de Secours (ELS)[5] functions as the local rescue team at the level of the village. Collectively, the BNGRC, these disaster risk committees, and other relevant organisations are integral to Madagascar's national disaster risk management strategy.

5.4 Water Management and Legislation in Madagascar

All Malagasy legislation in the water sector has been copied from the French legislation "without taking into account local communities' perceptions" (Interview 17). There are several different modes of managing water (Interview 17). This includes community-based management through an association of water users, as well as private management (Interview 17). The water sector requires a significant amount of money and is currently being financed by external and foreign partners, who tend to impose the private mode of management (Interview 17). While communes are also technically permitted to take charge of water management, they often lack the capacity to do so, and thus prefer delegating the management to the community or private sector (Interview 17). One technical expert highlighted that, although there are decentralisation structures in place, these are largely ineffective (Interview 17). Diego Suarez primarily sources its water from Montagne d'Ambre (Amber Mountain) (Interview 3), which is a national park located South of

[2] Regional Committee of Disaster Risk Management
[3] District Committee of Disaster Risk Management
[4] Commune Committee of Disaster Risk Management
[5] Local Rescue Team

the city (Antsiranana) in the Diana region of northern Madagascar, as pictured below in Figures 3 and 4.

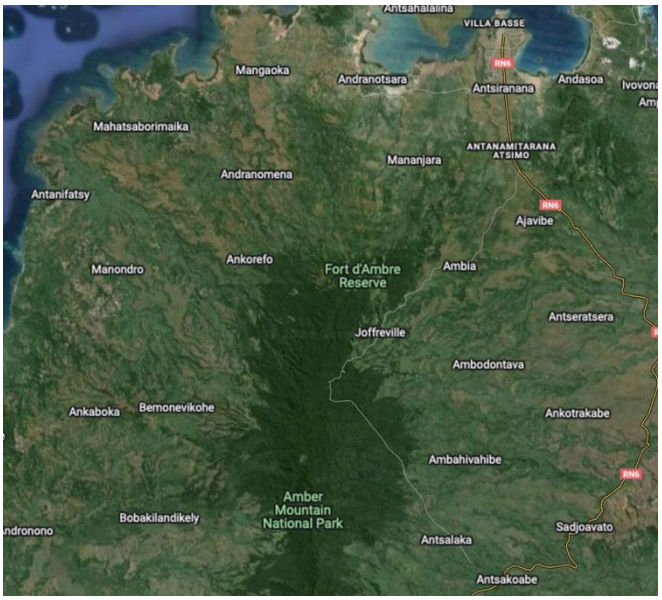

Figure 3: Location of Amber Mountain in the Diana region (Source: Google Earth Pro, [2024])

Figure 4: Waterfall in Amber Mountain (Photograph taken by the author, [2024])

5.5 Climate Change and its Impacts: Perspective of Field Experts (smallholder farmers)

The following section will describe the changes in climate and its impacts from the perspective of smallholder farmers. The focus for this section will thus solely be on the interviews conducted with field experts. Participants were asked if they had experienced any changes in weather and to identify the types of changes they have observed. Their responses highlighted several key themes, including drought and rainfall patterns, water access and sanitation, agricultural impact and cyclones. Following a description of the changes and their impacts, I will present the adaptive and coping strategies undertaken by the field experts, as well as the primary needs they have highlighted.

5.5.1 Changes Observed

Given the diverse interpretations of drought and thus varying definitions, research participants were invited to provide their own definitions and perspectives of what drought means to them. Through qualitative research, each participant's definition captures unique dimensions and impacts of drought within their respective contexts and communities. Table 1 presents the multifaceted perspectives of field experts regarding the complex phenomenon of drought in northern Madagascar, as articulated by participants during formal interviews. The following definitions thus reflect a nuanced understanding of how drought is perceived and understood by those directly affected by its impacts. 15 out of 16 participants clearly indicated that the North of Madagascar, specifically the Diana region, is beginning to be impacted by drought. The response of one participant was unclear in relation to the presence of drought, but he did note that he has observed evident changes in climate from his previous work in the salt marshes (Interview 9). Most of the participants (14) included "no rain" or "lack of rain" in their definition of drought, with several also referring to reduced agricultural productivity as an indicator of drought (Interviews 5, 7, 10, 11).

Two field experts reported experiencing drought during both the rainy and dry seasons, with a significant reduction in rainfall over the past years, which has led to a reduction in crop productivity (Interview 4). This concern was echoed by two female field experts, who indicated that rice and banana cultivation has become increasingly challenging due to drought conditions (Interview 5). One field expert stated that drought conditions vary annually, with odd-numbered years typically experiencing drought and even-numbered years experiencing rainfall (Interview 7).

Two field experts suggested that such changes are occurring because people don't respect the local taboos, which is leading to the problem of water scarcity (Interview 4).

During Interview 8, three field experts highlighted that a severe drought two years ago resulted in significant losses in livestock due to a lack of vegetation. They noted that, while drought previously only affected the South of Madagascar, it is now "coming to the North" (Interview 8). Four female field experts indicated that they have observed significant changes in weather patterns, including reduced rainfall, higher temperatures and shorter rainy seasons (Interview 11). They stated that such changes have led to crop damage, income loss, difficulties accessing water and death of livestock (Interview 11). However, several participants emphasised that they had anticipated such changes, having witnessed first-hand shifts in their environment and having received warnings from previous generations (Interviews 8, 10, 11). Three participants also referred to biblical teachings about global destruction, indicating that the changes forecast in the bible are indeed unfolding and highlighting the inevitability of the "destruction of the world and nature" (Interview 8).

Table 2: Drought Definitions – Perspective of Field Experts

Interview No.	Location	Definition	Drought in the North?
Interview 4 (2 participants)	Andranovondronina	No rain.	Yes
Interview 5 (2 participants)	Andranovondronina	No rain or possibility to grow crops.	Yes
Interview 7	Namakia	When there is no rain and it prevents all crops from growing. When there is no rain and no fruits are produced.	Yes
Interview 8 (3 participants)	Namakia	No rain, no forests and no trees.	Yes

Interview 9	Namakia	Lack of rain.	Unclear
Interview 10 (3 participants)	Namakia		
Participant 1		Unfruitful years and crops don't produce well.	Yes
Participant 2		When it is supposed to rain, there is no rain.	Yes
Participant 3		No rain.	Yes
Interview 11 (4 participants)	Namakia		
Participant 1		No rain.	Yes
Participant 2		No rain.	Yes
Participant 3		Lack of food, as crops don't grow as well as expected.	Yes
Participant 4		No rain, lack of products and no food.	Yes

5.5.1.1 Drought and Rainfall Patterns

All participants reported major shifts in rainfall patterns, noting a significant reduction in both the occurrence and duration of the rainy season (Interviews 4, 5, 7, 8, 9, 10, 11). Traditionally, the rainy season occurred between October and April, but most field experts highlighted that this period has now shortened to an average of three months (Interviews 4, 8, 10, 11), with two indicating that it has shortened to a period of just one month (Interview 5). Additionally, the amount of rainfall during this shorter rainy season has decreased substantially, with many participants suggesting that there is no longer a distinct rainy season, but rather a cyclone season that brings about flooding (Interviews 7, 8, 10, 11). Changes in temperature were also noted, with participants reporting higher and more extreme temperatures than in previous years (Interview 8). Furthermore, several field experts lamented the loss of trees, highlighting that during their childhood the mountains were covered with forest and there was abundant rainfall. They indicated

that people from the South are coming to the North and destroying the forest, leaving the landscapes barren where the used to be forest (Interviews 7, 8). One field expert indicated that this lack of water and rain due to drought is killing both people and animals (Interview 7).

5.5.1.2 Water Access and Sanitation

Water scarcity, identified as a consequence of climate change, emerged as a critical issue, severely impacting agricultural activities as well as the ability to meet basic needs. Additionally, the lack of water has affected livestock, with many animals suffering or dying from the shortage of food and water (Questionnaire, Interviews 8, 10, 11). Participants also expressed concerns about the lack of access to clean water. Many reported having to drink dirty water, the same water used by their zebu, especially during the dry season when rivers dry up (Interview 8). Some field experts fetch water from distant wells with unclean pumps and, to avoid diseases, boil the water, though many consume it as is due to resource constraints and taste (Interview 7, 8, 9, 10, 11).

The results gathered through the questionnaire conducted in collaboration with Azimut reveal several impacts of drought on menstrual management in the Diana region of Madagascar. Limited water availability limits the ability of women to wash the fabrics used during menstruation. Moreover, the absence of adequate sanitary facilities, such as toilets, exacerbates this issue, obligating women to wash their fabrics and perform hygiene routines near the river rather than at home. Teenage girls highlighted additional challenges due to the lack of water available in school bathrooms.

However, some women who participated in the questionnaire indicated that the limited access to water does not significantly affect the management of their periods, stating that they are

still able to wash their fabrics despite water constraints. Nonetheless, it is important to note that the questionnaire and the response of a technical expert also shed light on the cultural taboos surrounding menstruation (Questionnaire, Interview 17). Not only might such taboos intensify the difficulties faced by menstruating women and girls, who may feel ashamed to wash and dry their fabrics in public spaces, but they are also likely to limit the extent to which women feel comfortable discussing menstruation-related struggles. This social stigma, coupled with water scarcity, can significantly impact on the ability of women and girls to manage their menstrual hygiene effectively.

5.5.1.3 Agricultural Impact

The changing climate has forced smallholder farmers to seek alternative sources of sustenance. Participants highlighted the decline in crop productivity due to the lack of water and precipitation (Interviews 4, 5, 7, 8, 10, 11). Although the recent Cyclone Gamane brought significant rainfall, it resulted in flooding that destroyed crops (Interviews 7, 8, 9). Smallholder farmers who typically harvested substantial quantities of rice reported drastically reduced yields (Interviews 4, 5, 7, 8, 10, 11). For instance, smallholder farmers who traditionally produced rice as their primary crop now frequently travel to Diego Suarez to purchase rice, which is often of poor quality and imported from Central Asia rather than cultivated in Madagascar (Interviews 4, 5, 7, 8). Several female field experts noted a drastic reduction in their rice harvests, from 350 sacks to 150 sacks, due to insufficient rain and water (Interview 11).

The decline in crop productivity and livestock health has led to increased poverty and food insecurity, contributing to a rise in theft and a heightened sense of threat among smallholder farmers (Interview 8). Another challenge highlighted by field experts is the increase in pests, which

have become more prevalent with the changing climate and are increasingly damaging and killing crops (Interviews 7, 8, 10, 11). Field experts mentioned their inability to afford pesticides or their ineffectiveness and destructive nature, since they are also reported to worsen land degradation.

5.5.1.4 Cyclones

According to the field experts, cyclones have become more frequent and intense, leading to severe flooding that damages both crops and infrastructure (Interviews 7, 8, 9). Four participants noted that cyclones now account for the majority of rainfall in the Diana region, which disrupts traditional farming cycles and exacerbates water management issues (Interviews 7, 8). For instance, several participants (Interview 8) mentioned that they had planted additional seeds prior to the cyclone due to concern about decreased productivity as a result of insufficient rainfall. However, when Cyclone Gamane hit, crops were flooded and destroyed, leaving farmers who had planted all of their seeds with nothing (Interview 8).

5.5.2 Timeline of Observed Changes

Participants' perceptions of when the above changes began varied widely. Field experts in Andranovondronina noted significant changes since 2013 (Interviews 3 and 4), while others pointed to 2020 or more recent years as the start of worsening conditions. Some traced the beginning of these changes back to 1987 (Interview 7), highlighting a long-term trend of deteriorating weather patterns. Despite these variations, there was a consensus on the dramatic impacts of these changes on their livelihoods and that drought is starting to affect the North of Madagascar.

5.5.3 Informal Disaster Risk Management: Perspective of Field Experts

To cope with the impacts of climate change, field experts in northern Madagascar have developed a range of informal disaster risk management strategies covering water management and access, agricultural and economic adaptations, and support and infrastructure. However, many are struggling with the effectiveness and sustainability of these measures in the face of a rapidly changing climate (Interviews 8, 10, 11).

5.5.3.1 Primary and Secondary Activities of Farmers

Findings from several interviews conducted with field experts provide critical insights into the agricultural context of the Diana region. The vast majority of respondents (81% or 13 participants) reported engaging in agricultural activities both for sustenance and income generation, while the remaining 19% (3 participants) indicated producing solely for personal and household consumption. Two of these participants who produce for their own sustenance come from Andranovondronina, where local taboos prohibit the sale of milk (Interview 5), restricting its production exclusively for personal use.

Rice cultivation and the rearing of animals, particularly zebu (cattle) and chicken, emerged as the primary agricultural activities among smallholder farmers in the Diana region (Interviews 4, 5, 7, 8, 9, 10, 11). Zebu serve a variety of purposes in northern Madagascar, including land ploughing for agriculture (Interview 7), as depicted in the image below (Figure 5) showing a zebu used as a draught animal to prepare the soil for tomato planting. Additional roles of zebu include milk and meat production.

Figure 5: Zebu ploughing agricultural land in Namakia, Northern Madagascar. (Photograph taken by the author, [2024])

In terms of the influence of gender on agricultural roles in Northern Madagascar, interview responses indicated that female smallholder farmers in Northern Madagascar tend to hold roles similar to men in agricultural work, with some women also taking on leadership roles (Interviews 2, 7, 17). Both women and men engage in the same agricultural activities, except for tilling the soil with zebu (domestic cattle), which is predominantly a male task (Interview 7). Women, like their male counterparts, plant and harvest crops such as rice (Interviews 2, 7). Depending on their circumstances, women either work alone or alongside their husbands (Interview 7).

Diversification of agricultural activities is evident, with many smallholder farmers complementing their rice production and livestock by growing various fruits and vegetables (Interviews 4, 5, 7, 8, 9, 10, 11). This is illustrated by Figure 6, which provides a visual representation of the primary activities of farmers in the region. This figure includes all activities recorded by participants, with each participant growing several types of crops. Staples such as rice,

vegetables, tomatoes, cucumber, corn, melon and banana are commonly cultivated, alongside raising animals. Notably, all 16 participants (100% of field experts) recorded rice cultivation as their primary agricultural activity, while animal husbandry was the second most popular, mentioned by 14 (87.5%) of the participants. This is likely to be influenced by the difference between the responsibilities of men and women, as noted in the section on gender roles, given that the two field experts who did not mention raising livestock are women. The third most popular type of crop were vegetables, grown by 12 (75%) of the participants.

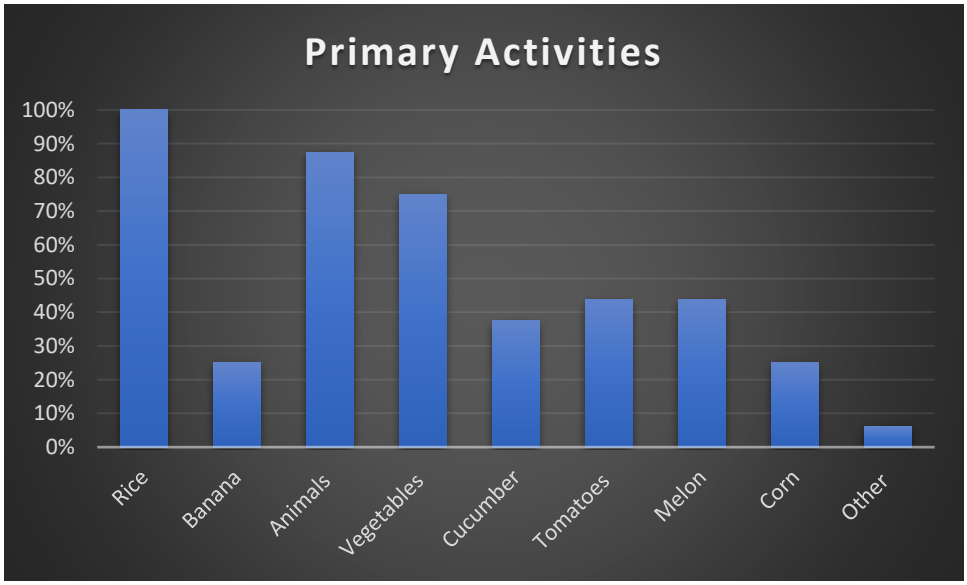

Figure 6: Bar graph illustrating the primary activities of field experts interviewed in northern Madagascar

However, the interview findings also underscore the significant challenges posed by shifting climate patterns and increasing water scarcity (Interviews, 4, 5, 7, 8, 10, 11). Such challenges obligate smallholder farmers to explore alternative means of sustenance and income generation, necessitating adaptations beyond their primary agricultural activities. The nature of these difficulties and adaptive strategies is described in further detail in the following sections.

In response to climate change and drought-induced water shortages, smallholder farmers have developed secondary income-generating activities and adaptive strategies, including the cultivation of alternative crops such as cassava and potatoes (Interviews 1, 7) rather than water-intensive crops such as rice. Some farmers (Interviews 7, 8) additionally described working in charcoal production, cutting down trees to produce charcoal, which is typically used for domestic energy such as cooking (Interview 8). Despite recognising the ecological importance of trees for landscape perseveration and local climate regulation (Interviews 7, 8), smallholder farmers reluctantly resort to charcoal production as a result of diminished crop yields and the need to earn an income in order to sustain themselves.

Further secondary activities including fishing for seafood, where smallholder farmers venture out to sea and sell their catch at the market in Diego Suarez (Interview 5). While this has always been a common secondary activity used by smallholder farmers to complement their primary activities during the dry season, the viability of fishing is increasingly threatened by intensifying and longer-lasting trade winds, transforming fishing into a more dangerous activity than previous times (Interview 3). As a result, where they once alternated between fishing and agriculture depending on the season, farmers now struggle to rely on either practice (Interviews 3, 4, 5, 17).

Another recorded secondary activity is working in the salt industry, where male family members take up temporary, zero-hour contract work in the nearby salt marshes, while women handle the buying and selling of salt in the local market (Interview 10). However, financial returns from salt sales remain minimal, highlighting the limited economic profitability of this option (Interview 10). Additionally, interview data reveals a subset of field experts who lack viable

alternatives or solutions and are simply attempting to adjust to their rapidly changing circumstances.

Figure 7 provides a visual representation of the secondary activities undertaken by smallholder farmers, who often engage in multiple tasks. These encompass activities such as charcoal production, cultivation of alternative crops, involvement in the salt industry and fishing. While many farmers undertake alternative income-generating activities, many have not yet found a viable solution, which is represented in Figure 7 as "No solution". This offers insights into the multifaceted and adaptive livelihood strategies adopted by smallholder farmers in response to evolving environmental and climatic conditions.

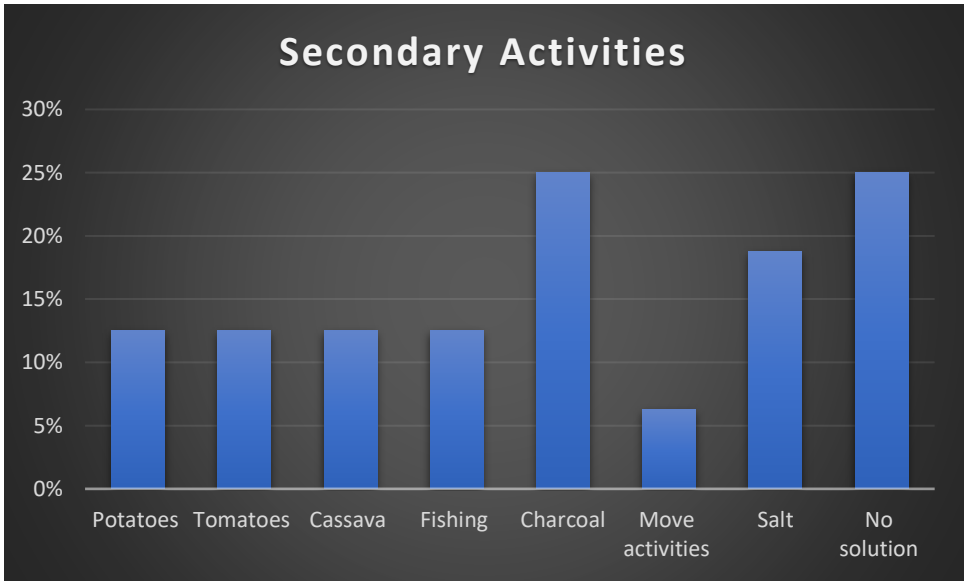

Figure 7: Bar graph illustrating the secondary activities of field experts interviewed in northern Madagascar.

5.5.3.2 Khat Cultivation

The shifts in agricultural practices have also seen many farmers turn to the cultivation of khat, which is a "shrub or tree whose leaves have been chewed for centuries" primarily by people living in Eastern Africa and the Arabian Peninsula (Balint, Falkay, and Balint 2009, 604). Khat is

more drought resistant than many other crops (Tofu and Wolka 2023), and contains several chemicals, including two stimulant drugs with effects similar to those of amphetamine (Balint, Falkay, and Balint 2009). Chewing its leaves results in increased alertness and suppressed appetite (Balint, Falkay, and Balint 2009), with locals from Diego Suarez reporting that it strengthens them and enhances their ability to work (Interview 15). Several of the field-expert interviews indicated that they themselves chew the leaves of khat, but do not cultivate it themselves (Interview 5, 8, 9). The increasing production and use of khat, however, comes with its own set of challenges and social implications, which will be further addressed in Section 6.6 of the Discussion.

5.5.3.3 Water Management and Access

As highlighted above, the primary issue facing the population of smallholder farmers in northern Madagascar is drought and consequent water scarcity. Despite previously having access to surface water via rivers, there is now a heightened need for groundwater, obligating smallholder farmers to manually dig their own wells to access water, often sharing this scarce resource with their livestock. During the dry season, rivers often run dry and water sources become increasingly difficult to access, forcing farmers to dig deeper into the ground for groundwater. Some farmers have been able to dig wells close to their home, as shown in Figure 9 below. However, others must travel for up to an hour for a round trip, which they must make several times a week. Similarly, university students living at the University of Antsiranana must collect water from wells located on the university campus. For students, smallholder farmers and the general local population alike, all water that is collected tends to be stored in yellow containers, as pictured below in Figure 8. The lack of clean water makes them more likely to drink and use contaminated water, exacerbating health risks.

Figure 8: Yellow containers used by the local Malagasy population in Northern Madagascar to store water. (Photograph taken by the author, [2024])

Figure 9: Well dug by local smallholder farmers in Namakia, Northern Madagascar. (Photograph taken by the author, [2024])

5.5.3.4 Agricultural and Economic Adaptations

Due to the unreliable and reduced rainfall, smallholder farmers have had to adapt their traditional agricultural practices. Those who previously focused on producing crops such as rice and raising animals are obligated to adapt to the changing climate. For instance, when rice production is low, they cultivate and consume alternative crops that are more resilient to drought, such as cassava and corn, using the income generated from vegetable production to buy rice in Diego Suarez (Interview 4, 5, 7, 8, 10, 11). As highlighted in the section on secondary activities, smallholder farmers also find alternative ways to diversify their income, for instance working in

charcoal production, the salt industry and fishing (Interviews 5, 7, 8, 10). Additional adaptations and coping strategies include making reserves of food and water (Interview 5), which is stored in the containers pictured in Figure 8, as well as planting additional seeds in preparation for a drought.

Furthermore, some farmers resort to moving closer to groundwater sources, where agriculture is more productive (Interview 7) or building "lakandrano" or "dams" in an attempt to store water (Interviews 7, 8). These "dams", as referred to locally, typically constitute small channels or swales built manually for the purpose of storing and absorbing water for agriculture. Unfortunately, several farmers stated that despite their efforts to adapt to drought conditions, many of these measures are suboptimal have proven unsuccessful and that they have no option but to focus on surviving each day (Interviews 7, 8, 10, 11). For instance, working in the salt industry is unreliable and provides little income, fishing has become increasingly dangerous, and charcoal production leads to further deforestation. Moreover, as illustrated below in Figure 10, building "dams" is ineffective if there is no rainfall to fill them.

Figure 10: Empty "dam" constructed by local smallholder farmers due to insufficient rainfall in northern Madagascar, illustrating the challenges of water storage in drought conditions. (Photograph taken by the author, [2024])

Furthermore, smallholder farmers reliant on fishing as a secondary activity must relocate to the Western side of the coast during the dry season because the Eastern side has become too windy. In response to water scarcity, some farmers have moved closer to groundwater sources, where crop productivity is higher. The economic impact of drought has forced farmers to diversify their income sources, as underscored in the sub-section on Primary and Secondary Activities of farmers. For instance, when agricultural production fails, many farmers resort to working in charcoal production (Interviews 7, 8), which further threatens local microclimates and reduces natural resilience through deforestation.

5.5.4 Challenges with Support and Infrastructure

Despite these increasing difficulties, smallholder farmers often receive little to no support from authorities. Requests for pesticides, crop machinery and seeds have gone unanswered (Interviews 8, 10, 11), while others are unsure of who they should turn to (Interview 5). The government's conservation initiatives, such as providing seedlings like quinine and acacia for reforestation purposes, have had mixed results (Interview 8). While the field experts recognise the importance of forest cover for the climate and ecology, acacia trees, in particular, consume a significant quantity of water and thus exacerbate drought conditions, leading to more cracked soil and dry land, as pictured in Figure 10 (Interview 8). Additionally, the construction of dams by local associations and organisations often proves futile, as there is insufficient rain to fill the constructed reservoirs (Interview 4). Furthermore, several field experts noted that while Azimut's project in Andranovondronina has improved access to water for human consumption, they emphasised the urgent need for water for their livestock, who are dying of thirst (Interviews 5, 8, 11, Azimut Field Mission, Questionnaire).

5.5.5 Primary Needs of Smallholder Farmers

When asked about their primary needs, the field experts highlighted several key necessities. The critical need for water was emphasised by the overwhelming majority (15 participants), emphasising its importance for both human consumption and for sustaining animals and crops. Improvements in road infrastructure were also deemed essential (Interview 5), as better roads would facilitate the transportation of goods to Diego Suarez and minimise damage during transit.

Agricultural machinery and materials emerged as another significant need (Interviews 5, 10, 111). Participants pointed to tractors as vital for enhancing productivity, as the current reliance on manual labour is increasingly challenging in the face of a changing climate (Interview 11). There was also a call for more seeds, particularly those resilient to climatic fluctuations, to ensure crop survival during droughts and floods (Interview 11). Additionally, several field experts stressed the importance of renewable energy, which would extend studying opportunities for their children and grandchildren (Interview 8). Three participants (Interview 10) also expressed a desire for an industry or market for fruit juice, explaining that this would diversify income sources and reduce reliance on traditional crops and livestock. Despite producing substantial quantities of fruit, field experts lamented the lack of a viable market for their produce (Interview 10).

5.6 Climate Change: Perspective of Technical Experts

The following sub-section will provide an overview of the responses of the technical experts in relation to the changes in climate recorded above, such as reduced precipitation, shortened rainy season, prolonged dry period and hotter temperatures. This sub-section will also address the impacts of these changes from the perspective of the technical experts, further highlighting the emerging evidence that drought is beginning to affect northern Madagascar.

5.6.1 Changes Observed

Table 2 presents the various perspectives of technical experts on the definition of drought, alongside whether they consider drought is beginning to affect northern Madagascar. From descriptions encompassing precipitation to agricultural implications and socio-economic

repercussions, the definitions, the following definitions reflect a nuanced understanding of how drought is perceived and understood by those at a greater distance than the field experts. While the findings from the interviews with the field experts reveal a near-unanimous agreement that drought is beginning to impact the North of Madagascar, the responses from the technical experts are more varied. All participants acknowledged a reduction in the length of the rainy season, with several indicating that this period has decreased from six months to just one month (Interviews 1, 3, 15).

Although the majority of experts (9) consider that drought is beginning to affect the North of Madagascar, three participants indicate that this is not the case (Interviews 2, 13, 14). Additionally, two disaster risk experts with whom I engaged in informal conversations clearly stated that there is no drought in northern Madagascar and that this is solely an issue in the South of the island. It is important to note that four out of these five individuals are not from the North of Madagascar. The participant from Diego Suarez indicated that he does not consider the current situation in the North to be drought due to the constant presence of groundwater and rivers, despite erratic rainfall patterns (Interview 2). One participant from Antananarivo acknowledged the reduction in rainfall and shortened rainy seasons, but highlights that drought is only present in the South of Madagascar (Interview 13), while the other participant from the capital associates drought with a lack of rain, which she considers only a prevalent issue in the South of Madagascar (Interview 14).

The perception of one participant was unclear, as he initially responded that he does not consider there to be drought in the North, but noted that the significant decrease in rainfall and crop productivity indicates the onset of drought (Interview 6). He describes the presence of drought in the North as a "new phenomenon" (Interview 6). Another participant indicated that many villages in the Diana region are now experiencing drought, which is often preceded by flooding.

However, he laments that the issue of drought is not adequately addressed by authorities (Interview 1).

During interview 3, the participant indicated that the changing precipitation patterns have led to a condensed rainy season and prolonged dry periods, which indicates the onset of drought in the Diana region. He further stated that the situation in the North has shifted and that drought is starting to become a concern (Interview 3). The four students clearly indicated that drought is prevalent in Diego Suarez and across most of Madagascar (Interview 12). They highlighted changes in rainfall patterns, increased temperatures and adverse effects on agriculture and water resources as indicators of this.

During interview 15, the participant contended that the populations of the Diana region and Diego Suarez specifically are evidently suffering from drought and the notable scarcity of crops and water demonstrates this (Interview 15). One expert (Interview 16) distinguished between three types of drought: economic, meteorological and hydrological, reflecting three of the drought definitions provided in the literature review (see Section 2.1). He described economic drought as the most severe, capable of leading to humanitarian crises, as it results in no harvest, food scarcity, and loss of income due to lack of rain. Second, he defined meteorological drought as less rainfall than expected, and hydrological drought as a situation where water becomes scarce. This latter form of drought was described as particularly problematic due to the reliance of the Malagasy population on agriculture and livestock. Interviewee 16 further clarified that while a single drought may not be so devastating, chronic drought has the potential to become catastrophic. Finally, during interview 17, the participant stated that the Diana region, including Diego Suarez more specifically, is clearly beginning to experience drought (Interview 17).

Table 3: Drought Definitions – Perspective of Technical Experts

Interview No.	Location	Drought in the North?	Definition
Interview 1	Diego	Yes	When rain during its season is rare or falls for a short time compared to other years past. Water insufficiency, rapid drying up of water sources or reduction in water flow in wells.
Interview 2	Diego	No	When there is no water and it is very dry.
Interview 3	Diego	Yes	Decreased precipitation, higher temperatures and a shorter rainy season.
Interview 6	Diego	Unclear	Lack of rain and crop productivity.
Interview 12 (4 participants)	Diego		
Participant 1		Yes	When sun destroys the green leaves and animals don't have food.
Participant 2		Yes	There is still water, but the water is not abundant or stable. When we look at the land, there are cracks, which shows the lack of groundwater.
Participant 3		Yes	Lack of water and trees.
Participant 4		Yes	Strong wind because when there is too much wind, there is not much rain.

Interview 13	Antananarivo	No	Lack of water, water for rain, agriculture, drinking. This includes a lack of water for zebu and animals.
Interview 14	Antananarivo	No	No rain.
Interview 15	Diego	Yes	Lack of rain and trees, inability to grow crops, lack of access to water, hot temperatures.
Interview 16	Antananarivo	Yes	Three kinds of drought: Economic drought, Meteorological drought and Hydrological drought. Economic drought is the worst kind that may lead to a humanitarian situation. No rain = no harvest = no food = no income. Meteorological drought = it is not no rain, but instead of 100% of rainfall, there might be 80% of rainfall (less rain than it should be). Hydrological drought = starts to be difficult because water is becoming rare. Water for food and livestock becomes rare. When thinking of drought, devastation comes to mind because water is the principle need of households, given the reliance on agriculture and livestock. It is an emergency if the water is rare or more expensive than usual. Chronic drought may lead to catastrophe.
Interview 17	Diego	Yes	"Prolonged periods of time where there is scarce access to water at least on the surface. There is little to no precipitation".

5.6.1.1 Precipitation and Rainfall Patterns

Consistent with the information provided by the field experts, there was unanimous agreement among the technical experts on the significant seasonal shifts observed in the region (Interviews 1, 2, 3, 6, 12, 13, 14, 15, 16, 17). Participants highlighted a notable reduction in the duration of the rainy season, coupled with a prolonged dry season compared to historical patterns (Interviews 1, 2, 3, 6, 12, 13, 14, 15, 16, 17). The occurrence of the traditional rainy season has now shifted towards a cyclone season, with rainfall predominantly associated with cyclones rather than the more predictable patterns of the traditional rainy season (Interviews 1, 2, 3, 12, 14, 15). For instance, during Interview 2, the participant noted that precipitation was previously equally distributed across the rainy season months, but it is now condensed into a much shorter period, approximately one month.

This shift results in extreme weather patterns: "after the flood we have a drought" (Interview 1), where what used to be reliable seasons have become immediate shifts from one extreme to the next. Most expert participants suggested that not only have there been seasonal shifts, but a decrease in overall rainfall. Several participants mentioned that winds have become significantly stronger (Interviews 3, 12), while another noted that precipitation distribution has shifted, with microclimates playing a larger role now than previously (Interview 1). One participant noted that in 1960, Montagne d'Ambre had 80 rivers running through it. However, this number has since reduced to 18 (Interview 2). He further mentioned that, while the rivers used to flow year-round, including during the dry season, they now only run for two or three months before drying up (Interview 2).

5.6.1.2 Cyclones

Most technical experts interviewed have observed a significant increase in both the frequency and intensity of cyclones, leading to severe flooding that damages crops and infrastructure (Interviews 1, 2, 3, 6, 12, 14, 16). Echoing the field experts, the technical experts also emphasise that the majority of rainfall in the Diana region now comes from cyclones rather than traditional rainy seasons (Interviews 1, 2, 3, 12, 14, 15), disrupting agricultural practices that were previously reliant on predictable weather patterns. One expert highlighted that disaster risk management agencies in Madagascar used to plan for two to three cyclones during the cyclone season, but during the 2021 season, six cyclones hit the island (Interview 16), illustrating a drastic rise in cyclone frequency.

5.6.1.3 Global Climate Change

All technical experts referred to climate change, indicating that these changes are not locally induced, but are part of global phenomena. During Interview 16, the participant discussed the shifts in rainfall, noting that while drought has been a prevalent problem in the South, it was previously never an issue for the North. However, drought has now started to become a significant problem for other parts of Madagascar, including the Diana region, and is projected to impact almost the entire country over the next 10-20 years (Interview 16). While almost all of the field experts also explicitly referred to climate change, their focus was situated in the local context and the impacts of these changes on agricultural production and water availability.

5.6.2 Observed Impacts and Responses

The following sub-section presents the impacts of the changes observed by the technical experts. These include impacts on agriculture, khat cultivation, water access and sanitation, health, biodiversity and conservation, and alternative income-generating activities.

5.6.2.1 Agricultural Impact

All expert participants highlighted a decline in crop productivity due to irregular rainfall patterns and extended dry periods (Interview 1), causing farmers to extend their agricultural lands, which leads to an increase in deforestation (Interview 1). Food shortages are becoming increasingly widespread, amplifying a nation-wide nutrition crisis and leading to a greater reliance on food imports, such as rice from China and Pakistan (Interviews 2, 14, 15). According to Interviewee 2, the Malagasy market is being threatened by cheaper international imports, a situation exacerbated by corruption and bribery. Countries who import goods into Madagascar are often made exempt from paying normal import fees or taxes if they directly pay members of the Malagasy government, who are concerned with making business over boosting local production (Interview 2). Consequently, this trade money does not reach the Malagasy population, but remains in the pockets of those who were paid directly (Interview 2). This undermines the national and local markets, as the imported goods are then sold for cheaper than the goods produced within the country by local farmers (Interview 2).

5.6.2.2 Khat Cultivation

As explained in the previous sub-section, chewing the khat leaves produces a stimulant-like effect. This is further clarified by one participant, who emphasises the population of Diego Suarez chew khat leaves due to the belief that it strengthens them (Interview 15). However, another participant highlights the dangers that khat plantations pose to water sources (Interview 3), such as Montagne d'Ambre. Farmers growing khat demand water, expressing their concerns to the Ministries of Agriculture and Water with the argument that they also belong to the agricultural sector and thus require water for their khat plantations (Interview 3). However, as explained by interviewee 3, legal authorisation for khat irrigation is impossible, leading farmers to take water illegally (Interview 3). Several participants highlight khat's extensive water use and its major role in forest destruction (Interviews 2, 3, 15), which the regional water authority attempts to counter through the use of satellite imagery (Interview 3). However, one participant underscores the limitations of satellite imagery in detecting illegal water use for khat cultivation, as dense forests obscure visibility beneath the canopy (Interview 3). He emphasises the importance of in-situ data to fully understand the situation on the ground, noting that satellite images showing intact forests masks the deforestation below.

Several participants express frustration with khat, noting that its use was once limited to men, but has now extended to children and young girls (Interviews 2, 15). One participant argues that widespread addiction to khat leads fathers to prioritise buying it over feeding their families, leaving children with nothing to eat (Interview 2). He also points out the absence of research on the topic (Interview 2), despite the serious health implications of chewing unwashed khat leaves on a daily basis (Interviews 2, 15). He identifies climate change and khat miuse as major threats to the Montagne d'Ambre, which is of crucial importance to the region (Interview 2). Several

participants indicate that khat cultivation is easy to tend and that this desire for "the easy money" (Interview 2) has replaced the cultivation of vegetables and rice, which requires a lot of time and water (Interviews 2, 15), due to its economic benefits.

5.6.2.3 Water Access and Sanitation

Water scarcity emerges as the predominant challenge confronting the Malagasy population, exacerbated by seasonal shifts, with the dry season extending and the rainy season growing shorter (Interview 1). The drying up of water sources due to drought onset in the North has prompted a heightened reliance on well-digging, as tap water becomes increasingly expensive and scarce (Interviews 2, 3). However, the high costs associated with digging wells further exacerbates the financial burden on already vulnerable communities. Moreover, even seemingly clean well water is often hazardous for human consumption, contaminated by excrement and bacteria, largely due to the common practice of open defecation, which leads to the spread of pathogens through groundwater (Interviews 3, 15). This is a prominent issue at the local university, where water access is frequently scarce, often leaving students without water for up to three days (Interview 12). Additionally, the latrine facilities are both inadequate and insufficient, with approximately one latrine for every 300 students (Interview 12). As a result, most students resort to open defecation by the sea instead of using the latrines, which contaminates much of the groundwater in the area (Interviews 12, 15).

Furthermore, Ambilobe, a municipality located South of Diego Suarez within the Diana region, was specifically highlighted for its issues with unsafe water, contaminated not only by sewage, but

also by its proximity to a cemetery where E. Coli bacteria has been detected (Interview 3). The contamination of water poses serious health risks, making it even more challenging to identify safe drinking water sources (Interview 3). While a focus group with local menstruating women and girls revealed that the lack of adequate latrine access and unavailability of water hinders their hygiene practices, a technical expert indicated that "lazy people don't do their hygiene properly" and that "women and girls neglect to track their menstrual cycles" (Questionnaire).

Several technical experts suggested that the issue is not a lack of water, but rather inadequate water management and distribution (Interview 3, 13), with disconnected pipes in Diego Suarez leaving residents without water on a daily basis. They noted that while water is always available, it is not always accessible, indicating that the problem in the North is not drought, but rather poor water management. However, the indication that the issue is solely poor water management contrasts with the information provided by the farmers, who have attempted to store water through the construction of dams (Interviews 7, 8), yet are faced with the problem that there is insufficient water to fill these dams. Further, they not only indicate that there is a lack of water for human consumption, but that there is an absence of rainfall, threatening their livelihoods (Interviews 4, 5, 7, 8, 10, 11). Social inequalities deepen the water crisis, as a diminishing middle class highlights the growing economic divide between rich and poor (Interview 2). The effects of water scarcity extend beyond immediate health concerns, not only affecting hygiene practices, but also worsening poverty and social disparities.

5.6.2.4 Infrastructure and Flooding

The vulnerability of Malagasy communities to climate change is heightened by inadequate infrastructure (Interviews 3, 6, 13, 14). With limited resources and infrastructure, Madagascar is ill-equipped to address the mounting challenges brought about by climate change (Interview 14). For instance, the island's inadequate infrastructure and absence of functioning sewage systems exacerbate the impacts of flooding, contaminating already precarious water supplies. Poorly maintained roads become impossible to navigate during disasters, hindering the transportation of essential supplies to affected areas and impeding post-disaster recovery efforts. Several participants referred to the situation in Ambilobe after Cyclone Gamane, which resulted in the collapse of a bridge that had connected the North and South of the city for over 70 years. The bridge was overwhelmed by the unprecedented rainfall accompanying the cyclone.

Although both field experts and technical experts highlight the limitations posed by the lack of infrastructure, particularly roads, their focus differed significantly. The field experts concentrated on more immediate challenges such as general lack of access to water and the difficulties of transporting produce from rural areas to the market in Diego Suarez. In contrast, the technical experts are more concerned with challenges related to disaster response and the exacerbation of risk due to inadequate infrastructure.

5.6.2.5 Health Issues

Multiple expert participants underscored a surge in health issues perceived to be linked to climate change. A certain type of skin disease has emerged within the population of the Diana region, predominantly affecting children who often experience fever as a symptom (Interview 1).

Although the participant was unable to provide the name of this disease during the interview, I was later able to verify that it is schistosomiasis, which is primarily a parasitic tropical disease propagated by poverty, poor sanitation and contaminated water (Verjee 2020, 154). Consequently, unsafe drinking water exacerbates this disease, which was further highlighted by a local nurse as one of the most common health problems for the population of Andranovondronina (Questionnaire). Although some people boil the water to avoid contracting diseases, many do not (Interviews 2, 3, 15). This leads to many cases of diseases such as schistosomiasis and typhoid (Interview 15).

The local water management authority uses geostatistical data to identify the regions with contaminated water and subsequently advises the community through a general assembly organised with the local population, authorities, and the district chief (Interview 3). However, some individuals feel offended and ashamed when informed that the water is contaminated by their excrement. The population is advised to use latrines to minimise contamination, but cultural taboos and practical limitations often hinder their use. Due to a lack of trust in the authorities, they must provide a visual demonstration of contamination by placing a clean string in water, followed by a string contaminated with faeces, which clearly contaminates the water, despite the water visibly appearing clean. This demonstration helps the community to understand that contamination is not always visible (Interview 3). While technical experts placed significant emphasis on the health risks associated with the changing climate, contaminated water supplies, and inadequate sanitation, field experts generally did not prioritise these issues, except for some noting the unclean water causing illnesses.

5.6.2.6 Biodiversity and Conservation

During Interview 1, the participant emphasised the precarious situation of biodiversity, which is heavily impacted by the changing climate. The tenrec, as pictured below in Figure 11, is a Malagasy endemic species that has shown a decline due to reduced rainfall (Interview 1). The participant noted that this species is not only critical for the ecology of the island, but also significant for Malagasy customs, as it is considered a sign of rain and is beneficial for the soil, thus advantageous for agriculture (Interview 1). However, this is just one example of how multiple species have shifted from "endangered" to "critically endangered" due to a combination of factors, including lack of water, high temperatures, and human activities (Interview 1). Six species have been found to be threatened, with four vulnerable and two endangered, primarily due to habitat loss (Stephenson et al. 2021).

Figure 11: Image of tenrecs (Source: Photograph taken by author [2024])

As expected, the technical experts placed more emphasis on conservation and threats to biodiversity than the field experts, who have more immediate concerns like food and water insecurity. However, as highlighted in the previous sub-section, the field experts did acknowledge the ecological importance of trees and their unwillingness to engage in charcoal production due to this.

5.6.2.7 Alternative Income-Generating Activities

Another consequence of climatic changes is the shift from agricultural activities to alternative income-generating activities. Farmers are increasingly engaging in less sustainable practices, such as charcoal production and mining, exacerbating deforestation and deteriorating local environmental conditions (Interviews 2, 12, 16). This shift is closely intertwined with migration patterns, with approximately 80% of charcoal workers in the Diana region originating from the Southern part of Madagascar (Interview 15). This migration exacerbates environmental challenges in the North, where locals are already feeling the early impacts of drought. Consequently, conflicts arise, and resistance against conservation initiatives aimed at curbing deforestation for charcoal production intensifies (Interviews 1, 15). In Interview 1, the expert underscored the challenge of local resistance against conservation efforts. Despite the work carried out by conservation organisations, the continuation of climate-induced problems generates a sense of distrust between the local community and these organisations, who face increasing resistance as a result.

Both field experts and technical experts highlighted the shift from primary agricultural activities such as rice cultivation towards alternative income-generating activities, such as charcoal production. However, the technical experts focused more on the unsustainability of these practices,

while the field experts emphasised the need to undertake more secondary activities due to the changing climate and lack of viable options. It is also important to note that mining was not mentioned by any of the farmers.

5.6.3 Formal Disaster Risk Management Strategies

The following sub-section addresses the existing disaster risk management strategies through the insights and perspectives of experts working in the field of Disaster Risk Management in Madagascar. This includes information on strategies for both preparedness and response. Preparedness strategies encompass measures taken to anticipate and mitigate the impact of disasters before they occur, for instance the development of early warning systems. Conversely, response strategies focus on immediate action following a disaster, such as emergency relief efforts, the provision of essential supplies and restoration of damaged infrastructure.

5.6.3.1 Preparedness

During the UN-SPIDER Conference on Early Warnings For All, there was great importance given to the development of Early Warning Systems. Technical expert interviews in Madagascar revealed several existing disaster risk management strategies that deal with early warning and preparedness. Most experts indicated that they were aware in advance that disasters would occur and that they are often able to prepare and alert local populations beforehand (Interviews 13, 14, 16, 17), particularly in the case of cyclones and flooding, for which there are specific strategies depending on the disaster. One expert highlighted the difficulty of predicting

the trajectory of a cyclone too far in advance, so communities typically receive alerts 5-10 days before the disaster hits via television, radio, and SMS broadcasts (Interview 16).

However, in rural areas, which often lack access to these communication mediums, alternative methods are used (Interviews 6, 13, 14). For instance, there is a colour alert system used for cyclones that is displayed in villages, where green represents a warning, yellow represent imminent danger, red indicates that the danger has arrived and the community should remain at home, and blue indicates that the danger has passed but caution is still necessary (Interviews 6, 13, 14). This enables rural populations to see the different stages of the cyclone. For instance, such an alert system supported some villages in Ambilobe when Cyclone Gamane hit, enabling them to prepare for and monitor the presence of the cyclone, which helps to reduce the impact (Interview 6). For flooding, rural communities monitor water levels using a simple colour-oriented alert system, an example of which is pictured below in Figure 12.

Figure 12: Colour Alert System for Flooding (Photograph taken by BNGRC and shared with author during interview 14[2024])

Drought monitoring poses a greater challenge due to its slow onset nature. Alerts should generally be sent from drought monitoring agencies three months before the peak of a drought to inform communities about which seeds to purchase and how many (Interview 16). The Integrated Food Security Phase Classification (IPC), coordinated by the BNGRC, plays a crucial role in this process, analysing economic, social, and nutritional situations, and using remote sensing and indicators such as Standardised Precipitation Index (SPI) and Normalised Difference Vegetation Index (NDVI) to predict drought conditions (Interview 16). One participant described how the IPC collects data from different actors in the field, including various NGOs and United Nations agencies (Interview 13). He stated that the IPC collect and publish the estimated risk and impact of drought, which enables relevant actors to prepare and alert communities. The IPC typically conducts its analyses in October, providing seasonal forecasts and predicting food availability based on these forecasts (Interview 16).

Interestingly, one expert suggested that Early Warning Systems may have limited usefulness, as warning people in advance does not prevent the disaster itself and destruction will still occur regardless (Interview 17). However, she acknowledged that knowing the severity of an approaching disaster, for instance whether a cyclone is category 1 or 5, could produce different responses (Interview 17). Nevertheless, she also highlighted that many people do not understand what a cyclone is and that even those aware of the imminent danger would be reluctant to evacuate for a variety of reasons, such as an unwillingness to leave their home or lack of viable alternatives (Interview 17). The indication that local populations do not understand what a cyclone is, however, contrasts with the information provided during the interviews with smallholder farmers, many of whom referred to cyclone-induced flooding during their descriptions of climatic changes and

impacts on agriculture. Another expert highlighted that "A man who has been warned, who has been informed of a danger, is doubly on his guard." (Interview 1).

5.6.3.2 Response

In terms of disaster response, Madagascar relies on several organisations, including the BNGRC, CPGU, international NGOs such as Humanity & Inclusion, and UN agencies such as UNICEF. BNGRC and CPGU are responsible for coordinating emergency activities, response, and preparatory actions, while other organisations focus on their specific sectors.

An informal conversation during the fieldwork in Antananarivo revealed that BNGRC uses satellite imagery to initially identify severely affected areas, for instance following cyclones or floods. However, due to the high costs associated with high-resolution satellite imagery, they rely on aerial surveys to conduct closer inspections of these areas. In the aftermath of cyclones, government agencies like the BNGRC and international NGOs, as identified above, provide essential supplies such as filtered water, beds, beans, rice, oil, and mosquito nets (Interviews 6, 13, 14). These organisations and government agencies also implement cash transfers to help smallholder farmers survive until their next harvest (Interviews 6, 13, 14) or to “rise up” following a disaster (Interview 14).

Despite these efforts, resources are often insufficient. For example, following Cyclone Gamane, BNGRC managed to reach only approximately 40% of the victims (Interview 14). In response to the collapse of the bridge in Ambilobe, several organisations and government agencies provided boats for individuals, particularly students and administrative staff to cross the river for free (Interview 6). Two participants noted that the response of Humanity & Inclusion was essential

to reducing disaster risk in Ambilobe in the aftermath of Cyclone Gamane (Interviews 3, 6). They provided essential supplies and equipment to 250 families just 72 hours after the disaster hit, as well as subsequently installing water and sanitation infrastructure (Interview 6).

One participant compared the quick response of Humanity & Inclusion to the inefficient response of the BNGRC (Interview 3), stating that Humanity & Inclusion managed the situation in Ambilobe more effectively because they had resources already available in the appropriate location. The participant suggested that BNGRC's centralisation efforts significantly slowed their response, and that when their aid finally arrived, it primarily focused on providing school supplies rather than meeting the more immediate needs of the population (Interview 3).

While rapid-onset disasters like cyclones and flooding require a quick and efficient response, the appropriate response for drought differs significantly (Interview 14), requiring year-round management. This is due to the constant nature of food insecurity, making coordination and response particularly challenging with limited resources (Interview 14). One participant described the typical response of the "Cellule de Prevention et de la Gestion des Urgences" (CPGU)[6], who distribute food packages containing supplies such as rice and beans, prioritising children and pregnant women (Interview 13). Subsequently, they distribute drinking water in the relevant community for the duration of one month, as well as providing local health centres with medication. Finally, they attempt to enhance the resilience of the population by providing cash to enable individuals to return to work (Interview 13).

[6] Prevention and Emergency Management Unit

5.6.4 Greatest Challenges within Work

The analysis of expert responses revealed several key themes concerning the primary challenges they face in their work. These themes outline critical obstacles that need to be addressed in order to enhance the effectiveness and sustainability of efforts in managing environmental and socio-economic issues, particularly in relation to disaster risk. Responses varied depending on the expert interviewed and their respective organisations. For instance, a conservation expert highlighted multiple challenges, with one of the primary issues being the lack of trust from the local population in conservation efforts, leading to resistance. This mistrust stems from scepticism about the effectiveness of conservation efforts in the face of worsening climatic conditions, despite ongoing initiatives to protect the environment. The distrust in authorities is further underscored during an informal conversation with a technical expert in Antananarivo, who highlighted the tendency of the Malagasy population to avoid authorities and prefer local or traditional methods, despite this often being sub-optimal for them.

Further challenges identified included the centralisation of decision-making and inefficient resource allocation. Some experts expressed frustration with the lack of understanding and mismanagement of resources by the BNGRC, hindering effective disaster response efforts. Other challenges include corruption, bribery and the complexities of persuading individuals in high-risk areas to evacuate or move their livelihoods elsewhere. However, when asked whether the BNGRC offers opportunities or some incentive for individuals and households to move elsewhere, the response was no (Interview 14). Conversely, the CPGU does appear to offer some incentive by helping families to build a house, providing them with resources such as a common water source and solar panels for energy. Moreover, experts emphasised the need for timely and accurate data

for effective disaster prediction and Early Warning Systems. However, the lack of resources, expertise, and capacity to manage multiple actors in the field pose significant challenges in developing these systems, particularly across rural areas (Interview 14).

5.6.5 Improvements Needed to Enhance Resilience

Regarding the needs of the Malagasy population, the analysis of expert responses revealed several critical areas that require action to improve the resilience of communities in the face of disasters. While primary need identified by the field experts is access to water for both human consumption and agriculture, the technical experts are more focused on water management and distribution (Interviews 2, 3, 15, 17). Experts suggested strategies such as the conservation of floodwater, reallocation of water finance, and construction of dams (Interviews 2, 3). As highlighted in the sub-section on the perspective of field experts, local farmers are already constructing small-scale "dams" in an attempt to adapt to extreme weather patterns, but this has been largely unsuccessful due to the lack of water for these "dams" to retain. One expert highlighted the necessity for a large government project to construct dams with the aim to store and better manage water (Interview 3).

Furthermore, the need for capacity building and training of local communities in relation to climate change and disasters was also highlighted by several participants (Interviews 1, 13, 14). Training local communities on climate change and disaster preparedness is crucial, as building local capacity can enhance resilience and improve community responses to disasters (Interview 1). Moreover, during Interview 1, the participant highlighted the importance of training communities for sustainable breeding of livestock, as well as minimising charcoal production and deforestation

(Interview 1) However, it is important to note that the farmers already show a deep awareness about the consequences of deforestation and the importance of trees. Another technical expert, in an informal conversation during fieldwork in Antananarivo, observed that the Malagasy population tends to spend money when they have it and struggle financially when they do not. This financial dynamic is closely tied to the seasonality of income, which fluctuates based on crop harvests. Emphasising the importance of cultivating a culture of financial saving, he underscored the need for the Malagasy population to shift their mindset and prioritising saving over immediate spending.

Other top-down approaches included the need for more government intervention to motivate local communities to grow rice, suggesting a ban on rice imports (Interview 2). It was further suggested that the introduction of machinery and modernisation of rice plantations could facilitate this, making rice production more efficient (Interview 2). He provides Indonesia as an example of effective rice production, highlighting that while 2-5 tonnes of rice are produced per hectare in Madagascar, in Indonesia they produce 11 tonnes per hectare (Interview 2). However, he emphasises that the problem in Madagascar is water, which prevents farmers from planting it in the same way as in Indonesia (Interview 2).

Moreover, one participant advocated for a remodelling of the education programme, emphasising that university curriculums should reflect the economic, agricultural and environmental needs of Madagascar, as well as training youth to be more entrepreneurial and creative (Interview 2). He underscores the importance of context-relevant education that integrates local knowledge and teaches children practical skills that they can apply in life (Interview 2). For instance, he highlights how he teaches children dependent on what knowledge they need:

"*For kids in the village, I don't teach them the chameleon, I don't teach them the snake. Because this is what they see and experience every day of their life. I take them and I bring them to the factory of tuna. And I tell them that is pollution. […] When we were kids, we swam in this ocean at the harbour. But now nobody can swim because the sharks are everywhere. Sharks for the tuna that they throw down to the ocean. Your pollution will not be sharks. Your pollution will be plastic bottles. […] But the kids in Diego, I took them to the waterfall and say have you seen that? How does it operate? Where does it come from? The level of quantity? What is above? […] That is two kinds of education. Very different. And you come from the United States, you are going to teach them what?"*

The participant criticises the prioritisation of Western knowledge over Malagasy knowledge, pointing out that many foreign organisations offer to send "experts" from the United States to provide environmental education in Madagascar, despite their lack of understanding of Malagasy culture and systems (Interview 2). "I ask them, which expert are you going to give me? An American expert? For Malagasy education? What does he know about Malagasy culture and Malagasy systems?" (Interview 2). He laments that knowledge from the West is perceived as superior, emphasising that it is just a different type of knowledge.

Additionally, several participants highlighted the need for decentralisation and a larger focus on the role of local governments (Interviews 2, 3, 16, 17). This would promote the diversity of the different regions of Madagascar, whilst focusing on actions relevant to local needs rather than attempting to homogenise the country (Interview 2). Furthermore, several experts emphasised the importance of development and improvement of infrastructure (Interviews 2, 14, 17) with a focus on roads to facilitate transportation between regions and municipalities, as well as to enhance resilience to floods and cyclones. Additionally, four experts identified the need for improved coordination between different sectors and organisations (Interviews 3, 13, 16, 17). For instance, many regional government representatives only follow orders from the capital, have insufficient

manpower, or are overworked (Interview 17). Decentralisation was proposed as a potential solution for this, as highlighted above.

5.7 Conclusion: Perspectives of Field Experts and Technical Experts

This chapter presented the results of my qualitative fieldwork in Madagascar. According to both field experts and technical experts, there have been significant seasonal shifts that have led to a shorter rainy season and a prolonged dry season, characterised by an overall decrease in precipitation and increase in temperatures. The primary impacts of drought and other disasters include reduced access to water and sanitation, diminished agricultural productivity and consequent food insecurity, death of livestock, a rise in water-borne illnesses such as schistosomiasis, and destruction of infrastructure.

In response to the changes in climate and increase in extreme weather, smallholder farmers have developed a variety of adaptive strategies and coping mechanisms. These include the construction of small-scale "dams", water storage, planting additional seeds, crop diversification and a transition towards alternative income-generating activities. Alternative activities primarily include fishing and working in the salt industry and charcoal production. However, charcoal production leads to an increase in deforestation, which further diminishes the region's natural resilience to climate change and leads to the loss of microclimates. While technical experts viewed this as a need for education, field experts demonstrated a clear awareness of these consequences and a reluctance to work in the charcoal industry, specifically due to the ecological harm it causes. Nonetheless, when drought conditions prevent their crops from growing, smallholder farmers are faced with no other option but to seek alternative means of generating income. Formal disaster risk management strategies are coordinated by the BNGRC, who use satellite imagery and develop

Early Warning Systems for disaster preparedness, as well as cooperating with a variety of NGOs and international organisations to provide disaster relief.

In relation to the question of drought in northern Madagascar, responses varied, with the vast majority of participants clearly indicating that drought is beginning to affect this region. However, some technical experts, particularly those based in Antananarivo, suggested that the appearance of drought could be a case of poor water management rather than actual drought. Definitions of drought varied in terms of detail, but there were several overlapping themes across definitions. Figure 13 provides a visual representation of the thematic distribution within participants' conceptualisations of drought. This illustrates the breakdown of categories within participants' definitions of drought, reflecting the diverse perspectives shared during formal interviews.

As demonstrated by Table 2 and Table 3, participants refer to several themes in their definition of drought, which is included in the calculations for Figure 13. A significant majority of (23) participants (85%) incorporated references to precipitation in their definitions, with some describing drought in few words as "no rain" or "lack of rain". Agriculture also emerged as a prevalent category, referred to by 41% (11) of participants, highlighting the profound impact of drought on crop yields and agricultural productivity. Water, identified by 30% (8) of participants, underscored the crucial role of water availability and access in defining drought conditions. Additionally, 19% (5) of participants highlighted the association between drought and forest depletion. Temperature and wind, mentioned by 7% (2) and 4% (1) of participants respectively, provided further insights into the climatic manifestations of drought.

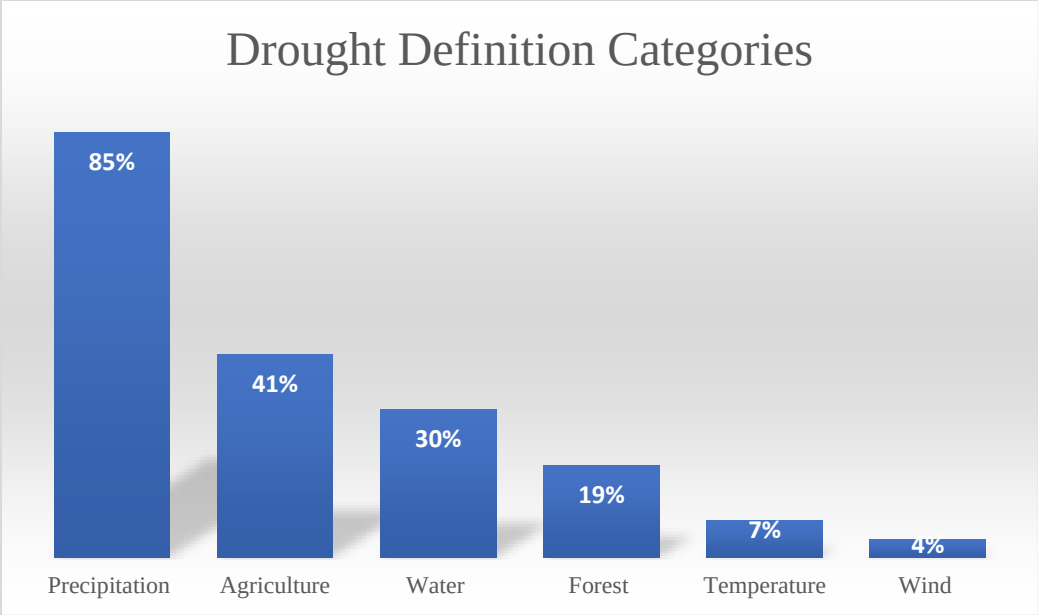

Figure 13: Drought Definition Categories

6 DISCUSSION

In this chapter, I discuss the findings of my research through the theoretical lens of epistemic injustice (see Section 3.2) and disaster coloniality (see Section 3.6), which refers to the way in which disasters exacerbate existing inequalities deeply rooted in colonial and racial histories. The link between coloniality and disasters is further illustrated in Figure 1 (see Section 3.5), which highlights how a hazard, when combined with exposure, vulnerability and coloniality, produces a disaster. This framework allows me to explore the colonial roots of disasters in Madagascar and how epistemic injustice impacts the perceived credibility of local knowledge compared to that of technical experts. This thesis aims to examine how the differing perspectives of field experts and technical experts influence the recognition and management of disasters in northern Madagascar by identifying how these stakeholders define and observe drought differently.

I begin by reintroducing the epistemic vices and virtues outlined in Section 3.2, which I follow by outlining my own positionality and reflections when researching the subject of drought in northern Madagascar. Secondly, I examine how the epistemic authority of the field experts regarding the existence of drought in northern Madagascar is undermined by epistemic injustice and the three vices, as outlined in the theoretical framework section. Subsequently, I provide a detailed discussion on how the impacts of disasters on water access and sanitation and agriculture are shaped by disaster coloniality. Next, I discuss how the epistemic vices that cause technical experts to prioritise quantitative, ex-situ data over qualitative, in-situ data and local knowledge leads to epistemic disadvantage and hinders effective disaster risk management. Then, I examine how the disparity between the primary needs of the field experts and the priorities outlined by the

technical experts can lead to ineffective and unsustainable solutions. Finally, I propose the "problem-posing concept" of education as a potential path towards epistemic justice.

6.1 The Epistemic Vices in the context of Madagascar's Disaster Risk Management

As established in the theoretical framework (see Section 3.2), Medina (2013) introduced three epistemic vices: epistemic arrogance, laziness and closed-mindedness, as well as three epistemic virtues: epistemic humility, curiosity and open-mindedness. When discussing the epistemic vices of the technical experts, it is essential to recognise the intersectionality of epistemic injustice (see Section 3.2). While some technical experts may be considered as possessing knowledge that is "superior" to that of the field experts, this is within the context of Madagascar itself, a country that has been colonised and continues to be marginalised by the global North. This means that the "epistemic authority" of the majority of technical experts, all but one of whom are Malagasy, is relative.

Many of the technical experts interviewed are integrated into the local context and also possess epistemic virtues, which many Western technical experts, for instance, would lack. Therefore, when discussing the perspective of the technical experts, it is important to note two points. First, that the evidence of epistemic vices identified in some responses provided by technical experts does not refer to all of the technical experts, as their perspectives varied significantly. This differentiation simply helps to distinguish them from field experts for the purpose of analysis. Second, that, like the field experts, many of the technical experts also face the disadvantage of being granted less "epistemic authority" in comparison to Western technical experts.

The first vice, "epistemic arrogance" is rooted in the colonial belief that Western knowledge and "science" is superior to local, traditional knowledges, which are considered inferior or invalid. This may lead researchers from the Global North or some technical experts in Madagascar to prioritise Western data and methods over the perspectives of local communities. In the case of this thesis, this can result in the dismissal of the problem of drought in northern Madagascar. Conversely, the epistemic humility of the field experts and some of the technical experts enables them to recognise their own cognitive limitations, encouraging openness to learning and climate adaptation. The second vice, "epistemic laziness" is developed out of the privilege of not needing to know. In the case of drought in northern Madagascar, this led some technical experts based in Antananarivo to oversee the disaster risk faced by smallholder farmers reliant on rain-fed agriculture in the Diana region.

In contrast, the epistemic curiosity out of the need to survive may motivate field experts to closely observe climatic changes and develop adaptive strategies to deal with disasters. Unlike technical experts, whose livelihoods do not depend on producing sufficient rice and vegetables or the survival of livestock, the dependency of the field experts on the climate makes them highly attentive to changes and the onset of disasters like drought. As established in the theoretical framework section, disasters are never "natural", but "socially produced" (Bonilla 2020, 1). Madagascar's susceptibility to disasters is therefore not only due to climatic changes and "natural" hazards, but is a consequence of multiple, interconnected factors, as illustrated in Figure 1 (see Section 3.5). The third vice, "epistemic closed-mindedness," leads some technical experts to neglect the vulnerability, exposure and coloniality aspects of disasters or the interconnectedness between them, a perspective that contributes to upholding disaster coloniality. In contrast, epistemic open-mindedness allows field experts and technical experts to understand these

interrelated factors and draw on diverse ways of knowing to enhance Madagascar's resilience to climate change and disasters.

6.2 Positionality

Failing to acknowledge my own epistemic arrogance when conducting this research would itself constitute a form of epistemic injustice. Prior to and during the fieldwork period in Madagascar, there were several instances where I began to question the local knowledge of the field experts regarding the existence of drought in the North. Several technical experts had advised me that if my research focus is on drought or water scarcity, I should focus not on northern Madagascar, but on the southern regions of the island, and I almost decided to follow their guidance. Alternatively, it was suggested that if I were to study the North, my focus should be on cyclones and flooding rather than drought. This advice led me to doubt the accounts of the field experts and question whether this so-called "drought" was, in fact, just poor water management and distribution.

Discovering the onset of drought in northern Madagascar through the narratives of field experts and local technical experts unveiled the epistemic arrogance that accompanies my own privileged perspective as a Western researcher, leading me to unconsciously and unwittingly prioritise certain types of knowledge over others. This is evidence of colonial structures dictating not only whose voices are listened to, but also whose voices are heard. Furthermore, it underscores how even individuals with the best intentions can succumb to epistemic vices. This is crucial to acknowledge when discussing the epistemic vices of the technical experts, who have also been oppressed by the same system of epistemic injustice and the imposition of Western knowledge.

Therefore, the epistemic vices are not flaws of individuals, but of a system rooted in coloniality and epistemic injustice.

6.3 The Question of Drought in Northern Madagascar

The findings revealed almost unanimous agreement among field experts that drought is beginning to impact northern Madagascar, while the perspectives of the technical experts were divided. Most technical experts in Diego Suarez agreed with the field experts, recognising the onset of drought in northern Madagascar. However, technical experts in Antananarivo largely denied the presence of drought in the North, attributing water access issues to poor water management. However, the definitions of the field experts emphasised the absence of rainfall and unproductive agriculture. This suggests that the issue extends beyond water management, as the evident reduction in precipitation significantly impacts rain-fed agriculture, which typically relies on seasonal rainfall rather than water management systems.

The geographical divergence in perceptions highlights how localised experiences and proximity to affected areas influence the recognition of disasters. The dismissal of drought by technical experts based in Antananarivo reflects a broader pattern of epistemic injustice through the marginalisation of local knowledge. Furthermore, this disparity underscores a colonial legacy, where centralised authorities often overlook or undermine the realities faced by local communities (Randrianja and Ellis 2009).

The findings further indicate that northern Madagascar is experiencing all four recognised types of drought: meteorological, agricultural, hydrological, and socio-economic. Three of these are identified explicitly by Interviewee 16, who appears to have combined agricultural and socio-

economic drought under the term “economic drought” (Interview 16). Despite differing in detail, the core essence of the definitions provided by the two types of experts remains consistent, focusing on the lack of rain, insufficient water, and unproductive agriculture. This indicates that the disparity in perspectives arises not from the definitions themselves but from differences in observation methods. Field experts observe climatic changes first-hand through their daily agricultural activities, while technical experts typically rely on data from satellite imagery and meteorology. While these methods are valuable, the reliance on a quantitative or birds-eye perspective may cause technical experts to overlook nuances only visible through qualitative, in-situ research. For this thesis, conducting fieldwork in person provided insights that desk-based research alone could miss, which could have led me to the same conclusions as the technical experts based in Antananarivo. However, observing the daily realities of smallholder farmers and collecting qualitative data helped me to gain valuable local knowledge that I may have otherwise overlooked.

Existing literature has already established that the southern regions of Madagascar are severely impacted by drought with increasingly rare instances of rainfall (Rigden et al. 2024, Makoni 2021, Harrington et al. 2022, Serele, Pérez-Hoyos, and Kayitakire 2020). This leads to famine, a lack of access to potable drinking water (Rigden et al. 2024), and migration towards the Northern and Eastern regions (Interviews 7, 8, 15) as the South of the island becomes increasingly uninhabitable. Although my research focuses on the North of Madagascar, it does not aim to compare the situations of the North and South or disregard the severity of drought in the southern regions. Instead, it seeks to reveal the potentially alarming implications of climate change for the entire island, as drought becomes more widespread. The findings of this research indicate that climatic regions traditionally categorised as “hot and semi-arid” are no longer the only regions

affected by drought and that even those with a "transition tropical" or "humid tropical climate" (Nematchoua et al. 2018, 887) are now also beginning to feel the onset of drought.

Given that the North of Madagascar is a region with traditionally higher levels of rainfall and humidity (Barimalala et al. 2021), it provides a "conservative" estimate of the impacts of disasters and climate change on Madagascar. Therefore, that this region is experiencing the onset of drought underscores the severity and urgency of the issue, highlighting the need for immediate action. Furthermore, the southern regions are more "experienced" with drought, having endured it for so long that they have developed adaptive strategies and coping mechanisms. Conversely, drought is a new phenomenon for the northern regions, making it particularly challenging for the population to develop adaptive strategies and coping mechanisms quickly enough to keep up with the rapid pace of the changing climate (Interview 16). Existing socio-economic vulnerabilities, the population's dependence on agriculture, and enduring coloniality collectively transform the onset of drought (hazard) into a disaster in northern Madagascar.

6.4 Access to Water and Sanitation

One of the primary consequences of the changing climate and onset of drought is deteriorating access to water and sanitation. Field experts primarily emphasise the immediate implications of water scarcity for both human consumption and agricultural use, with some also highlighting the health concerns associated with drinking unclean water. In contrast, technical experts placed more emphasis on the management and distribution of water, as well as underscoring the importance of educating communities about using latrines and drinking water from taps rather than wells. Additionally, the technical expert who indicated that "lazy people don't do their hygiene properly" and that "women and girls neglect to track their menstrual cycles"

(Questionnaire) attributes the problem of sanitation to individual laziness rather than a systemic problem. However, climate change is causing tap water to become increasingly expensive, while limited infrastructure like disconnected pipes are exacerbating the availability of water in sanitation facilities. This demonstrates that the problem is neither individual nor cultural, but rather a systemic issue, exacerbated by the changing climate, as well as factors such as vulnerability and exposure (see Section 3.5).

By emphasising the importance of educating communities on drinking clean water over the problem of water scarcity, local technical experts risk placing the responsibility on the communities themselves. Meanwhile, technical experts based in Antananarivo attribute the problem to poor local governance and management. However, these perspectives fail to acknowledge the deeply rooted systemic issues of unequal water access and drought, which are collectively increasing the scarcity of water. Communities often have little choice but to rely on contaminated groundwater sources and practice open defecation, which cannot be solved through education if there are no alternatives. This highlights a disconnect between the ideal solutions proposed by technical experts and the harsh realities faced by local communities. It demonstrates a form of epistemic laziness, where the privilege of the technical experts can make it difficult for them to truly understand the struggles of the local population.

The imposition of French water legislation in Madagascar without the consideration of local perspectives demonstrates the enduring coloniality that continues to shape Malagasy politics and resource management. This transforms what should be a public commodity into a privatised resource used to generate profit. The prioritisation of private water management by foreign partners reflects an epistemic arrogance and neo-colonial mindset that fails to recognise the needs of local communities (Interview 17). Prioritising profit over accessibility in a country where water

is already a scarce resource perpetuates inequities and undermines efforts to create sustainable and equitable water management systems. This is a fundamental aspect of disaster coloniality in Madagascar, highlighting how the present-day traces of colonialism exacerbates existing socio-economic vulnerabilities and exposure to hazards.

When technical experts assert that the problem lies not in drought or water scarcity but in water management and distribution, they present these issues as separate problems. In reality, drought and water management are two interconnected factors that reinforce each other to transform risk into disaster. The issue of water access is not only due to the onset of drought (a hazard) or solely the result of poor water management and distribution (exposure), but rather the combination of the two, which are further reinforced by colonial water legislation and centralised approaches (coloniality), as well as socio-economic vulnerabilities that prevent households from being able to afford clean tap-water (vulnerability).

6.5 Agricultural Impacts

The findings from both field experts and technical experts reveal a significant reduction in agricultural productivity due to climate change and the onset of drought, leading to increased poverty and food insecurity among smallholder farmers. While both field and technical experts acknowledge a decline in food availability, their perspectives diverge on the root causes and solutions. Field experts emphasise immediate concerns for crop yields and livestock health due to reduced rainfall and unreliable seasonal shifts. They also highlight the increase in pests, high costs of seeds, and destructive cyclones that devastate crops and disrupt farming cycles.

In contrast, several technical experts focus on more systemic issues such as corrupt international trade due to exemptions from import tariffs, causing imported produce to undermine the Malagasy food markets. This "system of colonial preference" originated during the French colonial period, where Madagascar was obligated to receive the majority of imports from France (Randrianja and Ellis 2009, 170) to create markets for French goods within the colony (Jarosz 1993, 370). The unequal power relations in the global economy and Madagascar's political instability reflect colonial legacies that exacerbate the island's vulnerability to climatic changes and extreme weather. Conversely, other technical experts attributed issues of water scarcity and reduced agricultural productivity to individual laziness, indicating that the northern Malagasy population "want the easy money" (Interview 2). They state that this laziness is one of the primary reasons for the shift away from rice and vegetable production towards cash-crop cultivation, which in turn increases food insecurity (Interview 2, 3, 15).

However, as established in the results section, the primary income-generating activity of the field experts is the cultivation of rice, various vegetables and animal husbandry. Despite their efforts to continue to produce food items for their own sustenance and to generate an income, they are facing severe reductions in agricultural productivity, which they attribute to the changes in weather. This demonstrates a divergence in perceptions of the problem. While several technical experts place responsibility on the individual and on Malagasy politics, the field experts suggest that this is part of a wider phenomenon related to climatic shifts. The epistemic laziness of attributing individual responsibility to the problem of agricultural unproductivity may allow technical experts to evade accountability and overlook the systemic nature of the issue. This perspective fails to recognise that the problem is multi-faceted and demands context-specific

solutions beyond merely using the "banking-concept" (Freire 2012) (see Section 3.3) to educate smallholder farmers on sustainable agricultural practices.

Framing the problem of agricultural unproductivity and food insecurity as individual laziness or lack of education fails to acknowledge the interconnected factors that collectively produce a disaster. Madagascar's colonial history (coloniality) has shaped its contemporary agricultural practices and economic market issues due to unequal power relations. This is combined with the dependency of local populations, particularly smallholder farmers, on agriculture and climate conditions (exposure) to deepen existing socio-economic vulnerabilities (vulnerability). Finally, when the population is faced with a drought or cyclone (hazard), these factors collectively produce a disaster.

6.6 Khat Cultivation

As established in Section 2.3 and Section 5.5.3.2, khat is a cash-crop, whose leaves are chewed for their stimulant effects (Balint, Falkay, and Balint 2009). The Ethiopian proverb "coffee is the poor man's khat" encapsulates the socio-economic complexity surrounding the cultivation and use of khat. In the results section, I have referred to khat as a response to climate change and the onset of drought. It is worth noting that this is my own interpretation and is not shared by all of the technical experts that I interviewed, as some view it as an entirely separate issue. The findings underscore two primary perspectives on khat: while it can serve as a crucial economic safety net and provide a feeling of boosted energy for consumers, its cultivation and use are stigmatised by technical experts primarily concerned with its health implications, environmental impacts and effects on the Malagasy food market.

As pointed out by Gezon (2012), khat is generally disapproved of by individuals with relatively high levels of Western education and wealthier members of the population. Consequently, the condemnation of khat by technical experts reflects a broader issue of epistemic injustice, where Western-educated elites often overlook the complexity of the situation for the local population and historical context that shapes agricultural practices. This critical perspective of khat without acknowledging its colonial origins as a cash crop introduced by farmers of French descent underscores a form of epistemic arrogance and closed-mindedness. The transition from traditional food crops to khat cultivation is not simply due to the laziness of individuals but is deeply intertwined with Madagascar's colonial history and climatic pressures.

Moreover, the increasing preference for khat over traditional vegetables reflects adaptive responses to changing environmental conditions. Unlike seasonal vegetables and rice, which are vulnerable to climate fluctuations and pest infestations, khat offers farmers a more resilient source of income throughout the year. There is a need for crop and income diversification as an economic safety net in the face of unpredictable weather patterns exacerbated by climate change. The concerns of technical experts about khat replacing food crops like rice and vegetables reveal an underlying epistemic arrogance, laziness and closedmindedness surrounding the issue of khat in relation to agriculture and food security in Madagascar.

Epistemic arrogance leads to the condemnation of khat, influenced primarily by Western stigma associated with drug use. Additionally, epistemic laziness prevents technical experts from truly understanding the socio-economic reasons behind the production and consumption of khat. Finally, epistemic closedmindedness allows them to avoid confronting the uncomfortable colonial history of Madagascar, which reveals the true reasons for the prominence of khat, particularly in Diego Suarez. While technical experts emphasise the risks associated with khat, such as

environmental degradation and water scarcity, they often overlook the economic and climatic pressures as well as colonial legacies that make vegetable production risky and khat cultivation more reliable for smallholder farmers.

This critical stance and failure to recognise the economic pressures faced by smallholder farmers may be in part related to the lack of quantitative figures to verify the decline in the price of vegetables. “Exotic vegetables” such as aubergines, carrots, cabbage and beetroots were not typically produced for subsistence, but for the market, which primarily existed for French settlers. However, this market declined when the French left Madagascar in the 1970s (Gezon 2012), demonstrating the importance of considering the decreasing vegetable prices when attempting to understand the drivers behind the transition towards khat cultivation. The absence of official statistics and economic analysis (Ibid, 128) hinders technical experts from understanding the drivers behind the shift towards khat. This underscores the value of qualitative data, particularly in cases where official quantitative figures are scarce, to provide deeper insights into the socio-economic and colonial dynamics influencing agricultural practices.

As established in Figure 1 (see Section 3.5), treating interconnected factors as separate issues is a form of epistemic closed-mindedness that can perpetuate disaster coloniality and reduce the effectiveness of disaster risk management strategies. The cultivation and consumption of khat are inextricably tied to Madagascar’s colonial history, which has shaped contemporary agricultural practices. Khat production is not only exacerbated by drought (hazard), but also by the socio-economic vulnerabilities (vulnerability) and agricultural dependency (exposure) of smallholder farmers in northern Madagascar, as well as Madagascar’s colonial history (coloniality). Recognising the complex interplay of these factors is crucial for developing sustainable and effective disaster risk management strategies that are appropriate to the local context.

6.7 Disaster Risk Management Strategies

Figure 1 (Section 3.5) illustrates the complex interplay of various factors that collectively lead to a disaster. When a hazard such as a drought or cyclone interacts with exposure factors like limited infrastructure or agricultural dependency, coupled with economic vulnerability and limited adaptive capacity, and is further exacerbated by unequal power structures and weak governance stemming from a colonial history, the conditions are created for a disaster. Disasters and their management are therefore deeply political. Montano (2021) underscores that inadequate risk management, combined with increased vulnerability resulting from poor decision-making and fragile socio-political structures, contributes to the creation of disasters. In the case of Madagascar, multiple vulnerabilities and exposure factors, as well as its colonial history, produce the perfect environment for disasters to occur.

6.7.1 Preparedness and Early Warning

The BNGRC and United Nations agencies such as UN-SPIDER have increasingly focused on developing and expanding Early Warning Systems as a disaster risk management strategy to rural areas in Madagascar in an effort to reach the most vulnerable populations. This enhanced focus on rural communities is undoubtedly a crucial step forward, as the most vulnerable to disasters are often simultaneously the most marginalised and neglected, which coincides with the rural-urban divide in Madagascar (Harvey et al. 2014).

Field experts and technical experts alike emphasised that they had anticipated the changes in climate, with field experts relying more on observation and generational knowledge than on official Early Warning Systems. Malagasy smallholder farmers have been adapting to climate

change by planting additional seeds, constructing “dams”, storing water, and diversifying their crops and income-generating activities. This self-initiated adaptation highlights the importance of recognising epistemic curiosity and open-mindedness, characteristics which enable field experts to recognise their own knowledge gaps and experiment with developing new strategies and coping mechanisms to survive changing climatic conditions.

One technical expert questioned the effectiveness of Early Warning Systems, noting that disasters seem inevitable regardless of advance warnings (Interview 17). This observation suggests that even if Early Warning Systems do alert people in advance, their utility is limited if no measures are in place to mitigate the risk. This reflects the earlier example of educating individuals and households on the importance of drinking clean water, which is ineffective if they have no alternatives. Persuading individuals and households to evacuate from high-risk areas was identified as a significant challenge for technical experts in disaster risk management (Interviews 13, 14).

Several participants noted that even with advance warnings, many people refuse to evacuate (Interviews 13, 14, 17), significantly diminishing the effectiveness of Early Warning Systems (Interview 17). Interpreting this as refusal suggests that people could evacuate and are just reluctant to do so. However, from the perspective of the affected communities, disaster risk management experts might be attempting to persuade them to do something that is simply not possible. Many individuals may lack the means to evacuate and cannot suddenly abandon their livelihoods. The focus, then, should not only be on alerting communities and persuading them to evacuate, but also on ensuring they have the necessary resources and support to take meaningful action to reduce their risk.

All of the field experts interviewed reported having grown up in the specific location where the interviews took place. Many individuals and households have deep-rooted connections to their land, with several generations having lived in the same location. For those living in poverty or those whose livelihoods are tied to the land, leaving everything behind can be unimaginable or even impossible. Displacement caused by disasters can devastate individuals and households, forcing them to choose between life and livelihood when the two are often inseparable. While some organisations and agencies such as the CPGU provide incentives for people to evacuate high-risk areas and rebuild their lives elsewhere, others focus on solely communicating the risks and attempting to educate households. While the intentions are to minimise risk and save lives, this perspective overlooks the profound complexities of displacement. People need not just education, but opportunities to envision a life elsewhere.

The assumption that communities simply require education about disaster risk reflects the three epistemic vices proposed by Medina (2013). Epistemic arrogance arises from epistemic laziness, where a lack of effort to understand the emotional and socio-economic implications of displacement leads technical experts to overlook this aspect of disaster risk. This tends to lead to the misinterpretation of communities' resistance as a lack of knowledge or education about risk, rather than recognising the complex implications of displacement from the perspective of those affected. This perspective promotes the belief that disaster risk specialists advocating for evacuation possess superior knowledge, whilst portraying affected communities as uneducated victims. Such an attitude stems from a "credibility excess" (Fricker 2007), where a speaker or "knower" is granted more epistemic credibility or authority than they may deserve, often due to social biases or prejudices (see Section 3.2). This inflated credibility not only positions the knowledge of technical experts as "superior", but it also exacerbates "testimonial injustice"

(Fricker 2007), where the credibility of another "knower" is diminished by the same prejudices. This can lead to the dismissal of the lived experiences and perspectives of those impacted by disasters and the prioritisation of the knowledge of disaster risk management experts.

Individuals in privileged positions often have not had to grapple with the profound emotional and practical implications of being forced to abandon their homes and livelihoods. This detachment may reduce their inclination to engage with or to understand these complexities. Therefore, Medina's concept of epistemic closed-mindedness further highlights how the privileged elite, shielded from the immediate consequences of disasters faced by marginalised communities during disaster displacement, may unintentionally perpetuate injustices. These injustices are amplified by the failure to address the root causes behind why disasters disproportionately impact vulnerable communities. This can be revealed by understanding the interconnected factors that constitute a disaster, as illustrated in Figure 1 (see Section 3.5). Ultimately, the true experts on the impacts of disasters are those who experience them first-hand.

6.7.2 Response and Adaptation

Smallholder farmers in northern Madagascar typically rely on rice production as their primary source of income, supplemented by vegetable cultivation, animal husbandry, and fishing. However, climatic changes and the onset of drought obligate farmers to find alternative income-generating activities and adapt to shifting rainfall and temperature patterns. While a technical expert expressed concern over the distrust of the Malagasy population in formal authorities, their preference for local or traditional methods appears justified. This justification stems from how colonial authorities have historically taken advantage of local populations by lending money at

extremely high interest rates in the pursuit of profit and control (Randrianja and Ellis 2009), as well as how repeated requests for support have remained unanswered. Such reasons for mistrust in authorities are further compounded by the prominence of corruption in Madagascar, which tends to leave local populations with little choice but to rely on traditional strategies.

This failure to address local needs is further demonstrated by the case of Cyclone Gamane in Ambilobe, highlighting the epistemic laziness present in the development of disaster risk management strategies. Despite their good intentions, the BNGRC's centralised approach delayed disaster response, which was further exacerbated by poorly maintained roads. Figure 1 (see Section 3.5) illustrates how a hazard (Cyclone Gamane) combined with exposure (inadequate infrastructure), coloniality (weak centralised governance), and vulnerability (socio-economic vulnerabilities) collectively result in a disaster. The centralisation that delays the disaster response of government agencies stems from a colonial legacy, rooted in a centralisation effort of the Malagasy government to fulfil the vision of French policymakers (Randrianja and Ellis 2009, 155).

When relief in Ambilobe finally arrived, it provided school supplies instead of urgently required food and water, demonstrating a failure to meet the immediate needs of the local population. This disconnect illustrates how centralisation rooted in coloniality and epistemic laziness can produce a distanced national perspective that overlooks local needs, exacerbating the vulnerability and exposure of communities to disasters. Furthermore, this underscores the critical importance of qualitative data in discerning what affected populations truly require, as they are the foremost experts on their survival needs.

6.7.3 The Limitations of Remote Sensing in Disaster Risk Management

While satellite imagery can be used to greatly enhance disaster risk knowledge and warning dissemination (BNGRC, UN-SPIDER Conference), it is also important to acknowledge the limitations of this research method. The "bird's eye view" perspective of remote sensing can sometimes result in marginalised populations becoming the "observed", with limited agency in the research process. As noted by Bennett et al. (2022, 740), satellite imagery is "collected and controlled by government agencies and commercial firms". Not only do these powerful actors possess the authority to decide who has the "right to look", they also tend to shape *"how* to look", as satellites continue to be designed largely for their own agendas (Ibid).

This epistemic arrogance, where Western research methods like remote sensing are deemed superior to local, qualitative knowledge, can hinder the development of a deeper understanding of the complexity of disaster risk. Many Global South countries lack access to high-resolution satellite imagery, while private corporations profit from the growing demand for access to these technologies. This is particularly evident in the context of Madagascar, where high-resolution imagery could significantly benefit organisations like the BNGRC by enabling them to identify affected areas more efficiently than spending time and resources on aerial surveys. However, the practical use of high-resolution imagery is hindered by its inaccessibility due to high costs. This represents another layer of injustice, as not only are those least responsible for climate change disproportionately impacted, but they also face the greatest barriers in accessing crucial resources for disaster risk management.

Moreover, the limited perspective of satellite imagery underscores the necessity of integrating in-situ, qualitative data with remote sensing data. This limitation is highlighted by the

case of monitoring tree cover loss in Montagne d'Ambre, where dense top canopy layers obscure ground-level conditions, complicating the detection of deforestation using satellite imagery alone. Remote sensing can be used to detect illegal logging or cash-crop plantations, for instance, by examining tree cover loss within the borders of a protected area or National Park, such as Montagne d'Ambre.

However, solely relying on remote sensing data to determine the drivers of deforestation can be complicated, as multiple factors may contribute to deforestation, not all of which are related to illegal logging or cash-crop plantations. Even if these activities are identified as the causes of deforestation, there may be underlying issues that cannot be detected using satellite imagery or even from in-situ quantitative data. For instance, field experts have reported increasing their engagement in charcoal production in response to reduced agricultural productivity caused by drought (Interviews 7, 8), leading to an increase in deforestation. This highlights how remote sensing alone can provide valuable information, but from a limited perspective. When combined with other research methods, such as qualitative insights from local populations, this "zoomed-out" perspective can be highly informative and valuable, particularly in the initial identification of a problem area.

Consequently, one approach would to initially identify potential areas of tree cover loss through satellite imagery, and then complement this with in-situ data, as well as involving local communities in an ethical research process, whose valuable local knowledge can be essential to determining the causes for tree cover loss. Recognising the root causes and incorporating local perspectives in conservation efforts can also enhance local support and mitigate conflicts between conservation organisations and local populations (Anthony et al. 2011). It is crucial not to prioritise one type of knowledge over the other; instead, combining both in an ethical research practice can

provide a more precise and comprehensive understanding of the situation and local context. This epistemic curiosity and open-mindedness can promote more effective and sustainable solutions that not only address the visible symptoms of the problem, but also its root causes.

6.8 Primary Needs and Improvements for Resilience

The primary needs of the Malagasy population, as identified by the field experts, include water for both human consumption and agriculture, improved road infrastructure, access to agricultural machinery and materials such as tractors and seeds resilient to climate change. Conversely, technical experts focused on areas such as water management and access, capacity building and education of local communities, decentralisation, improvement of infrastructure and roads, improved coordination between different sectors and organisations, remodelling the education system, and the modernisation of rice plantations. While field experts highlighted more immediate needs for livelihoods and survival, technical experts emphasised systemic changes.

Although both groups of experts recognise the critical importance of water, the field experts underscored the need for immediate access to water for survival purposes, while the technical experts advocated for sustainable water management systems. Similarly, both groups agree on the need for improved infrastructure, though their specific focus varies. While the field experts require better roads to facilitate the transportation of crops, the technical experts view infrastructure improvements as part of broader national development efforts.

Field experts prioritised urgent survival needs, such as water and climate-resilient seeds, reflecting the immediate impacts of climate change and drought on their livelihoods. In contrast, the technical experts focused on long-term systemic changes like education and capacity building,

which do not address the pressing needs of farmers, highlighting a potential disconnect between what the technical experts viewed as required changes and the actual needs of local populations. This is demonstrated by the reforestation efforts of the Malagasy government, where the provision of acacia and quinine seedlings exacerbate the impacts of drought by further drying up the soil. Additional improvements and strategies suggested by technical experts include the floodwater conservation through dam construction. As highlighted in the results section, many smallholder farmers are already constructing small-scale "dams" in an attempt to adapt to the changing climate. However, their efforts are to little avail if there is no water to retain, demonstrating a lack of opportunity for innovation when the climate is changing too rapidly for them to adapt.

Moreover, technical experts advocated for educating farmers on sustainable agricultural practices, assuming a lack of knowledge is the primary barrier. Field experts, however, demonstrated a clear awareness of environmental issues such as deforestation. The prominence of references to forest and trees in the drought definitions of the field experts underscores their awareness of the correlation between drought and deforestation, which has also been identified by Desbureaux and Damania (2018). Therefore, it is the absence of viable alternatives, not ignorance or limited knowledge, that drives smallholder farmers towards ecologically destructive practices like charcoal production.

Furthermore, the notion that the Malagasy population requires education on financial saving to alter their spending habits appears disconnected from local realities. In contexts where immediate needs must be met, prioritising saving money becomes challenging. This perspective is embedded in Western capitalist and individualistic ideals that tend to attribute the blame for food insecurity to individuals themselves. Furthermore, if such spending habits do exist, it is possible that they originated during the French colonial period, when unequal business between

colonial settlers left Malagasy farmers in debt and prevented them from saving money or investing in technology to increase agricultural productivity (Randrianja and Ellis 2009, 168).

The belief that local farmers and households simply require education not only reflects a form of epistemic arrogance, but also exhibits epistemic closed-mindedness. These epistemic vices might cause technical experts to overlook the perspectives of smallholder farmers coping with daily survival challenges, as well as the colonial history of Madagascar, which may elucidate the origins of such a financial mindset. Even with the best intentions, without a genuine understanding of the population's needs, they cannot effectively determine the required measures to improve the situation.

I propose that the solution lies not in the traditional "banking" concept of education (Freire 2012), typical of Western educational approaches, but in a participatory, problem-posing form of education that promotes the co-production of knowledge. This perspective aligns with one technical expert's suggestion to shift towards an education system embedded in the local context and tailored to address Malagasy needs (Interview 2). While Western education can offer valuable insights, it represents a different type of knowledge that is not superior, despite often being perceived as such. This shift would challenge the epistemic arrogance inherent in traditional Western educational models and underscore the value of integrating local knowledge.

Incorporating local knowledge into the Malagasy curriculum would make education more relevant and empowering. This transformation would shift the educational system towards a "problem-posing concept," where participatory approaches and mutual learning dissolve the traditional binary roles of teacher and student. Field experts are already aware of the consequences of deforestation and therefore do not require further education on the subject. Instead, they require support in identifying viable alternatives and enhancing their agricultural practices to reduce

reliance on charcoal production during droughts or other forms of extreme weather. Similarly, technical experts could benefit from developing a deeper understanding of the drivers behind increasing deforestation, knowledge that can be significantly enriched by the qualitative insights of local field experts.

While technical experts often focus on conservation issues, farmers face the problem of unproductive agriculture, which in turn leads to food insecurity and poverty. Addressing these intertwined challenges necessitates a participatory approach that facilitates the co-production of knowledge. This approach requires the cultivation of epistemic humility, curiosity, and open-mindedness to recognise the cognitive gaps inherent in each type of knowledge. Openness to alternative perspectives is essential to filling these gaps and enhancing understanding. Conversely, the perceived superiority of Western knowledge systems can hinder the development of locally appropriate strategies. To address this epistemic injustice, it is crucial to integrate local knowledge and expertise with broader technical insights through a participatory co-production of knowledge. Valuing and incorporating local perspectives facilitates the development of effective and sustainable solutions relevant to the immediate and long-term challenges faced by local communities.

7 CONCLUSION

This study concludes that northern Madagascar is beginning to experience the onset of drought, which is severely impacting the livelihoods of the local populations, particularly those of smallholder farmers. These impacts primarily include reduced access to water and sanitation, increased food insecurity due to agricultural unproductivity and death of livestock, and a rise in health problems, mostly due to water-borne illnesses such as schistosomiasis. Given the traditionally abundant rainfall in the North's "tropical" climate, the onset of drought in this region of Madagascar could have profound implications for the entire island, underscoring the gravity of climate change and the increasing prevalence of disasters.

Furthermore, while the semi-arid South has been experiencing severe drought conditions for several decades, this is a recent phenomenon for the North of the island. Consequently, local populations have not yet had the time to experiment with and develop adequate disaster risk management strategies, leaving them unprepared to cope with and adapt to the rapidly changing climate. Additionally, the lack of recognition of drought in northern Madagascar means that there are currently limited formal disaster risk management strategies in place to address this specific hazard in the region. The reliance on "Western" research methods and assumptions about community needs, without direct consultation, has hindered the effectiveness of formal disaster risk management strategies in northern Madagascar. The "testimonial" epistemic injustice (see Section 3.2) caused by the epistemic arrogance and laziness of technical experts has led to the perspectives and needs of local populations remaining unheard and therefore unanswered.

The socio-economic vulnerability of the local population (vulnerability), coupled with agricultural dependency and limited infrastructure (exposure), and colonial histories that have

heightened northern Madagascar's dependency on cash-crops and imported produce (coloniality), together with the onset of drought (hazard), collectively produce a disaster. This underscores that a hazard, such as drought, is not the sole cause of a disaster. Instead, it is the interplay of a hazard with vulnerability, exposure, and coloniality that creates the conditions for a disaster (see Figure 1), demonstrating that disasters are not "natural" but are the result of several interconnected and mutually exacerbating factors. Presenting these factors as separate issues, rather than recognising their interconnectedness, reflects an epistemic closed-mindedness that fails to acknowledge the coloniality of disasters.

Drought, widely recognised as a slow-onset disaster (Nhamo, Mabhaudhi, and Modi 2019), presents unique challenges for monitoring and mitigation (Interviews 14, 16). However, it could be argued that all disasters are slow onset. While cyclones, hurricanes, flooding and earthquakes may occur suddenly, "the threads of risks are spun out over decades, even centuries, until they crescendo into disaster" (Montano 2021, Location No. 1222). This is highlighted in Figure 1 (see Section 3.5), which illustrates how the interconnected threads of risks (vulnerability, exposure and coloniality) transform a hazard into a disaster. While drought may be a slow-onset "natural" hazard, the slow violence that transforms a hazard into a disaster is far from natural, a reality inherent across all types of disasters.

8 RECOMMENDATIONS

The disparity between the perspectives of the field experts and technical experts, particularly of those based in Antananarivo, demonstrates the need for the incorporation of local knowledge and in-situ data in Madagascar's Disaster Risk Management strategies. The observational and generational knowledge of field experts can complement quantitative and remote sensing data, offering essential insights for disaster risk management that might otherwise be overlooked. This approach would not only help technical experts to identify disasters, but also to develop effective, sustainable strategies appropriate to the local context. This must involve participatory approaches that validate and incorporate the lived experiences of local communities, particularly those of smallholder farmers. Their dependence on climate conditions for their livelihoods not only makes them disproportionately vulnerable to disasters, but also highly attentive to changes in climate. Recognising the legitimacy of local knowledge can lead to more sustainable and effective solutions that embrace the complexities and variability of local contexts. More broadly, this research underscores the value of qualitative research and the incorporation of diverse forms of knowledge, challenging the prioritisation of "Western" research approaches.

Furthermore, this study highlights the importance of moving beyond viewing disasters as "natural". This perception overlooks the multitude of factors that collectively transform risks or hazards into disasters and may lead stakeholders to treat interconnected challenges as isolated problems. Characterising disasters as random, singular occurrences prevents stakeholders from understanding the root causes of disasters, thereby impeding the development of effective disaster risk management strategies. Addressing the entirety of the issue rather than singular aspects and

understanding the reasons behind the disproportionate impact of disasters on marginalised populations are crucial steps towards enhancing disaster resilience.

Based on the findings of this study, it is recommended that further research is conducted regarding the problem of drought in northern Madagascar. Additionally, there is a critical need for increased research in climate change adaptation across Madagascar to assist relevant stakeholders in understanding and mitigating its impacts. Finally, enhancing access to free high-resolution satellite imagery for countries disproportionately vulnerable to disasters is crucial for facilitating effective disaster risk management strategies.

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10 APPENDICES

10.1 General Interview Questions for Technical Experts

1. How long have you been living in this region?
2. Please could you tell me a little bit more about your organisation?
3. What are your responsibilities? How long have you had this role?
4. What do you see as the main challenges in your work?
5. Have you experienced any changes in weather recently?
    a. What type of changes have you observed?
    b. When do you think these changes began?
    c. What have been the impacts of these changes?
        i. How have they affected your work?
        ii. How do you think they have affected the local population?
6. Have you experienced any resistance against your work?
    a. Why do you think that might be?
7. (If not mentioned) Have you observed an increase in extreme weather?
    a. Did you know in advance about cyclones, flooding, and/or droughts?
        i. (If yes) Did you observe how people prepared?
        ii. (If no) Do you think it might have been helpful to know in advance?
8. What has to be happening for you to speak about drought? What is drought for you?
9. From your perspective, is Diego and/or the Diana region starting to experience drought?
10. Is there any other information on this topic you think might be useful for me to know?

10.2 General Interview Questions for Field Experts

1. How long have you been living in this region?
2. What crops do you grow? Do you raise zebu?
3. Do you sell any products?
4. What is the main challenge you are facing at the moment?
5. (If not mentioned) Have you experienced any changes in weather recently?
    a. What happened?
    b. Were you affected?
    c. (If they use the word drought) What does drought mean for you? What have you seen that showed you it was a drought?
    d. How has this affected your work and daily life?
    e. Did anyone help you in that situation? What did they do? Would you have needed more/a different type of help?
    f. How did you respond to these changes/challenges?
        i. Have you modified the timing for planting or collecting crops?
        ii. Have you needed to change the type of farming you do or change which crops you grow?
6. Is it possible for you to predict changes in weather?

a. (If yes) What are the signs that drought will happen? How do you prepare?
b. (If no) Would it have been useful to know in advance? What might this have changed?

7. Is there any other information on this topic you think might be useful for me to know?