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Natural hazards in La Réunion island (France) since the mid-seventeenth century: production and analysis of a geohistory database (HistoRiskRun)

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Abstract. La Réunion is one of the French territories most exposed to natural risks. The island is exposed to seven major natural hazards: cyclones, floods, swells and tsunamis, landslides, earthquakes, wildfires, and volcanic eruptions. Numerous natural disasters have occurred on the island, as well as less significant natural events. This study presents a historical review of the direct impacts of natural events documented in departmental and national archives since human settlement on the island. Thus, in total 2,823 sources, referencing 1,266 events from 1655 to 2025 have been processed. The source's reliability is analyzed using a decision tree method. Based on the impacts, significance scores for each referenced event is established. An analysis of the evolution of impacts and mortality over time is conducted. A detailed geodatabase (HistoRiskRun) is created to capitalize information about natural hazards in La Réunion since its colonization. This database enhances documentation and understanding of past events and the evolution of risk management over time. This work provides elements to discuss the temporal evolution of impacts and mortalities associated with natural hazards and to relate these dynamics to the island's geo-socio-historical context.

1 Introduction

Natural risk results from the combination of natural hazard, vulnerability and stakes (D'Ercole et al., 1994). Risk therefore represents a potentiality, while an event is a reality. The concrete and damaging realization of a potential risk (Walter, 2008) can result in a disaster, when its severity, intensity and spatial extent are considerable. Therefore, high-intensity natural hazards result in considerable impacts on populations and assets, yet these events are not systematically recognized as disasters due to the varying levels of vulnerability and exposure of the stakes involved.

La Réunion is a volcanic island of the Indian Ocean exposed to seven major natural hazards, which can have cascading effects. The island experiences frequent hazards of considerable intensity. La Réunion holds world records for rainfall, with

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1,144 mm accumulated over 12-hour and 6,083 mm over 15-day. The return period for cyclones of category 1 or higher on the Saffir-Simpson scale is estimated at 5 years, and 47% of cyclones are associated by flooding and 40% by marine submersions (Desarthe and Moncoulon, 2017). Flooding results from the saturation of hydrographic networks and water tables, runoff from impermeabilized surfaces, and the arrival of large sea waves. Marine submersion is linked to swell phenomena, which can be cyclonic, austral or trade winds (DEAL Réunion, 2021). La Réunion is also affected by landslides (about 25% of the surface of the island is mapped in high landslide hazard) and coastal erosion. Seismic hazard is low but not negligible (DEAL Réunion, 2021; Duputel, 2022). Concerning wildfire, several hundred forest fires break out every year, with one major fire every 20 years (DEAL Réunion, 2021). The Piton de la Fournaise is one of the world's most active effusive volcanoes, erupting on average every 8 months (OVPF, 2022).

Climate change adds substantial uncertainty to projections of how these hazard-related impacts may evolve in the future. The latest models suggest a significant increase in the probability of major intensity tropical cyclones being exceeded (Kossin et al., 2020; Leroux et al., 2024). Despite high exposure to hazards and a high population density, the impact of recent natural hazards appears to be relatively under control in La Réunion. The last disaster to claim more than a hundred lives, was the cyclone of 1948, with 165 deaths, 90% of food crops destroyed and 3 billion CFA francs in damage costs (Jouanjean, 2011), approximately USD 1.22 billion (2025).

The analysis of natural hazard impacts over time provides a better understanding of territorial risk in terms of intensity, spatial distribution and vulnerability evolution. There are many historical databases that reference the impacts of hazards in France (Boisson et al., 2022; Zgheib et al., 2020; Giacona et al., 2017) or other countries (Schlögl et al., 2021; Barriendos et al., 2014; Macdonald and Sangster, 2017). Surveying cyclonic events is a long-standing tradition in La Réunion (Lavalley, 1876; De Martin De Viviès, 1944; Nomdedeu and Maestri, 2001; Jouanjean, 2011; Desarthe and Moncoulon, 2017). Several researchers have contributed to the development of historical databases on cyclones in the territory. For example, Desarthe and Moncoulon (2017) record 76 storms and cyclones that have caused damage since the 17th century. This focus on cyclones has, in a few cases, overlooked the importance of other hydroclimatic hazards, such as more local flooding or flash flooding. For example the flood of 1947 has caused 9 deaths in Bois Blanc (Sainte-Rose). It was forgotten until 2023, when discussion with inhabitants, archive work and a documentary by Alain Bertil revived it.

Volcanic eruptions have also been extensively studied, notably by the Observatoire volcanologique du Piton de la Fournaise (OVPF), which has forecast 84 eruptions between its creation in 1979 and 2023, i.e. 1978 eruption days (OVPF, 2022). Landslides are the subject of a specific database, maintained and updated by the Bureau de Recherches Géologiques et Minières (BRGM) since 1994 (Mirgon, 2001). A total of 3,086 events have been recorded since 1807. However, there is no information on the impact of landslides in this database. For forest fires, there is no historical record before 1955. In addition, these data are not consolidated into a single database.

This study presents temporal and spatial chronology of all natural hazard events across the island since the arrival of man on the island (1655), based on the HistoRiskRun geospatial database compiled from archival research (Dupont et al., under

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embargo). Based on these chronology, we propose here a first analysis of the evolution of hazard impacts on the island through time and relate to a geo-history contextualization.

2 Study Area

2.1 General geographical setting

La Réunion (21° 08'S, 55° 32'E) is a volcanic island located in the western Indian Ocean (Fig. 1), more than 900 km from Madagascar. Along with Mauritius and Rodrigues islands, it forms part of the Mascareignes. With a surface of 2,512 km² and a population of 911,000 (Insee, 2026), it has a density of 347 inhabitants per square kilometer. In 2020, it was the third most densely populated region in France, after Ile-de-France and Mayotte. Only 40% of La Réunion's land area is habitable (Jauze, 2003). A major part of the population is concentrated in coastal areas, whereas the interior of the island, including the Piton de La Fournaise volcanic region, is sparsely populated and largely uninhabited (Fig. 1).

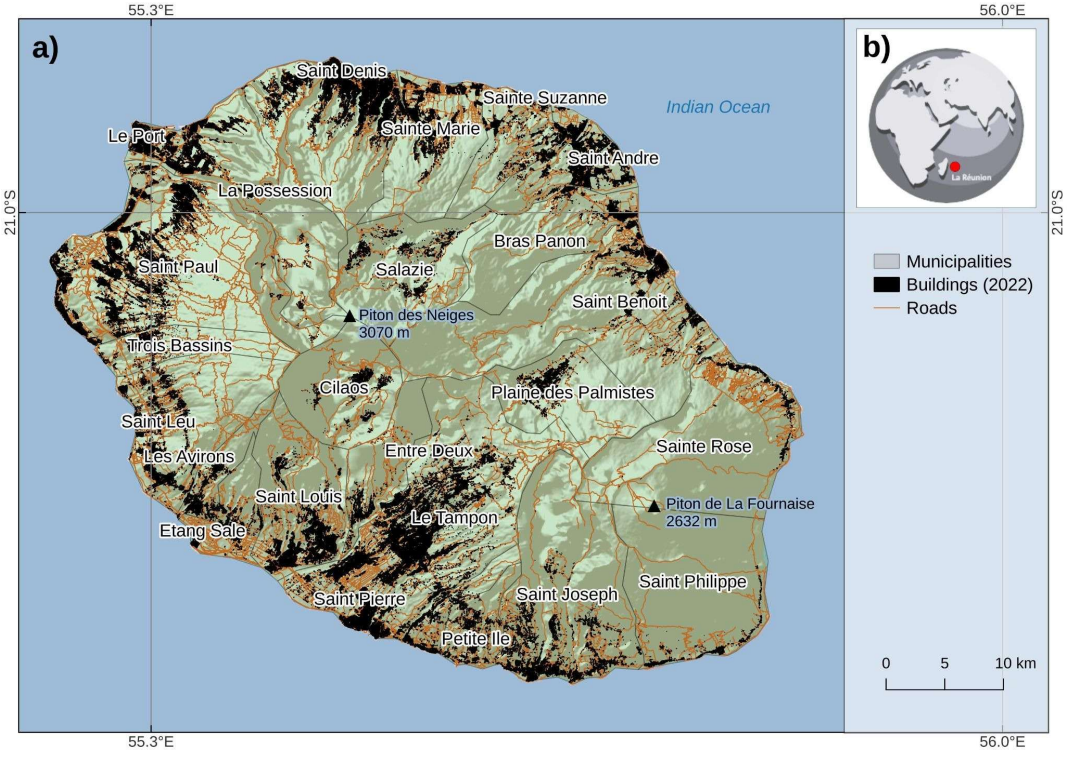

Figure 1: Location map of La Réunion. Adapted from Data.gouv.fr (https://www.data.gouv.fr/fr/datasets/carte-des-departements-2-1/) and ESRI Shaded Relief.

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With the Piton des Neiges culminating at 3,070 meters above sea level, the island's relief is steep and shaped by erosion. It enjoys a humid tropical climate tempered by the oceanic influence of the trade winds and lies in the tropical cyclone-forming basin of the south-western Indian Ocean.

2.2 General historical setting

From 1642 to 1946, the island was a French colony; in 1946, it became a French department, before being granted the status of an overseas region in 1982 (Combeau, 2002). It is from the 19th century, driven by rapid population growth, that land-use planning, including the construction of main arch structures was introduced to secure the territory from flooding, as well as improve the transportation of goods and people (bridges, levees, buildings, etc.). From this demographic view and referring to Sandron (2007), it is possible to distinguish several periods for the island:

i. During the settlement period (1663–1715), the island was populated by 1,500 colonists in 1715. The dwellings were straw huts built from local materials (trunks and branches). These were the most common form of precarious housing on La Reunion island until the 1960s. They are not resistant, particularly to cyclones.

ii. The coffee era (1715–1815), with massive recruitment of colonists and, above all, slaves. Inhabitants form around a front in the lower slopes and on the coast of Saint-Paul (Simon 2003).

iii. Period of sugar cane and the population influx (1815–1865). The number of inhabitants rises from 68,000 to 175,000.

iv. Period of demographic stagnation (1865–1919) and the population remained below 200,000 until the 1920's with multifactorial causes (economy, famines, epidemics and diseases, parasites, cyclones, etc.).

v. A second period of significant population growth occurred (1920–1980), when the number of inhabitants exceeded 200,000 and then reached 500,000. La Réunion's demographic transition took place during this 60-year period, although the island continued to experience relatively high population growth thereafter. In the 1940s, living on the island was still closely tied to natural phenomena and the seasonal cycle (Sandron, 2007). It was also a period of migration of the medical professions to the cities, following the Finance report of 1948, which highlighted the inadequacy of the health sector (insufficient number of doctors and establishments). At the time, La Réunion's epidemiological structure was similar to that of developing countries. The island is then undergoing one of the fastest demographic transitions in the world.

vi. The gradual end of population growth (1980–present).

2.3 Public policies on natural risk management

It was in the second half of the 20th century that the foundations of current risk management in La Réunion were laid. Progress was made in national risk legislation, particularly with regard to building standards, and solid-state housing became the norm on the island (houses called tomi or satec). This trend towards more resistant housing is helping to reduce vulnerability to climatic events. Significant events, such as Cyclone Jenny in 1962 or Cyclone Hyacinthe in 1980, led to a wake-up call (Jouanjean, 2011). The introduction of modern warning systems and the emergence of mass media play a

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crucial role in risk management and awareness, particularly for cyclones. Between the 1970s and the 1990s, new management policies took effect on a national scale. These included the creation of a compensation scheme for victims of natural disasters in 1982 (Morin, 2012), the Risk Exposure Plan (PER) in 1984, and the right to information in 1987. In La Réunion, large-scale programs such as the Plan Pluriannuel d'Endiguement des ravines (PPER) transformed the island's hydrological landscape. From the 1990s onwards, risk management became more global at the territorial level, and in particular at the level of watersheds, with the Barnier Law (1995) and the Risk Prevention Plans (PPR), the Bachelor Law (2003) and European Directives (2000). Plans have been drawn up for risk, crisis and post-crisis management.

The multiplicity of management programs helps to explain a reduction in people's vulnerability to natural hazards on the island. The literature offers a broad panorama concerning the impacts that have taken place on the island in recent decades (Stanziani, 2018; Duvat et al. 2016) but little about past events.

3 Methodologies

The search for known and documented natural events over time, both in specialist and scientific literature and in non-expert sources, is carried out firstly through a review of recent technical literature (1990–2020). This is followed by a bibliography of articles on natural hazards in La Réunion, with a particular focus on chronologies. To complete this work, databases compiled by various stakeholders were consulted: BRGM, Cellule de Veille Hydrologique (CVH), Office National des Forêts (ONF), OVPF, Direction de l'Environnement, de l'Aménagement et du Logement (DEAL), Caisse Centrale des Réassureurs (CCR), Observatoire du Littoral.

3.1 Reliability of the sources

Assessing the reliability of sources is essential, as it directly determines the robustness of the analysis and the validity of conclusions. Following, the methodology developed by Athimon (Athimon et al., 2022a; 2022b), the reliability of historical sources used in this study is assessed through two step analysis : (i) verifying the authenticity of an original document, ensuring that the document is genuine and not falsified or counterfeited. (ii) contextualisation of the archives in order to evaluate the reliability of the data contained within a document.

To this end, 29 parameters were entered into a descriptive record concerning the document, the author and the event cited. For each event identified, source lineage was established (Fig. 2), ensuring that the links between the various references can be traced. The source lineage consists in identifying the links between each source (who quotes whom). Reference bibliographies (literature), secondary sources and primary sources dealing with the same event are recorded.

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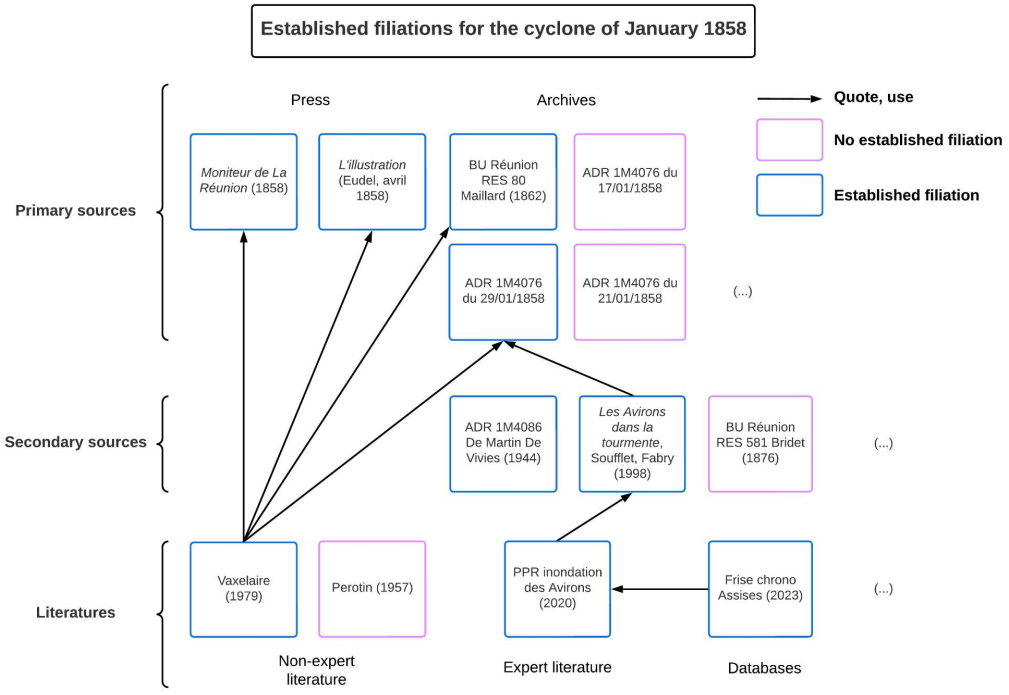

Figure 2: Table of historical sources (Inspired from Fradet, 2016; Athimon et al., 2022b): example for the 1858 cyclone.

Based on the notice and the source lineage established, source evaluation criteria then enables a reliability rating to the primary and secondary sources. To reduce subjectivity of this evaluation, a decision tree was established with closed-ended questions (Athimon et al., 2022b). This method is based on four evaluation criteria: the type of document, the link to the testimony, the overlaps and the coherence of the content of the source evaluated. The different elements of the decision tree are weighted. These weightings were based on the scores awarded for each criterion, using a multiplying coefficient to express a final score as a percentage of reliability. Only sources with a reliability score of at least 60% are considered sufficiently reliable.

3.2 The sources used

The old colonial archives of La Réunion are scattered across several places (Table 1): the departmental archives of La Réunion (ADR), the national archives of Overseas Territories (ANOM) as well as the archives of the National Library of France (BNF). Most of the documents consulted are from the ADR (73.8%).

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Archives consulted	Types of documents	Periods
ADR	various archive materials (letters, police reports, ordinances, inventories, newspapers, press articles)	ancient (1667–1790), modern (1790–1947) and contemporary (since 1947)
ANOM	archives of the secretariats of state and ministries responsible for the French colonies Private and corporate archives relating to overseas France Library, map library and icon library	the 17th to the 20th century
BNF	Professions of state engineers, in series F14 devoted to Public Works, for the history of the Ponts et Chaussées, with no specific background on the colonies	The 19th to the 21th century

Table 1: List of archives consulted.

Other places where archives have been studied include Archives Richelieu in Paris, the Bibliothèque Départementale de La Réunion, the BRGM archives, The Bibliothèque de la Résidence (for the Bourbon chronicles), the Fonds Océan Indien and the reserve of the Bibliothèque Universitaire de La Réunion, with, for example, Lescouble's diary (1812–1830) or the Bourbon chronologies (Maestri and Nomdedeu-Maestri, 2001; Nomdedeu and Maestri, 2001).

3.3 Creation of a geodatabase: HistoRiskRun

The events referred to in the archives consulted, are compiled in the geospatial database HistoRiskRun (Dupont et al., under embargo). The aim of this database is to focus more on risk than on hazards and to identify the impacts of events recorded in La Réunion since the 17th century. This scientific approach is in line with contemporary studies on the socio-economic impacts of past events (Athimon, 2019; Boisson et al., 2022; Dallons-Thanneur, 2025).

The sources consulted during this work are compiled into a general table, representing a total of 3,519 recorded events. Using this table, and through an automated process based on keyword searches and a systematic manual verification, the natural phenomena listed are categorised into seven specific tables, each corresponding to one of the natural hazards affecting La Réunion.

To capture cascading effects associated with a given phenomena, links between tables are established through shared attributes. In this way, some of the meteorological events, such as cyclones can thus act as catalysts for other events, such as floods, landslides or swells.

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In addition to natural hazards specific tables, a table of references and one about the sources consulted are created. A table linking the event to the source is created, in which the event description is specified. In this way, it is possible to run queries to extract the original information relating to a source or a specific event. The collected information is compiled in PostGIS format.

Recorded events are mapped spatially based on the polygonal boundaries of the affected municipalities. The polygon used is the actual municipal polygon (BDTOPO). Each event is associated by default with the municipal polygon; however, where more precise location details are available, three other types of coordinates may be used. The first is based on the neighbourhood, in which case the data used is the Iris polygon (statistical spatial unit in France) provided by INSEE. The second is at the watercourse level; where data permitted, a buffer zone around the watercourses was selected based on the hydrographic divisions from the BD Carthage database index. These buffers were established according to the average width of the watercourses across different classes, based on manual measurements taken upstream, midstream and downstream of the watercourses.

Finally, when available, using the specific geographical coordinates of a given address, the event is also represented by a point. The locations of the addresses are determined using Géoportail's geocoding service from a requested python code via the API: https://api-adresse.data.gouv.fr/search/.

3.3 Significance index

Relevant indicators have been proposed in various studies (Desarthe and Moncoulon, 2017; Boudou, 2015; Boudou et al., 2015; Garnier, 2010; Coeur, 2008). Boudou et al., (2015) have built for floods the most applicable methodology to our issue, by adapting it to other risks and focused solely on La Réunion for a period from 1655 to 2025. In this study, we analyze the impacts of natural events from the perspective of significance. Applied to a natural event, this term refers to an event that is remarkable. This is an event of particular interest to society, remembered for the distinctive features that set it apart from other events. According to Boudou (2015), a remarkable event has exceptional characteristics (hazards, damages and repercussions), has an impact on management and serves as a witness. The stakes of the remarkable term are both the socio-political and cultural construction of the event (Allard, 2001), its representation (Baggio and Rouquette, 2006), its characteristics and its consequences, as well as its memory (November et al., 2011). This methodology follows a general evaluation grid (Fig. 3), that enables to prioritize the significant events that have taken place in La Réunion. If information is missing, the minimum score is assigned by default.

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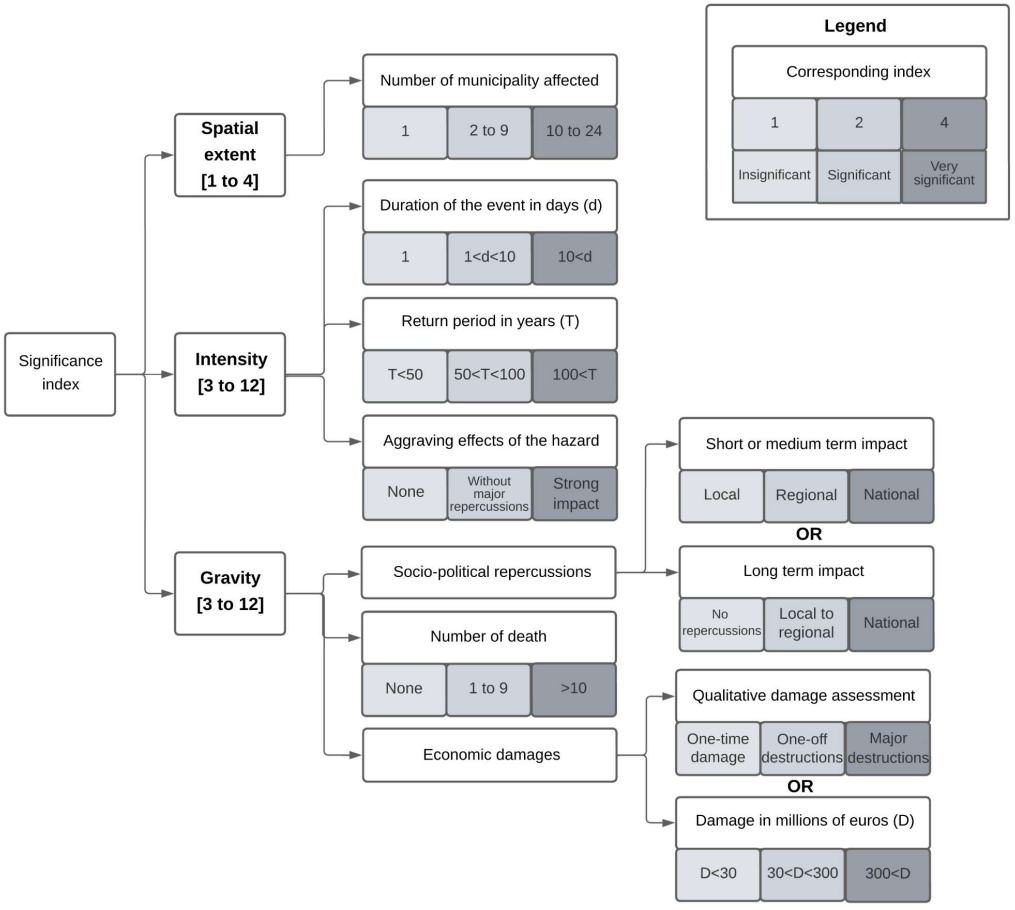

Figure 3: Significance index (adapted from Boudou et al., 2015) from 7 to 28. An event with an index of 7 is considered to have low significance, whereas an index of 28 indicates high significance.

200 **4 Results**

4.1 Sources consulted and their reliability

In total, 2,823 sources were consulted, mentioning natural events 4,889 times. A single source may refer to several distinct events on different dates, and may not have the same reliability rating. Overall all references listed in the database

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HistoRiskRun, 60.2% of the mentions have a reliability score greater than 80%; 28.7% scored between 60% and 80% and 11.1% scored below 60%.

The references are composed of 43.6% archives (letters: 81.8% and telegrams: 6.5%), 50.2% press, 5.1% technical and scientific literature (technical reports: 74.1% and scientific literature: 25.9%) and 1.1% databases (Fig. 4).

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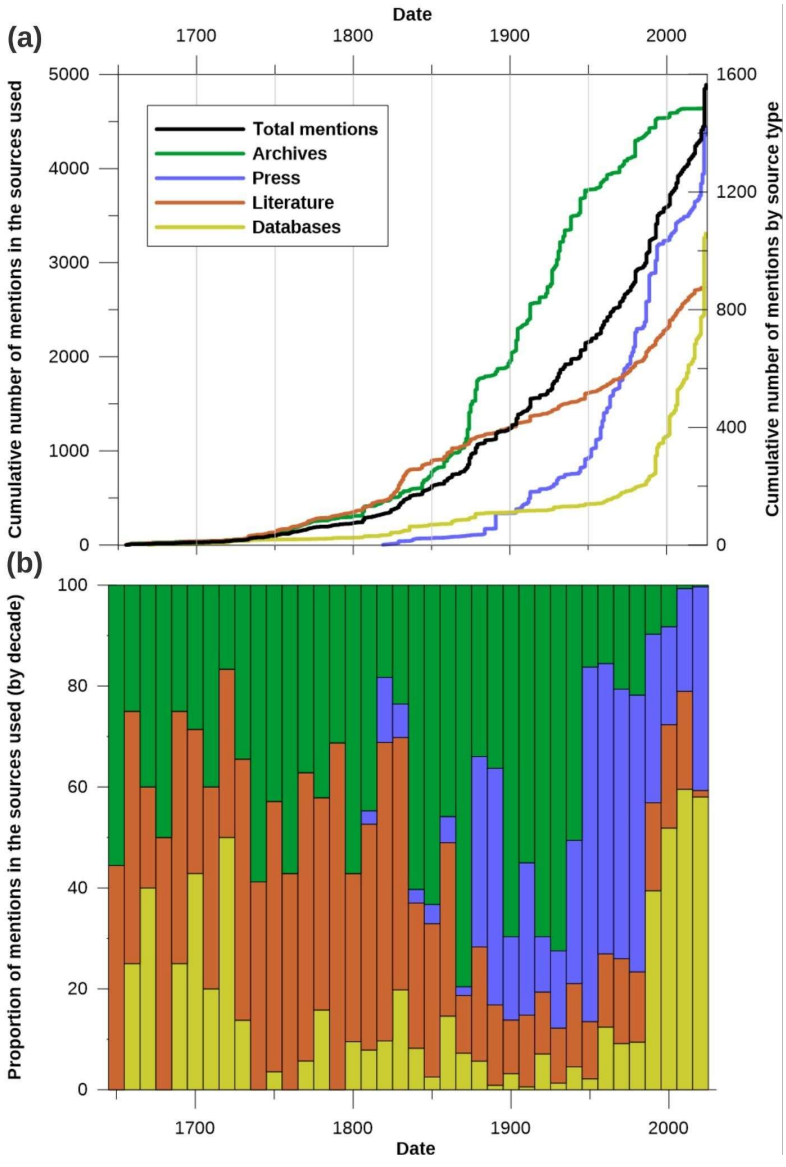

Figure 4: Cumulative number (a) and proportion (b) of mentions by types of sources consulted in the archives between 1650 and 2025 and stored in the HistoRiskRun database.

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Since 1655, there has been a marked increase in the number of mentions from sources consulted, with an initial rise after 1750, a second, slightly more pronounced rise around 1850, followed by further increases around 1950 and, finally since 2010 (Fig. 4a).

Years with the highest number of sources corresponds to cyclone Hyacinthe in 1980 (110 mentions), cyclone Firinga in 1989 (110 mentions), cyclone Hollanda in 1994 (88 mentions), cyclone Dina in 2002 (82 mentions), and cyclone Belal in 2024 (158 mentions). The sources of information on a natural event are therefore more numerous in years when events with various consequences for the island have taken place, particularly in recent periods.

Before 1800, the archives consulted consisted of letters, telegrams and a few ad hoc databases. In 1800, the first press documents were consulted, but remained marginal compared to the other sources consulted. Mentions of natural hazards in the press increased after 1880, and then followed a new impulse after 1950 whilst proportions of mentions derived from technical reports or scientific decline until 2020, when they become almost marginal (Fig. 4b).

The proportion of mentions from sources by decade shows that from 1960, mentions from press continue to increase while mentions from letters or telegrams starts to decrease. Archives decreased after the 1960s, to the benefit of the press and the databases. This trend continued to the benefit of databases in the 1980s up to the 2020s where press and databases constitute most of the sources consulted. The role of the press in the number of archives increased after 1880, notably with the important arrival of the treatment of natural events and their impacts, and then followed a new impulse after 1950.

4.2 Events and their significance index between 1655 and 2025

A total of 1,266 events are extracted from the archive work. Most of the events recorded are floods. A total of 414 cyclones and storms with impacts on La Réunion were recorded, along with 1,612 floods, 86 swells, 4 tsunamis, 1,024 land movements, 159 forest fires, 241 volcanic eruptions, 4 earthquakes, 23 droughts and 1 freeze (Fig. 5). In this context, hydrometeorological events include both damage and fatalities caused by wind and lightning, which are examined separately below. In addition to major natural hazards, other types of events have also been identified (drought and frost).

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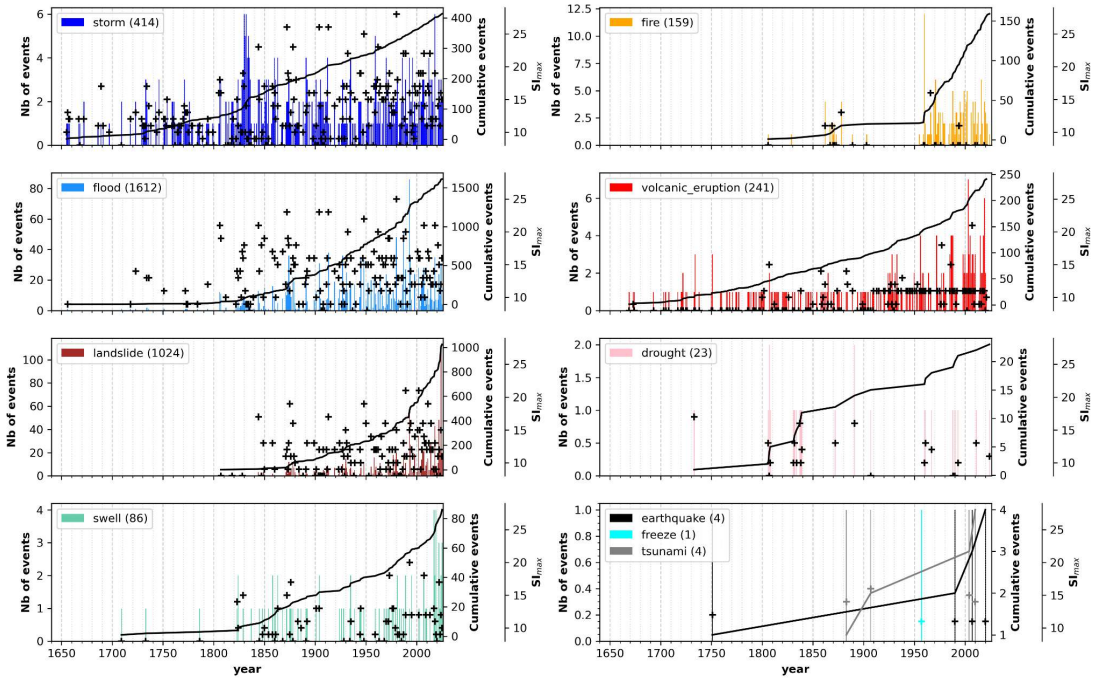

Figure 5: Number of events by year and maximum Significance Index (SImax) by type. Bars indicate the annual number of events, the line represents the cumulative number of events, and across denote the maximum SImax value recorded for each year. The total number of events referenced in HistoRiskRun is shown in brackets.

Of the events recorded, the exact date on which the event occurred could be determined in 91.6% of cases; for 4.9% of events, the month was known, and for 3.5%, the year was known. The recorded meteorological events occur predominantly between December and April, with a higher proportion in January and February, a period corresponding to the tropical cyclone season. Events of hydro-meteorological origin, such as floods, landslides and storm surges, show a similar temporal distribution. With regard to forest fires, they occur mainly during the defined regulatory period, namely from 15 August to 15 January. Southerly swells occur mainly between May and September. Finally, the other types of events studied do not show any significant seasonality.

The results allow for a comparison of scores across the entire period studied and between different types of risk (Fig. 5). The events recorded in La Réunion that received the highest significance scores occurred during cyclones. The five most significant events, with index of 25, 26 and 28, occurred in 1872, 1904, 1913, 1948 and 1980. The first date corresponds to the cyclone of February 1872, which claimed 25 lives. The cyclones of 1904 and 1913 are known to have caused significant material damage on the island, killing 24 and 15 people respectively. The cyclone of 1948 is also known as “the cyclone of the century”. Finally, the year 1980, as already mentioned, is linked to Cyclone Hyacinthe which also caused 25 deaths.

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The results show that few notable events were observed prior to 1800, with low to moderate indices (between 7 and 15). In the 19th century, a gradual increase in significance (indices exceeding 25) is observed, indicating both that more events are being recorded and that the variability of impacts is increasing. This can be explained by a source effect and an increase in the population living in areas exposed to these hazards. For example, the number of events recorded between 1812 and 1830 is higher because Lescouble's journal provides very detailed information on events that took place during this period. From the 20th century onwards, the number of recorded events has increased, with higher severity indices. Particularly significant events are more frequent, whilst those with moderate indices (between 7 and 15) remain stable. Since the 21st century, there has been a sharp increase in the number of recorded events (particularly storms, landslides and swells), and a decrease in the severity index of the most violent cyclonic events. An interesting question is whether this decline in the average severity index results from a decrease in the intensity of natural phenomena, as many islanders claim, or from the impact of these phenomena on the population.

4.3 Analysis of impacts link to natural hazard

Within the database, events have been geospatially mapped across various tables (Fig. 6). For the seven major natural hazards, as well as frost and drought, the municipality affected by the events is unknown in 0.9% of cases, and is identified for 99.1% of events. The location could be pinpointed to the local area level (neighbourhood, address, etc.) in 32% of cases. For the period 1950–2025, this rises to 99.5% of events with a known municipality of impact and 53% with the local area identified. The municipalities of Saint-Denis and Saint-Paul are the most affected by these events.

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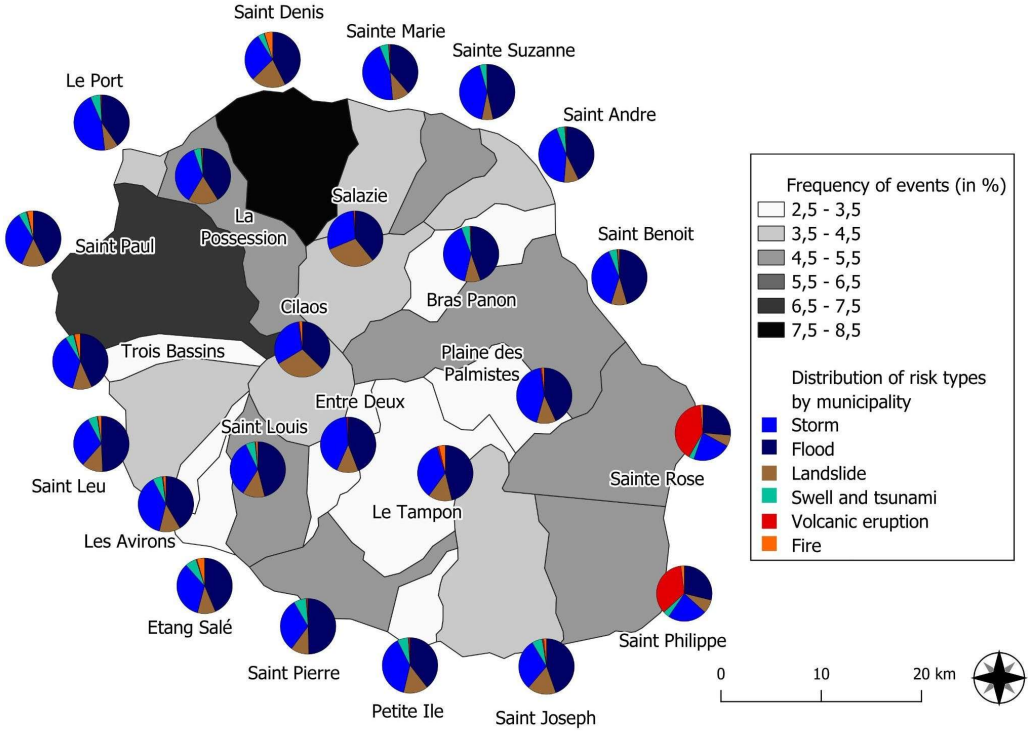

Figure 6: Occurrence of events and types of risk by municipality over the period studied.

Storms, flooding and landslides are the main types of phenomena that have had an impact on all the municipalities. High seas are, of course, observed only in coastal municipalities, and volcanic eruptions are much more common in Sainte-Rose and Saint-Philippe, where the Piton de la Fournaise volcano is located, due to an initial disparity in environmental exposure. The impact may be felt in other towns on the island, for example due to the hair from Pelés.

Impacts have been divided into different categories: personal injury, natural environment, agriculture, buildings and structures, tourist development and heritage, networks, sanitary, social, economic, institutional. The proportion of road network-related impacts among the recorded impact categories has been rising since the 19th century and became one of the dominant categories in the 20th century, accounting for over 50% of impact mentioned. These are the most frequently mentioned impacts because the island's topography and its reliance on roads can lead to a cascade of consequences. The steep ravines and the island's terrain mean that access to the coast is essential for many journeys. If roads are blocked, access to key locations such as hospitals may be severely compromised.

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The impacts on people (deaths and injuries) fluctuate over the entire period (1800–2025), but remain a stable and secondary component in terms of their proportion within the impact categories. The proportion of damage to natural environments increases slightly over the period, whilst the proportions associated with agriculture and buildings gradually decline in significance. Other types of damage remain generally marginal or fluctuating.

4.4 Analysis of impacts link to natural hazard

The historical data collected has enabled to analyze the evolution of mortality link to natural hazards on La Réunion island since 1655, by studying the date, the place of residence, the number of deaths referenced, the hazards involved, the gender and age of the people concerned, as well as the exact causes of death, where available. A total of 1,990 deaths linked to natural events between 1689 and 2025 were recorded, of which 1,493 could be located, i.e. 75% of the total (Fig.7a). The accuracy of these locations is established by points located at sea (in 8.3% of cases), at commune level (66.5%), at district level (21.4%) or at exact address (3.8%). Over the entire period, an average of 5.9 deaths per year were recorded. More specifically, 6.5 deaths per year were recorded between 1689 and 1950, compared with 3.8 between 1950 and 2025.

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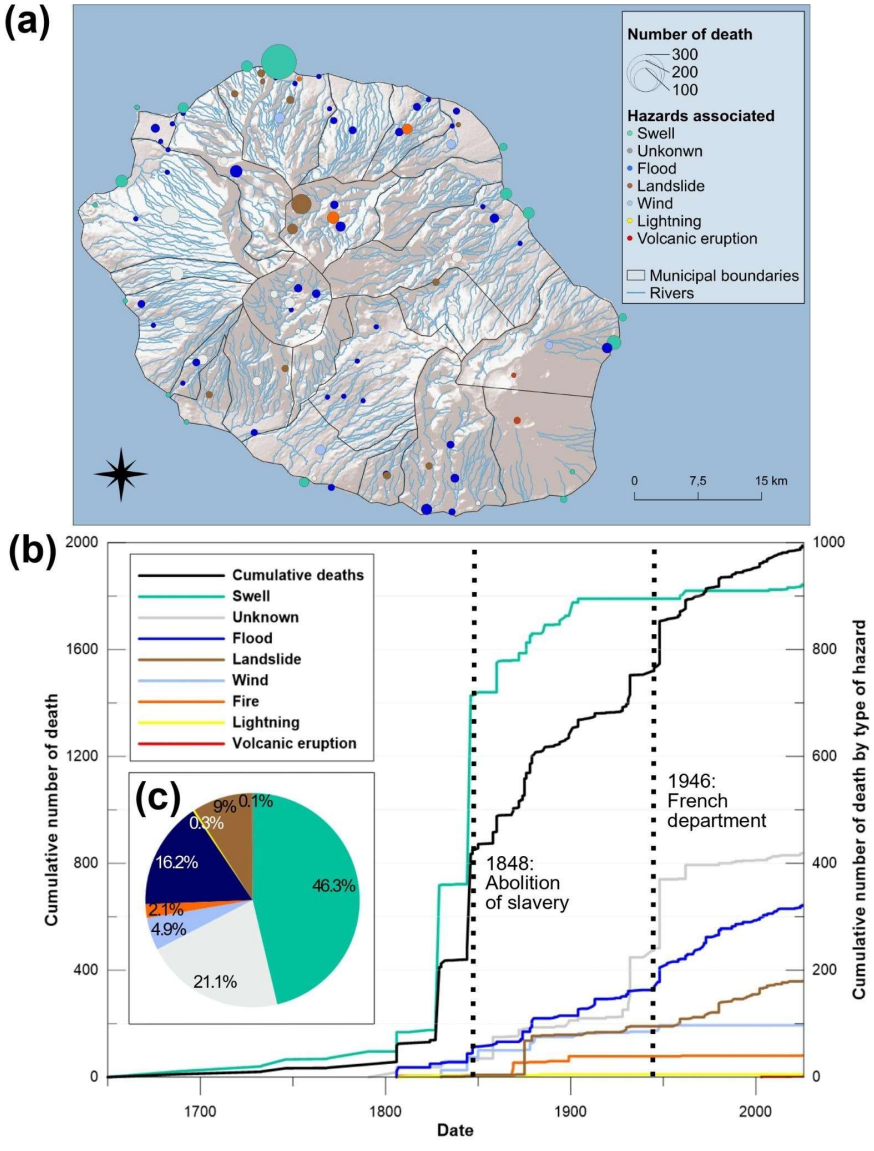

Figure 7: Map of events that caused the most deaths (a), cumulative number of deaths per year (b) and proportion of deaths (c) by hazard type between 1655 and 2025.

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Before 1800, only a few deaths were recorded (48), due to the small population size (around 60,000 inhabitants) and the limited availability of data (Fig. 7b). The number of deaths increased between 1800 and 1848. During this period, when slavery was practised in La Réunion, most deaths related to rough seas were due to shipwrecks. After 1948, the number of deaths remained relatively stable, but the number of deaths from unknown causes increased considerably. The number of deaths began to decline from 1946 onwards. Only deaths linked to floods and landslides remained stable, at 1.5 and 0.9 deaths per year respectively over the entire period.

Between 1820 and 1950, several events led to high mortality rates, such as the cyclones of 1829 and 1846, which caused 260 and 350 deaths respectively, mainly due to shipwrecks resulting from swells. This high mortality rate can be explained by the higher level of maritime trade prior to the abolition of slavery in 1848, as well as the lower reliability of cyclone forecasts. The first official public warning system dates from 1959 (Jouanjean, 2011).

Swells are the main cause of death recorded (46.3% or cases since 1655, but 100 % of cases before 1800) (Fig. 7c). Next came deaths of unknown cause (21.1%), followed by flood-related deaths (16.2%), then there were deaths due to landslides (9%), and wind-related deaths (4.9%) and deaths due to other hazards (2.5% for fires, volcanic eruptions and lighting). During the colonial period (1655–1848), out of 850 deaths recorded, 117 were slaves and 672 sailors.

Over this period, 60% of deaths involve men, against 6% women, and 34% are unknown (Fig. 8a). However, this high proportion of men in deaths persists over time: between 1950–2025, the share of men in recorded deaths remains twice as high as that of women.

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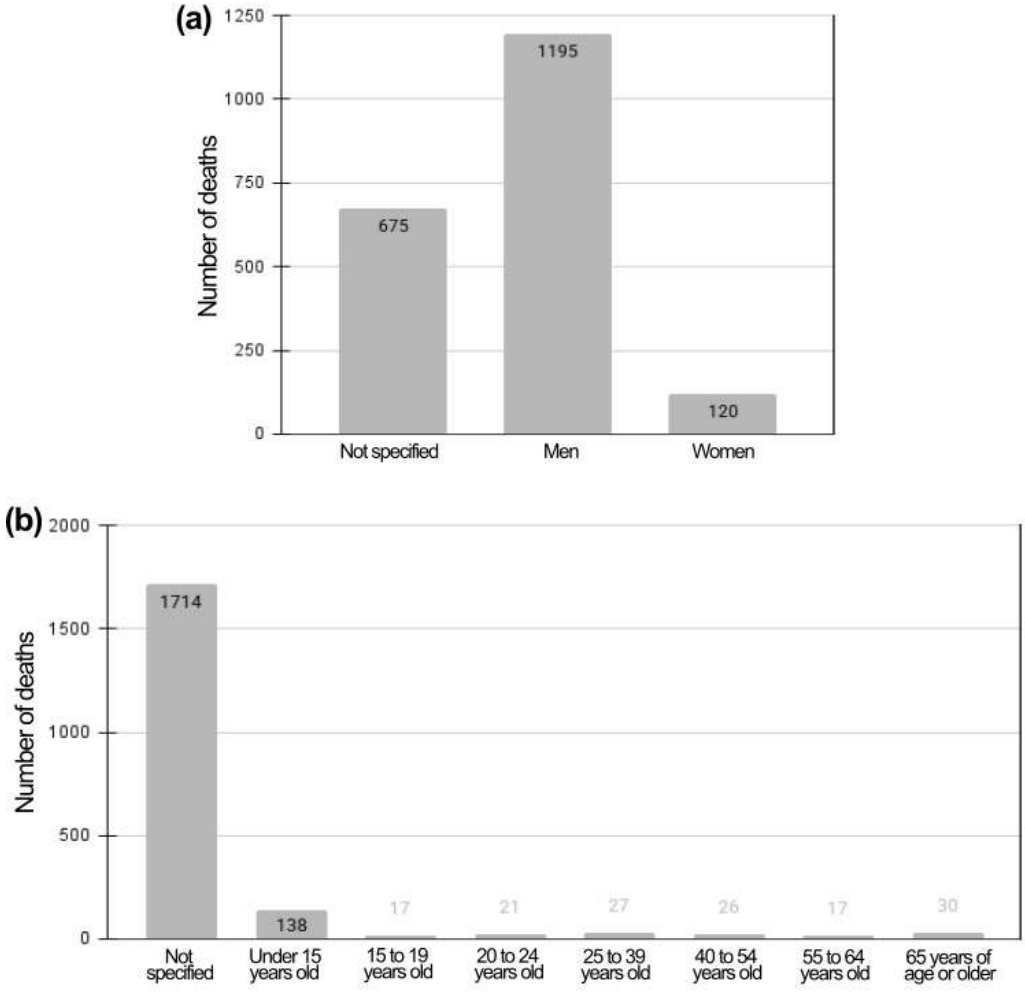

Figure 8: Breakdown of recorded deaths by gender (a) and age (b).

The age of the deceased has been identified in 13.9% of cases since 1655, and in 43% of cases since 1950 (Fig. 8b). The lack of detailed data means that no real trends can be identified in this respect, but it is interesting to note that the age category most cited is always that of under 15 years of age (50 %). This could be explained by a greater propensity to take risks

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among younger generations, particularly due to their lack of experience; but also to society's lower tolerance of mortality among the youngest age group, which results in a higher citation rate for this age group.

Since 1950, more than a quarter of all drownings (41 out of 151) have involved crossing a submerged riffle. On La Reunion, many deaths occur in this circumstance after an intense rainfall event. This was the case for the heavy rains at the end of January 2024, which claimed four lives a few days after the passage of cyclone Belal.

5 Discussion

5.1 Source reliability and completeness

The bias linked to the number of sources available in the research conducted must be taken into account (Furet, 1983; Nora, 1997). Between 1655 and 1700, there are 28 references from the sources used for 12 events listed in the database. For the year 2023 alone, there are 37 mentions for 18 recorded events. This is explained in particular by the intensification of damage assessments — linked to an increase in stakes and impacts — and feedback from the mid-20th century onwards, as well as by the growing media coverage of events (increase in mentions in the press). The greater availability of sources for recent periods means that the number of data points and impacts identified today is higher than for earlier periods, particularly as many documents have been lost. The trend curve for the various sources (Fig. 4a) follows an upward trend similar to that of data from other studies (Boisson et al., 2022; Dallons-Thanneur, 2025).

The aim of this work, which was to improve the reliability of available sources and data concerning natural hazards in La Réunion, has been achieved. Events can be added as they occur. The data from the HistoRiskRun database complements existing work, such as the chronology of 76 tropical cyclones in La Réunion (Desarthe and Moncoulon, 2017); or the classification of damage resulting from five major cyclones that occurred between 1931 and 2002 in La Réunion, compiled by the Caisse Centrale de Réassurance (CCR), which provides insight into the distribution of damage types associated with these events (Desarthe et al., 2018). The database is not, however, exhaustive and can be further expanded.

Indeed, the archival work has certain gaps. Firstly, regarding press reviews which, as mentioned earlier, have not been subject to a comprehensive survey since the mid-20th century. Secondly, the parish and municipal archives have not been examined due to a lack of time. As the work covering the island's 24 municipalities is very substantial, it offers a complementary avenue of research to the database produced during this thesis. Furthermore, the written and iconographic sources of the Bishopric, and more generally those originating from ecclesiastical authorities, have not been unearthed, nor have the sources and testimonies available on social media. Research work involving an exhaustive inventory of these elements would enable the database to be completed and the findings to be cross-referenced with the sources already used.

For example, a follow-up study on deaths linked to hydrometeorological risks over the period from 1950 to 2025 is currently underway and brought to light new details (circumstances of death, exact locations, etc.). Furthermore, a postcard held at the ADR (Illustration C. Laffont, created by Eric Venner in 1990) indicates that 57 ships are believed to have sunk around the

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island of La Réunion between 1800 and 1900. In total, 51 shipwrecks are listed in this database, 35 of which occurred between 1800 and 1900. One might therefore wonder whether the number of shipwrecks is underestimated in the database.

In the HistoRiskRun database, some of the sources used for cyclones are secondary sources. For example, in 1876 Lavalley produced a chronology of cyclones between 1657 and 1874 (Lavalley, 1876). Paul de Martin de Viviès, an engineer and head of the Meteorological Service, also compiled a list in 1944. These details were taken up by Yves Pérotin in 1957, but the sources used are not cited therein. A report by the Ministry of Transport also records cyclones occurring between 1657 and 1967. Finally, Jouanjean (2011) compiled a list of cyclones between 1901 and 2007. These various authors are the main sources for cyclones and their consequences during the 17th century and the early 18th century. Indeed, the primary sources used by the authors have not always been identified. There are therefore uncertainties and omissions regarding this early period of La Réunion's history.

Some documents could not be consulted or used for several reasons. Archives storage locations have changed several times since 1736. In the 1810s, many archives were lost due to their poor condition. In 1905, the post of archivist was abolished and the archives were left in a state of total neglect. The last example is that of the destruction of documents by humidity, heat, darkness and termites, notably following the cyclones of 1944 and 1945, which flooded the ground on which the documents were stored.

A number of disruptions also curtailed the archive research work initially planned. These included the closure of the ADR building (reading room) due to cyclone Belal in January 2024, in addition to the building work periods. Regarding the recovery of existing databases, some sources of information could not be accessed due to the General Data Protection Regulation (RGPD). For example, insurers have data on the location of damage (to insured persons) during cyclones, but confidentiality prohibits the use of this data. The database HistoRiskRun should therefore not be considered exhaustive, but rather as close to it as possible.

5.2 Significance index and contextualization

The results (Fig. 9) confirm the observations of Velásquez-Espinoza and Alcántara-Ayala (2024), who indicate that the frequency and severity of cyclones observed around the world have not undergone any notable increase, but that the damage caused is rising sharply, particularly the economic costs. Rapid growth, particularly urbanization, is often blamed in the USA (Weinkle et al., 2012; Lau et al., 2022).

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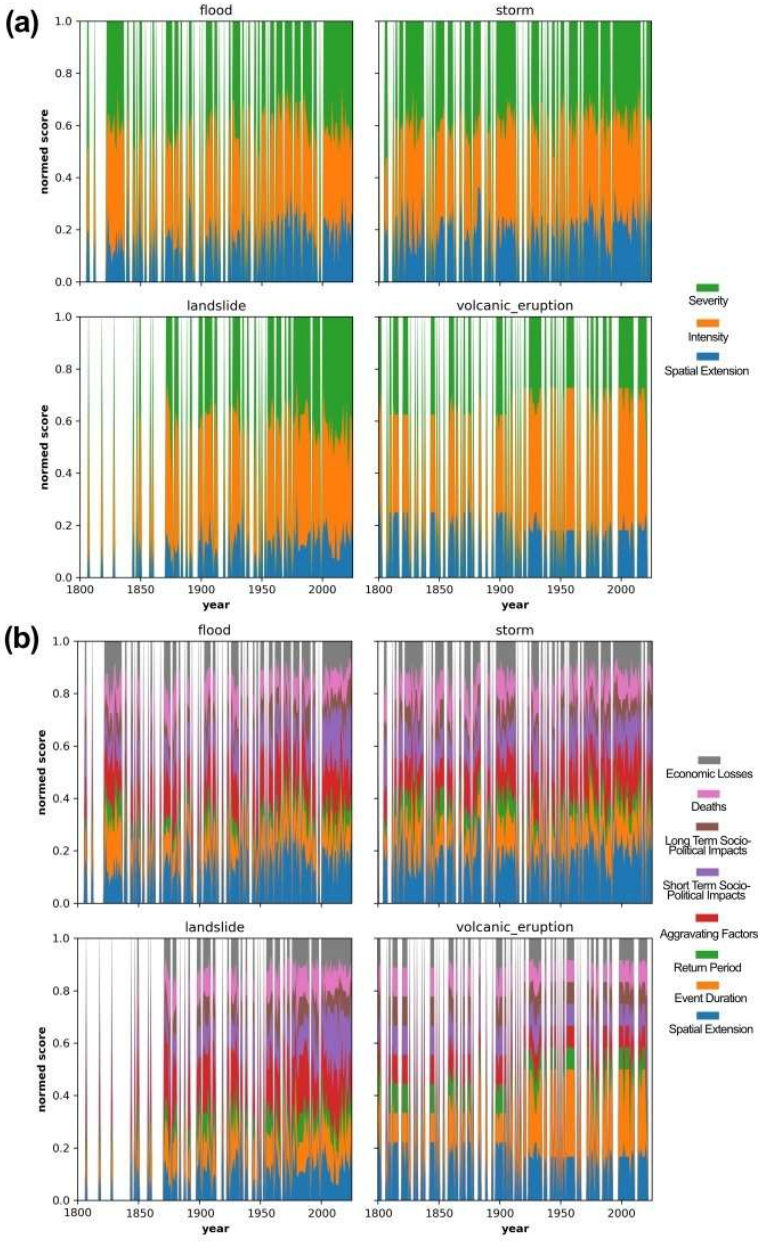

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Figure 9: Normed decomposition of significance indices over time based on severity, intensity and spatial extension (a) and in detail (b). For each table and for each year, the maximum value for each criterion was recorded. Normalisation was carried out by calculating the sum of these values and then dividing each criterion by the maximum value of that sum. This makes it possible to compare how the maximum values for each criterion have changed over the years, as well as their relative proportions.

To understand the trend in the significance index, one must take into account the local context, particularly urbanisation, socio-historical, economic and bioclimatic contexts must be taken into account. The 1870s were marked in particular by several cyclones that caused considerable damage. In February 1872 and March 1874, two devastating cyclones struck the island. They had a considerable impact on the colony's economy, particularly on agriculture. In November 1875, a landslide at Grand Sable, in the Salazie cirque, killed 63 people in just 15 minutes (Vaxelaire et al., 1979). At that time, most buildings were constructed of straw. The significance of events is therefore high between 1800 and 1950 (Fig. 5).

The proportion of the population living in urban areas rose from 20% in 1946 to 86% in 1999, but over the same period, the proportion of permanent housing rose from 8% to 98% (Sandron, 2007). This helps to explain the increase in significance observed around 1980 and 1990 (Fig. 5).

The average significance of all phenomena, with the exception of swell and volcanic eruptions, has fallen since 2000's. As far as volcanic eruptions are concerned, the spectacular collapse of the Dolomieu crater on Piton de la Fournaise in 2007 is one of the main reasons. Furthermore, one person lost their life during the 2003 eruption and two others in 2021.

La Réunion's status between 1642 and 1997, first as a French colony, then as a French department, a French Région and finally as an outermost region of the European Union, has given it a degree of economic stability and a strong commitment to natural risk management. Since the 1950s, a policy of habitat improvement and protection through diking has led to a change in infrastructure that has had a major impact on cyclone-related impacts. There has been a transition from straw dwellings to wooden construction under corrugated iron, and then to more solid "hard" structures. The number of wind-related deaths has fallen significantly since the last such deaths, which occurred in 1948. This drop in mortality has occurred at the same time as a reduction in wind-related destruction of homes, due to changes in building capacities and standards, as well as containment rules. Since the 21th century, buildings have been built in solid construction and are much more resistant to cyclone winds.

From the 1980s, a policy of protection through prevention was implemented at national and local level. From the 2000s onwards, a policy of protection through mitigation is desired (decentralization of GEMAPI powers, nature-based solutions, etc.). All these trajectories enable us to understand how risk management policies have contributed to reducing the significance of natural hazards in La Réunion since 1655.

Furthermore, the implementation of these policies allows for better risk assessment. For example, in the case of a rock falling onto a road, the clearance work would previously have been carried out by local residents. Today, the mobilisation of technical services means that this type of event is more noticeable.

The geographical distribution of the population in relation to the terrain is also a factor to be taken into account. Gay (2008) notes that on La Réunion, residential areas are distributed across low-lying areas, slopes and highlands. For example, low-

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altitude areas are more exposed to coastal hazards and flooding, whilst high-altitude areas are more prone to strong winds and landslides, which is reflected in the results (Fig. 6).

Mortality linked to natural hazards also reveals the importance of social trajectories. For example, the higher mortality rate among men than women may be linked to distinct gender roles (the social construction of virility) and resulting in different vulnerabilities and exposures (Wilkinson, 2015). These mortality reveals historical, structural and residual inequalities. Slaves, as objectified people, appear in the lists of material goods destroyed during a cyclone, and their numbers are, in this context, well documented. Moreover, they are the ones who take the greatest risks on land, as shown by several references to slaves crossing swollen rivers to carry out tasks requested by their masters, and they are the most vulnerable populations, due to less secure housing conditions.

6 Conclusion

This research into the impact of natural hazards on La Réunion since 1655 was carried out using existing archives, press reviews, literature and databases. This research has validated 2,823 references in terms of reliability, which are stored in a new database: HistoRiskRun. From this work, 1,266 events are indexed, which include cyclones, floods, landslides, earthquakes, swells and tsunamis, forest fires and volcanic eruptions.

According to the significance index, cyclones are the dominant hazard affecting La Réunion, followed by floods and landslides. Since the beginning of colonization, cyclones have played a central role in shaping the island's history, triggering cascading impacts such as flooding, landslides, widespread agricultural losses, and periods of insalubrity and uninhabitability.

The number of deaths linked to natural events has fallen drastically since the 1950s. Since the 2000s, the impact of natural phenomena on the population appears to have diminished. La Réunion's status has evolved, first as a French colony (1642), then as a French department (1946), a French region (1982) and finally as an outermost region of the European Union (1997). These results allow us to draw a parallel between the impacts observed and factors relating to the local context, such as the increase in urbanization, the number of inhabitants or road networks. On the other hand, changes in the type of buildings constructed or progress in national and local risk management help to reduce the impact. These factors need to be taken into account in a context of global change and uncertain climate projections. This work provides insights into how to improve hazard assessment and management using historical data. The HistoRiskRun database is very rich, but not totally exhaustive. To complete it, research needs to be carried out, for example in municipal archives. The aim is also to enable events to be updated by different contributors as and when required, thanks to the open source functionality.

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Code and data availability

The data on which this study is based are currently under embargo. Once the article has been published, they will be freely available at the following address: Dupont, M., Rault, C., Villeneuve, N. and Chaput, M.: HistoRiskRun: a geohistorical database on natural disasters and their impacts in Réunion.

Author contributions

MD designed the research, conducted the archival searches and produced the statistics. CR designed the software development. MD and CR produced the illustrations. All co-authors wrote and edited the manuscript.

Competing interests

The contact author has declared that none of the authors has any competing interests.

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