ASSESSING SEYCHELLES' VULNERABILITY AND ADAPTATION TO A HISTORICAL LANDSLIDE DISASTER THROUGH ARCHIVAL RESEARCH.

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5 June 2017 in Johannesburg

DECLARATION

I declare that this Research Report is my own, unaided work. It is being submitted for the Degree of Master of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

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(Signature of candidate)

On the___5th___day of___June_____2017__in___Johannesburg

ABSTRACT

Global climate change and its related actual and potential impacts to society has called for studies that look to the past to better understand historical climate trends and how they may inform future climate trends. Specific in this area of research is environmental histories, wherein information on historical climate events and disasters are retrieved from historical documentary sources, i.e. archives, in order to study the potential causes and effects of these occurrences, as well as levels of vulnerability and resilience through the analysis of coping and adaptation strategies of societies.

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RESEARCH STATEMENT

Research Statement

This research focused on the severest natural disaster to impact Seychelles throughout its history of human settlement, a double-disaster event, known locally as the *Lavalas*, which saw the impacts of a tropical cyclone followed by consequent landslides in October 1862. The double-disaster event caused the most extensive destruction and loss of life of any natural hazards that have impacted the island nation, due to the fact that the tropical cyclone and the resultant landslides impacted the main and biggest island, Mahé in particular, which was and continues to be where a large majority of the population resides. Though the event is well remembered by local society, as evidenced by the memorial dedicated to it situated in town and by the fact that mass services are held commemorating the tragic event, very little was understood about the causes, impacts and coping mechanisms surrounding the event. This Masters research study therefore utilized available primary sources to investigate details concerning this event. Historical documentary sources contained in the national archives in Seychelles, Mauritius and the United Kingdom were consulted to retrieve data on the weather and climate, geomorphological impacts, and on casualties, injuries and damages relating to the event. The purpose of obtaining such data was to understand the vulnerabilities, impacts and coping strategies involved in this historical event in order to shed light on the present vulnerabilities and coping strategies in light of the global increasing occurrence of natural hazards and a changing climate.

Aims & Objectives

The aim of this research was to assess Seychelles' past vulnerability, adaptation and coping mechanisms to the severest natural disaster experienced on the islands; namely the *Lavalas* landslide disaster of 1862. The objectives of this research were to expand on the detail of knowledge pertaining to the 1862 *Lavalas* event with regards to the circumstances and causes, the actual unfolding of events, and the impacts and mechanisms of the disaster through textual analysis of historical documents contained in the National Archives of Seychelles, Mauritius, and the United Kindgom, as well as to assess the country's level of vulnerability and adaptation to landslide disaster in response to the 1862 event. The final objective of this research was for the historical causes, vulnerabilities, impacts and coping strategies involved in the 1862 *Lavalas* to inform possible causes, vulnerability, impacts and coping strategies in light of contemporary risk to natural hazards.

Scope of the study

As stated above, the study focused on obtaining and extracting data on the 1862 *Lavalas* occurrence from historical documentary sources in order to understand the climate and meteorological background of the event, the human, agricultural and infrastructural impacts of the event on society, as well as the means of coping with the consequences of the impacts. The study therefore focused in detail on the 1862 *Lavalas* disaster, which begins with the onset of the tropical cyclone on 9 October 1862 (the meteorological data of which comes from ship logbooks that were in the area) and extends to April 1863, as the historical documentary sources that were selected to contain relevant data spanning this timeframe. The study did not, however, focus on the climate and meteorological data for the area that preceded and succeeded the event, as meteorological data were not recorded in Seychelles (apart from ship logbooks recording meteorological abnormalities when in the area). Further, though contemporary examples of natural hazards impacting Seychelles are discussed in the study, the findings of the *Lavalas* event are not directly applied to any contemporary disaster occurrence, but are nonetheless intended to inform possible contemporary occurrences.

NOMENCLATURE

An important note on the use of terms for the purposes of analysis must first be stated; the term *Lavalas* is a Seychellois Creole word for *avalanche*, and is how the event in question is referred to in Seychelles. While semantically the term explicitly refers to the landslide aspect of the event, in this study it is used to refer to the entire weather event, which took place over a period of three days (10-12 October 1862) and, which is consistent with the implication of the term in Seychelles. This is presumably due to the fact that the landslide is considered to be the more destructive aspect of the event, or possibly because it is thought of as a single weather disaster, rather than as being composed of one destructive weather event that triggered another destructive event (i.e. tropical cyclone triggering landslide). When each of these events is referred to individually, they are respectively referred to as *tropical cyclone* or *hurricane* and *landslide* (though the term mostly used in the archives is *landslips*, which is a British alternative term for *landslide*). The distinction of the terms *tropical cyclone* and *hurricane* are discussed above in the introduction. As the term *tropical cyclone* is recorded to have come into use in the mid-nineteenth century ("Tropical cyclone", 2014), it may not have yet been in wide use, which may be the reason that the term *hurricane* is used by the authors of the historical documents to refer to the climatic aspect of the disaster.

CHAPTER ONE: INTRODUCTION

1.1 Environmental Histories

Due to the increase of natural hazards and erratic climatic conditions as a result of global and environmental change, the terms 'vulnerability' and 'adaptation' have come into high usage, as they are the two most important factors in the consideration of society and a shifting climate. In the field of global change, the term adaptation refers to the development of characteristics or mechanisms that allow organisms to cope with and survive in environmental changes. In the social science field, however, the definition of adaptation expands the scope of environmental changes beyond biophysical stresses to include economic and demographic changes (Smit & Wandel, 2006). According to social science studies, cultural practices based on behavioural adjustments and innovation that have been developed in order to allow societies to survive are considered adaptations, and societies that are able to cope with change swiftly and with little difficulty are considered to have high adaptability or, in other words, have higher resilience (Smit & Wandel, 2006). Vulnerability is determined by the exposure and sensitivity of a system to hazardous conditions, as well as by the resilience of the system to cope, adapt to and recover from the impacts of the hazardous conditions. Generally, therefore, a system that is more exposed and sensitive to a particular climate condition or hazard will be more vulnerable, while a system that has a higher adaptive capacity will generally be less vulnerable (Smit & Wandel, 2006). What is problematic about this notion for the study is that in the case of Seychelles, the system is less exposed and *therefore* sensitive to certain climate conditions. Importantly pointed out in Füssel and Klein (2005), effective adaptation is dependent on two preconditions: information on what to adapt to and how to adapt, as well as the resources to implement adaptation strategies. The fact that there was no prior information on what to adapt to in the case of the *Lavalas* – as well as in the case of the December 2004 tsunami – is what increased the vulnerability of society to the events.

The historically unique increase in frequency and severity of disasters over the last thirty years – a possible consequence of the greenhouse effect – has contributed to the development of a new kind of risk culture that looks to the past and is based on the systematic retrieval of disaster memories from archives (Pfister, 2011). The use of documentary sources in the study of environmental histories is a well-established practice. This is for the reconstruction of climate and to describe climate events and variability for historical periods for which no instrumental data are available in a number of regions (Garcia Herrera *et al*., 2003, 2004). The IPCC-SREX report points out that the vast majority of available historical data for hurricanes is limited to a specific and recent period in history; generally from the mid 20th century to the present in the case of tropical cyclones. This, coupled with the uncertainties in historical tropical data, do not permit the identification of any clear trends in tropical cyclone activity that point to Global Climate Change (Garnier & Desarthe, 2013). There has therefore been a call for research that looks to other historical sources to obtain hurricane data for a more informed analysis of global climate change trends. One such study, with the aim of rectifying the historical data gaps in order to be able to study the frequency and occurrence of these events, used pre-satellite data from six tide gauges in the southwest United States to produce a series on the intensity of storm surge (Grinsted *et al*., 2012). While the study did not prove a link between cyclonic activity and global climate change, it did indicate a difference in the frequency of these events between colder and warmer years (Garnier & Desarthe, 2013), which remains important for the prediction and preparation of such events.

The nature and origin of historical documentary sources are very diverse; from ship logbooks and chronicles, to traveller's journals and reports by members of religious orders. The value of each of these documentary sources depends on the type of climate data that is sought; traveller's journals can offer very detailed information, however, covering only a short period of time, while chronicles can offer information spanning longer periods of time, but is much less detailed (Garcia Herrera *et al*., 2003). Historical documentary sources are particularly suitable for the study of past landslide and hurricane activity, as such extreme events and their consequences on society are frequently recorded (Garcia Herrera *et al*., 2004). Historical documentary sources provide information recorded either intentionally or unintentionally by people; such sources may include maps, newspaper articles, church chronicles, postcards, drawings, and personal letters (Crozier *et al*., 2004). The study of these unpublished materials contained in archives offer a supply of unpublished events and data to inform research (Garnier & Desarthe, 2013). Historical documentary sources for the study of 'typhoon' landfalls in Guangdong, Southern China, have facilitated the reconstruction of a thousand year time series dating as far back as AD 975 (Liu *et al*., 2001). Despite the fact that the quality of historical evidence is strongly dependent on available records and the recording procedures used in their production, studies based on this approach have provided an indication of at least the minimum level of landslide activity in an area (Crozier *et al*., 2004).

Another value of studying the spatio-temporal patterns of tropical cyclones over a region is that it may assist with climate modelling and projections (Fitchett & Grab, 2014). Likewise, the assessment of the risks and vulnerabilities of a society and place to past natural hazards may assist with the development of adaptation and mitigation strategies for potential future occurrences. Detailed understandings of the frequencies, trajectories, and intensities of past storms facilitate the planning of impacts as well as mitigation strategies of future tropical cyclones, as such information gives insight into tropical cyclone return periods, identifies climatic drivers, and assists in disaster planning based on previous damage (Nash *et al*., 2015). Garnier and Desarthe's (2013) study uses the data of unpublished materials contained in historical archives to produce a catalogue of cyclone events for the Mascarene Islands, and whose findings represent new and reliable data that may inform the development of strategies by decision-makers with regards to the adaptation of small island societies to potential climatic hazards. They propound that it is, in fact, possible to extend considerably the chronology of storm data by opening the subject up to social and historical data. This repository containing little explored climate data is considered to be extensive enough to allow climatologists and climate scientists and modellers to reconstruct a chronology of events dating as far as 300 or 500 years back – depending on the available relevant data (Garnier & Desarthe, 2013).

In Nash *et al.*'s (2015) study, descriptions of storm damage contained in historical sources are used to construct the first chronology of tropical cyclones that made landfall on Madagascar in the latter half of the 19th century and, where possible, to reconstruct the tracks of past tropical cyclones over land. Nash *et al.* (2015) explain the absence of long-term instrumental records for Madagascar; while there are records of historical tropical cyclone hits on Madagascar for the period 1889-1929, which include maps of approximated storm tracks, they offer only a general indication of cyclone intensity due to the use of early instrumental pressure data from Antananarivo. It is for this precise reason that historical sources are invaluable in the reconstruction of historical tropical cyclone occurrences (Nash *et al.*, 2015). Boose (2004) corroborates that the best approach to estimating occurrences, intensities and tracks of tropical cyclones is the analysis of reports of storm damage. It is interesting to note how historical reports on tropical cyclones and hurricanes are not only valuable in the context of a complete lack of other recorded information, but also especially where instrumental records may be questionable. Other studies of a similar nature include Alexander (1983) *"God's Handy-Worke in Wonders" – Landslide Dynamics and Natural Hazard Implications of a Sixteenth Century Disaster*, which re-explores a landslide in 1584 through historical documents, and Nash et al. (2015) *Tropical cyclone activity over Madagascar during the late nineteenth century,* which, by focusing on the period 1862-1900, uses the discussion of storm damage in European missionary correspondence and other historical records to identify individual tropical cyclones and reconstruct their intensity and track. The principal objective of Alexander's (1983) paper is to reveal the gaps in current knowledge of mechanisms and effects of large landslides, and to show that historical records of a *Bergsturz* can significantly add to the more scientific, but nevertheless limited observations of the modern era. Despite the wealth of geomorphic literature, there have been very few systematic studies of *Bergstürze* as hazards to human use of the land and of their consequences. Additionally, there are relatively few documented examples of the causes, mechanisms and effects of *Bergsturz* landslides (Alexander, 1983). Since *Bergstürze* have been little studied in terms of their hazardousness to humans and their activities, the effects of the 1584 landslide concerned with in the study are of interest to those concerned with the historical dimension of natural disasters (Alexander, 1983). For the Nash et al. (2015) paper, historical documentary sources have proved invaluable resources for reconstructing past tropical cyclone activity in the absence of long-term instrumental records for the island. Since long-term instrumental records also do not exist for Seychelles, historical documentary sources provide the only information on such historical disasters.

The problems identified by Crozier *et al*. (2004) that are associated with historical based approaches, include: (1) the historically based frequency – magnitude record may be a response to environmental conditions that no longer pertain to the area, and (2) the longevity of evidence is a function of the time and magnitude of the event; therefore the record may give a false impression, e.g. indicating that in the past there were fewer but bigger landslides compared with more recent periods (Crozier *et al*., 2004). These are factors to consider when analysing historical records, however, they should not make that much difference to the outcome of the research as the study is not concerned with a frequency-magnitude record, or whether the environmental conditions of the area are the same, and it is well-known and accepted that the event in question is the severest of disasters in the islands' history.

What is of greater concern to the interdisciplinary approach than the reconstruction of a series of events for the purposes of better modelling, is a better understanding of the impacts of these events on societies and populations, and the strategies that they developed in order to adapt to such occurrences (Garnier & Desarthe, 2013). Bilsky's (1980) *Historical ecology: essays on environment and social change* widened the field of environmental history through the recognition of the variety of structural societal responses to resource scarcities and ecological crises throughout time and space (Williams, 1994). As highlighted by Garnier & Desarthe (2013), the systematic use of the terms: ‘risk’, ‘exposure’, ‘vulnerability’ and ‘sustainability’ are evidence that the social dimension has come to the forefront of debates on global change and thus also of the strategic objectives of the International Panel on Climate Change (IPCC). This may be due to the increasing influence of the social sciences on the scientific community, as a result of the recognition that interdisciplinary solutions are required to tackle the interdisciplinary problems posed by global change.

1.2 Environmental Disasters

Though natural disasters are a relatively minor threat to Seychelles in comparison with Mauritius, Reunion and Madagascar, there is nonetheless a range of natural hazards that have impacted the archipelago. These are tsunamis, tropical cyclones and landslides and mass movements, and each is discussed in the following section.

The 2004 Sumatra-Andaman earthquake, which resulted in widespread tsunamis throughout the Indian Ocean, resulted in Seychelles being impacted by a series of powerful tidal surges on 26 December. Three lives were lost as a direct consequence of this occurrence, and many homes and livelihoods suffered damages (*Seychelles Post-Tsunami Environmental Assessment*, 2005, Chang-Seng & Guillande, 2008). Since then, tsunamis have become a natural disaster of concern to Seychelles and other previously unaffected southwestern Indian Ocean (SWIO) countries (International Council for Science, 2007). The number of casualties of the disaster for the entire Indian Ocean region came to 186 980 dead and 42 880 missing, with the number that died in the event in Seychelles totalling 3 and the number of those that went missing 7. The number affected by the tsunami in Seychelles totalled 4 830, and it is considered to be the most destructive disaster in the country’s history (Guillande and Malatre, 2012, International Council for Science, 2007). A preliminary assessment of the impacts to ‘environmental infrastructure’ of the December 2004 tsunami on Seychelles concluded a “total restoration estimate” of 7.25 million Seychelles Rupees (which was at the time equivalent to US$1.3 million), which was soon after the preliminary assessment considered an underestimate (National Rapid

Environmental Assessment, 2005). Seychelles' erosion risk is very high, which is why landslides were a result of the torrential rainfall that followed the tsunami, as was flooding of the coastal plains and damage to drainage systems (National Rapid Environmental Assessment, 2005), which contributed to the high cost of reparations. This disaster brought realization that a tsunami warning system should be put in place for the Indian Ocean (International Council for Science, 2007) and was also the reason that Seychelles' Division of Risk and Disaster Management was founded (*DaLA*, 2013).

Langlade (2013) offers some explanations for the use of words such as hurricane, typhoon and tropical cyclone. If maximum wind speeds are less than 34 knots, the storm activity is referred to as a 'tropical depression', if maximum wind speeds are between 33 and 64 knots (average winds must reach over 34 kt in order to meet the criteria for naming a storm), it is referred to as a 'tropical storm' and if maximum wind speeds are greater than 63 knots, then various terms are used depending on where on the globe it occurs: 'hurricane' in the north Atlantic and north-eastern Pacific, 'typhoon' in the northwestern Pacific, 'severe tropical cyclone' in the southwestern Pacific and the southeastern Indian Ocean, 'severe cyclonic storm' in the north Indian Ocean, and finally 'tropical cyclone' in the southwestern Indian Ocean. This semantic difference is corroborated by the International Council for Science (2007), which states that weather events characterised by violent winds and rainfall are known as 'tropical cyclones' in the Indian Ocean and as 'hurricanes' in the Atlantic Ocean.

Tropical cyclones form between latitudes 5° and 20° and have sustained wind speeds of 250 km/h or higher (International Council for Science, 2007). The Southwest Indian Ocean basin sees the formation of as many as eleven to twelve tropical cyclones every year during the season, between November and April. Many of these impact Mauritius, Reunion, Madagascar and Mozambique (Malan *et al*., 2013). As tropical cyclones make landfall, a dome of ocean water covers the shoreline, causing damage to coral reefs, mangroves and fisheries. Huge economic losses may result from these storms due to infrastructural damages and damages and loss of crops. Moreover, the heavy rainfall associated with tropical cyclones may trigger landslides and spread disease (International Council for Science, 2007). On average, 12 cyclones occur every year in the southwestern Indian Ocean (SWIO) (International Council for Science, 2007).

The spatial and temporal pattern of tropical cyclone formation is affected by various large-scale, low-frequency modes of ocean-atmosphere variability such as ENSO (Nash *et al*., 2015). Although the connection between ENSO and tropical cyclone frequency in the Indian Ocean is not yet strong enough, tropical cyclone formation in the south-western Indian Ocean is more frequent during El Niño phases, and so they are even used as a predictor of south-western Indian Ocean tropical cyclone activity. Since sea surface temperature (SST) has to be above 26-27°C in order for tropical cyclogenesis to occur (Malan *et al*., 2013), it would make sense for the likelihood of tropical cyclone activity occurrence to increase during El Niño periods, which are characterised by increased SST. Recent studies are suggesting that the smallest number of tropical cyclones in the south-western Indian Ocean coincide with strong La Niña events, while the largest number are concurrent with strong El Niño events (Nash *et al*., 2015). El Niño events are characterised by an increase in hurricane formation and intensity in the Pacific Ocean and by a decrease in the Atlantic Ocean (Astier *et al*., 2015), however, the limited amount of research undertaken on the SWIO region has not allowed for any scientific consensus on how these events may affect hurricane genesis in the Indian Ocean. Cyclone warnings are disseminated to other islands in the SWIO region from the Regional Specialised Meteorological Centre on Reunion and broadcast by radio and television and published in the press and in schools, religious groups, etc., which has played a role in the reduction of cyclone fatalities (International Council for Science, 2007).

Landslides, ground movements and mudflows have been a natural disaster of major concern in Seychelles following the great landslide or *lavalas* (literally meaning 'avalanche' in Seychellois Creole) of 1862 (Chang Seng *et al*., 2008). It is generally accepted that the severity of a disaster depends on two parameters: the number of victims, and the financial cost of damages (Pfister, 2011), by these parameters, the infamous 1862 *lavalas* is the severest natural disaster to have inflicted the Seychelles throughout its populated history. It is only the granitic, or 'inner' islands that are subjected to landslides, as these islands are affected by ground movements, however, there are very few of these events recorded on islands other than the main island, Mahé, which, with the highest peaks plunging into the steepest slopes, is most affected by such events and has 85% of the country's total population residing on it, rendering it particularly vulnerable or at risk (Chang Seng *et al*., 2008, DaLA, 2013). However, studying these geomorphological processes has been complicated by the fact that the intense weathering and erosion of soils combined with the rapid growth of vegetation, removes all traces of past landslides (Chang Seng *et al*., 2008), making it essential to refer to historical records to obtain data on these types of past events.

Landslides are geomorphological processes referred to as mass movements, which are comprised of mudflows, soil erosion, debris flows, debris avalanches, and debris and rock falls. These mass movements are intricately linked to the landform, material, structural, hydrological, climatic, and vegetative conditions within which they occur (Galli *et al*., 2007), and the human factors that contribute to these mass movements include overpopulation, deforestation and poor land management practices (International Council for Science, 2007). Careful study of these relationships can thus reveal patterns and thresholds that differentiate stable from unstable conditions (Crozier *et al*., 2004). Damaging slope failures are mostly slides, slide-earth flows, and complex or compound movements that commonly travel short distances and move at slow to moderate velocity, allowing people to escape when landslides occur (Galli *et al*., 2007). The debris transportation processes of large landslides, however, have remained a matter of intense debate. Causes apart, the literature defines a *Bergsturz* as a large rock fall generating a fast flowing stream of debris (Alexander, 1983). Erismann (1979), as cited in Alexander (1983), proposed several mechanisms of self-lubrication by diffusion of the lubricant (either air or water) into the moving solid mass of debris, thus decreasing its strength and coefficient of friction, enabling very rapid flow to take place. This latter description of a landslide, or

Bergsturz, seems to better fit the historical landslide event in question in this study, with the lubricant being vast amounts of water.

In global terms, landslides generate a small but important component of the spectrum of hazard and the increasing risk that faces humankind (Crozier *et al*., 2004), however, landslide risk could be on the rise due to modelling studies suggesting that during this century there will be a global decline in storm occurrence, but an increase in storm intensity (Malan *et al*., 2013). Despite slope failures causing frequent and widespread damage and loss to populations and built-up environments in many parts of the world, little is known about the vulnerability to landslides. Lack of information about vulnerability to landslides has limited the ability to determine landslide risk (Galli *et al*., 2007). The science related to slope stability problems has transformed landslides from 'acts of God' to comprehensible geophysical processes, and society demands that with such knowledge comes responsibility and obligation (Crozier *et al*., 2004). It is the intersection of humanity with landslide activity that has recast a natural land-forming process into a potential hazard and it should come as no surprise then that landslide hazard and risk studies are positioned clearly at the nexus of social and scientific concerns – two cultures that have not always been perceived as having compatible agendas – as the effective research and management of risk requires the integration of a wide range of interests (Crozier *et al*., 2004).

Galli *et al*. (2007) cite various authors on their definition of landslide vulnerability, quite specifically. According to Varnes (1984), landslide vulnerability is the degree of loss to a given element (or set of elements) at risk resulting from the occurrence of a landslide of a given magnitude in an area, and according to Vandine (2004) it is a measure of the robustness or fragility of an element or a measure of its exposure to or protection from the expected potentially damaging landslide. Finally, Alexander (2005) views landslide vulnerability as the ability of an element to withstand mass movements of given types or sizes. The vulnerability to ground movement or landslides differs according to the cause of the phenomenon; there is the vulnerability of naturally unstable landforms triggered by a natural event (such as rain), and then there is the vulnerability caused by human construction in inappropriate locations (Chang Seng *et al*., 2008). Despite the stability status of a given slope, a trigger – which is usually extrinsic – is needed to initiate movement. Natural triggers include rainfall, earthquakes, volcanic eruptions, and fluvial and coastal weathering, while human-induced triggers include explosions, slope cutting and slope loading (Crozier *et al*., 2004). These triggers are also dynamic (e.g. pore-water pressure) and passive (e.g. rock structure) factors that may be considered in terms of the roles they perform in destabilising a slope.

Sources for historically determined frequency-magnitude relationships of landslide disasters are based on either natural archives from the field (eg. hill slope evidence – morphology, deposits, dendrogeomorphology, varved lake sediments) or on human archives (eg. church chronicles, postcards, newspapers, letters) (Crozier *et al*., 2004). An analysis of hydrometeorological data has revealed that most of the mass movements in the Seychelles occur after several days of ceaseless, heavy rainfall, causing soil fractures in the granite due to saturation (Chang Seng *et al*., 2008). Since the density and rate of vegetation growth has not allowed for the study of natural archives on the site or area of the historical disaster in question in this study, human archives are heavily relied on to supplement such information.

There has been a perspective shift in disaster research and analysis; from an exclusive focus on 'extreme events' to include and give equal weight to the societal and human-environmental relations which prefigure disaster. The more recent global perspective views hazards as basic elements of environments and as constructed features of human systems, rather than extreme and unpredictable events as they were previously perceived. Anthropological research defines disasters as a process or event involving a combination of potentially destructive agents – either natural or technological – and a population in a – socially or technologically produced – condition of vulnerability (Oliver-Smith, 1996). Further research on mass movements would assist in the stabilisation of slopes and in the enforcement of land use planning in vulnerable areas in order to mitigate the impacts of mass movements on societies (International Council for Science, 2007).

1. 3 Environmental Context

1.3.1 History

The Seychelles were visited, or at least sighted by Admiral Vasco Da Gama in 1502, which is the reason for one of the island groups being named '*Amirantes*', as well as presumably by early Arab sailors before that (Scarr, 2000). In 1742, France took possession of the archipelago, and in 1770, French settlers and their slaves, totalling twenty-eight people, were the first to settle there, specifically on St Anne island, right in the bay of Mahé (Chang-Seng & Guillande, 2008). The French retained possession of the Seychelles until 1810, when like Mauritius, the islands were ceded to the British (Scarr, 2000), who ruled the archipelago first as a dependency of Mauritius, and later, in 1903 as a Crown colony in its own right (McAteer, 2000). Seychelles achieved independence from Britain in 1976, remaining as part of the Commonwealth (McAteer, 2000).

1.3.2 Geography

Seychelles is an archipelago of some 115 granitic and coralline islands located between 4° and 11° south of the equator and 46° and 56° east, or spread over 1.3 million square kilometres of the western Indian Ocean, and it is approximately 1600 kilometres east of mainland Africa (Scarr, 2000, *DaLA*, 2013, *Seychelles Post-Tsunami Environmental Assessment*, 2005). 41 of these islands are granitic with a rugged topography and are all situated within a 50 km radius from Mahé, which is the reason they are called the 'inner islands'. The remainder of the islands are coralline, which rise just a few metres above sea level (*Seychelles Post-Tsunami Environmental Assessment*, 2005, Chang-Seng & Guillande, 2008). Over 95% of the Seychelles population live on the three biggest granitic islands; Mahé (86%), Praslin (8%) and La Digue (2%), and the population density of these three islands was 468 inhabitants per square kilometre in 2005 (*Seychelles Post-Tsunami Environmental Assessment*, 2005), so this figure is presumably now higher.

1.3.3. Topography

The following excerpt is a description of the structural nature of the town of Port Victoria from 1864 (New Zealander);

> Surmounted by and at the foot of a range of lofty mountains, Port Victoria, its public buildings and private dwellings stand upon a flat surface composed of red argillaceous earth, (words missing from document), covered by sea sand and greywacke and granulite; which form in many instances the very unsubstantial basis upon which the different buildings are erected. The two rivers which immediately supply the town take their source from different parts of the mountains, the highest source being at least 1000 feet above the level of the sea and it will therefore be readily understood that the gradient described by them in their descent is at an excessive inclination. So that even during the usual rainy season from December to March the rains generally overflow their banks, and are diverted from their usual course.

Civil Commissioner Mylius was responsible for the laying out of the streets named Albert and Victoria, which must have entailed the land reclamation of a considerable area, as Webb (1964) explains that this area was previously covered by marsh.

1.3.4. Climate

Given Seychelles' proximity to the equator, there is very little seasonal variation, and temperatures and humidity remain generally high throughout the year at an average of 26.9° C and 80% humidity (Chang-Seng & Guillande, 2008). The period from May to October is dominated by the southeast trades, which usually result in cooler and drier conditions, while the October to May period is considered the cyclone season for the SWIO, and wetter weather is characteristic in Seychelles during this time, with the rainy season being December, January and February. Though most of the Seychelles islands, and particularly Mahé and the inner granitic islands, is out of the direct track of tropical cyclones, TC feeder-bands in the region sometimes affects these islands, resulting in gale-force winds, flash floods, and severe thunderstorms (Chang-Seng & Guillande, 2008). The 'Seychelles Dome' (SD), as Yokoi *et al*. (2008) have dubbed it, is an oceanic thermal dome situated around the Seychelles archipelago. According to Yokoi *et al*. (2008), the unique location of the SD is the reason for its seasonal variation in wind stress being dominated by the Indian monsoon to the north and the trade winds that prevail to the south.

Importantly, the sea surface temperature anomaly (SSTA) in the SD region influences the onset of the Indian monsoon and thereby also the climate conditions in various regions of Asia. Studies have shown that the onset of the monsoon is delayed by nearly 1 week when the SSTA of the SD is above normal. This is due to the fact that warm SSTA inhibits the inter-tropical convergence zone (ITCZ) from advancing over India. Further, tropical cyclone occurrence is closely linked with the thermocline depth anomaly and the SSTA in the southwestern Indian Ocean (SWIO) (Yokoi *et al*., 2008).

It is importantly noted by Rao & Behera (2005) that the inter-annual variations of the SWIO north of 10°S is primarily influenced by inter-annual Rossby waves (associated with the Indian Ocean dipole*), while the area south of 10°S is affected by ENSO. This has significance for the Seychelles context, as the main island and other 'inner' and granitic islands are located in the former region, while the 'outer' or coralline islands are mostly located in the latter region. The climate of the island group is affected by the El Niño and La Niña Southern Oscillations (ENSO) (Chang Seng & Guillande, 2008), as data show that there have been severe weather events impacting the islands during nearly every ENSO event (*DaLA*, 2013). El Niño periods have been characterised by extreme rainfall causing flooding and landslides, as well as coral bleaching and a loss of revenue from fisheries, while La Niña periods have brought about droughts and the resultant acute water shortages, as well as forest fires and epidemic outbreaks, which, in the context of a small island nation threatens the wellbeing of the entire population (Payet, 2005). The effects of the 1997/1998 El Niño on the archipelago were extensive, with what may have been the most severe case of coral bleaching in the Western Indian Ocean, as well as flooding and landslides – the most severe of which had last been experienced in 1862 – causing damage to over 500 houses and almost 40% of public roads, as well as considerable agricultural losses (Payet, 2005, Payet *et al.*, 2006). Moreover, climate scenario models have concluded that it is 50%-80% likely that rainfall on Mahé for the December, January, February period will increase by a maximum of 12.4% or +38.6mm in the next century (*DaLA*, 2013, Chang Seng & Guillande 2008), which may likely increase the incidence and severity of landslides.

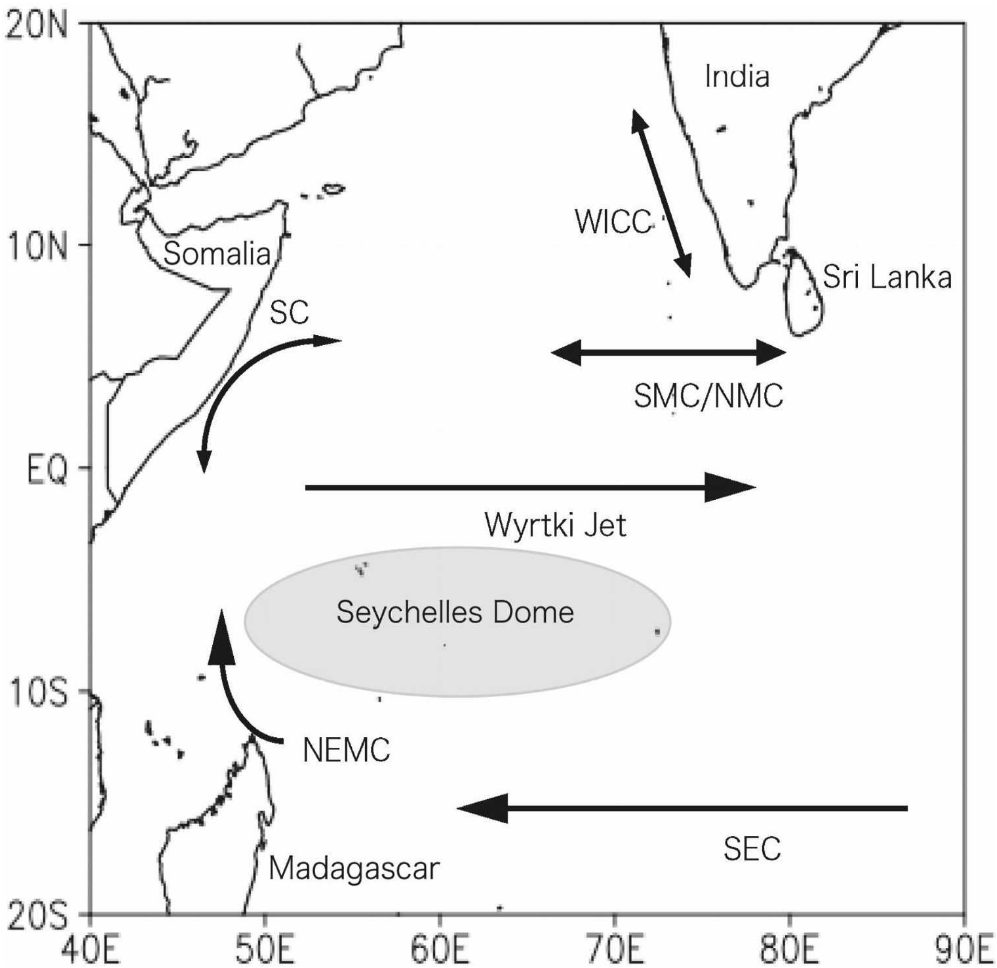

Figure 1: Western Indian Ocean and the Seychelles Dome.

WICC: West Indian Coast Current
SMC: Southwest Monsoon Current
NMC: Northeast Monsoon Current
SC: Somali Current
NEMC: Northeast Madagascar Current
SEC: South Equatorial Current

(Yokoi *et al.*, 2008).

1.3.5 Vulnerabilities specific to the context of the study

The following sub-section discusses the particular conditions and circumstances that render Seychelles vulnerable to the occurrence of natural disasters. Discussed in particular is the fact that Seychelles is part of the small island developing states (SIDS), which is a group of nations that share particular characteristics and vulnerabilities in the face of global climate change, the conditions of the south-western Indian Ocean region in which Seychelles is situated, and finally the specificities of Seychelles and its particular vulnerability and susceptibility to natural hazards.

Seychelles is a 'small island developing state' and as such is susceptible to a range of vulnerabilities and stressors that it has very little control over. Small island developing states (SIDS) is a diverse group of nations and territories that share characteristics, or rather 'disadvantages' such as high population density, limited land and human resources, sensitive biodiversity, high dependence on tourism, vulnerability to natural hazards, remoteness and small economies (Briguglio, 1995, Wong, 2014). Many of these islands are susceptible to natural disasters such as cyclones, earthquakes and landslides, and while they are not unique in this regard, they are unique in the extent of the impact that natural disasters have on them; damage per unit of area and costs per capita are significantly larger due to the small size of the country's territory and the corresponding relatively high population density (Briguglio, 1995, 2003). With the looming threat of global climate change increasing the frequency and intensity of natural hazards of these vulnerable islands – which, together contribute less than 1% of global greenhouse gas emissions – SIDS continue to assert their rights and vulnerabilities in climate change negotiations (Wong, 2014).

Small island states are vulnerable to soil erosion as a result of erosive rainfall, particularly those in tropical environments, as intense rainfall has a high erosive potential, which can break up and transport large amounts of sediment (Nel *et al.*, 2013). While soil erosion is a global phenomenon, it is particularly problematic in an island context where accelerated erosion is a result of limited land availability and land use pressures coupled with steep and degraded slopes, as well as rainfall variability (Sumner *et al*., 2016), which is why islands stand to benefit from erosion risk assessments, which inform conservation strategies and land use planning (Sumner *et al*., 2016). Important to note is that erosion risk and soil loss is not only dependent on the amount of rainfall, but also on the physical nature of rainfall, in the context of tropical islands. Erosive rainfall is related to rainfall depth, topography and altitude (Nel *et al*., 2013). Sumner *et al*. (2016) found that, as expected, high altitude parts of islands receive more extreme rainfall than the coast, which causes higher than average kinetic energies and erosivity. Corroborating this, long-term mean annual rainfall indicates approximate levels of rainfall for different parts of Mauritius island; 600 mm on the western coast, 1400 mm on the eastern coast and 4000 mm on the central elevated interior (Nel *et al*., 2012). Though tropical islands are found to have excessively high amounts of rainfall, a large proportion of this rainfall does not cause erosion, as the proportion of rainfall that is associated with erosion risk is characterised by short, sharp, intense rainfall events and tropical cyclones (Nel *et al*., 2012, Sumner *et al*., 2016).

Despite the fact that the SWIO region is home to vulnerable populated areas and is one of the main oil tanker shipping routes on the globe, studies dedicated to the region remain limited (Astier *et al*., 2015). On Mauritius, Comoros, Seychelles, Zanzibar and Reunion, 100% of each respective population live within 100km of the sea, and, unique to Seychelles, a high 42.3 % of the population live below 5-metre elevation above sea level (Guillande & Malatre, 2012). The SWIO is exposed to the Southern Indian Ocean cyclonic belt, which sees the formation of an average of 5 cyclones per year. However, different parts and islands of the SWIO are very diversely affected by this cyclone activity. Zanzibar almost never experiences cyclone activity, with the last and only recorded cyclone to reach Zanzibar having been in 1872, while the entire landmass of Madagascar is hit annually be several cyclones and tropical storms. The Mascarene Islands, situated in the Southern Indian Ocean, like Madagascar, are exposed to and affected by these storms, while Comoros is on the margin of the cyclone belt and Seychelles is scarcely affected by the tails of some storms

(Guillande & Malatre, 2012). The abovementioned countries are also subjected to droughts, particularly during ENSO periods. Parts of Comoros, Seychelles, Reunion, Madagascar and Zanzibar are exposed to moderate to severe drought economic impact, while Mauritius has a high level of economic impact on the entire island of Mauritius (Guillande & Malatre, 2012).

Though much of the south-western Indian Ocean islands (particularly Madagascar and the Mascarenes) are accustomed to weather visitations such as hurricanes and tropical cyclones, the Seychelles archipelago, being more affected by the monsoons, is not. In fact, Columbia University's Natural Disaster Profile for Seychelles, which is derived from the EM-DAT database maintained by Centre for Research on Epidemiology of Disasters in Belgium (Guillande & Malatre, 2012), provides the following table:

Table 1: Natural disasters in Seychelles for the years 1997-2004 (*Seychelles Natural Disaster Profile*).

Disaster	# of Events	Total Killed	Avg. # Killed	Total Affected	Avg. # Affected
Cyclone	1	0	0	6,800	6,800
Drought	-	-	-	-	-
Earthquake	-	-	-	-	-
Flood	1	5	5	1,237	1,237
Volcano	-	-	-	-	-

It should be noted that although the table accounts for natural disasters that occurred in Seychelles between the years 1997 to 2004, a natural disaster that is not listed in the table and, which affected Seychelles in December 2004, is the now famous tsunami. Furthermore, only major and noteworthy events are identified, while many smaller events are not accounted for (Guillande & Malatre, 2012), as reflected in Table 2 below. Nevertheless, if these statistics are compared with those for Madagascar, Comoros and the Mascarenes, we find that the Seychelles is less exposed to natural disasters than its neighbours. Recorded natural disasters for these islands between 1980 ad 2010 indicate that Seychelles has been impacted by 4 events, in which a total of 8 people died, while Mauritius has had 15 events, in which 12 people have died, Comoros has had 17 events, in which 148 people have died, and Madagascar has had 53 events, in which 3 887 people have died (Guillande & Malatre, 2012). This, however, as discussed further on, is perceived as contributing to the vulnerability of the country and its population, rather than contributing to its resilience – particularly with the threatening increase of these occurrences. An extensive investigation of archives regarding the impact and victims of natural disasters recorded 89 'significant' events from 1862 to 2008. It should, however, be noted that over 90% of the events recorded in the database occurred during the last 30 years (Chang-Seng & Guillande, 2008), meaning that they were not considered significant enough to be recorded on the EM-DAT database.

Table 2: List of 89 significant events from 1862 until 2008 (Chang Seng & Guillande, 2008).

Event	Number
Tsunami	2
Storm/ strong winds/ cyclone	19
Drought	6
Heavy rainfall	21
Flood (due to heavy rainfall)	14
Landslide/ rock fall/ mud flow (due to heavy rainfall)	14
Forest fire	13

Nonetheless, due to the geographic positioning, as well as the topography of the Seychelles archipelago, the small island developing state is rendered vulnerable to a range of natural hazards that occur in this Indian Ocean region; tropical cyclones, storm surges, tsunamis, torrential rains, flooding, landslides and mudflows – many of which are likely to increase with the effects of global climate change. Though Seychelles has been relatively out of the path of tropical cyclones due to its location, some climate trends have noted that the cyclone belt in the Indian Ocean may be widening, which could possibly put Seychelles at higher cyclone risk (*DaLA*, 2013). Further, data indicate that an extreme weather event has occurred in Seychelles for nearly every El Niño and La Niña periods (*DaLA*, 2013). The concentration of development on the narrow coastal zones, the fragility of the economy and population's livelihood, and the sensitivity of ecosystems make the country particularly vulnerable to the impacts of these natural hazards (*DaLA*, 2013).

Tropical cyclones 'Felleng' and 'Fantala' both impacted Seychelles in the last few years; the heavy rainfall resulting from Felleng in January 2013 in the region caused serious flooding and landslides on the southeast coast of Mahé (*DaLA, 2013*). Tropical Cyclone Fantala, the strongest recorded tropical cyclone to have formed over the Indian Ocean basin, was the sixth cyclone that occurred in the Indian Ocean during the 2015/2016 TC season. Forming on 11 April 2016, it made landfall on Farquhar Atoll – a group of ten small islands located 770 km SSW of Mahé – twice; on 17 April 2016 with maximum sustained wind speeds of 350km/h and on 19 April 2016 with maximum sustained wind speeds of 157km/h (Government of Seychelles, *PDNA*). Significant damages were sustained to the environment, to the limited infrastructure and to the coconut palm tree groves, and on 20 April 2016, the Seychelles Government declared the Farquhar atoll group a disaster area (Government of Seychelles, *PDNA*). Fortunately, no lives were lost or serious injuries sustained during this event, as the Island Development Corporation and the Seychelles Coast Guard evacuated most of their staff from the island and those that remained took shelter in the only concrete bunker, which is located on Faquhar Atoll and used as a cyclone shelter. The Department of Risk and Disaster Management, the Seychelles National Meteorological Service, Island Development Corporation and the Seychelles Coast Guard all collaborated closely in the days leading up to Tropical Cyclone Fantala making landfall on Farquhar (Government of Seychelles, *PDNA*).

The particular social vulnerability of natural resource-dependent communities was generated by an alternative conceptual model called the Natural Resource Community (NRC), and was defined as a population living within a bounded area whose primary cultural existence is based on the utilization of renewable natural resources, and the viability of which is threatened when there is a disruption in the natural resource base (e.g. contamination after oil spill) (Oliver-Smith, 1996). This is relevant to the Seychelles, whose economic and social vulnerabilities are expressed through their dependence on natural renewable resources, such as fishing and agriculture due to the remoteness of the islands – both of which would have been significantly impacted by the historical landslide disaster; the former to a lesser extent while the latter to a much greater extent. Sea-level rise, storm surges and changes in rainfall patterns pose serious threats to the welfare of the population, much like the effects of global climate change on the fishing and tourism industries are expected to be on the national economy and the population's livelihoods (DaLA, 2013).

As there are very limited resources in the way of scientific and academic studies that pertain specifically to Seychelles – given its small size and the near negligible number of hazards that visit the islands – the literature reviewed in the study extends globally, and is thus limited in how it can inform the study. Naturally, research from neighbours such as Mauritius and Reunion, which have historically been far more accustomed to such visitations are relied upon due to their regional similarities, however, potentially to the detriment of research on Seychelles, as it is geographically and geologically unique. It is for this very reason that studies of this nature are critical to conduct in the case of Seychelles, as historical documentary sources contained in archives provide primary materials and data for places that otherwise have little to no instrumental records and which are sometimes then falsely aggregated with the data for the nearest or characteristically-closest neighbour. Such data is thus highly valuable in informing contemporary research that considers historical events and occurrences.

CHAPTER TWO: *LAVALAS*

2.1 Account of the *Lavalas* event

Apart from the anecdotes and details available from the archives, much of the narrative of the *Lavalas* event comes from the account of Bishop Vincent W. Ryan of Mauritius, detailing the experiences of those he visited while at Seychelles shortly after the disastrous event. Bishop Ryan and Surveyor-General, Captain Morrison, R. E. travelled together to the Seychelles from Mauritius by the next mail steamer, and Superintendent of Police, Mr. Prince, had gone a few days earlier by a sailing-vessel (Ryan, 1864). Tony Mathiot, a local journalist and historian, compiled a retelling of the "unprecedented" 1862 *Lavalas* and its impacts drawn from the archives in both Seychelles and Mauritius, in which he deems the 1862 *Lavalas* "an unprecedented natural catastrophe for the archipelago" and "the most dreadful event in the history of Seychelles" (Mathiot, 'The Lavalas Of 1862'). Prior to that, Webb (1964) also recounted the "night of terror" drawn from various archives, including Bishop Ryan's account (1864). The following account is thus a re-telling of the tragic event as informed by the historical archive documents, as well as by the above-mentioned authoritative accounts and is intended to contextualise the disaster for the reader.

From noon of Friday 10 October until Saturday 11 October at around noon, there had been a gusty SE trade wind, and from Saturday 11 October until 4 a.m. on Sunday 12 October, the wind had been "increasing to hurricane violence" until noon of the same day when the gales were at their peak before dying out later that afternoon (Transactions of the Bombay Geographical Society, 1864, pii). The mountains overlooking Victoria town following days of ceaseless, torrential rains had become saturated and the rivers and watercourses that trickled down the slopes had swelled their banks causing the streets to be inundated with water and mud. At around 10 pm on Saturday, 11 October 1862, the centre of the storm concentrated on the hills overlooking Victoria; hurricane squalls and torrents uprooted old timber trees – whose roots had absorbed so much water that the surrounding soil became soft – and giant granite boulders and sent them in an avalanche of water gushing down the slopes at an estimated rate of seven miles per hour towards town, where the squalls had ripped up and destroyed many homes and people (Ryan, 1864, Webb, 1964, Mathiot, 'The Lavalas Of 1862', New Zealander). At around noon on Sunday, 12 October, a cliff face of the *Trois Frères* mountain crumbled down towards the town taking everything in its wake.

The large house which had accommodated the Sisters of St Joseph du Cluny, a capuchin priest, Father Jérémie Giantomaso, and some eleven children was lifted off its foundation and collapsed into the mud, which suffocated many of those inside – some of whom had fled there for safety. Bishop Ryan (1864) explained that, "this body of water seems to have been the cause of most of the deaths which occurred in the town." Father Jérémie was the only survivor, rescued from the mud hours later (Mathiot, 'The Lavalas Of 1862'). A young woman who was rescued during the disaster gave birth to her child the following day (Ryan, 1864). Another woman, who gave her account to Bishop Ryan, told how she had sought refuge with her children from one place to another, until when all had blown down and been carried away, she managed to get through the mud to the church where several other families had gathered for shelter. There were corpses of children near them and as night fell, the voice of a man was heard shouting "sauve moi! Sauve moi!" ("*save me! Save me!*") until it gradually faded and, as they supposed, he drowned (Ryan, 1864). Bishop Ryan was visited by Monsieur Dubois, who lived approximately a mile and a half south of town. He told him of the destruction that occurred there; even the two sturdy caoutchouc trees that had sheltered his house had been flattened by the gusts. Mr Mulloy told how he heard a thunder-like sound and on opening the door to his elevated house, he saw the rush of water and rocks tearing down and sweeping away houses that "looked like ships tossed about in the sea" (Ryan, 1864).

It had been fortunate that the H. M. S. "Orestes" under Captain Gardner had been in the harbour and so was able to administer immediate relief in the form of food, labour and communications. Bishop Ryan (1864) also explains that the Mayor of Port Louis had intended to hold a meeting in aid of the Lancashire Distress Fund, but had chosen to instead make an appeal at once for the population of Seychelles. The ground floor of Government House was occupied by a detachment of the police force, while the upper story was occupied by a big group of Indian prisoners, who had been sent to help with the clearing of the debris (Ryan, 1864).

By Wednesday 15 October, a "Comité de Secours" was formed by some of the inhabitants to assess and bring about relief to victims of the *Lavalas* (Mathiot, 'The Lavalas Of 1862'). At the committee meeting, four classifications of those eligible for relief were established; 1) those who needed food, 2) those who needed tools and materials, 3) those whose loss of relatives and poor health made them dependent on others, and 4) those whose loss of property should be offered some compensation (Ryan, 1864). At this time, Dr James Henry Brooks, government medical advisor, had established a temporary hospital for those suffering from fractures and lacerations. He also made an emergency request to the medical officer of Mauritius for an urgent supply of medicine and other medical articles (Mathiot, 'The Lavalas Of 1862').

The Anglican Church, St Paul's, was for the most part undamaged, and so its tower was filled with bags of rice, as there was no other available building at the time (Ryan, 1864) and its bell was rang at noon each day signalling those in need to come receive food. The stock of rice in the government store had been significantly damaged and so a shipment of 1800 bags of rice was sent from Mauritius immediately after the Colonial Secretary received news of the disaster, later in October (Mathiot, 'The Lavalas Of 1862'). Brunton had determined in his assessment of damages around the island that there were approximately 60 bags of rice and 6 to 7 thousand tons of maize available in shops, which was estimated to be just enough to sustain the population until the shipment from Mauritius arrived.

The churchyard was also occupied, due to the impossibility of accessing the cemetery. Bishop Ryan (1864) explained that this would become a solemn memento of the *Lavalas.* A mother and her three children were buried in a single grave in the churchyard as access to Victoria cemetery was virtually impossible. This cemetery had been severely impacted by the *Lavalas* with some limestone tombs being reduced to rubble that was scattered around, and with some more recent graves being washed away so that there was no discernible trace of them. For the burial of those who died in the *Lavalas,* their corpses were sunk into water-laden graves by means of weights and by being pushed down with a long pole (Mathiot, 'The Lavalas Of 1862' , Webb, 1964). The bodies of the two nuns (Sisters of St Joseph du Cluny) were, however, buried in the foundation of the cathedral of Immaculate Conception, which was being constructed at the time. On November 13 1862, Bishop Ryan (1864) gave a sermon, which, he writes, was well attended, and, which suggests that the population prioritized religion during this time of devastation.

On Friday 17 October, the tally of those who had lost their lives in the event had reached 67 (19 men, 27 women, 21 missing) and on Sunday 19 October, the body of what was estimated to be a thirteen year-old girl was recovered from the mud near Government House, while a woman died from wounds she had received during the event. Brunton's report dated on this day stated that the mud had begun to dry up, but the town was nonetheless in a "pitiable" state. The mud on Royal Street had become compact under the strong October sun, requiring labourers to cut out a canal in which the St Louis River could flow though. Three boats from Mauritius, Dart, Surprize and Romp, brought an abundance of food provisions to the inhabitants.

Figure 2: Photograph of St Paul's Church from the sea shortly following the *Lavalas* (with its tower clearly visible).
('The Lavalas Of 1862' - http://www.pfsr.org/history-of-seychelles/the-lavalas-of-1862/)

Figure 3: Sketch of St Paul's Church facing the sea.

('The Lavalas Of 1862' - http://www.pfsr.org/history-of-seychelles/the-lavalas-of-1862/)

CHAPTER THREE: DATA & METHODOLOGY

This chapter discusses the methods employed in the study with regards to the approach of the research, the identification, selection and collection of the data used, the materials used, and the analysis of the data. The extraction of climatic data from documentary sources is time-consuming, as many are not digitised requiring the consultation of the originals (Garcia Herrera *et al*., 2003). As this study concerns the most notable natural disaster in Seychelles' settled history, the consultation of archived materials was much simplified in comparison to studies of a similar nature that deal with the reconstruction of climate variability, which requires sifting through numerous pages of documents to determine which contain meteorological references or references to damage, which may be a result of meteorological conditions (Garcia-Herrera *et al*., 2005). With the date of the event already well known and remembered, obtaining the relevant historical documents from the National Archives in Seychelles was relatively problem-free; all the documents from 1862 and 1863 dated after the date of the event pertain to the *Gran Lavalas.* Analysis of the archives thus centred around extracting and cross-checking data on the impacts of the *Lavalas*; weather and climate, casualties and health, damages to property and agriculture.

3.1 Research approach

The research approach employed in the study was inductive rather than deductive, as rather than testing a theory the study used primary sources to reinvestigate a known event in order to obtain a new theoretical understanding of the event. Details of the *Lavalas* had already been obtained from historical archived documents by authors and historians, who then published accounts of the tragic event in books and in newspapers in Seychelles, which thus led to an isolated understanding of the event in that it is viewed as a freak landslide occurrence, when in fact close study of all the relevant and available historical documents shows that a tropical cyclone – the only one known to have impacted the main island in such a way throughout the history of its inhabitation by people – struck Mahé and surrounding islands bringing destructive weather and eventually causing extensive landslides throughout the island. The *Lavalas*, which is correctly considered to have caused the greatest loss of life in Seychelles' history, is importantly considered in this study to represent the possibility of a double-disaster event occurring on the country's main island, where such occurrences continue to be unfamiliar and unexpected, as well as the possible vulnerabilities, impacts and coping strategies of the present.

The main philosophical issue that was experienced with the world of research during the undertaking of this study was the need to link a scientific and academic basis throughout the different processes of the study and the difficulty in acquiring one that adequately fits the relevant context. The consequence of this was either having too little yet relevant and reliable information on the one hand, or having a diverse range of information of which very little was reasonably relevant to the particular study on the other hand. Furthermore, of the information obtained from research done on Seychelles specifically, the reasons for undertaking these studies in the first place is often a hindrance to the quality of quantity (or both) of the data that they provide. For instance, much of the scientific research undertaken for Seychelles (excluding scientific reports of a conservational nature) is limited to reports commissioned by the government or other large institutions such as the United Nations, with a specified goal in mind, meaning that much of the valuable data they provide is extremely brief and mostly meant as background information, and in some instances the vast array of quantitative and statistical data may even be inadequately critically assessed due to the shortage of other comparable studies.

3.2 Research Design

3.2.1 Identification and selection of data sources

As the study dealt with an already well-known historical event, the process of identification and selection of data sources was relatively simplified: the date of the event is widely known and the historical documentary sources contained in the National Archives in Seychelles from that period are limited. Therefore, in the case of data source identification and selection for the historical documentary sources in Seychelles, it was simply a matter of requesting from the Directoyet againr of the National Archives all the historical documentary sources pertaining and relating to the 1862 *Lavalas*. These documents are all dated October 1862 and offer data on the immediate causes, effects and coping strategies relating to the disaster. The identification and selection of data sources contained in the Mauritian National Archives was initially problematic, as although it is well understood in Seychelles that much of the country's historical data are contained in the archives in Mauritius, trying to narrow down the relevant documents via the institution's online database proved troublesome, as it was not possible to visit the Mauritian National Archives in person. However, after some effort and correspondence with the Principal Archives Officer, who was able to direct me to the files of documents that pertained to the *Lavalas*, all of which was then ordered and received from the National Archives in Mauritius. Finally, with the identification and selection of the data sources consulted in the National Archives in the United Kingdom, their online database was used to search files of documents relating to Seychelles. Since there were not many, all that were available and relevant to the study with regards to date were ordered for consultation in the UK.

3.2.2 Collection of data

The primary materials used in this study are historical documents contained in the National Archives in Seychelles, and in the National Archives in Mauritius. These historical documents are official and epistolary in nature, ie. made up of correspondence such as letters and reports from administrative authorities in Seychelles to those in Mauritius and are all dated between October 1862 and April 1863. The reason for these documents being selected as the primary sources for the study is that there are many relevant details and much valuable information contained in these documents pertaining to the worst natural disaster in Seychelles' history that is not necessarily recorded anywhere else. For instance, details such as barometer readings and numbers of casualties and information on coping mechanisms and adaptation to the disaster. Maps dated both before and after 1862 were also obtained from the British National

Archives (Kew) in London and used to inform the study. My analysis of the historical documents at the UK National Archives in Kew, London, however, were different from my analysis of the historical documentary sources from Seychelles and Mauritius – having searched the archives database for documents on Seychelles for a number of years before and after 1862, the most relevant archives contained there were a number of maps from the nineteenth century (both preceding and succeeding 1862). These maps represent the port of Victoria and Mahé and her surrounding islets, and inform the study with regards to names of places and points, which have since changed and, which are made reference to in the historical documents.

The data obtained from the archives can only be useful and informative to climate scientists if a historian is able to translate the 'social' data into more quantitative data. Although barometers and thermometers came into common use toward the end of the eighteenth century, when descriptions of weather events were from then on accompanied by instrumental records (Garcia Herrera *et al*., 2003), their use was not until much later in the case of the Seychelles. Due to the general absence of instrumental data prior to the 1850s, the information that the archives provide on these events is mostly related to the damages caused to societies. The instrumental data that are available from the 1850s includes the strength and orientation of winds, as well as barometric pressure (Garnier & Desarthe, 2013). As there is no knowledge, nor indication of any meteorological establishment in the Seychelles at the time – apart from a brief mention of an on-shore aneroid barometer accompanying a meteorological table below, the instrumental data (wind direction and strength and barometric pressure) that are available to the study is derived from and is only available due to the presence of the ships (H.M.S "Orestes" and the "Nepaul") that were in the harbour at the time of the event in question, and thanks to the fact that all senior British officers on sea vessels were obliged to maintain a daily logbook at sea, as well as in harbour – though the latter in briefer form (Garcia Herrera *et al*., 2004).

Logbooks are a unique and important source of historical climate data, as their purpose is to consistently describe in as much detail as possible, certain meteorological variables such as wind strength and direction, precipitation, etc. This is what facilitates the interpretation of meteorological entries from ship logbooks and what allows for the "immediate and straightforward applications of historical data to climate studies" (Garcia Herrera *et al*., 2003, p1027), which is the case for this study. British ship logbooks are often very formalised and as such offer very little literary expression with regards to weather conditions and storm descriptions. Nonetheless, the daily mapping of wind strength and swell direction can be useful in the reconstruction of hurricanes, the identification of previously unknown events, and the confirmation of events (Garcia Herrera *et al*., 2004). In Fitchett and Grab's (2014) study, the first period of records of cyclone landfalls in the southwest Indian Ocean (1850-1899) were based primarily on ship logs. Wheeler (1987) suggests that meteorological data from ship logbooks is reliable due to his research findings that showed how several ships gathered in the same area recorded consistent weather conditions. He explains that any apparent inconsistencies are a result of imprecise use of meteorological terms – which, currently are more precisely delineated – rather than of inaccurate observations. Apart from ship logbooks, very few documentary sources offer such explicit meteorological data, and as such meteorological information must be drawn from a diversity of documentary sources, such as reports on specific weather events or impacts, which, for example, detail damages to lives and property (Garcia Herrera *et al*., 2003). This is true for this study, as the logbooks of ships The *Nepaul* and H.M.S *Orestes*, which were at the time of the meteorological occurrence sailing through the islands and harboured in Victoria harbour respectively, and whose logbooks are found in the Transactions of the Bombay Geographical Society as discussed below in this chapter.

Nash *et al*. (2015), focussing on the period 1862-1900, used descriptions of storm damage contained in historical records (i.e. European missionary correspondence) to identify individual tropical cyclones and to reconstruct their intensity and track over land (where possible). The period 1862-1900 was selected as it is the richest in 'European language' historical records, owing to the presence of Europeans from the 1860s. These historical records include letters, diaries, personal papers, quarterly and annual reports written by missionaries, which were sent on to the relevant headquarters in Europe. These documents offer rich descriptions of weather, climate and environment (Nash *et al.*, 2015).

Table 3: Primary historical documentary sources and in-text referencing codes

Code	Location	Description
SNA (please see note on coding of historical documents from Seychelles National Archives in the paragraph below Table 3).	Seychelles National Archives	Official correspondence sent from the dependency to the colony regarding damages and relief (further document details below).
MNA SD 64/No 74 24.04.1863 'Damages caused by late hurricane at Seychelles.'	National Archives of Mauritius	Official correspondence between the colony and the dependency regarding damages and relief (further document details below).
TNA CO 700/SEYCHELLES No 1 CO 700/SEYCHELLES No 2 CO 700/SEYCHELLES No 6 CO 700/SEYCHELLES No 10	The National Archives of the UK (Kew)	Maps and plans from the Colonial Office.

The National Archives in Seychelles was in the process of relocation due to fungal problems with the air-conditioning system, which was damaging the historical documents. For this reason, the historical documents pertaining to the *Lavalas* event were scanned and mailed and so the only information regarding their organization in the archives is some page numbers, which themselves show no decipherable order and many of which are crossed out with other numbers written next to them. A total of 24 A4 scanned pages were received and the contents of which were selected for use in this study are listed below.

As expected, there was some overlap of historical documents between those from the archives in Seychelles and those from Mauritius, as letters were sent between officers of government in each of these places. The duplicate documents are only listed once – in the list of the Mauritius archive documents. The historical documents from the National Archives in Seychelles that were consulted in this study include:

- A report on the state of the island written by Police Inspector R. P. Brunton and addressed to Acting Civil Commissioner and District Magistrate, E. Dupuy dated 17 October 1862.
- A letter following up the report adding a few details by Inspector Brunton to Acting Civil Commissioner Dupuy dated 19 October 1862.
- A letter from Acting Civil Commissioner, Dupuy to the Colonial Secretary in Mauritius, F. Bedingfield informing of the disaster at Seychelles and dated 15 October 1862.
- A follow-up letter from Dupuy to Bedingfield dated 18 October 1862.
- A letter from Government Medical Officer, Dr James Henry Brooks to Chief Medical Officer in Mauritius, A. Gordon dated 18 October 1862.
- Minutes No. 60 of 1862 signed by W. Stevenson and dated 31 October 1862.
- Appendix No. 1 to Minutes No. 21 of 1862 signed by F. Bedingfield.
- A book by A. W. T. Webb entitled "The Story of Seychelles" drawn from the archives in Seychelles and published in 1964.

The historical documents from the National Archives in Mauritius that were consulted in this study are as follows:

- Minute No. 10 of 1863 signed by Major General, M. C. Johnstone.
- Appendix No. 1 to Minutes No. 4 of 1863 signed by E. Dupuy.
- A letter from Superintendent T. Prince to E. Dupuy dated 15 November 1862.
- A report of the damages and impacts of the disaster written by Police Inspector, R. P. Brunton.
- A return of damages written by Brunton.

- A report of damages and impacts of the event by Surveyor General, W. L. Morrison dated 24 November 1862.
- A letter from Colonial Secretary F. Bedingfield to E. Dupuy dated 28 October 1862.
- A despatch from the Secretary of State, F. Rogers at Downing Street dated 27 December 1862.
- Appendix No. 2 to Minutes No. 7 of 1863 signed by Civil Commissioner, Swinburn Ward.
- A note on the distribution of food signed by S. Ward and Dr Brooks and dated 17 March 1863.
- A note on the resolutions of the Government Relief Committee signed by S. Ward.
- A note on the rules of distribution of food signed by S. Ward.

Secondary sources from the years 1862-1864 also provide much valuable information with regards to the Seychelles weather event:

- The concluding chapter of Bishop Vincent Ryan of Mauritius' 'Journals of An Eight Years' Residence in the Diocese of Mauritius, and of a Visit to Madagascar' (1864) is also a revealing piece, as it recounts his voyage to Seychelles after hearing of the disaster, and also the information he gathered from journeying around the island to witness the devastation and to hear the testimonies of the island's inhabitants.

- The Proceedings of the Mauritius Meteorological Society (1862)

- The Proceedings of the British Meteorological Society (1861-1863)

- The Transactions of the Bombay Geographical Society (1863-1864), which contains an extract of a letter from Captain W. Curling of the S. S. 'Nepaul' dated 28 December 1862 relaying weather observations and descriptions and instrumental measurements from the ship's logbook while anchored 50 miles off the Seychelles from 2 p.m. Saturday 11 October until midnight of Sunday 12 October.

- The newspaper article from the New Zealander (1864), which was a weekly newspaper that was in print from 1845 to 1866 in Auckland, New Zealand. The issue of December 20 1864 included an article entitled *The Seychelles Islands and a Late Hurricane Here*, though there is no author to attribute it to (New Zealander).

3.3 Data Analysis

According to Garcia Herrera *et al*. (2003), three types of situations are often encountered when extracting data from historical archives:

- the treatment of non-instrumental meteorological observations
- the interpretation of documents that provide explicit information on climatic events or impacts
- the development of climate proxies

(Garcia Herrera *et al*., 2003).

Data analysis for this study entailed the textual analysis of the relevant historical documents containing detailed information on the climatic experience preceding the devastating event, on the impacts and effects of the climatic and geomorphological events, and on the mechanisms of coping with the disaster. With regards to climatic details, it was necessary to distinguish between those relating to the climatic experience (being the 'tropical cyclone' or 'hurricane') and those relating to the geomorphological experience (being the '*lavalas*'). In Nash *et al.*'s 2015 study, storm damage for each tropical cyclone was mapped out according to settlements as it was according to these, that European observers reported damages. These impacts included damage to buildings and vegetation caused by:

1. Strong winds
2. Freshwater flooding (heavy rainfall)
3. Coastal flooding (storm surges)

Similarly, my study involved the analysis of whether reported damages that had occurred due to heavy winds and rainfall, which is characteristic of the tropical cyclone, or whether they occurred due to the landslide and mud and debris flows, which occurred as a consequence of the effects of the tropical cyclone.

Wilkinson's (2012) report expounds the value of ships' logbooks contained in British archives in obtaining 'high resolution, instrumental and non-instrumental climatic data'. His paper also provides an explanatory summary of the data found in logbooks for the period 1850-1899, which is useful in the interpretation of the ships' logbooks data in this study; air temperature and pressure data are found in logbooks after 1850, which is true for both ship's logbooks in this study; sea surface temperatures were recorded by 1870, and perhaps as early as the mid 1860s, which is evidently not the case for these ships' logbooks and which makes sense for the time frame indicated; wind force was recorded according to the Beaufort Scale, which clarifies the meaning of the numbers given for wind speed; and weather was recorded according to a lettered scheme, which is found in the meteorological table by Inspector of Police, R. P. Brunton (British Meteorological Society Proceedings, 1863) together with their meanings. Wind directions were magnetic until c. 1920, which is thus the case for all the wind directions recorded in these logbooks; by the 1870s, observations were by regulation recorded at 4, 8 and 12 o' clock, both am and pm, and more frequently in stormy weather, which is particularly evident in the logbooks for this study – though it is some years prior to the 1870s – as weather observations are recorded for those three hours, both am and pm, with some extra observations recorded at other hours – presumably due to the stormy weather conditions. Type, maker and position of instruments were cited in logbooks from the 1890s, which is not relevant to the application of this study as it is some decades before the 1890s and finally, sea state was consistently recorded from 1890s, though it would appear that sea state was recorded in the logbooks used in this study, perhaps due to the unusually stormy conditions at the time.

IBTrACS provides trajectory data for the south-western Indian Ocean from 1848 onwards and so was consulted in this study, however, Garnier and Desarthe

(2013) argue that the most reliable information only dates back to 1880, and that it cannot be confirmed whether all tropical cyclones have been accounted for (Nash *et al*., 2015), which may account for the apparent absence of the 1862 tropical cyclone over Seychelles.

Table 4: Saffir-Simpson Hurricane Wind Scale (SSHWS) (Schott *et al*., 2012).

CATEGORY	SUSTAINED WINDS (mph, knots, km/h)	DAMAGE CAUSED BY WINDS
1	74-95, 64-82, 119-153	Very dangerous winds will produce some damage.
2	96-110, 83-95, 154-177	Extremely dangerous winds will cause extensive damage.
3	111-129, 96-112, 178-208	Devastating damage will occur.
4	130-156, 113-136, 209-251	Catastrophic damage will occur.
5	157/<, 137/<, 252/<	Catastrophic damage will occur.

Table 5: Beaufort Scale ('Beaufort Wind Scale').

Wind Force	Description	Speed (mph, knots, km/h)	Appearance of Wind Effects	
			On Water	On Land
0	Calm	<1, <1, <1	Sea surface smooth and mirror-like.	Smoke rises vertically.
1	Light Air	1-3, 1-3, 1-5	Scaly ripples, no foam crests.	Direction shown by smoke drift but not by wind vanes.
2	Light Breeze	4-7, 4-6, 6-11	Small wavelets, crests glassy, no breaking.	Wind felt on face; leaves rustle; wind vane moved by wind.
3	Gentle Breeze	8-12, 7-10, 12-19	Large wavelets, crests begins to break, scattered whitecaps.	Leaves and small twigs in constant motion; light flags extended.
4	Moderate Breeze	13-18, 11-16, 20-28	Small waves 1-4 ft. becoming longer, numerous whitecaps.	Raises dust and loose paper; small branches moved.
5	Fresh Breeze	19-24, 17-21, 29-38	Moderate waves 4-8 ft. taking longer form, many whitecaps, some spray.	Small trees in leaf begin to sway; crested wavelets form on inland waters.
6	Strong Breeze	25-31, 22-27, 38-49	Larger waves 8-13 ft. whitecaps common, more spray.	Large branches in motion; whistling heard in telegraph wires;

				umbrellas used with difficulty.
7	Near Gale	32-38, 28-33, 50-61	Sea heads up, waves 13-19 ft., white foam streaks off breakers.	Whole trees in motion; inconvenience felt when walking again the wind.
8	Gale	39-46, 34-40, 62-74	Moderately high (18-25 ft.) waves of greater length, edges of crests begin to break into splindrift, foam blown in streaks.	Twigs break off trees; generally impedes progress.
9	Strong Gale	47-54, 41-47, 75-88	High waves (23-32 ft.), sea begins to roll, dense streaks of foam, spray may reduce visibility.	Slight structural damage (chimney pots and slates removed).
10	Storm	55-63, 48-55, 89-102	Very high waves (29-41 ft.) with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility.	Seldom experienced inland; trees uprooted; considerable structural damage.
11	Violent Storm	64-72, 56-63, 103-117	Exceptionally high, (37-52 ft.) waves, foam patches cover sea, visibility more reduced.	Very rarely experienced; accompanied by widespread damage.
12	Hurricane	73+, 64+, 118+,	Air filled with foam, waves over 45 ft., sea completely white with driving spray, visibility greatly reduced.	Devastation.

It was hoped that the Beaufort Wind Scale was used in conjunction with the SSHWS to determine the likely damages of the hurricane in a contemporary context, as wind forces were recorded over Saturday 10 October 1862 and Sunday 12 October 1862 according to the Beaufort Scale. These values gave an indication of wind speeds, which was anticipated to be used to ascertain the possible damage caused by the meteorological aspect of the disaster as determined by the SSHWS. Though the possible damages described by the SSHWS fit into a more contemporary context, they would have been compared with the actual recorded damages of the event for the assessment of the level of vulnerability. However, since the first SSHWS category has sustained wind speeds of 74-95 mph/ 64-82 kt/ 119-153km/h, and the Beaufort Scale's final category (wind force 12), which is defined as 'hurricane' has wind speeds of 73+ mph/ 64+ kt/ 118+ km/h, which is just less than the SSHWS category 1, it was realised that there was not enough of an overlap of these two scales to be used against one another ('Beaufort Wind Scale', Schott *et al*., 2012). It should nevertheless be noted that hurricane wind damage is also dependent on other factors such as duration of high winds, change of wind direction and age of buildings and structures (Schott *et al*., 2012), which may account for the reason that the damages experienced in the disaster of this study seem to befit wind speeds much higher than those experienced.

The wind forces (which were recorded according to the Beaufort Scale) provided by the two tables above are entirely consistent with one another, though there are some minor discrepancies between them with regards to wind direction, indicating that one is not simply a copy of the other. The wind forces recorded range from a 'moderate breeze' at noon on Saturday, gradually increasing with every four hour observation to a 'violent storm' at noon on Sunday when the landslide, or geomorphological aspect of the event occurred. It subsequently gradually decreased until finally reaching a 'light air' at midnight of the same day.

The research approach of this study was strongly guided by the research topic itself: the nature of the research to be undertaken and the resources available to do so. What was most challenging to the study, however, was the insufficient number of scientific studies in the context of Seychelles containing data relevant to the study and the critical considerations regarding the obtainment and production of said data. Again, the identification and selection of the data sources used in the study were directed by the research topic and the primary sources available to study it. The collection of data took place during trips to Seychelles and the United Kingdom, as well as in correspondence with Seychelles and Mauritius while in Johannesburg. Most important to the climatic details presented in this study was the use of ship logbooks that were in the vicinity during the event due to the absence of any other instrumental meteorological data in the area. Analysis of the data obtained from the historical documents reveals details of the entire event from the onset of the meteorological effects of the tropical cyclone to the human and infrastructural devastation caused by it and the extensive landslides. These data are also used to understand the likely effects of such an occurrence through contemporary scales such as the SSHWS and the Beaufort scale.

CHAPTER FOUR: FINDINGS

Any account of human environmental adaptation that fails to consider the interaction of social, technological and natural processes of hazards and disasters is far from complete (Oliver-Smith, 1996). It is for this reason that information obtained from historical documentary sources on the natural processes (climatic and geomorphological) and the specific vulnerabilities are assessed along with the impacts on society and the means of coping and adaptation for a more complete understanding of the *Lavalas* event and in the consideration of the possibilities of a similar event in a contemporary context. This chapter looks at the findings of the data obtained from primary historical archival texts, which are categorised under the following sub-headings: 'climate reconstruction', which has daily meteorological accounts for the days that the tropical cyclone was experienced, as well as tables, descriptions and figures detailing very specific meteorological conditions relating to the tropical cyclone occurrence; 'landslides', which details the occurrences, locations and destruction of landslides during the event in question; 'agriculture', which discusses the agricultural losses relating to the disaster; 'casualties', which provides numbers of people and animals killed and injured during different stages of the event and lastly, 'infrastructural damages', which considers the damages to homes and buildings as a result of the disaster.

4.1 Climate Reconstruction

Friday 10 October 1862:
On Friday, the weather was dark and murky, with light wind from S. Erd and an overcast sky (New Zealander, 1864, Proceedings of the Mauritius Meteorological Society, 1862). Passing showers in the morning turned to constant rain by the afternoon (Proceedings of the Mauritius Meteorological Society, 1862) and a "singular density of the atmosphere" throughout the day until around 10 pm that night, while the barometer had been falling, though quite imperceptibly – as can be seen from the table below. The "heavy squalls" and "fitful gusts of wind" that commenced on this day were later to be understood as the antecedents to the

hurricane (New Zealander, 1864). From the “Nepaul”, which was anchored 50 miles off Mahé, from noon, From Friday 10 October to Saturday 11 October at around noon, there had been a gusty SE trade wind, which was not out of the ordinary (Transactions of the Bombay Geographical Society, 1864).

Saturday 11 October 1862:
Saturday was again riddled with “frightful squalls” and “gloomy dark weather”, as the island was flogged with “strong gales” (New Zealander, 1864). Until noon on Saturday, the S.E. winds had remained light, the sky was overcast and the “squally, rainy weather” persisted while the barometer, though slowly, continued to drop. By noon, the wind had picked up and was blowing in strong gusts from South, veering round to S.W. and West and picking up to moderate to strong gales in the course of the afternoon into the night. Both the wind and sea had been “increasing to hurricane violence” (Transactions of the Bombay Geographical Society, 1864, pii) and by midnight, there was a strong gale blowing from Westward and the overcast, squally and rainy weather continued (Proceedings of the Mauritius Meteorological Society, 1862). Incessant heavy rains caused rivers to swell and overflow their embankments, and the town is described as already being “inundated” on this day (New Zealander, 1864).

Sunday 12 October 1862:
On Sunday morning the wind freshened from W.N.W. accompanied by “hard squalls and rain” (Proceedings of the Mauritius Meteorological Society, 1862). The most violent conditions were experienced between 6 and 10 a.m., as the gale was at its peak on this day, with “terrific gales and squalls” at around noon (New Zealander, 1864). Eugene Dupuy wrote that at around 4 pm on Sunday “violent” winds began, changing direction from South to north-westerly and then north-easterly (SNA) but by seven that evening, the wind had decreased from a “whole gale at N.W.” to a moderate wind from north, and by midnight it had diminished – the sky still overcast, this time with lightning (Proceedings of the Mauritius Meteorological Society, 1862, p36). Massive amounts of mud had clogged up the natural outlets of rivers, thus causing the town to be further inundated, while immense gushes of water loaded with boulders, rocks and uprooted trees

charged down the mountain and hill sides, picking up ruins of houses and bridges and carrying them out to sea. This "avalanche of water" was estimated as running at the rate of seven knots or nautical miles per hour (New Zealander, 1864).

Table 6: Meteorological Report compiled by R. P. Brunton (British Meteorological Society Proceedings, 1863, 330);

	Wind.	Force.	Weather.	Barometer. (inches)
Saturday, Oct. 11, noon	S.E.	4	o. c. q. r.	29.950
4 p.m.	S.	5	o. c. q. r.	29.883
8 p.m.	S.W.	7	o. c. q. r.	29.900
12 a.m.	W.S.W.	9	o. c. q. r.	29.826
Sunday, Oct. 12, 4 a.m.	W.N.W.	7	c. q. r. t.	29.782
8 a.m.	W.N.W.	11	c. q. r.	29.710
Noon	W.N.W.	11	g. c. q. r.	29.700
2 p.m.	N.W. by W.	8	g. c. q. r.	29.748
			g. c. q. r.	29.834
4 p.m.	N.W.	6	o. r. q.	29.902
8 p.m.	N.N.E.	4	....	29.932
12 a.m.	N.E.	1	o. c.	29.960

o. Signifies overcast.
c. Signifies cloudy.
q. Signifies squally.
r. Signifies heavy rain.
g. Signifies gloomy.
t. Signifies thick.

This table is accompanied by the following remarks by R. P. Brunton (1863, p330);

> This hurricane, the only one on record as having done so, passed directly over Mahé; it was accompanied by incessant and very heavy rain, but with no thunder or lightning. It was probably a cyclone, of no very great diameter, as the 'Nepaul' Steam Packet experienced it at 30 miles distance from the island, and had the wind S.E. and E., on Saturday night. The 'Nepaul' lost two of her boats. Since Wednesday 15th the weather has been fine. Wind S.S.E. to S., with a few slight showers.

Table 7: "An abridged Meteorological Table of the weather", which was derived from observations on board H.M.S "Orestes", an American whaleman "Charles Carroll", as well as an on-shore aneroid barometer (Proceedings of the Mauritius Meteorological Society, 1862, p35-6).

Date	Hour	Wind	Force of Wind	Barometer
October 11	Noon	S.W.	4	29.950
	4 p.m.	S.	5	29.883
	8 p.m.	S.W.	7	29.900
	12 p.m.	W.S.W	9	29.826
October 12	4 a.m.	W.N.W	7	22.782
	8 a.m.	W.N.W.	11	29.710
	12 p.m.	W.N.W.	11	29.748
	2 p.m.	N.W. by W.	8	29.834
	4 p.m.	N.W.	6	29.902
	8 p.m.	N.N.E	4	29.932
	Midnight	N.E.	1	29.960

The ship, the 'Nepaul', which left Port Louis on 6 October and arrived at Mahé on 13 October must have experienced a "heavy gale from the Southward" while approaching the limits of the trade, and whose log-book will contain additional information regarding the nature of the storm (Proceedings of the Mauritius Meteorological Society, 1862, p36).

Table 8: Data from the logbook of the S. S. 'Nepaul' (Transactions of the Bombay Geographical Society, pii)**.**

Hours	Winds	Barometer	Thermometer	Revolutions per minute	Remarks
Sat 11 Oct 1	ESE				Fresh gale and cloudy, with drizzling rain and heavy SE sea on.
4	ESE	29.90	72	62	Fresh gale, with constant heavy rain.
8	ESE	29.88	77	62	Wind very variable, with same weather.
12	SE	29.78	75	61	Noon; fresh gales with constant heavy rain and very heavy sea, with dirty threatening weather, very heavy

					sea on. Ship taking it much water.
Sun 12 Oct 1	SE	29.50			Heavy rain, with strong gale and furious gusts, and a very heavy sea. Shipping much water over all.
3	ESE	29.40			Same weather; ship rolling heavily; starboard cutter washed away.
4		29.42	78	41	Blowing furiously; weather very thick, and rain falling in very heavy torrents, with a high mountainous sea breaking over the ship fore and art.
6	E	29.48			Wind veering; put ship's head to the S and E.
8	EN	29.54	78	40	Same weather, but gusts less violent; a very heavy sea still running.
12	EN	29.78	76	42	Noon; wind moderating with less sea, heavy appearance to eastward.
Mon 13 Oct 12	ESE	29.92	75	59	Fresh breeze, thick rainy weather, and long easterly swell.

It was observed that the storm originated on 9 or 10 October 1862 to the East of Mahé travelling westwards. The SE winds recorded at the start of the storm were a consequence of the SE trade winds and the northerly winds towards the end of the storm a consequence of the NW monsoon, and it was not until it reached west of south that it become part of the storm circle (Proceedings of the Mauritius Meteorological Society, 1862). Tables 6, 7 and 8 above all record SE winds at the outset of the storm, while only Tables 6 and 7 record the wind veering WN, due to the fact that Table 8 is from the logbook of the 'Nepaul', which was at a distance of 50 miles from Mahé during the storm and, which may be the reason for this difference. Moreover, the barometer readings recorded in the logbook of the 'Nepaul', though differ ever slightly, are nevertheless consistent with those of the "Orestes" in that they descend from Saturday 10 October until the afternoon of Sunday 12 October when they ascend again. The revolutions per minute are also consistent with the reports of the storm, as they are high on Saturday afternoon and decrease quite significantly on Sunday afternoon. The barometer readings in Port Louis for the same time period, which falls in line with those experienced at the Seychelles – barometer falling from 10 October until 12 October when it started rising again around noon, and the wind squally from SE (Proceedings of the Mauritius Meteorological Society, 1862, p36):

> The barometer at Port Louis was distinctly affected. It began to fall during the night of the 10th. At 9 1/2 P. M. on that day it stood at 30.312, and at the same house on the 11th at 30.252 ; and it continued falling till the forenoon of the 12th, when it again rose. The wind during those days was squally from S. E. to E.b.S., and the weather cloudy.

It was noted that "this storm had all the characteristics of a cyclone"(Proceedings of the Mauritius Meteorological Society, 1862, p36) and Captain Curling of the "Nepaul" wrote that the weather event, which passed northwards right over the Seychelles was "undoubtedly a hurricane" (Transactions of the Bombay Geographical Society, pii).

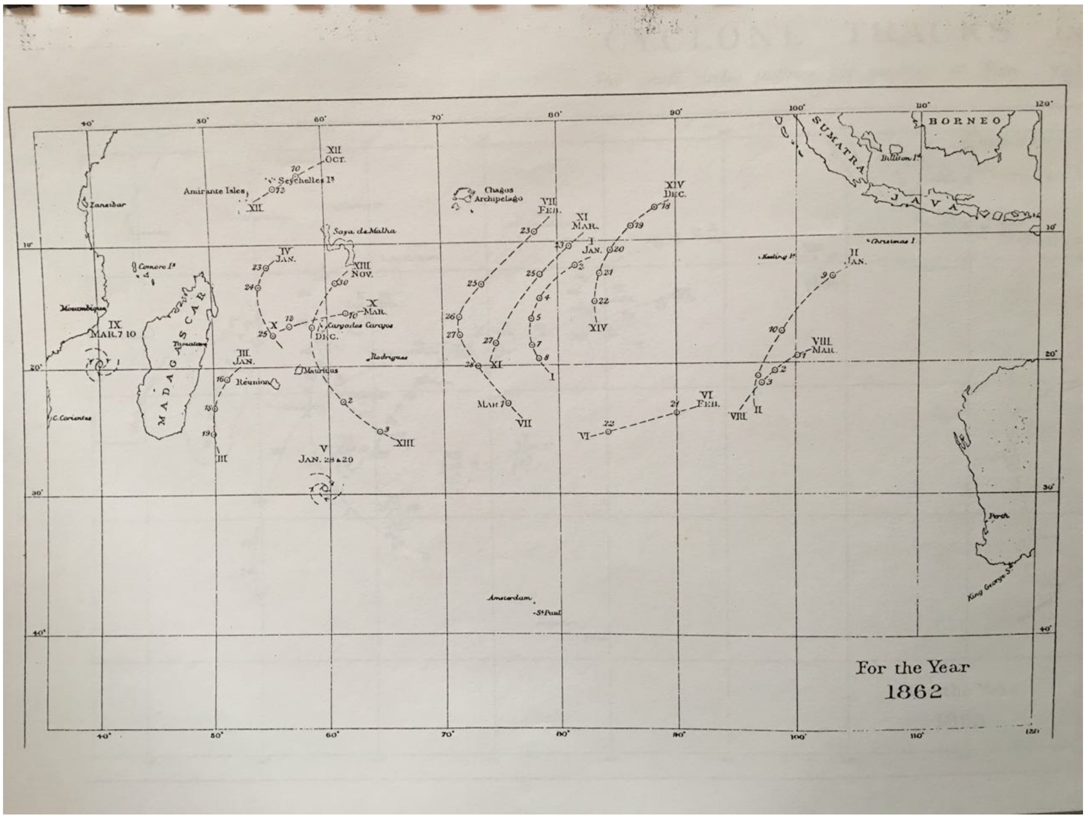

Figure 4: Representation of TC occurrences in the Indian Ocean for the year 1862 (Proceedings of the Mauritius Meteorological Society, 1862).

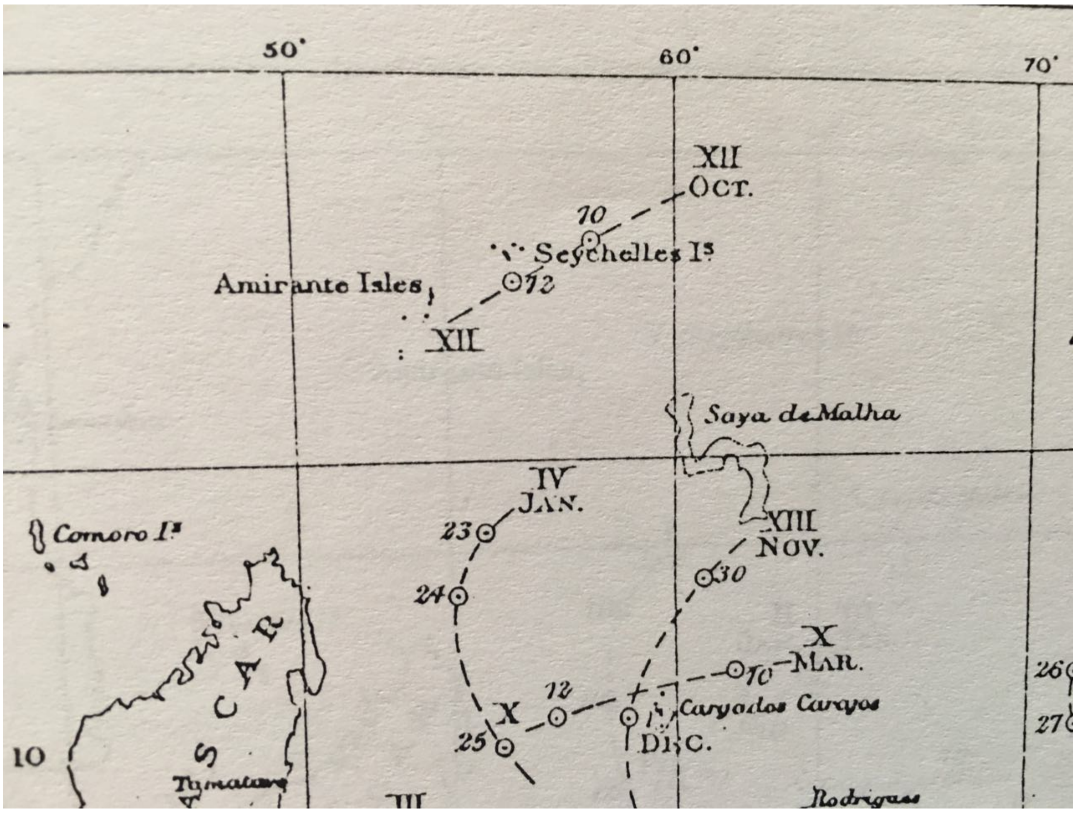

Figure 5: Previous diagram enlarged showing TC passing over Seychelles on12 October 1862 (Proceedings of the Mauritius Meteorological Society, 1862).

4.2 Landslides

District Magistrate and Acting Civil Commissioner, Eugene Dupuy, wrote in his letter of 15 October 1862 that following three days of rains and one day of violent winds, at around noon on Sunday 12 October, "part of the "*Trois Frères*" Mountain was washed down, and the slip of earth and stones carried away the upper part of Port Victoria Town, and buried in mud the lower part of it." He also wrote that the only intelligence that had been received from anywhere beyond Victoria at that stage had come from a capuchin priest from Anse aux Pins, who had informed that there had been "slips of earth from the Mountains" in his district (SNA, pp185-7).

Surveyor General, W. L. Morrison assessed the islands for the causes and impacts of the weather event, which he then reported in a letter to the Colonial Secretary in Mauritius on 24 November 1862. His explanation of the weather event that led to the disaster was that the amount of rainfall experienced in those few days, which was during the S. W. monsoon from April to October, was irregularly more than usual, requiring the soil to absorb a large quantity of water (MNA: SD 64/No74). This, coupled with the irregularities on the mountain slopes that created basins of pooled water, which then saturated the surrounding earth, weakened "the cohesion of the particles of the soil" (MNA: SD 64/No 74, p390). After visiting all the major landslides, Brunton similarly concluded in his assessments of all the significant landslides that they were caused by "heavy rains softening and loosening the earth" and by the pooling of water in certain places (MNA: SD 64/No 74, p387).

From his examination of the landslides on Mahé, Morrison articulated his understanding of the origin of the landslide that hit Town from the mountains overlooking it (MNA: SD 64/No 74, p390);

> When, too, the face of the precipice, or sides of a ravine, approached to the perpendicular, the mass of earth, (or conglomerate of earth, sand and boulders), acted upon both by the rain which had so constantly fallen, and by the disruptive power of the filtration from the basins in close proximity, would be gradually

> loosened, until it could no longer resist the pressure, when it would be precipitated, in a stream of liquid and stones, down the slopes of the mountain, leaving the chasm thus made therein an opening into which would naturally rush the drainage from the higher levels around, by which the volume and destructive effects of the slip would be further augmented.

The rush of mud, rocks, stones and water descended from 1000 feet above sea level, where it met with the St Louis river, which had swollen its banks and burst together in a channel of somewhere between 300 and 500 feet until finally it spread to flood the lower section of town from Quincy Street and over Victoria Street where it finally filled in 400 feet of the sea frontage from the Wharf Wall at a depth of 1 to 2 feet (MNA: SD 64/No 74, p391). The St Louis River had dug itself a new channel in the bed of the displaced matter. The beds of the streams leading to the ocean were all choked up, coconut trees had been uprooted and the gardens and yards destroyed and covered in 2 to 4 feet of mud, as were many of the floors of the buildings in town. Morrison estimated that there was no less than half a million tons of debris that gushed down the slopes in the landslide, which had become "an irreclaimable waste of sand, thickly covered with immense masses of granite rocks" (MNA: SD 64/No 74, p391). The boulders that had been hurled down the slopes led Morrison to speculate the escape of people and animals from their paths as having been miraculous, as the boulders that he measured weighed 75 tons, and another, which was carried a distance of 300 feet weighed 500 to 600 tons (MNA: SD 64/No 74).

It was observed by the surveyor general that landslides had taken place all around the island, some of which fell from a higher distance than the one over town, however, none as destructive (MNA: SD 64/No 74). Inspector Brunton's five-day assessment of the southern parts of Mahé allowed him to observe that "all along the coast, slips of greater or lesser extent have taken place", but that the most destructive [presumably, after the one in town] had occurred at Plaisance and Paris, where 24 people had died, while other heavy landslides had occurred at Pointe Capucin, Anse Boileau, Mountain Duriz and Belle Ombre (MNA: SD 64/No 74, p387). Plaisance, as well as 'Petit Paris' is located just south of Victoria, which may explain why it was most severely impacted by landslides. Bishop Ryan of Mauritius' account describes the state of the island following the disaster as he approached it by ship, "The tremendous landslips which had taken place, especially to the left of the town, as we looked from the ship, gave the idea of most complete and overwhelming destruction." The fact that Bishop Ryan states that "left of the town" was particularly impacted by landslides corroborates the report of Inspector Brunton, as Plaisance and [Petit] Paris are located just left of Victoria when looking at it from the sea (Ryan, 1864). Pointe Capucin is the southern-most tip on the eastern coast of the island, while Anse Boileau is adjacent to Anse aux Pins (which is known to have suffered grave landslides) but is situated on the western coast of the island. Mountain Duriz and Bel Ombre are situated in the north-west of Mahé. Through the positioning of the geographical points in the description, much of Mahé is encompassed. From this, it appears that much of the damages sustained during the weather event were due to the landslides, though undoubtedly a significant amount of the damages was nonetheless due to the hurricane, as Brunton confirms, "in additional to the damage caused by the wind, great loss of life and property was occasioned by a landslip" (Proceedings of the Mauritius Meteorological Society, 1862, p36).

4.3 Agriculture

The vulnerability of an island and its society to cyclones is expressed by Garnier and Desarthe (2013) in economic and food security terms; the island's economy was seriously impeded by the damage and destruction of crops and infrastructure, which in turn threatened the food security of the population. In fact, not only did this have an effect on the economy of the Mascarenes, but also throughout the world; the extensive destruction of all coffee trees, clove trees and corn on these islands resulting from severe hurricanes in the early 19th century caused the global price of corn to rise six fold (Garnier & Desarthe, 2013). Winds and floods associated with cyclonic activity had devastating effects on food crop production by ripping up crops and causing them to rot. In the case of the Mascarenes, societal staples such as corn, cassava, rice and potatoes were badly impacted by such weather occurrences (Garnier & Desarthe, 2013), which is also somewhat true in the case of Seychelles.

Agricultural plantations such as crops and trees are particularly vulnerable to wind and flood damage, and so economy and livelihoods are impacted upon with the advent of tropical cyclones, which puts a further strain on recovery from the event (King *et al*., 2010). Superintendent Prince reported on 15 November 1862 that although many cassava and sweet potato crops had been damaged, there was no hunger or shortage of food (MNA: SD 64/No 74). Inspector Brunton clarified in his report of 21 November 1862 that an equal amount of cassava, sweet potatoes, maize and cane crops were in apparent good condition, as were damaged by the event. The majority of the "poor inhabitants" explained to him that they were salvaging what they could from the crops that were only partially destroyed by the rain and that when what little of that was finished, they would have to wait for the cassava and sweet potatoes to ripen and would not have much to sustain them in the interim (MNA: SD 64/No 74, p388-9).

What was particularly evident after the event was that the production of [coconut] oil would be considerably reduced for several years due to the severe impact the event had had on existing plantations, coupled with the impossibility of obtaining produce from new plantations for some years (SNA). Over 1500 coconut trees were blown down on St Anne and 200 on Cerf (MNA: SD 64/No 74, p387). As for Mahé, it was on the flat coastal zones where the greatest destruction of coconut trees took place, particularly at Anse aux Pins, Anse Royale and Baie Lazare, which was the worst impacted throughout the island by the N. W. wind (MNA: SD 64/No 74). Large quantities of coconuts were collected after the storm, however, most of them were unripe and were therefore unusable. Brunton explained that the number of trees reported as having been 'blown down' in the return is more than in reality, as many of the trees with broken branches would grow back, although it would take some time for these trees to once again yield fruit. He estimated that it would take between two and four years for these damages to repair (MNA: SD 64/No 74).

The significance of coconut tree plantations to the economy of the Seychelles was explicitly expressed in reports of damages, as was the dependence of the population on the surrounding natural resources, and specifically on trees. King *et al*. (2010, p417) eloquently expresses the impacts of the loss of trees on such a society;

> Vegetation provides society with meaning, amenity, ecology and livelihood. Meaning attaches to trees and plants of iconic, spiritual or historical significance. These meanings may be highly culturally specific or may simply relate to individual families. The loss of trees or groves of cultural significance intensifies the sense of loss, and contributes negatively to recovery.

The fact that the economy relied nearly exclusively on the production and export [as well as, supposedly, the local use] of coconut oil means that the extensive losses of coconut plantations represented a very dire state for the population, which must have complicated the already unfamiliar nature of the meteorological event. Coconuts continue to be an important staple for the population of Seychelles, as it is used for its water, milk, flesh, oil and shells, and so was presumably relied on more heavily in the nineteenth century.

Morrison wrote that much of the land that was unsuitable for coconut plantations would be suitable for growing cotton, which requires a soil depth of only 6 inches, as it is unsafe for a population to rely on one produce as their resource (MNA: SD 64/No 74). Dupuy wrote on 28 December 1862 that if it were possible to obtain an abundance of cheap labour, he would advise the inhabitants to not limit their industry to coconut plantations – which he adds is "of remote and doubtful produce" – and, to which, he explained, they were compelled to turn due to the shortage of labour following the abolition of slavery (MNA: SD 64/No 74, p386). Based on these suggestions, Johnstone wrote that the introduction of cheap labour for the diversification of industry be given immediate attention and action (MNA: SD 64/No 74).

4.3 Casualties

Death, injury and homelessness are the devastating impacts of tropical cyclones on populations (King *et al.*, 2010). In the second half of the 19th century, health risks associated with the cyclones became a concern for authorities, as the destruction of pipelines and wells had allowed water to become contaminated and polluted (Garnier & Desarthe, 2013). In fact, in 1913, there were outbreaks of typhoid fever in several isolated mountain towns around Réunion Island after the destruction of roads and bridges, necessitating the deployment of military doctors to these villages on horses and donkeys for treatment and to distribute bleach (Garnier & Desarthe, 2013).

A letter from District Magistrate and Acting Civil Commissioner, Eugene Dupuy, on 15 October told of the tragedy at the nunnery, "The scene of the greatest misery was the house of the Sisters of Charity, which, having been supposed the safest place of shelter, became the grave of many." In this letter, he explained that Roman Catholic Prefect, Father Jérémie, who was surrounded by four other bodies, was the only survivor amongst those buried in the mud (SNA, p185-7). At the time of writing, the number of bodies in town that had already been buried amounted to fourteen. Dupuy also explained that he intended to gather the 'influential inhabitants' to advise them to scatter themselves beyond the town so as to protect themselves from 'pestilential fever', which he forecasted would be the consequence of the state of the town (SNA, p185-7).

In Police Inspector Brunton's letter dated 17 October 1862, he explained that both police and civilians had used their greatest efforts to find and dig out bodies buried in the mud; eight bodies had been recovered in that specific area and one body was still to be found, but was presumed to have been carried far away – probably to sea. On Monday 13 October, the bodies of two children had also been recovered floating down the river of mud and had been taken to the Protestant Church where they were buried along with six others, as access to the cemetery had been restricted by fallen trees and rocks and the rush of water (SNA, p182-3). The bodies of the two 'Sisters of Charity' were buried in the Roman Catholic

Church (which was not damaged) by permission of the Acting Civil Commissioner. Others ("with ghastly wounds") had been taken to the District Court House, where they were attended to by Dr. Brooks. A temporary hospital had also been established by Dr. Brooks, accommodating at the time 11 inmates with broken limbs. Importantly, he notes that this was in no way an approximation of the numbers of injured persons. He does provide a table of the figures of "killed and missing" persons up to the date of writing (SNA, p182-3):

Table 9: Inventory of killed and missing persons on 17 October 1862 (SNA, p183).

	M.	F.	Sex not known.	TOTAL
Town	7	16	...	23
Country	12	11	21	44
GRAND TOTAL				67

No more lives had been lost in town at the time of writing, but more declaration of deaths were expected to come from the rest of the island, as information from the rural districts of the island had not yet been gathered. On the islands from which intelligence had been received (Cerfs, Praslin, Anonyme, Silhouette), no lives had been lost as a result of the event (SNA).

Following this letter, on 19 October 1862, Brunton wrote another letter, adding that "portions of the body of a child" had been found at the ruins of the nunnery the day before, and that on the day of writing, the body of what was presumed to be a thirteen year-old girl had been found in the mud along Government Street. A woman had died in hospital from the wounds she had sustained during the event (SNA, p182-3).

Bishop Ryan of Mauritius' account offers a chilling recollection of the event with regards to casualties (Bishop Ryan, 1864):

> Two children were carried by the flood into Mr. Vaudin's yard, one dead and the other just expiring. A most thrilling account was given me afterwards by a woman, who had been driven with her children from one refuge to another; and,

> as all had been blown, down or carried away, just managed with help to get through the mud to the church, where several families were gathered, with the corpses of the children near them. After it was dark, and the lamps were lit in the church, they heard the voice of a man shouting, "Sauve moi! sauve moi!" and it gradually diminished in strength, till, as they supposed, he was drowned.
>
> One heartrending case of bereavement was that of Mr. Arthur Barallon, whose emotion in describing it to me was very touching to witness. When the dead were counted, lie had lost his father, two sisters, two nephews, three nieces--eight in all. Such instances as these may serve to give an idea of what the work of desolation has been.

In a population of 7560, 75 lives were lost (Scarr, 2000). Mr Arthur Barallon, had lost his father, two sisters, two nephews and three nieces in the tragic event, which "may serve to give an idea of what the work of desolation has been" (Bishop Ryan, 1864). "These are but examples of a death roll which seems never to have been fully assessed though one writer has estimated it as over seventy", however, in the chaos following the disastrous event, many bodies were buried without registration, and many were washed out to sea (Webb, 1964, p24).

Tropical cyclones also bring about various related secondary health impacts, such as sewerage systems leaking into the surrounding environment, polluting a region's water supply. This, as well as high humidity levels that accompany tropical cyclones [which usually occur in high humidity zones in any case] may result in mould, bacterial infections, which may lead to gastric illnesses and an increase in mosquito-borne diseases (King *et al*., 2010), "With any tropical cyclone there are also a number of related secondary health impacts. Sewerage systems are compromised and may leak into the environment or become unusable, resulting in gastric and bacterial illnesses and infections. This may contribute directly to pollution of a region's water supply, but even without sewerage problems water supplies are often cut off by infrastructure damage and power supply disruption, and polluted from general run off. High humidity levels that accompany cyclone impacts, result in mould and additional bacterial infections, as well as an increase in mosquito borne diseases" (King *et al*., 2010, p415).

4.4 Infrastructural damage

Superintendent (of Police) Prince, inspected the northern part of Mahé on 13 November 1862 and reported that the destruction of property had mostly only occurred on the eastern side of the mountains, and that from North East Point to North West Bay there had been very little damage, with one property having "suffered considerably" and with many roads and paths having been significantly damaged (MNA: SD 64/No 74, pp387-8). It may be deduced that this property, as well as some of the roads and bridges in the northern part of the island, sustained damages from the climatic event (hurricane) – either from the violent winds or the heavy rainfall – rather than from the geomorphological event (landslides), which was the cause of much of the rest of the island's infrastructural damages. Police Inspector Brunton undertook a five-day assessment on foot of the state of the southern parts of the island, which he described as the "most extensive" and the "most populous" from 11 to 16 November 1862 (MNA: SD 64/No 74, p387). He reported that the swamps on the flat land between the sea and the foot of the mountains had overflowed from the heavy rains between 10 and 12 October and formed deep channels in the loose, sandy soil toward the sea, which had destroyed many of the roads and paths, and which had required him to cross waist-deep waters in some parts, as Royal Street is described as having turned into a river (MNA: SD 64/No 74, p388, Mathiot, "The Lavalas of 1862"). The paths and roads on the hills had not sustained much damage, but a large bridge at Rivière Rochon and two bridges near Plaisance had been destroyed (MNA: SD 64/No 74, p388). Prince also reports that "the whole of the bridges between 'La Rosière' and North West Bay'" had been torn away and that "the roads (if they may be so called)" were in a terrible state, though his parentheses suggest that they were not in a good state prior to the event in any case (MNA: SD 64/No 74, p387). Morrison corroborates that the 'roads' for lack of a better word, had been rendered impracticable and that the bridges had been washed away in great numbers (MNA: SD 64/No 74, p391).

The impacts of the torrents on the cemetery were extensive; granite boulders that were dislodged from the first fall of the cliff had rushed down to the cemetery wall, which came crumbling down, making way for the rush of water to carry a demolished house right past the graves, and to carry away the entire buildings which had been used for receiving coffins and shading the minister and attendants at a funeral (Bishop Ryan, 1864). The dilapidated cemetery wall can still be seen today, and there is no sign of any building. Only the elevated section of the cemetery was spared demolition (Webb, 1964), as can still be clearly seen today. Graves and tombs in the upper section are more or less intact, while graves on the lower section are mostly indiscernible and buried.

Nash *et al*. points out that, "geographical variations in building styles needed to be noted" in the assessment of infrastructural damage resulting from natural hazards (2015, p3254). The houses and huts situated in the capital in the nineteenth century were single storey and constructed mainly of wooden slats covered with leaves, and as such were easily blown down, though just as easily reconstructed (MNA: SD 64/No 74, Webb, 1964). Garnier and Desarthe (2013) also point out that the damage and destruction of homes caused by cyclones was, without doubt, dependent on the type of building and the materials used to construct them. The homes of the population's most vulnerable groups were constructed of wood and roofed with straw or palm branches, and therefore stood little to no chance against the violent squalls of the region's cyclones: "Mostly, they are uncovered, overturned or sucked up by the cyclone and thrown far off" (Garnier & Desarthe, 2013). Some 90 to 100 residents were left homeless and had gathered in one house for the few days following the event, while others had spent the Saturday night and the Sunday in open air (MNA: SD 64/No 74). Much of these residents' furniture, clothing and livestock had either been lost or damaged by the rain. This impact is articulated below (New Zealander);

> Numbers of poor shivering, terrified ex-apprentices – the black population, descending from the mountains to seek refuge in the town; their straw huts having been already carried away or destroyed by the raging torrents. At noon of Sunday terrified gales and squalls. Ruins of houses, sheds, bridges &c, borne along by the current seaward.

> Many wooden houses in town started from their basements and borne bodily along by the "avalanche". Others with portions torn and carried away to incredible distances.

Garnier and Desarthe (2013) also explain that the damage and destruction of public buildings (such as churches, schools, administrative buildings, etc. - usually built of stone) represented a profound trauma for society. These buildings were amongst the first to be rebuilt following a disaster funded by public money and donations. While the damage and destruction of stone buildings must have signalled the extent of the impact, it could not have been the worst impact, as mentioned above, the homes of the most vulnerable groups were mostly completely destroyed or blown away. It thus appears that this 'profound trauma' would have been experienced by the groups in society of higher social standing, rather than the groups who had lost their actual homes and livelihoods in the weather event. Moreover, it is an insightful note that Garnier and Desarthe (2013) offer here on the use of public money and donations; rather than furnishing homes for the poorest groups of society, priority was given to buildings that somewhat falsely represented the state of the islands.

Though there is much consideration of the different types of buildings and their destruction for the Mascarenes and Madagascar, James Henry Brooks, Government Medical Officer in Seychelles at the time, reported that houses were totally unequipped for such weather occurrences, "the houses for the most part, therefore, not only in the town but country, were built in a careless and insecure manner, and but ill adapted to offer any resistance". District Magistrate and Acting Civil Commissioner at the time, Eugene Dupuy corroborates this in one line, "Not a single house has not suffered somewhat as a result of the event."

Noteworthy is Webb's (1964) mention of the state of government buildings at this time:

> By 1850 government buildings had reached such a state of dilapidation that, save for the kitchen of Government House and a small 'pavillion' used as offices, all were deserted and past repair. Keate and his staff were living and working in

hired buildings, the considerable rental for which provoked Mauritius to demand a plan to end the expense.

Government House had escaped serious damage as the St Louis River had wound around the hill upon which it stood. It did, however, sustain some damages to the kitchen, verandah and drainage (MNA: SD 64/No 74). Bishop Ryan, however, described the remarkable difference between the state of Government House prior to and following the event, “It would be difficult to conceive a more impressive contrast than that presented by the Government House as we knew it in 1856, and in its desolate condition on the occasion of this visit in 1862” (Ryan, 1864). Government House, which is described as being single-storeyed and constructed primarily of wood, was completed during Civil Commissioner Wade’s time, who occupied it until his death ten years later (Webb, 1964). After negotiations between the dependency and Mauritius, it was decided that certain plots and properties be sold and new ones acquired, and a new Government House would be constructed.

Table 10: Inventory of damaged and destroyed property and killed and deceased people and animals for the different parts of Mahé (SNA, p28).

	Blown down or carried away.							Damaged.					Killed or Died.			Killed.		
	Wooden Houses	Wooden Huts	Out Houses	Huts	Bridges	Coconut Trees	Boats	Stone Houses	Wooden Houses	Out Houses	Huts	Boats	Men	Women	Children	Oxen	Sheep	Asses
Town	..	98	..	..	8	..	9	1	..	..	..	5	4	10	11	..	..	..
Northern part	..	5	..	10	..	5172	..	..	4	..	5	..	..	..		22	..	..
Southern part	..	107	108	285	3	24399	13	4	111	30	43	8	21	17	12	20	25	12
TOTAL	.	210	108	295	11	29571	22	5	115	30	48	13	25	27	23	42	25	12

Reports from Félicité, Silhouette, La Digue, Denis and North Islands indicated the destruction of trees, straw huts having been blown down, and cassava and other crops having been washed away. Nevertheless, the damages sustained on these islands were not extensive (MNA: SD 64/No 74). Île Platte, one of the coral southern islands, sustained few damages, while on Frégate Island – on which there was a distillery, a large house and two outhouses, which were unroofed – some 30 acres of cane plantation was destroyed, and several trees were torn up (MNA: SD 64/No 74).

Since it is clear that no island other than Mahé experienced landslides, it is clear that some other islands did experience the effects of the hurricane, which helps with the analysis of damages, as all the impacts are then understood to be a result of the meteorological event, which allows for the direct application of the Saffir-Simpson Hurricane Wind Scale (SSHWs). From the reports of uprooting of trees, huts having been blown away, crops washed away, unroofing of outhouses and destruction of plantations, but damages nevertheless not extensive, it may be inferred from the SSHWS that the effects of the hurricane experienced on these other islands would have been a category one hurricane, which states that "very dangerous winds produce some damage" (Schott *et al*., 2012). It is noteworthy that on Sunday 12 October 1862, both La Digue and Frégate Islands had had mild and calm weather (MNA: SD 64/No 74) and both Praslin and Curieuse had had no signs of destruction, nor did their inhabitants seemed to be aware that the influence of a hurricane had been experienced in the islands (MNA: SD 64/No 74).

Figure 6: Photograph of rubbled graves on the lower section of the old cemetery.

CHAPTER FIVE: DISCUSSION

5.1 Vulnerability, Coping and Adaptation

"Disaster mitigation and societal impact are separate, interrelated concepts." (King *et al*., 2010, 409). The key elements of disaster mitigation and social impacts in the context of tropical cyclones are tropical cyclone impacts, vulnerability, resilience and mitigation (King *et al*., 2010). Tropical cyclone impacts include understanding the intensity, frequency and incidence of the cyclone, the impacts to property, the environment, infrastructure and industry, as well as the intangible social losses. Vulnerability involves understanding the risk equation in terms of societal, community, household and individual vulnerability, as well as the influence of climate change. Resilience involves the identification of indicators of risk such as social capital, the role of organisations and best practice strategies for resilient communities (King *et al*., 2010). Mitigation involves taking physical measures, facilitating education and awareness, tropical cyclone warnings, and building capacity (King *et al*., 2010).

5.1.1 Vulnerability

It may be deduced from Superintendent Prince's report, which states, "the roads (if they may be so called) are in a wretched state", that the state of the roads prior to the disaster did not exactly merit the name (MNA: SD 64/No 74, p387), which may have meant increased vulnerability to natural disasters. Surveyor General Morrison corroborates this in his letter, "The very limited means of communication (roads they cannot be called) which have hitherto existed…" (MNA: SD 64/No 74, p391). Poorly constructed roads and paths, which were easily damaged and destroyed, meant that the population of the island at the time were not able to move around the island without great efforts. This in turn means that there may have been many inhabitants who were not able to access town in order to seek relief with regards to food and shelter.

Police Inspector Brunton explained in his report that the flat lands [where many homes would have been situated and continue to be currently] between the sea and the bottom of the mountains had always been swampland (MNA: SD 64/No 74), meaning that those zones were likely to be inundated in the event of not only a landslide, but heavy and excessive rainfall and improper drainage. The houses in Town were crowded and were poorly built, and the streets were narrow without real drainage. It is later stated that drainage had been cut into the lower part of Town, “an advantage it has never previously enjoyed” (MNA: SD 64/No 74, p397), which, again, signals the town’s vulnerability to inundation prior to the adaptation of proper drainage following the disaster.

The need for a public hospital – even a small one – was critical, as the efforts of Dr Brooks were “almost rendered futile by the want of the most ordinary proper accommodation for patients” (MNA: SD 64/No 74, p392). The lack of a decent medical facility from which Dr Brooks could operate and in which patients could stay for treatment meant an increased vulnerability in the face of the worst historical disaster, as emergency measures were thus the only chance of recovery and survival. A letter was sent in 1837 from the Medical Office of Seychelles to the Chief Medical Office of Mauritius, in which the general lack of medical facilities was articulated. A specific request for supplies of vaccine was made, due to a majority of the inhabitants not being vaccinated (Webb, 1964). Many years later, when Civil Commissioner Keate proposed the closing down of the leper colony on Curieuse Island in order to use the funds, as well as the staff, to open a general hospital in Victoria, his proposal was not approved (Webb, 1964), and so there continued to be no proper medical facility up until the time of the disaster in 1862. A small hospital called St John of God Hospital was eventually constructed in 1866, after many years of want (Mathiot, ‘The Story Of The Seychelles Hospital’).

A note on the position of Seychelles as a dependency of the British crown colony of Mauritius proved to be both advantageous and disadvantageous for the vulnerability and resiliency of the archipelago. It was disadvantageous to vulnerability that all matters had to go from Seychelles, through Mauritius and finally to Great Britain and back through this same channel, which meant that much time lapsed during this process, and that many people were involved in the approval of matters concerning the Seychelles, whether regarding land-use, funds for development and facilities, etc. Conversely, it was advantageous that Seychelles could rely on relief from Mauritius, which was not too far a distance.

5.1.2 Impact on society

Acting Civil Commissioner, Eugene Dupuy wrote on 28 December 1862 to the Colonial Secretary in Mauritius that it was concluded from assessments around the island that in several cases the extent of damages originally ascertained had been exaggerated. This was true in the case of Brunton's assessments, as was indicated in his report, which stated that the number of trees having been reported as blown down in the return had been exaggerated, as many of the trees, though broken, had not been totally destroyed, and that many inhabitants had exaggerated the extent of losses of sustenance crops (MNA: SD 64/No 74). Morrison confirmed this when he stated that the statistical data obtained by Brunton and Prince would indicate that the supposed losses were more than in reality (SNA, MNA: SD 64/No 74). Although Brunton stated that the inhabitants were inclined to exaggerate their losses, he admitted in the same sentence that 'the hurricane had been a grave event for many inhabitants (MNA: SD 64/No 74). It is therefore likely that this reported exaggeration was due to the fact that the severity of the damage and destruction experienced during the *Lavalas* had not before been experienced by the inhabitants. Dupuy also gives insight into the emotional state of the population following the disaster and under more regular circumstances, "…and the misery, which is not now much above its ordinary level, will yearly be more deeply felt, by the impossibility of obtaining immediate produce from the new plantations." (MNA: SD 64/No 74, p386).

While sweet potato takes 3 to 4 months to ripen and cassava 6 to 9 months, Brunton was of the opinion that the arrival of the schooners, "Dart", "Surprize" and "Romp" from Mauritius had precluded the probability of famine and scarcity, as the food they had brought with them had not only created a "sufficiency", but an "abundance of food" (MNA: SD 64/No 74, p389). From Town right around the south of the island to Bel Ombre, not a single case of hunger or famine could be found amongst both poor and wealthy inhabitants. Though there was suffering during the weather disaster, as well as the persistence of poverty generally, the food provisioned by the government was reported to have been "judiciously distributed" and to have been sufficient or even more than sufficient for existing and potential needs (MNA: SD 64/No 74, p389). With regards to the sum of £1007, which was voted for the cost of tools and provisions and to cover other relief needs, Major General Johnstone wrote on 21 February 1863, that the supplies furnished by this sum appeared "to have been abundantly sufficient for the relief of real distress" (MNA: SD 64/No 74, p385).

An important insight, which, in the case of this study is confirmed by the information available in the archives, is how public service and government organisations continue to function after a disaster (though under different circumstances and with different priorities), while those who rely on other livelihoods do not enjoy the same advantage, as King *et al*. (2010, p417) articulates, "People employed in the public sector continue to be on the payroll and are directly involved in recovery activities. However, many farms, small businesses, shops and manufacturing facilities are likely to be put out of business in the aftermath of a tropical cyclone, either through direct damage to premises, crops and machinery, or through disruption of supply and communications."

5.1.3 Coping

Communities are groups of people who share a common sense of connection and belonging. People in a modern urbanised context belong to multiple 'communities'; residential neighbourhoods, school, work, religious groups, etc. and these networks contribute to social capital, which is an important aspect in resilience (King *et al*., 2010). The communities of most of the islands' inhabitants at the time would have had very small and limited communities and thus limited social capital and resilience, as the multiple abovementioned communities would have involved the same people (religious, work, residential, etc.) As Seychelles was a dependency of the British colony of Mauritius at the time, Mauritius was responsible for relief assistance. Much mention is also made of the valuable assistance of the H.M.S. “Orestes” crew and captain, which were in the harbour of Victoria at the time of the weather event (MNA: SD 64/No 74), and who shared their supplies of food for those in need, as well as provided labour for the reparations of the town (SNA). As the roads and paths were unusable prior to being properly cleared, transportation around the island was limited to water carriage, which was costly, dangerous and impracticable (MNA: SD 64/No 74). Some of the wooden government buildings in town were raised on to blocks of wood as a temporary measure (MNA: SD 64/No 74), supposedly to lift them from the inundation, while the prisoners vacated the prison and were kept in Government House, whose structure is described as being “very insecure”, after vacating the prison, where “less than 300 cubic feet of air has been the quantity frequently afforded to each prisoner” (MNA: SD 64/No 74, p393), which is indicative of very rudimentary means of dealing with the disaster. A schooner, *Romp*, was sent from Mauritius with provisions of relief for the victims of the event, supplied at the expense of that colony (MNA: SD 64/No 74). The Colonial Secretary at Mauritius, F. Bedingfield, wrote that a reserve of these provisions was to be kept for the use of police, prisoners, the leper establishment or any other person who was entitled to make a claim from government, and suggested that the food should only be gratuitously supplied to those destitute who are incapable of working towards reparations and only be liberally supplied to those destitute who are able to work. (MNA: SD 64/No 74).

The provisions sent to Seychelles from Mauritius included; 800 bags of rice, 10 casks of salt beef, 100 bundles of salt fish and 50 bags of flour (MNA: SD 64/No 74), the distribution of which was all clearly stipulated. Some of the rice (at $2.50 per bag) and flour was sold and the proceeds of which was used to pay the workmen. The “Government Relief Committee”, which was made up of the Civil Commissioner, the District Magistrate, the Superintendent of Police, and the Government Medical Officer (MNA: SD 64/No 74), would meet every Saturday to decide on every individual who came forth in need of relief, if they were deemed “deserving of assistance” they would be provided with a ticket, which was available for one month from the date of issue and that was to be presented to the distributor at the Protestant Church at 1 pm the same day. This would entitle the ticketholder to 3 lbs of rice and 1 lb of salt fish per week, and the names and addresses of each party to which food was issued was recorded in a register, and needless to say, no relief was issued to those who did not follow the abovementioned procedure (MNA: SD 64/No 74). This systematic relief seems to have been successful in granting food to those in need, while ensuring that the provisions would last to continue providing for as long as there was such a need. Eugene Dupuy stated in earnest that from his experience, he believed that the equatorial climate of Seychelles would prove a great obstacle to the welfare of the population (MNA: SD 64/No 74). It is unclear, however, whether this means in terms of agriculture and food security, or in terms of health, or in terms of reparations and reconstruction of homes, etc.

5.1.4 Reparations

Bedingfield wrote on 28 October 1862 that an officer of the department of the Surveyor General would be sent from Mauritius by the following mail steamer in order to commence reparations, and less than a month later, wooden homes and huts had been reconstructed, as they were easily reconstructed (MNA: SD 64/No 74). Most of the bridges, which were mostly carried away in the storm, were not of a great length and were thus also easily reconstructed. The construction and reparation of roads, bridges and buildings, however, was only partially underway by 21 February 1863, as progress had been restricted by the lack of skilled labour in the dependency, which was specifically required for the construction of a prison (MNA: SD 64/No 74).

All the prisoners who were able to work were put to the task of clearing the St Louis riverbed of granite boulders, sand and debris so that the rivers would again flow through their channels to the sea with the following rainfall – had they not cleared it, “the streets would have remained impassable up to the present time”, which was written on 16 March 1863 (MNA: SD 64/No 74, p397). With their assistance, the streets were cleared and many houses that had been thrown off their foundations had been replaced.

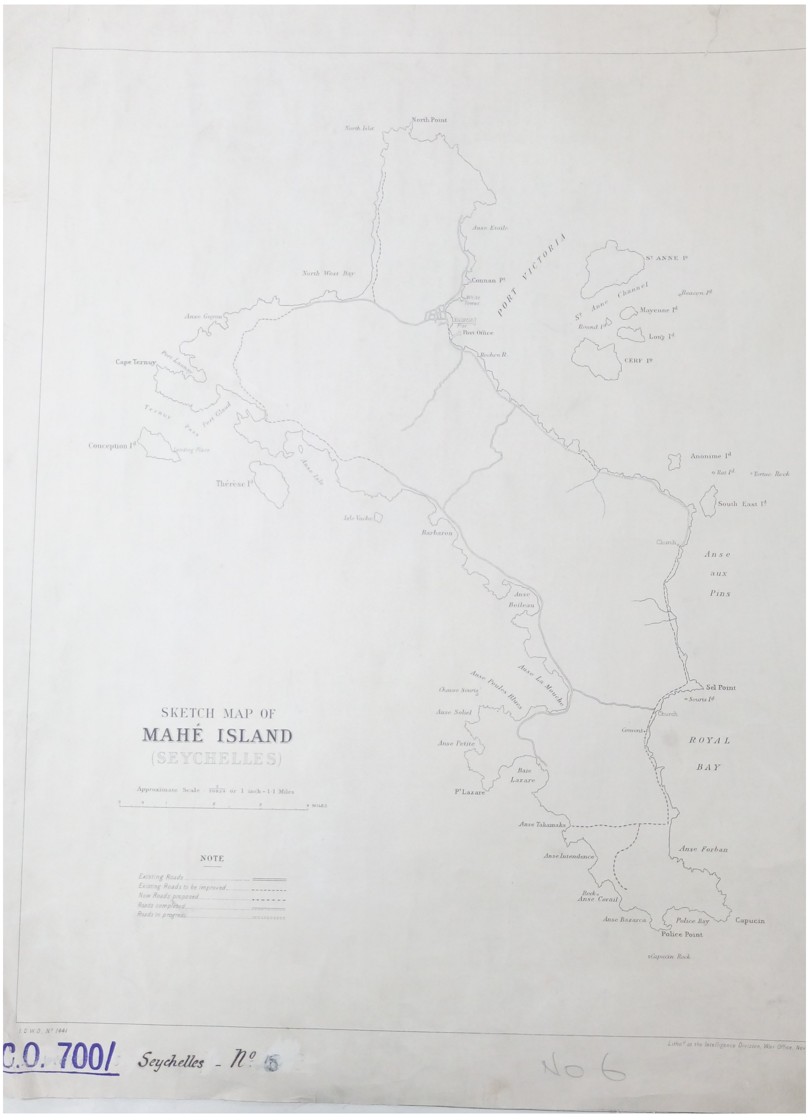

Figure 7: Map sketch of Mahé from the Intelligence Division, War Office dated November 1899.

The map represents; existing roads, existing roads to be improved, new roads proposed, roads completed, and roads in progress around the island.

(TNA: CO 700/SEYCHELLES No 6)

5.1.5 Adaptation

Disasters are at the interface of society, technology, and the environment, and are fundamentally the outcomes of the interaction of these features. In this way, disasters signal the failure of a society to adapt to certain features of its natural and socially constructed environment sustainably, which is why the increasing frequency and severity of natural disasters is central to issues of development and sustainability. The increase in frequency and severity of disasters is thus also a formidable test in evaluating the levels of resilience and sustainability, as well as human environmental adaptations (Oliver-Smith, 1996). As such, Morrison declared that while the destruction of infrastructure on Mahé had been extensive, it was nonetheless an opportunity to make great improvements to the old infrastructure of the island (MNA: SD 64/No 74). A new, more suitable course for the St Louis River was dug out of the mud and the old channel was filled in by the prisoners (MNA: SD 64/No 74). The sea frontage, which was the space between the mouth of the St Louis River and the Victoria Pier, had been flooded with mud from the landslide and so was filled in with the sand that was cleared from the streets and around public buildings so as to recover valuable land from the sea (MNA: SD 64/No 74). Mathiot ("The Lavalas of 1862") confirms that the landslide had filled in an area of approximately 400 metres long extending from St Paul's church – which would have then been right opposite the church. This filled-in land would later be extended to provide a sports field, which was initially called Gordon Square and later renamed Freedom Square. Scarr (2000) corroborates this as he states that a recreation field was laid out where the slip had filled the sea, and which was years later named Gordon Square after General Charles Gordon, who visited Seychelles while he was in command of the Royal Engineers in Mauritius (1881-1882) (Faught, 2008) and in recognition of his identification of the Seychelles as the true Garden of Eden.

As the houses in Town were cramped and the streets were narrow, Morrison suggested that new streets be opened, while existing ones be widened, and that before any building is erected, its access to the street should first be properly aligned. Drainage was also then first incorporated into the lower part of Town (MNA: SD 64/No 74). Mathiot ("The Lavalas of 1862") explains that the then newly constructed post office (1861) (Webb, 1964), which was built of rock, was among the few structures that withstood severe damage and destruction, and the consequence of the *Lavalas* was that future buildings were to be built of stone and lime to better withstand the elements.

5.2 Freak Storm

The Disaster Risk Profile of Seychelles states that, considering the number of victims of natural hazards since significant settlement of the archipelago in the late 18th century, Seychelles may be regarded as one of the safest countries in the Indian Ocean (Chang Seng & Guillande, 2008). While this is certainly a positive thing, the fact that Seychelles has been little impacted by natural hazards throughout its populated history means that it has also been little prepared for the impacts of such visitations, and as such increases its vulnerability and decreases its resiliency.

The captain of the "Nepaul", which was anchored at a distance from Mahé, remarked that the region in which Seychelles is located had been until then considered unaffected by 'gales' (Transactions of the Bombay Geographical Society, 1864). The New Zealander (1864) articulates the peculiarity of Seychelles' oblivion to such weather occurrences – despite the frequency of such visitations throughout the south-western Indian Ocean region, while contextualising it in agricultural terms:

> Whilst the island of Mauritius although not more than 16° south of the Seychelles is visited annually with a hurricane of a greater or lesser strength, and which in proportion to that strength, invariably leaves violent traces of its angry passage on the cornfields and forests, resulting frequently in heavy pecuniary loss to the planter – Mahè, and its sister islands, have never within the memory of the "Oldest Inhabitant" experienced a similar visitation; indeed it has been a boast of the Seychelles that whilst Mauritius was in constant danger of losing her sugar crop through the "Coup de vent," or hurricane the Seychelles planter could safely count on his produce of cocoa nuts &c., from year to year, as nothing save the petty ravages of a few rats could possibly affect their growth or yield.

In Garnier and Desarthe's study (2013), an analysis of the available archives indicated that this type of meteorological event was a frequent occurrence in the region, and had thus engendered the impacted societies to develop original strategies of adaptation. The analysis of the available archives for the 1862 *Lavalas* in the Seychelles, however, proves that this type of meteorological event was so infrequent that the impacted societies were totally unprepared for it. James Henry Brooks, Government Medical Officer, expressed this in his report to the Chief Medical Officer in Mauritius; the absence of such occurrences in the archipelago meant that the inhabitants considered them not only improbable but impossible (SNA).

The meteorological report compiled by R. P. Brunton confirms the exceptional nature of the weather event in one short line, "This hurricane, the only one on record as having done so, passed directly over Mahé" (British Meteorological Society Proceedings, 1863). The way that this is expressed goes one step further than the New Zealander article, which states there had been no similar occurrences in the memory of the oldest inhabitant, as it seemingly refers to the absence of such an occurrence in written records from the French colonial period (which preceded the British colonial era of the islands, and which, also represented the first settlers of the islands), as well as supposedly other records, such as maps and ship reports from the region.

Bishop Ryan of Mauritius confirms the unlikeliness of such a visitation on Seychelles' islands. What is not clear, however, is whether those in Mauritius were startled by the news of the hurricane that hit Seychelles simply due to the fact that Seychelles was never usually hit by hurricanes, or also because Mauritius had not experienced any effects of this hurricane. This ambiguity is found in the beginning of Bishop Ryan's account, "Very soon after my return from Madagascar we were startled by the intelligence that a severe hurricane had visited the Seychelles, and that there had been great loss of life and property from the effects of its violence. Those islands are so completely out of the usual track of hurricanes, that in former days, when men-of-war were stationed at Mauritius, they were sent to the Seychelles during the hurricane season." (Ryan, 1864).

The (Proceedings of the Mauritius Meteorological Society, 1862) opens with an insightful first line, "The mail has brought to us intelligence of a hurricane at the Seychelles, a locality which has hitherto been considered exempt form such visitations." The notice explains further on why it had been thus considered:

> No hurricanes are experienced at the Seychelles in our hurricane season, because those islands are then in the monsoon region, while the hurricanes take their origin on the borders of the trade-wind, and travel to the Southward. But it frequently happens that while a hurricane is raging to the Southward of the Seychelles, strong N. Wly and Westerly winds prevail there, which are actually the winds forming the Northern and N. E. sides of the storm. It is in October and April, at the change of the monsoons, that hurricanes are most likely to occur in those latitudes, and even then they are of very rare occurrence.

5.3 Disaster Memory

Memory plays an important role in the analysis of historical disasters in terms of different aspects. Firstly, 'living' memory (ie. the memories of those who are alive or of the 'oldest inhabitant') is used as a tool to measure past frequency and intensity of events in cases where there is a lack of records or some uncertainty with the records of such, and secondly, 'collective memory', which is the collective remembrance of an event as shared and "passed down" by family members and society to subsequent generations who were not witness to the event. The significance of 'disaster memory' is also in the role that it plays in the facilitation of adaptation and coping strategies.

The first notion of 'living' memory, or memory of the 'oldest inhabitant' has been used in a range of studies on historical hazards where there is a lack of relevant and reliable records, in order to draw conclusions on the frequency and/or intensity of such occurrences. What is particularly useful about this type of approach is that the experience, rather than the facts, of an event is considered, which may be more reliable in the context of disaster and vulnerability. This notion of memory is frequently referred to in the historical documents pertaining to the 1862 *Lavalas* due to the fact that it was the first occurrence of its kind during the British colonial era of the islands and there were no records of any similar occurrences during the preceding French colonial era. However, the shortfall of this type of memory tool in the context of the *Lavalas* is that the first settlers – of which there were but less than thirty – only settled in Seychelles around 1770 (Scarr, 2000), making such memory extremely limited and therefore practically unreliable. Nonetheless, the fact that this type of memory is rather limiting in the current context should not discredit it altogether, as it does indeed corroborate what is deduced from written records – that no similar occurrences were experienced throughout the period of history of the settlement of the islands. The New Zealander (1864) uses this type of memory to express the infrequency of such an occurrence in the Seychelles archipelago; never in the memory of the oldest inhabitant (at the time) had there been any similar visitation, while Nash *et al*. (2015, p3255) use it to interpret the intensity of an occurrence, "the severity of the storm over Antananarivo was such that according to Sibree (1893) '…no one we believe, even the oldest inhabitants, can remember anything approaching it.'"

According to Maurice Halbwachs, as cited in Pfister (2011), groups arrive at 'collective memory' when they are able to envisage a common experience. An example of this 'collective memory' is 'family memory,' which draws on every day oral communication and storytelling in the remembrance of experienced disasters. This notion of 'collective memory,' or, rather particularly, the notion of 'family memory' seems to have been responsible for the transmission of the memory of the disaster concerned with in the study, because even though there are no eyewitnesseses alive, it is still a part of the 'collective memory' of the nation. As Webb (1964, 23) states, "The twelfth of October 1862 will linger long in the memory of the Colony." Pfister (2011) also speaks of 'social short term memory,' which is wiped out with the death of the last eyewitness of the event in question. With regards to the event concerned with in this study, as alluded to above, the last eyewitness would have died sometime around the middle of the twentieth century. Memories that go further back thus need to be underpinned with historical documents, for example newspaper articles, chronicles, photo albums, etc. (Pfister, 2011).

In contrast to war, the memory of natural disasters is markedly short-lived, when it is in fact crucial for the development of coping strategies (Pfister, 2011).

Severe disasters must be remembered to safeguard against the same devastating impacts if they recur (Pfister, 2011). According to Viglione *et al*. (2014), the awareness of past occurrences of flooding [or disasters of other natures] perpetuates the belief among communities that flooding may occur again in the future. This belief stems from the fact that the disaster did actually occur in the past, as well as from 'collective memory', which is a community's ability to retain the awareness of risk through the remembrance of a disaster, as these factors effect the level of perceived risk of a community (Viglione *et al*., 2014). Collective memory plays a significant role in the risk coping culture of communities (Viglione *et al*., 2014), which is why the documentation of disasters and extreme events is a key element of risk cultures. This tradition has been practiced in China for thousands of years, where chroniclers communicated risk by noting down narratives of extraordinary events such as extreme weather and climatic conditions, natural disasters, fires and famines (Pfister, 2011). Memorials are also used to communicate and remember risk; much like war memorials commemorate soldiers and civilians who may have given their lives, so too do disaster memorials commemorate the victims of past natural disasters, as well as serving as a warning for future and potential disasters (Pfister, 2011). The 1862 *Lavalas* was commemorated in a memorial, which was unveiled exactly 150 years after the event in October 2012. The memorial, which stands over the St Louis River – the banks of which swelled and overflowed, inundating the town – was an initiative of the Ministry of Tourism and Culture in collaboration with the Ministry of Environment and Energy, the Seychelles Heritage Foundation, and the Department of Risk and Disaster Management ('1862 Lavalas: Memorial Pays Tribute To Landslide Victims'). Then Minister of Environment and Energy, Rolph Payet, pointed out at the unveiling of the memorial that the *Lavalas* had been a disaster waiting to happen, as there had been extensive clearing of forests for timber for the reparation of war vessels and for other construction needs. He said ('1862 Lavalas: Memorial Pays Tribute To Landslide Victims'):

> Today's unveiling of the plaque in remembrance of this event and to all those who lost their lives, is important for us to reflect on the devastating force of nature and how we as mere beings can, through better disaster prevention, avoid such a terrible loss from ever occurring in our country. What happened 150 years ago can never be allowed to happen to our small nation.

The memorial was blessed by both the Catholic and Anglican Bishops, and all guests observed a minute's silence for the victims of the 1862 *Lavalas.* The fact that the memorial was erected 150 years after the country's greatest disaster is testament to the significance of the event, and an attempt to not forget it. Ex-votos represent another form of cultural disaster memory, and were often produced as testimony of divine intervention. An ex-voto may be in the form of a painting, or even a football shirt, which is exhibited in a public space, most often inside a church (Pfister, 2011). In fact, even a church or other religious buildings may be an ex-voto, if it serves as a disaster memory in the public domain, much like the small chapel near Lake Ruitor in the Aosta Valley built in 1606 (Pfister, 2011). With regards to ex-votos pertaining to the historical disaster in question, on the memorial of the 1862 *Lavalas* itself, is a picture of the disaster, as well as a poem written by Bishop Ryan of Mauritius following his visit to the island to witness the disaster (Durup, 2012). Moreover, two days following the unveiling of the 1862 *Lavalas* memorial, on the exact 150 year anniversary of the event, a memorial mass was held in St Paul's church – which played an instrumental role in the recovery and relief of victims of the *Lavalas.* Attendees included the Health Minister, Land Use and Housing Minister, as well as the chief executives of the Department for Risk and Disaster Management. The Priest noted during this service that heavy rains such as those that caused the *Lavalas* had hit Mahé again in 2004 following the tsunami, and that were it not for better infrastructure and drainage systems, as well as quicker mobilisation and communication, a repeat of the 1862 disaster may have been likely ('Lavalas Victims Remembered In Service At Packed St Paul's').

The more individuals and groups bear past events in mind, the greater the risk of their recurrence is perceived to be. Also, the more frequently they occur, the more likely people are to anticipate them and try to develop adequate adaptive strategies (Pfister, 2011). Perhaps it is the frequency, or rather the infrequency of such disasters in Seychelles that has not permitted the development of adequate adaptive strategies. According to Franz Mauelshagen, as cited in Pfister (2011), all preventative strategies are based on the expectations that are generated by the recurrence of such experiences, or in other words, risk perception of natural hazards is essential to effective management and mitigation strategies (Brennan *et al*., 2016). A lack of knowledge about events creates a low perception of risk, which accounts for the level of impact of the *Lavalas* on the population of Seychelles in 1862. The 'disaster gap', which is the rare occurrence of severe hazards during a century, is a significant element in explaining the loss of functional disaster memory (Pfister, 2011). Perceiving the risk [of disaster] to be less than it is – due to this 'unlearning' or forgetting– puts a community at escalated risk of an event (Viglione *et al*., 2014). An example of this is Switzerland's lack of severe disasters during the period 1882-1976, which resulted in a process of non-remembrance and unlearning, and thus a total lack of civilian disaster awareness and preparedness (Pfister, 2011). It is for this reason that I wished to ascertain whether Seychelles' and its population have undergone a 'process of unlearning' due to the absence of landslide disasters as severe as the historistical landslide disaster of 1862, or, whether Seychelles and its population – having experienced an apparent increase in disasters in more recent decades – have retained the lessons learnt.

Figure 8: The *Lavalas* memorial, which includes a brief description of the event, a photograph taken shortly after the event, and a poem written by Bishop Ryan of Mauritius inspired by the devastation he witnessed while visiting the island soon after the event.

Figure 9: The *Lavalas* memorial stands right over the St Louis River and right next to the Post Office (where the photograph is taken from).

5.4 Lessons learned

With respect to what Seychelles has learned from the 1862 disaster, local historian, Julien Durup, says perhaps nothing (Durup, 'Lavalas'). In the late 1970s, there was a landslide at Serret Road, which a South African expert came to study and, in his report, he offered precautions with regards to use and maintenance of land and natural landscapes in order to avoid similar future disasters, however, none of these precautions have been properly implemented or even acknowledged (Durup, 'Lavalas').

Famous French trader, Pierre Poivre's legacy in the Seychelles was cinnamon; it took so well to the environment that it spread and covered the hills of Mahé. Scarr (2000) explains that without these cinnamon trees to hold the soil, there would have been more occurrences like the 1862 *Lavalas*, and that in the early 1870s, risk of another similar occurrence was heightened with the fading memory of the Lavalas, as Sauzier cut out more timber on the slopes in order to make space to grow coffee. In a modern context, land higher and higher up on the slopes is constantly being cleared of vegetation, as well as blasted to clear and flatten granite rock, in order to make way for development, such as the construction of new homes and properties. If careful assessments of the land are not first properly conducted, rainfall and other environmental factors may have disastrous effects on new development.

The most recent disastrous event to impact Seychelles was the Indian Ocean tsunami of 26 December 2004, which shares much in common with the 1862 *Lavalas* disaster in that it totally caught the population unawares, and also in that they may both be considered a double disaster event, rather than a single disaster event. What this means is that in the same way that the 1862 *Lavalas* entailed a hurricane impacting the islands, which then triggered the landslide, the 2004 tsunami impacted the islands, following which heavy and ceaseless rainfall triggered landslides and mudflows.

CONCLUSION

The global trend of the increasing incidences of disaster has evoked research on reconstructions of climate variability, as well as mitigation and adaptation strategies of communities in the face of disaster through the study of historical documentary material. This study combined both these areas of research, as it involved both a recreation of the climatic details pertaining to the 1862 *Lavalas* event, as well as an analysis of the coping and adapting strategies of society following said event. The retrieval of historical documentary sources has proven to be essential for the study of environmental histories, particularly historical disasters, for the Indian Ocean, and particularly for the Seychelles. Data on the causes and effects of a disaster – especially in the context of a country that has experienced very few disastrous events throughout its inhabited history – is important for the understanding of vulnerabilities, possible catalysts, as well as possible impacts of disaster in a specific context, just as data on the coping and adapting strategies related to these disasters informs possible management and mitigation strategies. Other factors, such as memory, also play an important role in the impact of disaster; the memory of disaster is an important contributing factor to risk perception, which determines the preparedness and thus also the resilience of a community to a disaster. As the 1862 *Lavalas* disaster is largely considered the most severe and unprecedented natural disaster in the history of the country, there was no knowledge and understanding of the possibility of such occurrences in the archipelago prior to it, which meant that the population of the time was totally unprepared for it, which also meant that it had a profound impact on the population and was thus to be remembered by generations to come as collective memory. As the collective memory of disaster is integral to risk perception of a community, remembrance of disaster is essential to the management and mitigation of future occurrences, especially in the event of an increasing frequency of natural hazards.

The unprecedented rate at which the global climate is shifting, causing erratic changes in the occurrence of natural disasters, has called for the kind of research that studies historical experiences of natural disasters in order to understand the causes, the impacts and the coping strategies developed by specific societies and communities in response to disasters. Historical documentary sources, many of which are contained in archives around the world, prove invaluable sources from which to obtain data on the causes, impacts and coping strategies of these disasters, as they supplement other documentary sources with primary and in many cases new and unused data, and in other cases, where there is a complete lack of any other documentary sources besides those historical documents contained in the archives, such as is the case in this study, these primary sources offer the data required for research.

Seychelles, as compared with other small island developing states, as well as with other countries in the south-western Indian Ocean region, is relatively far less affected by destructive natural hazards. While this may be a positive thing, it has also meant that Seychelles has had fewer opportunities to adapt to, mitigate or cope with destructive natural disasters. The 1862 *Lavalas* event is thus the first event of its kind to impact the islands in the one hundred years of human settlement prior to 1862, which explains the vast loss of life, property and general destruction. This, however, is also what makes the event a very important one to study, in order to understand the vulnerabilities that existed prior to the event, how these vulnerabilities were realised in the impacts of the event, and how society dealt with these impacts.

The climatic details identified in the climate reconstruction findings of the study are an important addition to the body of knowledge on the *Lavalas*, as the event was not previously understood as comprising two disastrous occurrences: not only extensive landslides, but also the only and severest tropical cyclone to impact the inhabited islands of the Seychelles. The climatic details presented in the study have not before been gathered and organised in such a way, as the data obtained in this section comes from a diverse range of historical documents, this section also importantly indicates that tropical cyclones have impacted not only the outer lying islands (closer to Madagascar than to the main island, Mahé) as continues to be the case, but also the inner islands, where a large majority of the Seychelles population continues to reside. The data obtained on the occurrence of landslides in the event also importantly informed which parts of the main island may be most at risk to similar occurrences if the structure of the land is in any way compromised due to meteorological factors. The damages and destruction of agriculture is also an important insight of the study, as food security at a household level was significantly threatened as evidenced by the number of those made destitute by the event, who gathered daily at the church to receive food rations. The islands' only agricultural industry was the production of coconut oil from coconut plantations, which were the most extensively destroyed crop, resulting in further dire economic consequences for the population. The injuries and casualties that were a consequence of the *Lavalas* are the highest recorded figures in Seychelles' history and the section on casualties in the findings chapter indicates how lives were lost at different stages throughout and following the event. The section on infrastructural damage offers new details on the impacts of the event, as well as, importantly, new details and understanding of the adaptation of society to the infrastructural consequences of the disaster.

In the discussion chapter, details of the islands' and its residents' vulnerabilities are discussed as obtained from the primary historical documents and are important to understanding the effects and consequences of the event. These same historical details also inform contemporary research on the particular vulnerabilities of a given society and in this way assist in developing the resilience of societies to natural disasters and the consequences of a changing climate. Due to all these specific vulnerabilities, the impact on society was extensive and profound, and most significantly, it left on society a lasting sentiment of gloom. What did result from the consequences of the *Lavalas*, however, were reparations that adapted to and benefitted from the structural changes caused by the event. Also discussed is the unlikely occurrence of the *Lavalas* event for a range of reasons, as supported by the primary historical archive documents. Finally, and perhaps most relevant to the body of research, the lessons learned from the disaster are discussed, as it is a major reason for environmental – and in particular, disaster – histories to be excavated from the archives.

REFERENCES

Primary Sources

National Archives of Mauritius (MNA): SD 64/ No 74 (24.04.1863).

Seychelles National Archives (SNA): Documents pertaining to the *Lavalas* 1862.

The National Archives of the UK (TNA): CO 700/SEYCHELLES No 1.

The National Archives of the UK (TNA): CO 700/SEYCHELLES No 2.

The National Archives of the UK (TNA): CO 700/SEYCHELLES No 6.

The National Archives of the UK (TNA): CO 700/SEYCHELLES No 10.

Secondary sources

Alexander, D. (1983)"God's Handy-Worke in Wonders" – Landslide Dynamics and Natural Hazard Implications of a Sixteenth Century Disaster in Professional Geographer, 35(3), pp. 314-323

Astier, N., Plu, M. and Claud, C. (2015). Associations between tropical cyclone activity in the Southwest Indian Ocean and El Niño Southern Oscillation. Atmospheric Science Letters, 16(4), pp. 506-511.

'Beaufort Wind Scale'. NOAA. Available: http://www.spc.noaa.gov/faq/tornado/beaufort.html. 2017. [Accessed 19 March 2017].

Blackstone, William. Commentaries On The Laws Of England.

Brennan, M., O'Neill, E., Brereton, Finbarr, Dreoni, I. and Shahumyan, H. (2016). Exploring the spatial dimension of community-level flood risk perception: a cognitive mapping approach, *Environmental Hazards*, DOI: 10.1080/17477891.2016.1202807.

Briguglio, L. (1995), Small Island Developing States and Their Economic Vulnerabilities. World Development, 23(9), pp. 1615-1632.

Briguglio, L. (2003). The Vulnerability Index and Small Island Developing States – A Review of Conceptual and Methodological Issues. University of Malta. Retrieved from: http://www.um.edu.mt/__data/assets/pdf_file/0019/44137/vulnerability_paper_sep03.pdf.

Brunton, R. P. Meteorological Report of Hurricane at Seychelles, on 11th and 12th October, 1862, Proceedings of the British Meteorological Society, Vol 1, 20 November 1861 – 17 June 1863. August 1863. London: Taylor and Francis, Red Lion Court, Fleet Street.

Chang-Ko, L.A. (June 1991). Sensitivity of Seychelles coastal areas to possible significant sea-level changes. Retrieved from: http://www.oceandocs.org/bitstream/handle/1834/8375/ktf00534.pdf?sequence=1&isAllowed=y

Chang Seng, D. and Guillande, R. (July 2008). *Disaster Risk Profile of the Republic of Seychelles*. United Nations Development Programme. Retrieved from: http://www.unisdr.org/files/18276_18276disasterriskprofileofseychelle.pdf

Crozier, M. J. and Glade, T. (2004) Landslide Hazard and Risk: Issues, Concepts and Approach.
Durup, J. 'Lavalas'. (November 2012). Available: http://www.seychellesweekly.com/November%2018,%202012/letter_durup.html. [Accessed: 13 April 2016].

Erismann, T. H. (1979). Mechanism of Large Landslides. *Rock Mechanics, 12*, pp.15-46.

Faught, C. Brad. (2008). GORDON: Victorian Hero. Potomac Books, Inc. Washington D.C.

Fitchett, M. and Grab, S. W. (2014). A 66-year tropical cyclone record for south-east Africa: temporal trends in a global context, *Int. J. Climatol. 34*. 3604-3615.

'Fujita Tornado Damage Scale'. NOAA. Storm Prediction Center. (January 2017). Available: http://www.spc.noaa.gov/faq/tornado/f-scale.html. [Accessed 19 January 2017.]

Füssel, H-M. and Klein, R. J. T. (2005). Climate change vulnerability assessments: an evolution of conceptual thinking in CLIM, pp. 1-29. Retrieved from: http://s3.amazonaws.com/academia.edu.documents/46322990/fuessel_klein_2005.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1496683690&Signature=JlVm42kK0BA8F%2F7odwx%2BA1CSTx4%3D&response-content-disposition=inline%3B%20filename%3DClimate_change_vulnerability_assessments.pdf

Galli, M. and Guzzetti, F. (2007). Landslide Vulnerability Criteria: A Case Study from Umbria, Central Italy in Environmental Management*,* 40, pp. 649-664.

Garcia Herrera, R., Garcia, R. R., Prieto, M. R., Hernandez, E., Gimeno, L. and Diaz, H. F. (2003). The use of Spanish historical archives to reconstruct climate variability, *American Meteorological Society*, pp. 1025-1035.

Garcia-Herrera, R., Gimeno, L., Ribera, P. and Hernandez, E. (2005). New records of Atlantic hurricanes from Spanish documentary sources. *Journal of Geophysical Research, Vol 110*, doi:10.1029/2004JD005272.

Garcia Herrera, R., Rubio Duràn, F., Wheeler, D., Hernàndez Martín, E., Rosario Prieto, M. and Gimeno, L. (2004). The use of Spanish and British documentary sources in the investigation of Atlantic hurricane incidence in historical times.

Garnier, E. and Desarthe, J. (2013). Cyclones and Societies in the Mascarene Islands 17th-20th Centuries, American Journal of Climate Chance, Vol. 2(1), DOI:10.4236/ajcc.2013.21001.

'Glossary Of NHC Terms'. NOAA. Available: http://www.nhc.noaa.gov/aboutgloss.shtml. 2017. [Accessed 19 March 2017].

Grinsted, A., Moore, J. C. and Jevrejeva, S. (2012). Homogenous Record of Atlantic Hurricane Surge Threat Since 1923, Proceedings National Academy of Sciences, 109(48), pp. 19513-19514.

Guillande, R. and Malatre, L. (2012). A Rapid Overview of Natural Disaster Risks on Islands Project Partners. Indian Ocean Commission. Retrieved from: http://commissionoceanindien.org/fileadmin/resources/ISLANDSpdf/A_rapid_overview_of_natural_disaster_risks_on_ISLANDS_project_partners.pdf

Hutanuwatr, K., Bolin, B., Pijawka, D. (2013). Vulnerability and Disaster in Thailand: Scale, Power, and Collaboration in Post-tsunami Recovery in *Forces of Nature and Cultural Responses*, pp. 69-92.

International Council for Science. ICSU Regional Office For Africa SCIENCE PLAN. 2007. Natural And Human-Induced Hazards And Disasters In Sub-Saharan Africa. Available: http://www.icsu.org/icsu-africa/publications/reports-and-reviews/icsu-roa-science-plan-on-hazards-disasters/Doc%20SP03.1_ICSU%20ROA%20Science%20Plan%20-%20Hazards%20and%20Disasters.pdf.

J F P Galvin. An Introduction to the Meteorology and Climate of the Tropics. Wiley Blackwell.

King, David, Jim Davidson, and Linda Anderson-Berry. "Disaster Mitigation And Societal Impacts". Global Perspectives On Tropical Cyclones: From Science To Mitigation. Johnny, C. L. Chan and Jeffrey D. Kepert. 4th ed. Singapore: World Scientific Publishing Co. Ptc. Ltd., 2010.

'Lavalas Victims Remembered In Service At Packed St Paul's'. *Nation.sc*. N.p., 2012. Web. 7 Jan. 2017. Available: http://www.nation.sc/article.html?id=236149. [Accessed November 2016].

Liu, K., Shen, C. and Louie, K. (2001) A 1000-Year History of Typhoon Landfalls in Guangdong, Southern China, Reconstructed from Chinese Historical Documentary /records, Annals of the Association of American Geographers, 91(3), pp. 453-464.

Malan, N., Reason, C. J. C., Loveday, B. R. (2013), Variability in tropical cyclone heat potential over the Southwest Indian Ocean, *Journal of Geophysical Research, 118* (12), pp. 6734-6746. DOI: 10.1002/2013JC008958.

Mathiot, Tony. 'The Lavalas Of 1862'. *Pfsr.org*. Retrieved from: http://www.pfsr.org/history-of-seychelles/the-lavalas-of-1862/. [Accessed: 13 April 2016].

Mathiot, Tony. 'The Story Of The Seychelles Hospital'. *Ministry of Youth Sports & Culture*. (n.d.) Available: http://www.pfsr.org/history-of-seychelles/the-story-of-the-seychelles-hospital/. [Accessed 10 February 2017].

Martin, M., Bastienne, L. and Vel, T. (15 July 2009). Risk and Disaster Management: Public Awareness Strategy for Seychelles. Retrieved from: http://www.s4seychelles.com/uploads/6/1/6/7/6167574/disaster.educationawareness_s4s.pdf.

McAteer, William. Hard Times in Paradise. Seychelles: Pristine Books, 2000.

McLeod, M. K., Slavich, P. G., Irhas, Y., Moore, N., Rachman, A., Ali, N., Iskandar, T., Hunt, C., Caniago, C. (2010). Soil salinity in Aceh after the December 2004 Indian Ocean tsunami, Agriculture Water Management, Vol 97(5), pp. 605-613.

Nash, D. J., Pribyl, K., Klein, J., Endfield, G. H., Kniveton, D. R. and Adamson, G. C. D. (2015). Tropical cyclone activity over Madagascar during the late nineteenth century, *Int. J. Climatol, 35*, 3249-3261.

National Rapid Environmental Assessment – Seychelles Tsunami. 2005. Department for Risk and Disaster Management, Ministry of Energy and Environment, Seychelles. pp. 96-111.

Nel, W., Anderson, R. L., Sumner, P. D., Boojhawon, R., Rughooputh, S. D. D. V. and Dunputh, B. H. J. (2013). Temporal Sensitivity Analysis of Erosivity Estimations in a High Rainfall Tropical Island Environment. Swedish Society for Anthropology and Geography. DOI:10.1111/geoa.12017

Nel, W., Mongwa, T., Sumner, P.D., Anderson, R.L., Dhurmea, K.R., Boodhoo, Y., Boojhawon, R. and Rughooputh, S.D.D.V. (2012). The nature of erosive rain- fall on a tropical volcanic island with an elevated interior. Physical Geography, 33, 269–284.

Oliver-Smith, A. (1994). Peru's Five-Hundred-Year Earthquake: Vulnerability in Historical Context in Disasters, Development and Environment. Retrieved from: https://aas.uncg.edu/ashby/human-adaptation/documents/3%20OliverSmith500year_eqrthquake.pdf.

Oliver-Smith, A. (1996). Anthropological research on hazards and disasters in Annual Review of Anthropology, Vol. 25, pp. 303-328.

Payet, R.A. (2005). Climate policy implications of the recent ENSO events in a small island context. Climate and Africa, ed. Pak Sum Low. Cambridge University Press.

Payet, R.A. & Agricole, W. (June 2006). Climate Change in the Seychelles: Implications for Water and Coral Reefs. Ambio, 35(4) pp 182-189. DOI: http://dx.doi.org/10.1579/0044-7447(2006)35[182:CCITSI]2.0.CO;2

Pfister, C. (2011). "The Monster Swallows You": Disaster Memory and Risk Culture in Western Europe, 1500-2000 in Rachel Carson Center Perspectives, Vol. 1, pp. 3-23.

Proceedings of the Meteorological Society of Mauritius, Volume VI, pages 35 to 43. 1862.

Rao, S. and Behera, S. K. (2005). Subsurface influence on SST in the tropical Indian Ocean: structure and interannual variability, Dynamics of Atmospheres and Oceans, 39, pp. 103-135.

Ryan, V. W. (1864). Mauritius and Madagascar – Journals of An Eight Years' Residence in the Diocese of Mauritius, and of a Visit to Madagascar by Vincent W. Ryan, D. D. Bishop of Mauritius. Project Canterbury. London: Sheeley, Jackson and Halliday. Available: *anglicanhistory.org/africa/mu/ryan18647.html.*

Scarr, Deryck. Seychelles Since 1770. London: C. Hurst, 2000. Print.

Schott, T., Landsea, C., Hafele, G., Lorens, J., Taylor, A., Thurm, H., Ward, B., Willis, M., and Zaleski, W. (February 2012). The Saffir-Simpson Hurricane Wind Scale. Retrieved from: http://www.nhc.noaa.gov/pdf/sshws.pdf.

Sébastien Langlade. (October 2013) *The SouthWest Indian Ocean cyclone basin*. Regional Specialized Meteorological Centers (RMSC): METEO FRANCE. Retrieved from: http://severe.worldweather.wmo.int/TCFW/RAI_Training/Cyc_Bassin_SWI_oct2013_LANGLADE.pdf.

Seychelles Damage, Loss, And Needs Assessment (DaLA). 2013 Floods. Government of Seychelles. 2013. Available: http://www.gfdrr.org/sites/gfdrr/files/Seychelles_DaLA_2013_Floods.pdf. [Accessed 19 June 2016].

Seychelles Natural Disaster Profile. (2004). New York: Columbia University. Available:

https://www.ldeo.columbia.edu/chrr/research/profiles/pdfs/seychelles_profile1.pdf [Accessed 7 March 2017].

Seychelles Post Disaster Needs Assessment (PDNA). 2016. Tropical Cyclone Fantala. Government of Seychelles. Available: http://documents.worldbank.org/curated/pt/767291481886997139/pdf/111075-WP-P151462-PUBLIC-SeychellesFantalaPDNAFinal.pdf. [Accessed 6 March 2017].

Seychelles Post-Tsunami Environmental Assessment. 2005. Asian Tsunami Disaster Task Force. Geneva: United Nations Environment Programme.

Smit, B, Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. Global Environmental Change 16, pp. 282-292. Retrieved from: http://www.uio.no/studier/emner/annet/sum/SUM4015/h08/Smit.pdf.

Sumner, P., Nel, W., Rughooputh, S., Boojhawon, R., Dhurmea, K., Le Roux, J. and Anderson, R. (2016). Rainfall Erosivity and Soil Erosion Risk Assessment in Tropical Island Environments: A Case Study of Mauritius. Geomorphology and Society, Advances in Geographical and Environmental Sciences, DOI 10.1007/978-4-431-56000-5_13.

'The New-Zealander'. National Library of New Zealand. Available: https://paperspast.natlib.govt.nz/newspapers/new-zealander. [Accessed October 2016].

THE SEYCHELLES ISLANDS AND A LATE HURRICANE HERE. (20 December 1864). New Zealander, Volume XXI, Issue 2305. Available: https://paperspast.natlib.govt.nz/newspapers/NZ18641220.2.27

The Transactions of the Bombay Geographical Society. From January 1863 to December 1864. Volume XVII. Bombay: Education Society's Press, Byculla. Pp. ii-xi. Retrieved from: https://books.google.mu/books?id=zF5OAAAAIAAJ&pg=PA339&lpg=PA339&dq=Seychelles+Hurricane+1862&source=bl&ots=St2JT3z5RO&sig=Hf8Pn3vRvNOXB0oemHRJJEctEQI&hl=en&sa=X&ved=0ahUKEwjGxv-9p5zQAhWBNj4KHdkBAM8Q6AEIQjAI#v=onepage&q=Seychelles%20Hurricane%201862&f=false

'Tropical cyclone'. (2014). In *Oxford English Dictionary* (3rd ed.).

Viglione, A., Di Baldassarre, G., Brandimarte, L., Kuil, L., Carr, G., Salinas, J. L., Scolobig, A., Blöschl, G. (2014). Insights from socio-hydrology modelling on dealing with flood risk – Roles of collective memory, risk-taking attitude and trust, Journal of Hydrology, http://dx.doi.org/10.1016/j.jhydrol.2014.01.018.

Webb, A. W. T. The Story of Seychelles. July 1964. Chapter B: Birth and Growth of the Township of Victoria pp. 18-34.

Wilkinson, C. (2012) British Logbooks in UK Archives, 17th-20th Centuries – a survey of the range, selection and suitability of British logbooks and related documents for climatic research in Climatic Research Unit Research Publication 12.

Wheeler, D. A. (April 1987). Sailing Ship's Logs As Weather Records: A Test Case, The Journal of Meteorology, Vol 13(128), pp. 122-125.

Williams, M. (1994). The relations of environmental history and historical geography, Journal of Historical Geography, 20(1), pp 3-21.

Wong, P. P. (2011). Small island developing states. WIREs Clim Change. 2011. Vol.2 pp. 1–6 DOI: 10.1002/wcc.84.

Yearwood, S. Developing Micro-Insurance as a Climate Adaptation Strategy for Small Island Coastal Communities: Comparing the needs, viability, and feasibility for micro-insurance in Mauritius, Seychelles, Saint Lucia and Jamaica. Retrieved from: http://givrapd.org/wp-content/uploads/2014/03/WP3-Developing-Microinsurance.pdf

Yokoi, T., Tozuka, T., Yamagata, T. (2008). Seasonal Variation of the Seychelles Dome. Journal of Climate, 21, pp. 3740-3754.

'1862 Lavalas-Memorial Pays Tribute To Landslide Victims'. *Nation.sc*. N.p., 2012. Available: http://www.nation.sc/article.html?id=236117. [Accessed: 13 April 2016].