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Natural Hazards and Climate Change Impacts on Food Security and Rural–Urban Livelihoods in Mozambique—A Bibliometric Analysis and Framework

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Abstract: Mozambique is confronted with numerous risks related to food security and natural disasters. The study conducted a literature review on natural hazards and food security. This can help to identify gaps and further areas of research. A bibliometric analysis was conducted using standardized text search terms, and the VOSviewer tool was used to analyze over 7000 scientific articles and cluster over 60,000 keyword co-occurrences. The results show that research on natural hazards for food security needs to be integrated. The priority topic of disasters focuses on specific hazards such as climate change, floods, and hurricanes, which are also linked to demographic and other social variables. More studies on food security, such as droughts, sustainable development, and other human and social conditions, are being conducted. Resilience as an emerging research paradigm needs to be addressed in comparison. One result is an analytical framework on impacts on food security in the context of disaster risk, based on the empirical findings of the literature review. It shows how everyday risks such as disease or food security can be conceptually better linked to natural hazards and resilience. It shows that further research is needed on the interlinkages of multiple risks, of which Mozambique is an outstanding example. The methodology presented is also applied to provide a framework for linking multiple risks to food security and natural hazards. The innovative dimension of the research is that this inquiry constitutes one of the pioneering attempts to conduct a bibliometric analysis of the linkages between natural hazards, food security, and resilience in Mozambique. Another noteworthy contribution is introducing a novel analytical framework that integrates food security and disaster risks.

Keywords: resilience; sustainable development; sustainable livelihoods; literature analysis; bibliometric analysis

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1. Introduction

Mozambique is one of the countries most affected by hunger and natural hazards [1]. It is also affected by civil conflict and war, epidemics, and diseases such as malaria or HIV [2]. Rural livelihoods predominate the area, and due to climatic conditions, droughts, and other processes, malnutrition and food insecurity are prevailing [3,4]. Despite tremendous efforts by international organizations to provide food and development aid, the conditions have improved, but malnutrition and high death rates due to diseases or natural hazards prevail [5]. It is, therefore, still important to conduct scientific research into the reasons and drivers of risk in Mozambique. Hence, a literature analysis of major risks and disasters related to rural livelihoods and food security has been conducted. The literature analysis assesses which studies and topics have predominated research so far. Based on these results, future directions and needs for further research are derived from the results of this article. To understand what is necessary to research, the body of literature is analyzed regarding which already substantial work exists to permit literature analysis. On the other hand, such results can indicate gaps in the current research.

Currently, there is an increasing international trend in analyzing how risks are interconnected and how compounding events and creeping processes create interdependencies and dynamics that provide future challenges [6–8]. The debate about future development pathways is especially strong within the scientific fields of climate change research and sustainable development [9]. Mozambique experienced high death tolls due to natural hazards, and rural livelihoods are closely dependent on climate [10,11]. Therefore, sustainable development and rural livelihoods have become major research interests [12]. Recent research analyzes the interrelations between climate change and armed conflicts and how far international law already covers both [13]. This is not only overlapping the drivers of risk, but also the compounding drivers of the impact that are increasingly being analyzed. For instance, increasing urbanization drives marginalization and segregation, contributing to higher climate change risks [14]. Urban and rural areas, on the other hand, are analyzed in terms of farmers' perceptions of climate change and their information-sharing networks using mobile phones [15]. Contributions of climate change to natural hazards' compounding events, such as rainfall and tidal waves, are analyzed for coastal cities such as Maputo [16]. Research on climate change in Mozambique covers sustainable livelihoods, especially vulnerable populations, agriculture, droughts, storms, and floods [17]. Daily practices in dealing with hazards, such as floods and participatory processes at the local level to engage with climate change actions and participatory urban planning, are adaptation actions and 'everyday realities' that are analyzed in various studies [18–20]. Agricultural investments and road infrastructure are drivers of adaptation and development under the uncertainty of climate change scenarios, as is the case for neighboring countries [21,22].

Concerning natural hazards, the socio-economic development of least developed countries is of special interest to studies using climate change development scenarios [23]. Related research covered the loss and damage debate influencing political discourse on climate risk and compensation financing [24]. Similar research covers Disaster Risk Reduction policies in Mozambique, exposing financial and coordination gaps [25]. There is relatively little research about natural hazards in Mozambique comparing natural hazard types. Most research focuses on specific natural hazard types, such as flood risks and related management, governance, or analytical aspects [26]. Major cyclones and their impacts are covered in scientific studies and media based on huge damages and losses [27]. Supporting humanitarian preparedness and response through early warning systems is related to cyclone research [28]. Droughts are covered in rainfall patterns, agriculture, and related famine and child mortality risks [29,30]. Recent studies cover analytical methods such as deep learning or machine learning for flood hazard mapping [31,32]. Resilience is analyzed for farmers coping with natural hazards with a financial and risk management perspective [33].

Concerning food security, malnutrition is a major determinant in Mozambique and urban areas [34]. However, most research covers agricultural areas and farmers' strategies and resources dealing with food production and food security [35]. Land holdings are a major determinant of income and food security in war-affected northern Mozambique [36]. Biofuel feedstock is a special topic of attention in research and analyzes the smaller production rates of small-scale farmers versus agro-industrial projects, illustrating an ambiguous role of sustainability principles [37,38]. The income and employment of smallholder farmers remain the focus of recent research on food security [39,40].

Studies analyzing rural–urban relations to livelihoods, climate change, or natural hazards are scarce. One study investigates migration decisions due to environmental stress and finds perceptions of weather events that are highly correlated with economic situations in the coastal city of Beira [41]. New economic niches are created by female vendors in urban or peri-urban areas selling small-scale agricultural products [42]. Urbanization in Mozambique or Angola was driven by rural farmers' demands to diversify income in urban informal sectors, limited market opportunities, and a lack of infrastructure [43].

This article explores how many studies have looked into climate change, natural hazards, disaster risks, diseases, daily risks, sustainable development, rural livelihoods,

and connected fields. It is interesting to analyze how far interrelations between those fields already exist. These interrelations are analyzed using a bibliometric analysis. The co-occurrence of keywords in scientific articles is analyzed using a bibliometric clustering tool. The results are intended to be helpful for science and non-governmental organizations (NGOs), as well as development planning and governance. The main hypothesis guiding this article is that multi-risk analysis studies are still underrepresented in Mozambique.

2. Materials and Methods

Mozambique is bordered in the south by South Africa and Swaziland, in the west by Zimbabwe and Zambia, and the north by Malawi and Tanzania. To the east, Mozambique shares a long coast with the Indian Ocean. It is predominantly low-lying terrain, with vast agricultural and even undeveloped stretches of land. The climate is tropical to subtropical, with more rainfall along the coast due to the regular seasonal influence of the Indian Ocean monsoon grains. The south of Mozambique is dryer than the north. Temperature averages range from 20° to 23° in winter and 24° to 27° in summer [44]. Mozambique experienced a Civil War for 16 years that ended in 1992, with 5 million people being forced into migration [11]. Several disastrous floods have affected the country and displaced hundreds of thousands. Cyclones and grouts are other recurrent hazards.

An initial online literature search guided the search strings and selection of the main focal problem keywords. Similarly to a snowball principle [45], the conceptual focus was informed by the information provided by a conference [46] to which the author was invited. The conference in Mozambique, 14–15 February 2024, focused on rural food environments and on the invited session on the relation of rural livelihoods to resilience and of food security to disaster risks. The conference marked the end of a three-year research project focusing on rural livelihoods [47].

In addition to that information and the online literature, the search first focused on reports of international and local NGOs and their findings about needs assessments connected to the overall topic of rural livelihood, risks, sustainable development, disaster events, food security, and its related aspects. Additional fields of interest also informed the further selection, such as whether there are differences between rural and urban populations, vulnerabilities, livelihoods, and risks. This information collection then informed the selection of the main research questions that later guided the selection of the literature analysis, focusing on scientific literature only.

The method in this study consists of a literature analysis based on a Scopus database search with search strings, including abstract, title, and keyword information. The Web of Science and Google Scholar results were also screened. Still, since they mostly produced overlaps, the study selected only one platform, Scopus, to make it easier for comparison studies to use the same search strings and samples. The temporal coverage of the Scopus database varies according to the search term combination. For example, the terms Mozambique AND war go back to the earliest publications from the 1960s. Publications about the Mozambican Civil War that ended in 1992 are covered. However, since all the publications may not be digitized or registered, it could imply a representation bias. Language is another bias observed in the publication results. For the search term combination Mozambique AND war, from around 800 results (title, abstract, and keywords), only 25 were in Portuguese and 12 were in French, while English dominated as a language.

The files of 19 topical search strings were exported as CSV files. A bibliometric cluster analysis of co-occurrences of keywords was conducted with the help of the VOSviewer tool, version 1.6.20. Parts of the functionality of the open-source tool have been used, but it was mainly used to generate systematic keyword occurrence data and was analyzed further using Excel, version 16.66.1.

The guiding research questions for this article are as follows:

Which are the predominant risks in Mozambique, and which relations of risks can be observed? This main research question is further broken down into more specific research questions to narrow down the focus:

RQ1. Regarding food security and rural–urban livelihoods, which are the predominant risks in Mozambique that are considered in research?
RQ2. Which of those risks are interconnected in terms of hazard–vulnerability relations?
RQ3. Which of those risks are daily or disaster risks, and which are connected to which type of vulnerable populations?
RQ4. How can those interconnections be integrated into a conceptual framework?

2.1. Context and Relevance of Hazards and Risk in Mozambique

Mozambique has high population growth rates and young segments of society [48]. Population and related urban growth are to be expected, as well as a transition from rural to urban livelihoods. This transition will differentiate the population into rural, small, provincial, and major urban centers. It is, therefore, an important time to take stock of the conditions and different risks within rural and already existing urban areas. This can help to better plan for future development and improve livelihoods in a way that is customized to the local context. At the same time, social and cultural contexts also have to be observed. It is therefore important to also analyze which population segments, age groups, gender, and other factors already shape risks in Mozambique.

Diseases and health-related risks will be analyzed since they take high death tolls every year. This will be compared with death tolls from disaster events, mainly from natural hazards. The term 'daily risk' is used here for those health-related risks that occur regularly, are captured in annual statistics, and are relatively similar each year. For example, the number of people dying from HIV ranges from around 40,000 per year [49], malaria to around 15,000 [50], and tuberculosis from around 12,000 [51].

The EM-DAT [52] disaster database shows that Mozambique has continuously experienced different types of disasters, with deaths of over 100 people per year in the past decades (Table A1 in the Appendix A). The highest death toll has been a drought from 1979 to 1981, with an estimated 100,000 deaths. This is followed by 800 people dying in the riverine flood in the year 2000. The types of disasters range from floods, cyclones, and drought on the natural hazard side to cholera outbreaks, road and rail accidents, and explosions on the artificial side.

Comparing this number of events with the highest number of people affected is shown in Table A2 in the Appendix A. A staggering number of millions of people were affected due to droughts, floods, and tropical cyclones. Many of these cyclone events happened quite recently, such as cyclones in 2019, 2021, or 2022, and also the 2020 and 2021 droughts.

2.2. Bibliometric Analysis

Bibliometric analysis is an established method in many fields of science [53–55]. It analyzes different sources of literature systematically and uses graph theory or statistics to indicate interrelations of keywords, authorships, etc. [54,56]. Research trends and developments can be analyzed by tracking keyword occurrences over time [57]. Different tools exist to support extracting keywords or other information, analyzing their statistical occurrences, and weighting similarities using graph theory. The VOSviewer is one of the other tools that are open and not restricted by a paywall. It is also applied to analyze standard science literature platforms such as Web of Science or Scopus [58,59].

The settings are described to make them comparable to follow-up studies or studies in neighboring countries. The import settings in the VOSviewer were set to a bibliographic data map and co-occurrence—all keywords. Import thresholds were set with a target of max. 50 keywords in the first run; keywords that were not relevant, such as "article" or "Mozambique" or neighboring country names, were removed. The first run mainly enabled a first visual interpretation of the main keywords occurring. This aided in the identification of keywords to select for further analysis. The visualization settings were set to maximize line sizes and labels. Several runs were conducted with the same files, excluding keywords not connected to the original research focus of the guiding research questions.

In the second run, keywords, such as area or methods, were excluded, and hazard, risk type, vulnerability, or context-related keywords were kept. In the third run, all keywords were retained, except those without any link to another keyword in the VOSviewer (the tool automatically offered this option in the final exporting step). It was exported as a JSON file, and then the number of keywords that occurred was analyzed in Excel.

The exact phrasing of the search terms and identified keywords, including plural or alternative expressions, is captured in the representation of the results further below. In particular, population characteristics such as age groups or rural/urban contexts related to livelihoods were captured.

The result table (Tables 1–7) shows the keywords per item. The top three items per focal problem and the total sums of the columns and lines are highlighted in gray for better readability and visualization. In case there are equal numbers, a max. of three are highlighted in gray. Keywords that were the same as the term used in the focal problem, such as climate change, malnutrition, resilience, or vulnerability, were excluded from highlighting. Only five or more keyword occurrences are selected for the top three rankings since lower numbers are considered insufficient to conclude. The results show the absolute numbers of keywords per focal problem to identify the suitable keywords for further research and the related data sets from the search strings. In addition, the data were normalized as keywords per number of articles and included in the Appendix A for comparison.

2.3. Data Set

The data set consists of results from Scopus conducted for 19 search strings with a sufficiently high number of over 7000 resulting articles and over 60,000 keywords. Search string results with less than 100 articles were excluded since they produced less than 1000 keywords as data sets and were therefore regarded as insufficient for further cluster analysis. Both thresholds are based on experience with previous analyses and publications that showed that sampling below a certain threshold does not produce sufficient entries in title or keywords to generate clusters in the bibliometric analysis. This rough value was gathered through previous experience working with the VOSviewer and related publications. The search was conducted for all search strings on the same day, 19 December 2023, to enable a consistent data set. In previous studies, it had been observed by the author that even within a few days, new entries of publications can enter a database such as Scopus.

Such strings consistently included the country name Mozambique as connected with the focal problem keywords. The main focal problem keywords were selected according to the most predominant natural hazards and also the most predominant types of diseases in Mozambique. Human-caused hazards of other types, such as road, rail, or industrial accidents, were excluded due to the relatively lower death tolls and to narrow the focus to rural livelihood conditions.

Additional search terms included urban and rural contexts. Case study regions of the related conference project were tried. Still, the number of results in Scopus regarding the available scientific articles needed to be higher to enable a more systematic bibliometric analysis. As an alternative for an urban center, the city of Maputo was retained and produced over 270 articles. Finally, a few selected additional search terms were included in light of current research interests in disaster risk, such as transformation, infrastructure, and resilience. The overall search terms risk, disaster, security, and safety were also included to cover the main research question and the focal problem of risk.

The number of articles that were found already revealed heterogeneity in the findings. Most articles were found on the topic of risk connected to Mozambique. Articles on food follow this, but the further connection and limitation to food and security have already resulted in a much lower number of findings. The search term food was retained to enable a later comparison to one of the focal problems and research questions centering around food

security. The VOSviewer tool analysis identified different keywords from those articles (Table A3 in the Appendix A).

Interestingly, the ratio of keywords per article also varies. That ratio (last column in Table A3 in the Appendix A) may indicate how much the topics of the focal problems and the research intention are also reflected in the results. While the number of keywords and articles is highest for the term risk, the ratio of keywords per the number of articles is relatively low compared to the other search string combinations. For example, the search string Mozambique AND safety produces the highest ratio of keywords per article. As a first assumption, the data set of Mozambique AND safety could provide more keywords into connections that are relevant to this study's scope. This assumption will be tested by analyzing the data in more detail in the results section.

More search string combinations were tried, but articles were excluded due to the low number of results in Scopus, as shown in Table A4. Therefore, analyzing the originally intended research question about multiple risks took time. Different expressions and combinations of the terms multi AND risk were tried. Also, in the more detailed analysis, the findings of individual keywords within articles around multi-risk were analyzed to try to identify explicit research on this topic of interrelated risks. The overall number of findings of articles in research about Mozambique, with over 15,000 articles, indicates how prevalent topics such as risks are. With a finding of 1700 articles from 15,000 about risks, the topic of risk is a predominant topic for Mozambique overall. This underlines the scope and relevance of the research.

3. Results

The results from the literature analysis are structured in the following according to different topics. These topics emerged during the literature analysis of the raw data and the clusters provided by the VOSviewer. To better organize the results and improve the readability, many topics were organized into focal problems defining the tables' first column. The next topics in the header row of the tables are keywords such as cyclone, drought, etc., that emerged from the VOSviewer analysis but were also guided by the research question focus. Finally, many column-defining keywords were reorganized into different tables according to hazards, disease, types, population, and livelihood tables, and research paradigms were separated into different tables.

Table 5 shows the first topic of hazards. From the range of hazards, climate change consistently has the highest number of keyword occurrences, except for articles mainly related to civil war or safety. The findings for rural AND risk are also comparatively lower than for other focal problems or hazards in Table 1.

Rain, war, and pandemic have the lowest keyword occurrences from all hazards analyzed. On the other hand, droughts and floods have high numbers, as well as cyclones and epidemics. This shows many articles within those hazard topics, resulting in many keywords related to our research questions. The results mainly indicate keywords that are promising for further literature analysis. But, at the same time, it is interesting to identify very low numbers of keywords, lower than five, for example. These keywords and focal problems can help to identify research gaps or areas for further research.

The results of the table can also be analyzed line by line for each focal problem. Since a detailed description would exceed the manuscript's length, only examples per table are discussed. For example, the focal risk problem mainly relates to epidemics, climate change, and floods. Droughts have lower keyword coverages within the risk data set by comparison. This is interesting since droughts have produced the highest numbers of deaths and also people affected by far in Mozambique. However, it might be another limitation that droughts are only sometimes identified as disasters. It is a matter of definition and, therefore, also terminology as to whether droughts are regarded as disasters, 'Slow-onset events', or slow and creeping processes. This could add another bias to the search results and reveal a gap in identifying droughts as disasters in this context. This indicates that

traditional risk research and the risk topics in Mozambique are broader and therefore need further analysis.

Table 1. Keyword occurrences as derived from the bibliometric cluster analysis for the terms around the topical area of hazards.

Focal Problem	Climate Change	Cyclone(s)/ Cyclonic Storm(s)/ Hurricane(s)	Drought(s)	Epidemic(s)	Pandemic(s)	Flood(s)/ Flooding(s)	Rain	War	SUM
Risk	70	22	18	95	32	63	20	17	337
Malnutrition	7	6	8	4	12	5	1	2	45
Food	43	16	31	35	14	18	6	13	176
Food security	15	5	13	6	2	4	3	1	49
Drought	49	6	100	11	3	28	9	6	212
Flood	51	30	21	10	0	165	18	1	296
Cyclone	32	94	4	8	5	55	5	0	203
Civil war	1	0	3	6	1	1	0	19	31
Security	20	5	14	7	5	8	4	6	69
Safety	3	2	1	6	5	3	0	1	21
Climate change	309	24	34	4	3	47	22	0	443
Disaster	32	53	14	19	7	66	2	8	201
Transformation	6	0	1	0	0	5	3	1	16
Infrastructure	21	12	3	6	3	18	2	8	73
Vulnerability	50	7	8	7	3	21	4	4	104
Resilience	36	4	7	5	8	7	1	5	73
Urban AND risk	11	0	2	9	2	7	1	4	36
Rural AND risk	6	0	6	10	4	7	2	3	38
Maputo AND risk	9	0	1	11	1	4	2	1	29
SUM per item	771	286	289	259	110	532	105	100	2452

The following focal problems have been selected to provide different data sets and additional information to identify better which risks are relevant in research on Mozambique. Regarding the highest number of keywords per focal problem, the data set of articles around climate change produces even higher numbers than the data set about risk despite a lower overall number of articles and keywords. Research keywords around climate change center mostly around floods, followed by droughts and then cyclones. Floods are the third highest number of keywords related to the hazards in Table 1. Floods are related mostly to climate change, cyclones, and droughts and, therefore, are similar to the climate change data set.

As a major research interest of this article, food security produces the relatively highest number of keywords for climate change, droughts, and epidemics. Analyzing the urban or rural focal problem rows, the overall keywords are lower than climate change or risk. Interestingly, however, rural and urban risk data sets have high numbers of keywords for epidemics, followed by floods. Climate change is also prevalent in both data sets but has a higher coverage in urban risk articles.

The next collection centers around diseases, as shown in Table 2. The highest numbers of keyword occurrences per disease type are for HIV infections and malaria, followed by diarrhea. This is consistent with the findings of the most predominant occurrences in the VOSviewer analysis of the data sets. Although the main focus was on natural hazards with the highest death tolls, such as droughts or floods, within the focal problem of risk, HIV and malaria seem to be predominating and have much higher overall keyword numbers, over 300, as compared to the hazards table, for example. This underlines our research

assumption that diseases and what are termed here as daily risks are just as important, if not more important, to compose the overall risk, at least in research about Mozambique.

Table 2. Keyword occurrences as derived from the bibliometric cluster analysis for the terms around the topical area of diseases.

Focal Problem	Cholera	Diarrhea	HIV	HIV Infections	Malaria	Tuberculosis	SUM
Risk	29	55	91	303	338	75	891
Malnutrition	2	38	11	30	29	21	131
Food	14	12	5	12	12	4	59
Food security	1	2	2	1	0	0	6
Drought	3	4	1	1	6	1	16
Flood	7	2	0	0	8	0	17
Cyclone	8	2	0	3	4	0	17
Civil war	0	0	1	9	0	0	10
Security	1	2	2	3	3	1	12
Safety	4	14	6	1	55	10	90
Climate change	3	4	0	0	12	0	19
Disaster	14	7	0	4	12	4	41
Transformation	0	0	1	4	1	0	6
Infrastructure	5	5	5	16	5	4	40
Vulnerability	1	1	5	15	6	1	29
Resilience	0	0	3	2	1	0	6
Urban AND risk	3	11	7	26	11	2	60
Rural AND risk	2	14	22	58	47	13	156
Maputo AND risk	1	9	16	51	23	7	107
SUM per item	98	182	178	539	573	143	1713

The focal problem of risk has the highest number of keywords, followed by malnutrition and the combination of rural AND risk. Food security has a very low number of keywords related to disease topics.

Analyzing a few selected focal problems, risk and malnutrition share the same types of diseases with the highest numbers of such terms. But also, rural as well as urban focal problem sets confirm that HIV and malaria are the most prevalent diseases covered in studies. Other diseases, such as cholera and tuberculosis, are not within the top three highest numbers of keywords, but still, they show a high coverage in the area of focal problems, such as risk, malnutrition, food, safety, or disaster. And, especially for the focal problem of rural AND risk, tuberculosis also has a relatively high number of keywords.

Table 3 shows the keywords for the different population age groups. This can help identify which population groups have different risks covered in scientific studies. Adults have the highest number of keywords, followed by children and infants. Aged people are relatively low by comparison. The focal problems with the highest keywords are risk, followed by rural AND risk and Maputo AND risk.

The gray highlighting shows that children and adults consistently comprise those age groups with the highest numbers of keywords and the most focal problems. Food security only has adults with more than five keywords, which may indicate that this topic has yet to be covered regarding age, profile, and population differences. This also applies to other focal problems, such as cyclones or resilience. This might indicate future areas of research that could still be emerging, or it could, on the other hand, show that population

and age factors have not yet had such an interest and maybe thereby relevance. Rural AND risk topics seem to cover adults as well as infants and children, and there is no major discrepancy to urban AND risk topics.

Table 3. Keyword occurrences as derived from the bibliometric cluster analysis for the terms around the topical area of age groups.

Focal Problem	Newborn	Infant	Child	Preschool Child	School Child	Young Adult	Adult	Middle Aged	Aged	SUM
Risk	137	255	355	206	47	271	639	276	110	2296
Malnutrition	35	78	85	63	2	16	38	16	7	340
Food	14	42	68	40	6	23	74	27	13	307
Food security	2	3	3	4	0	2	7	3	0	24
Drought	1	4	10	6	1	0	6	1	1	30
Flood	3	4	9	4	1	4	9	5	3	42
Cyclone	1	3	7	3	0	0	4	1	2	21
Civil war	1	7	7	2	1	2	12	6	1	39
Security	2	3	7	4	0	4	13	4	0	37
Safety	15	41	35	33	4	31	85	33	18	295
Climate change	1	1	2	2	0	0	6	2	2	16
Disaster	4	10	16	10	0	3	19	7	5	74
Transformation	0	1	3	0	0	2	9	2	2	19
Infrastructure	8	10	18	8	1	5	20	8	5	83
Vulnerability	4	3	12	3	2	7	19	6	2	58
Resilience	1	0	2	2	0	2	6	3	2	18
Urban AND risk	9	22	41	26	6	41	91	50	19	305
Rural AND risk	28	64	74	55	3	59	127	59	21	490
Maputo AND risk	25	41	50	26	5	56	132	64	28	427
SUM per item	291	592	804	497	79	528	1316	573	241	4921

Table 4 investigates further population characteristics related to gender, social and economic conditions, and livelihoods. The highest numbers of keywords are captured for female and male characteristics, followed by pregnancy. Females and males are also consistent for all focal problems. Other items, such as education, income, livelihood, refugees, or vulnerable populations, only have selected areas with high numbers of keywords. Or, in the case of vulnerable populations, they are not well covered, except for the data set about risk or maybe rural AND risk and vulnerability.

Table 4. Keyword occurrences as derived from the bibliometric cluster analysis for the terms around the topical areas of gender and livelihoods.

Focal Problem	Female	Male	Pregnancy	Education	Income	Livelihood	Refugee(s)	Vuln Pop	SUM
Risk	861	675	180	50	27	10	22	31	1856
Malnutrition	103	86	21	2	2	0	1	4	219
Food	128	104	12	16	16	11	18	3	308
Food security	12	8	0	2	10	4	1	0	37
Drought	10	7	1	0	1	2	6	1	28
Flood	13	11	3	1	0	3	4	1	36
Cyclone	8	8	1	1	1	1	1	3	24
Civil war	18	11	4	3	2	0	7	1	46
Security	22	18	1	7	12	5	5	0	70

Table 4. *Cont.*

Focal Problem	Female	Male	Pregnancy	Education	Income	Livelihood	Refugee(s)	Vuln Pop	SUM
Safety	109	83	26	9	0	1	6	0	234
Climate change	10	7	1	2	1	10	1	1	33
Disaster	21	18	5	4	0	2	17	4	71
Transformation	12	8	1	5	1	1	3	1	32
Infrastructure	40	28	9	17	5	5	8	0	112
Vulnerability	26	13	8	3	6	8	4	7	75
Resilience	7	5	3	2	1	6	0	0	24
Urban AND risk	106	84	14	12	4	2	0	2	224
Rural AND risk	185	152	35	16	10	5	8	7	418
Maputo AND risk	167	123	95	10	1	2	0	3	401
SUM per item	1858	1449	420	162	100	78	112	69	4248

The focal problems with the highest number of keywords are risk, rural AND risk, but also Maputo AND risk.

Table 5 summarizes items around mortality and morbidity. Mortality is most related to risk studies, but also to morbidity, malnutrition, and rural and risk data sets. Mortality is further broken down into different age groups. However, they show low numbers by comparison. Selected health-related problems, such as malnutrition or stunting, were added to enable a comparison of death rates. Stunting or lower than average growth of children and adults is important in food security and malnutrition research and has therefore been added. Obesity has been added to compare urban, rural, developed, and underdeveloped areas.

Table 5. Keywords occurrences as derived from the bibliometric cluster analysis for the terms around the topical areas of morbidity and mortality.

Focal Problem	Mortality	Newborn Mortality	Infant Mortality	Child Mortality	Maternal Mortality	Morbidity	Malnutrition	Stunting	Obesity	SUM
Risk	126	15	32	16	32	58	44	13	34	370
Malnutrition	36	0	10	3	4	17	134	14	9	227
Food	18	1	2	1	0	6	35	5	6	74
Food security	3	0	0	0	0	1	7	1	0	12
Drought	9	0	1	2	0	5	9	0	0	26
Flood	5	0	0	1	1	1	1	0	0	9
Cyclone	2	0	0	0	0	0	2	0	0	4
Civil war	7	0	7	4	2	0	0	0	0	20
Security	6	0	0	0	0	2	7	1	0	16
Safety	13	3	4	0	4	6	2	0	0	32
Climate change	11	0	1	1	0	4	6	0	0	23
Disaster	11	0	2	3	2	4	7	0	0	29
Transformation	0	0	0	0	0	0	0	0	0	0
Infrastructure	9	1	4	4	1	2	1	1	0	23
Vulnerability	5	0	0	0	1	1	2	0	0	9
Resilience	2	0	0	0	2	0	1	0	0	5
Urban AND risk	11	0	3	2	2	7	4	4	12	45
Rural AND risk	24	1	6	4	3	17	10	4	9	78
Maputo AND risk	14	1	3	2	12	4	3	1	5	45
SUM per item	312	22	75	43	66	135	275	44	75	1047

The highest number of keywords appear for risk, followed by malnutrition and rural AND risk. Mortality and morbidity also have the highest numbers of keywords for all focal problems. Interestingly, rural and urban risks again share the same high occurrences of keywords covered in scientific articles for mortality and obesity. Stunting is related to risk and malnutrition, but not so much in studies about urban or rural risk.

Table 6 shows items related to local and regional contexts. The highest number of keywords exist for rural areas, followed by urban areas. The results show that rural areas are predominant in more focal problem data sets than urban areas and are highly related to our research scope. The highest numbers of keywords were captured for focal problems or risk data sets, followed by rural AND risk and food. Overall, this shows that rural context and food security are highly interrelated with risk topics. For the city of Maputo, hospitals have relatively higher coverage and studies than other focal problems, except for risk.

Table 6. Keyword occurrences as derived from the bibliometric cluster analysis for the terms around the topical area of local context.

Focal Problem	Rural Area(s)	Urban Area(s)	Hospital(s)	School(s)	Primary School(s)	SUM
Risk	123	61	38	13	5	240
Malnutrition	11	4	8	4	1	28
Food	40	15	2	1	0	58
Food security	13	3	0	0	0	16
Drought	4	2	0	0	0	6
Flood	10	3	0	0	0	13
Cyclone	3	0	0	0	0	3
Civil war	4	2	0	0	0	6
Security	18	9	0	0	0	27
Safety	12	10	6	1	1	30
Climate change	6	5	0	0	0	11
Disaster	7	1	0	0	2	10
Transformation	2	1	0	0	0	3
Infrastructure	21	10	6	0	0	37
Vulnerability	12	4	1	3	0	20
Resilience	6	0	0	0	0	6
Urban AND risk	32	62	5	0	0	99
Rural AND risk	123	27	7	2	0	159
Maputo AND risk	8	25	17	3	1	54
SUM per item	455	244	90	27	10	826

Again, it is interesting to analyze those focal problems that have a low number of keywords. Cyclones, for example, have not been covered in scientific studies regarding rural or urban contexts very much so far. It is also less the case for drought as a topic or even climate change. This could be related to these hazards having large regional coverage. The low numbers of keywords for schools or primary schools mainly show that these are insufficient for further analysis. Schools and hospitals would be interesting local hubs to connect studies to.

Finally, Table 7 shows various scientific terms that drive current research interest. The most keywords are captured for sustainable development, vulnerability, and poverty. Poverty had been expected to play a dominant role related to food security risks and rural livelihoods. Interestingly, resilience is a paradigm that has yet to be covered by

high occurrences in articles, except for climate change. Multi-risk is not covered at all by keywords. The table also shows that using different search term variations was useful. Sustainable development produced many more results than sustainability, for example. This did not work for multi-risk. Similar combinations with development were not found to produce more results for terms such as vulnerability. For resilience, it has to be said that some focal problems show zero results here. However, in combination with other terms, it often produced one result, for example, for ecological resilience. For reasons of consistency, however, they have not been added; they have also been checked for every data set, and they have never produced more than one result.

Table 7. Keyword occurrences as derived from the bibliometric cluster analysis for the terms around the topical area of research paradigm.

Focal Problem	Resilience	Sustainability	Sustainable Development	Vulnerability	Multi Risk/ Multi-Risk/ Multiple Risk	Poverty	Migration	Extreme Event(s)	SUM
Risk	5	13	26	34	0	50	40	5	173
Malnutrition	0	0	3	1	0	13	0	0	17
Food	4	20	26	14	0	34	7	3	108
Food security	1	9	16	8	0	9	0	1	44
Drought	0	4	1	8	0	9	4	9	35
Flood	1	4	8	10	0	2	3	10	38
Cyclone	0	5	4	6	0	0	1	11	27
Civil war	1	1	3	1	0	6	1	0	13
Security	4	11	25	11	0	14	3	1	69
Safety	2	2	4	1	0	8	2	0	19
Climate change	10	10	14	32	0	8	10	12	96
Disaster	0	1	5	13	0	5	5	5	34
Transformation	0	3	4	2	0	2	2	0	13
Infrastructure	0	8	17	5	0	16	4	2	52
Vulnerability	6	8	8	84	0	13	5	5	129
Resilience	27	4	8	13	0	7	1	0	60
Urban AND risk	0	1	4	7	0	10	3	1	26
Rural AND risk	2	2	4	11	0	16	12	0	47
Maputo AND risk	1	1	5	2	0	8	2	1	20
SUM per item	64	107	185	263	0	230	105	66	1020

The highest number of keywords per focal problem is retained for risk, food, and vulnerability. Overall, this table shows that traditional paradigms, such as vulnerability and poverty, prevail, while novel topics, such as resilience, multi-risk, or extreme events, are still rather low by comparison.

To summarize the results differently, all focal problem data sets were merged into one data set, which was then analyzed in the VOSviewer. Figure 1 shows the results of all those combined key terms used in the detailed literature analysis above. Three classes are shown for only keywords with many occurrences in all focal problem data sets. The blue cluster is around malaria and is related to infants, newborns, children, and pregnancy. The green cluster is based on HIV infections and tuberculosis. These diseases are mainly related to gender and age characteristics, mainly to adults or aged persons. The last red cluster is related to climate change, droughts, epidemics, and diarrhea. These topics are related to the contexts of rural and urban areas, poverty, and education. The figure shows that, overall, research studies focus on certain types of diseases and population groups. While malaria seems to be more prevalent among younger persons, HIV infections are more related to adults. Studies also consider rural or urban contexts, and other vulnerability characteristics, such as education or poverty, prevail in studies covering climate change and droughts.

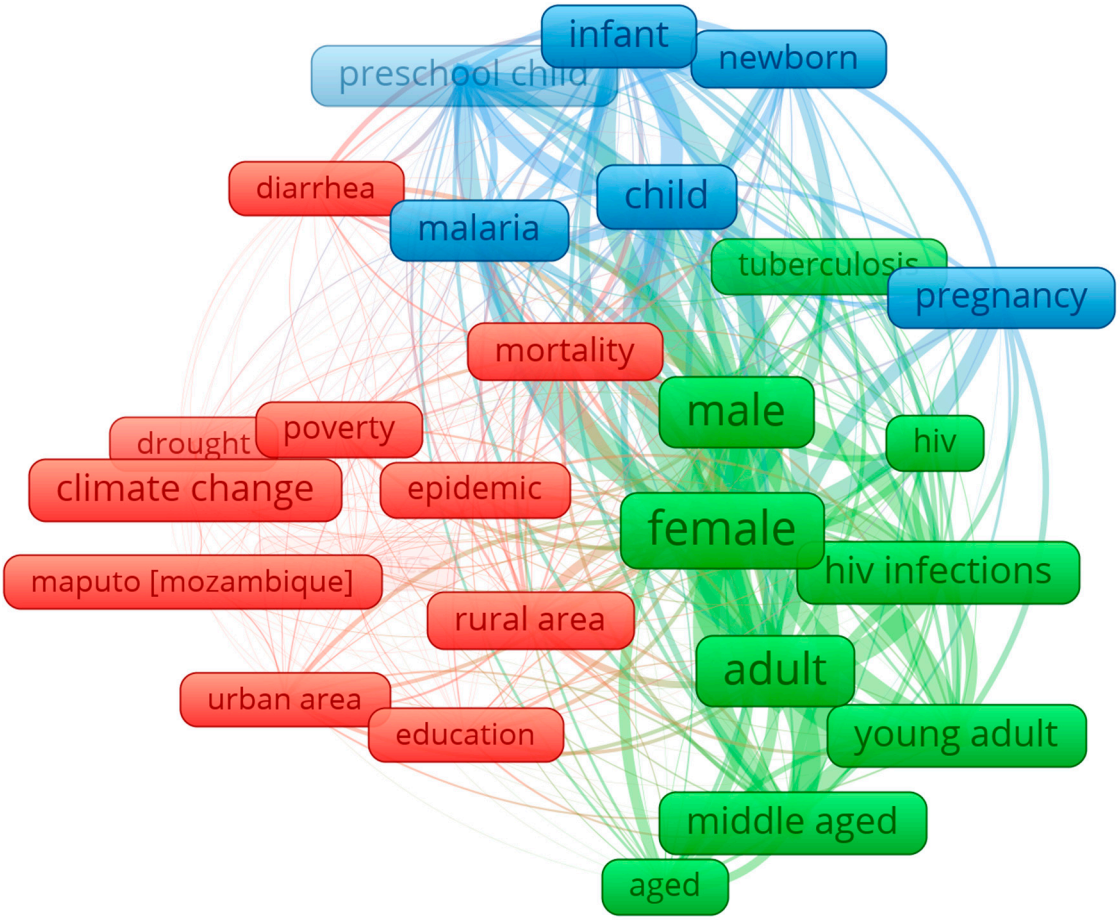

Figure 1. All files with 22,643 keywords; 100 overall, meeting the threshold of minimum occurrence of 90; selection only of those keywords analyzed in the tables.

4. Discussion

4.1. Interpretations of the Main Results

The literature's overall analysis reveals that the keywords mostly match the original scope and our research questions. As the scope of the study centers around natural hazards, food security, and rural livelihoods, the highest numbers of keywords also occur predominantly in these areas.

However, the results are mainly informative in indicating which other search terms and items appear in context to such focal problem scopes. It also shows how different focal problem search strings produce different results, resulting in different databases for further interpretation. Listing 19 focal problems, therefore, helps to capture better which topics of risk are more prevalent in which types of focal problems, keywords, and context. At the same time, analyzing which search terms or paradigms, such as resilience or multi-risk, still need to be covered in scientific studies is just as interesting. This can be very informative in identifying research gaps and further research needs. However, it can also help in the future or in neighboring regions with comparison studies.

For example, in other studies related to multi-risks and urban and rural contexts in East Africa or the Middle East, I have found a similar pattern that multi-risks and interrelations of risks are still underrepresented in research [60]. The results also show similarities but discrepancies in seemingly similar fields, such as security and safety. Safety studies center much more around population characteristics, and security studies seem to be related more to development, context, or natural hazards than diseases. The analysis also reveals a difference in the relations and numbers of keywords between hazards or diseases. This points towards differences in risk in the context of single disastrous events versus

more daily risks, such as health impact by diseases or epidemics (Figure 1). Visualizing the literature findings helps to picture the persisting traditional research gaps between the disciplines and topical areas. For example, there are different fields in Figure 1 of research around diseases and other health issues and the fields of environmental research. This might be due to persisting epistemological issues that hinder the integration and comparison of different types of hazards. It is also interesting to see that while there are differences between rural and urban areas, they are covered within the same sets of focal problem studies to a similar degree of importance.

Upcoming research paradigms, such as transformation [61,62] or critical infrastructure [63,64], were included, next to more established focal problems like vulnerability or resilience. Transformation and adaptation are recent research topics in the context of climate change [65]. The transformation of food systems is another field specifically connected to food security [66]. However, more research seems necessary to disentangle the behavioral and structural aspects of the effectiveness of such an adaptation. And research on critical infrastructure can contribute to investigations of cascading effects or interdependencies [67,68]. The findings in this article can indicate in which fields paradigms such as transformation are already investigated and in which hazard or vulnerability contexts. The findings show that infrastructure research is related to certain hazards and vulnerabilities. They also show that transformation studies have yet to cover many risk-related hazards or topics of vulnerability in Mozambique.

4.2. Limitations of the Method

Conducting the study, it was identified that much of the study is driven by the conception of the focal problem in our minds [69]. The naming and selection of search terms are as decisive for the overall result as the selection of data sets and variables in neighboring fields, such as risk index calculations [70]. Other methods and software can be used to expand further and deepen the analysis. For example, qualitative text analysis and related software, such as Atlas.ti or MAXQDA, would be very useful in identifying the relations between terms and even text passages [71]. However, the focus of the study was first to identify the database for further analysis and analyze the capabilities of cluster analysis software, which, in this case, is the VOSviewer.

At the beginning of the literature analysis, different ratios of keywords per article were found based on the search string results of some articles and some keywords. The preliminary assumption was that this ratio could give a rough first indication, with which search string combinations could produce a higher number of relevant keywords to the scope of the article. After the detailed analysis of the results in the article, it can be observed that the low ratio of keywords per article, such as for civil war or security, is also represented by lower numbers of findings of classes or occurrences in the detailed tables. However, although the search string combination Mozambique AND risk also had a low ratio of keywords per article, it still produced among the highest findings in the more detailed tables. This is likely related to the highest number of results of articles and the highest number of keywords, by far, in comparison to the other search strings.

In conclusion, the ratio of keywords per article is only an imprecise first measure. The number of articles found as a first indication still serves better, but analyzing how many keywords are captured in those articles is also interesting. Rather than pointing towards topics, we can assume that the ratio of keywords per article would express certain fields of research and their traditions of abstract or title lengths, for example.

A major limitation of the methodology is the comparably low number of keywords per item. Within a sample of about three thousand keywords, fifty or even just five keywords hardly permit further quantitative assessment. Still, however, it is possible to analyze such occurrences in bibliometric analysis, which is widely applied [72,73]. Therefore, the visual interpretation was expanded by analyzing the raw data extracted from a cluster analysis tool, such as the VOSviewer. By manually checking and selecting the results, further problems were observed. It is difficult to derive a consistent data set

because plural expressions, related terms, or synonyms often exist. Aggregating similar expressions, such as adult or adolescent, and plurals, such as adults, we need to be aware of possible distortions with other age groups that do not have such synonyms. However, the differentiation between infant and newborn is also problematic. The search term selection is a broader field for many more detailed individual problems related to how they are phrased in different contexts, for example whether a cyclone or a hurricane should be aggregated or kept separately. Another limitation is that the search terms and articles are written in English. However, even within this, there is a problem between British and American English, which might have led to further distortions or omissions of certain terms. The focus on English as a scientific language in the context of climate change and Africa is well documented, underlining problems of the marginalization of other languages such as Portuguese or African native languages [74,75]. Overall, however, it proves to be useful that open access tools, such as the VOSviewer, allow many settings and export not only the final images but also the raw data.

As for interpreting the study results, it must be disclaimed that the number of keywords only serves as a very indirect indicator of the keywords covered more prominently in articles. It does not directly permit us to derive whether this means more or less significance. It also does not allow us to conclude which topics are more related. This requires an analysis of the individual articles that cannot be replaced by how they are represented here. However, since the first literature search produced few articles with an exact combination of search terms in the title and abstract, this broader bibliometric analysis was better suited to obtain an overall impression of research coverage about risks in Mozambique. Based on this first broad overview, research, gaps, and the selection of further research search terms can be better guided.

4.3. Application of Weightings to the Interrelations Forming a Framework

Several possible applications are working further with the results above. First, the findings of items emerging from the data search in the literature could help derive major factors for conceptual and analytical frameworks. While most frameworks in disaster risk are derived from overall considerations, this could be a methodology to justify the selection of individual components and factors of a framework. For example, significant keywords by the number of keywords appearing in the literature search according to the context of this study are summarized in Figure 2. This figure answers research question 4 by visualizing an analytical framework on food security in the context of disaster risk based on the keyword appearance identified in the existing literature. The keyword cooccurrences have been clustered according to the existing conceptual components of the PRA framework and logic.

The selection is still driven by the author's perspective on focal problems, such as food security and disaster risk. Existing frameworks, such as the pressure and release model, have inspired the framework layout [76]. However, some caveats must be mentioned at this stage as well. First of all, it is highlighted by yellow boxes in each component that additional factors might be missing and would need to be added if found relevant. Such a process of deriving components of a framework should be conducted solely based on a literature analysis. Another caveat is that it is only based on the existing literature and will, therefore, miss novel streams of research that have yet to be highly cited.

However, it can also help to contribute to the growing research about climate impacts or impact chains [77–79] by providing a conceptual framework that deeply differentiates drivers of hazards and diseases, settings, and conditions.

A connected application could be useful, especially for semi-quantitative disaster risk assessments or indicator approaches. For example, the aggregation of variables and indicators to form a risk index is often dependent on information about the relative weighting of each variable or factor. The bibliometric analysis could also inform us of keyword occurrences. Figure 3 shows an example where the interrelations of hazard components on the left side and disease components have been merged for three problem areas: disaster, food

security, and resilience. This is just an example to show that this is feasible and could also be conducted only for one or all nineteen focal problems used in this paper. The aggregated numbers per hazard keyword, such as climate change, could be used as a weighting input for a risk assessment or composition of a risk index. The right-hand side of Figure 3 shows keywords and, therefore, factors that describe human and socio-economic conditions that render people vulnerable but could also help foster and build their resilience against the disaster impact of food insecurity.

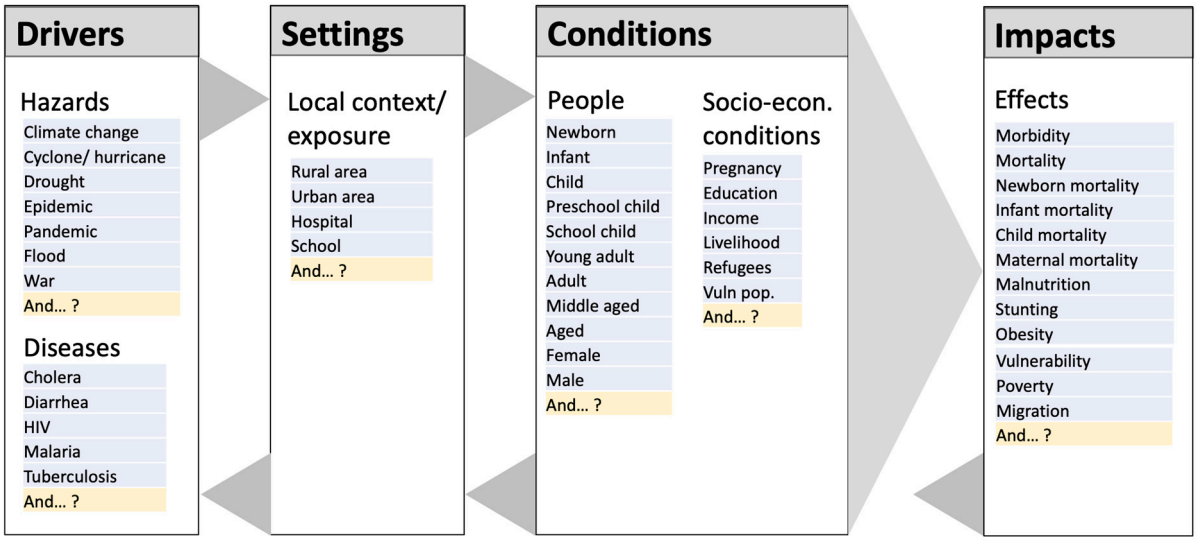

Figure 2. Analytical framework on food security drivers, settings, conditions, and impacts in the context of disaster risk.

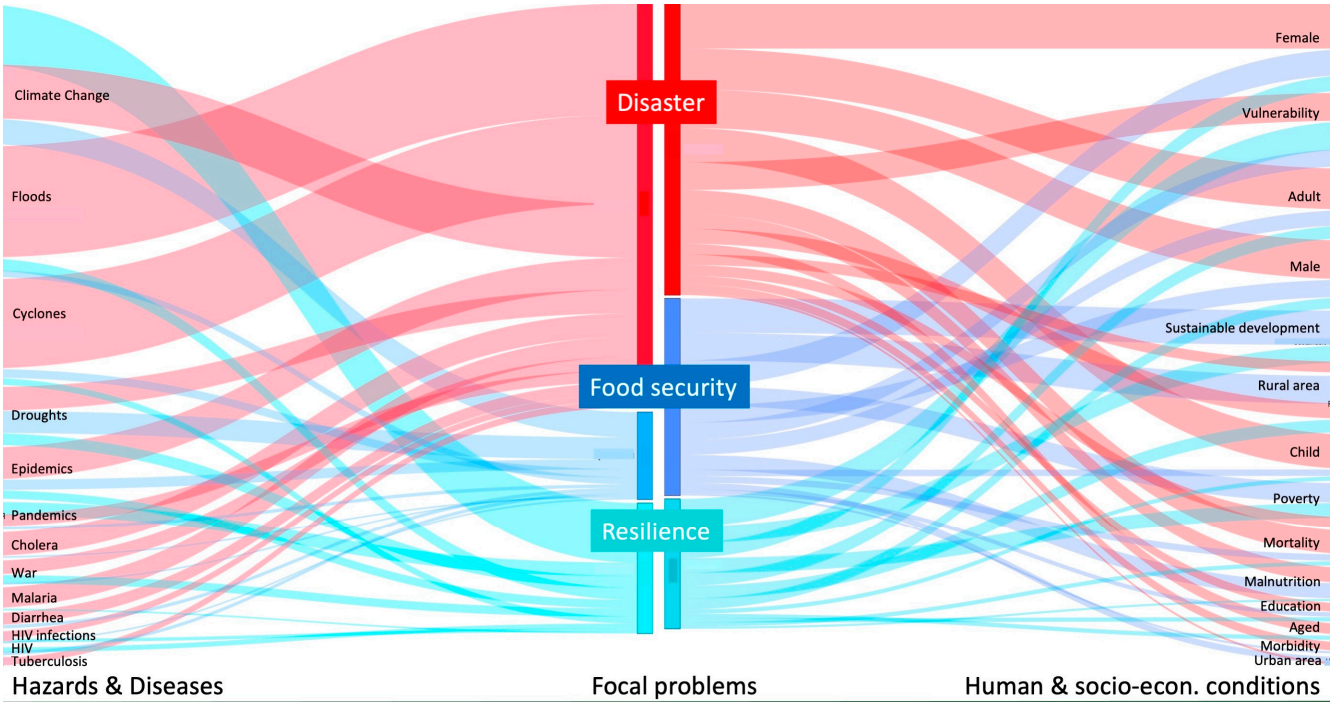

Figure 3. Sankey diagram with relations and weighting factors for food security drivers on the left and impacts on the right, in the context of disaster risk and resilience.

Again, this weighting approach faces the same limitations as the conceptual analytical framework above. It is based on the existing literature only and must be adjusted to each

case study and regional context. One must be aware of and informed of the additional components not captured by either keyword or search term.

The Sankey diagram (Figure 3) highlights more disaster research than food security or resilience connected to climate change, floods, and cyclones. Climate change is also connected to food security and resilience, but the impacts of major floods and cyclones are a predominant theme. On the left side of hazards and diseases, natural hazards predominate in this type of literature. This indicates that if food security wants to connect to holistic livelihood and sustainability topics, this is still a different research area than dedicated disaster research. It could be inspiring to consider how sustainability, resilience, and disaster research can be better integrated on this side. Resilience is the topical area with equally high relations to the hazards, disease, and human and socioeconomic conditions. It, therefore, appears as if resilience can balance hazards and impacts quite well.

On the other hand, food security predominates in covering human and socioeconomic conditions. Disasters are tilted towards the hazard side of research. This could illuminate connections between disciplinary and thematic fields by observing which relate more to hazard origination or impact chains. The picture derived here for Mozambique seems to match the overall observations that disaster research still lacks research on the impact side of things such as impact chains [77–79]. At the same time, it shows that on the impact side, disaster research is very much aware of gender aspects or children and also has a great connection to vulnerability studies. At the same time, those vulnerability studies are restricted to demographic aspects. Also, within the food security context, certain topical areas are of major research interest, such as sustainable development, rural areas, and poverty. Overall, all three problem areas, disaster, food security, and resilience, appear to show a certain type of research footprint here. Therefore, they are characteristic for combining specific streams and maybe research trends. However, Figure 3, at the same time, visualizes persisting gaps due to such a thematic focus. This can inform scientists about persisting research gaps in cross-disciplinary research and decision-makers about their actions on scientific findings. For instance, the IPCC should be made more aware of the persisting research gaps, which provide the foundation for the assessment reports [80].

5. Conclusions

Mozambique is strongly affected by daily risks of diseases and disasters such as natural hazard events. Research and practice increasingly acknowledge and address the interrelations of risks and impact chains. The sustainable livelihoods approach is one conceptual example that has found wide international application. Pressure and release conceptions have furthered our understanding of development chains and interconnections of vulnerabilities with hazards. Food security has been selected as a focal topic in this study, showing the interrelations covered by scientific research between daily and disaster risks in the context of livelihoods. Mozambique is facing the development of rural to urban populations, and it is important to take stock of the body of scientific literature. Future development pathways to sustainable development toward climate change adaptation or to end poverty and hunger need to monitor the development of risk-informed knowledge [81].

Analyzing hazard vulnerability relations, this study shows that certain human and social conditions of livelihoods are covered in studies about food security with a different focus on interrelations than, for example, studies focusing on disasters, climate change, or natural hazards. Typical patterns of risk assessments of diseases connected to demographic profiles emerge, such as HIV or malaria being connected to different age groups and urban or rural settings. An important outcome of the study is that despite the great amount of disease-related morbidity and mortality and natural hazard events in Mozambique, certain major conceptual aspects, such as vulnerability or resilience, still need to be covered widely. Another important finding is that studies on natural hazards and disaster events still need to be connected to daily risks and livelihood conditions. This indicates that, despite conceptual advancement and emerging frameworks in the context of climate change adaptation towards more research on interconnected or compounding risks, this

has yet to be taken up in Mozambique. Another contribution of the study is that existing frameworks could be validated by comparing them with publication outputs. The study also shows how to derive conceptual frameworks from a bibliometric analysis. This can also derive weightings for the interrelations between hazards and human and social conditions. Low weightings indicate research gaps and inspire future research.

The originality of the methodology lies in employing the VOSviewer to cluster keywords and derive insights from thousands of publications. The article comprehensively analyzes the academic dialog concerning the interrelations between natural hazards, climate change, and food security within the Mozambican context. It employs a bibliometric approach, examining over 7000 scholarly articles and categorizing more than 60,000 keywords to clarify the research trajectories relevant to these domains. Based on this bibliometric result, the article adds a new conceptual framework as a crucial advancement within the discipline to better integrate drivers and settings of diseases and natural hazards with conditions and impacts on different demographic population groups.

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Appendix A

Table A1. Deaths in Mozambique EM-DAT 2023.

Year	Disaster Subtype	Event Name	Total Deaths	Total Affected
1981	Drought		100,000	4,750,000
2000	Riverine flood		800	4,500,000
1997	Bacterial disease	Cholera	619	26,783
2019	Tropical cyclone	Cyclone 'Idai'	603	1,501,500
1990	Bacterial disease	Cholera	588	4000
1992	Bacterial disease	Cholera	587	225,673
1971	Riverine flood		500	500,000
1977	Flood		300	440,000
1994	Tropical cyclone	'Nadya'	240	2,502,000
2002	Rail		195	168
1983	Bacterial disease	Cholera	189	5679
2015	Riverine flood		160	177,645
1977	Explosion	Coal mine	159	
2008	Bacterial disease	Cholera	155	19,310
2009	Bacterial disease	Cholera	155	19,310
2013	Riverine flood		119	240,000
2007	Explosion	Ammunition depot	117	450
1984	Tropical cyclone	'Domoina'	109	350,000
1998	Bacterial disease	Cholera	109	2000
1991	Rail		109	100
1956	Tropical cyclone		107	
1990	Bacterial disease	Cholera	106	
1988	Tropical cyclone	'Filao'	100	4000
1998	Bacterial disease	Cholera	100	600
2016	Road		93	50

Table A2. Affected people in Mozambique EM-DAT 2023.

Year	Disaster Subtype	Event Name	Total Deaths	Total Affected
1979	Drought			6,000,000
1981	Drought		100,000	4,750,000
2000	Riverine flood		800	4,500,000
1990	Drought			3,300,000
2020	Drought			2,700,000
1994	Tropical cyclone	'Nadya'	240	2,502,000
2016	Drought			2,300,000
2021	Drought			1,562,771
2019	Tropical cyclone	Cyclone 'Idai'	603	1,501,500
2005	Drought			1,400,000
2017	Tropical cyclone	Cyclone 'Dineo'	7	750,102
2022	Tropical cyclone	Tropical cyclone 'Gombe'	63	736,123
2001	Drought		9	600,000
2001	Coastal flood		79	549,326
2007	Drought			520,000
1971	Riverine flood		500	500,000
1985	Riverine flood		8	500,000
1981	Flood			500,000
2008	Drought			500,000
2021	Tropical cyclone	Tropical cyclone 'Eloise'	11	481,901
2010	Drought			460,000
1977	Flood		300	440,000
2019	Tropical cyclone	Cyclone 'Kenneth'	45	400,094
1997	Riverine flood		35	400,000

Table A3. Scopus search strings for Abs., title, and keywords.

Search Terms	Number of Results in Scopus (Articles)	Keywords in VOSviewer	Ratio of Keywords per Article
Mozambique AND risk	1754	11,976	6.8
Mozambique AND malnutrition	189	2169	11.5
Mozambique AND food	917	7456	8.1
Mozambique AND "food security"	239	1998	8.4
Mozambique AND drought	248	2283	9.2
Mozambique AND flood	277	2553	9.2
Mozambique AND cyclone	188	1776	9.4
Mozambique AND "civil war"	241	1441	6.0
Mozambique AND security	512	3409	6.7
Mozambique AND safety	262	3738	14.3
Mozambique AND "climate change"	447	3847	8.6
Mozambique AND disaster	223	2018	9.0
Mozambique AND transformation	224	1670	7.5
Mozambique AND infrastructure	445	3652	8.2
Mozambique AND vulnerability	228	2191	9.6
Mozambique AND resilience	137	1495	10.9
Mozambique AND urban AND risk	187	2461	13.2
Mozambique AND rural AND risk	293	3060	10.4
Maputo AND risk	272	3245	11.9
SUM	7283	62,438	

Table A4. Excluded search string results.

Search Terms	Number of Results in Scopus (Articles)	Reason for Exclusion
Mozambique AND multi-risk	0	No hits
Mozambique AND "multi risk"	0	No hits
Mozambique AND "multiple risk"	4: HIV, malaria	Insufficient number of hits
Mozambique AND "critical infrastructure"	2	Insufficient number of hits
Mozambique AND urban AND hazard	23	Insufficient number of hits
Mozambique AND "natural hazard"	25	Insufficient number of hits
Mozambique AND "extreme event"	37	Insufficient number of hits
Mozambique AND famine	24	Insufficient number of hits
Moamba	20	Insufficient number of hits
Buzi	42	Insufficient number of hits
Ribaue	11	Insufficient number of hits
Mozambique AND storms	145	Captured by cyclones mostly
Mozambique AND livelihood	348	Topics too broad, connection to risk, disaster, food not always given
Mozambique AND war	749	Topics too broad, historic and national wars
Maputo	1615	Topics too broad
Mozambique	15,047	Topics too broad

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