



Review article

Impact of natural disasters on student enrollment in higher education programs: A systematic review

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ABSTRACT

This study aims to evaluate how natural disasters affect student enrollment in higher education programs, considering both immediate and long-term consequences. The PRISMA guidelines were adhered to in conducting this review. Multiple databases, such as Web of Science and Scopus, including those with articles from January 2000 to February 2023, were thoroughly searched. Articles focusing on how natural disasters affect students' enrollment in higher education programs met the inclusion requirements. A total of 22 studies were deemed eligible for inclusion and detailed analysis. The findings suggest that natural disasters have a negative influence on higher education enrollment, with the most severe effects being felt by disadvantaged populations. This study reveals that natural disasters impact various aspects of the enrollment process, such as application, acceptance, registration, attendance, retention, and graduation, in higher education due to infrastructural and psychological impacts. Key variables linking natural disasters to enrollment changes include damage to institutional infrastructure, economic and psychological strain, resource limitations, loss of social support networks, and disruptions to academic programs. Enhancing resilience involves adopting online learning, providing financial support, flexible enrollment policies, mental health services, disaster preparedness training, resilient infrastructure development, and collaborative institutional programs. The study highlights the need for comprehensive, context-specific disaster management strategies that address both immediate and long-term educational needs. It identifies potential solutions, including online learning platforms, financial aid, flexible enrollment policies, mental health support, disaster preparedness training, infrastructure resilience, and collaborative programs with other institutions. Context-specific programs are essential to support impacted students by rebuilding educational infrastructure and providing financial and emotional support, thereby ensuring their continued access to higher education. This study offers valuable insights for disaster management, educational policy, and future research on this critical issue.

1. Introduction

Natural disasters affect almost all sectors worldwide, such as infrastructure, economy, and society, and the education sector is no exception. The effect on higher education, particularly student enrollment, represents a facet of these disturbances that is often underestimated [1]. This study analyzes the connection between natural disasters and student enrollment in higher education programs worldwide, highlighting the significance, importance, and demand for additional research into this crucial issue.

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As the frequency and intensity of natural disasters continue to increase due to climate change and other environmental variables, understanding their diverse consequences is more crucial than ever. Between 2000 and 2019, natural disasters harmed nearly 4 billion people globally, causing an estimated \$2.97 trillion in economic damages [2]. As important pieces of the social infrastructure, higher education institutions have not been immune to these disturbances. Many studies have shown that there have been material losses, monetary losses, and disruptions to academic activities [3]. Studies have suggested that natural calamities can greatly interrupt educational trajectories, impacting students' choices to enroll, persist, or graduate from higher education [1,4–6]. It is crucial to comprehend and tackle these effects, since they are essential not only for maintaining uninterrupted schooling in the short term but also for ensuring long-term societal strength and recuperation [7]. An accurate understanding of the impact of natural hazards on student enrollment requires an in-depth investigation. This study summarizes the available literature, identifies research gaps, and provides information for creating evidence-based interventions and policies. So, it can deepen our understanding of the complex problems higher education institutions face in an increasingly uncertain global environment by assisting in creating effective strategies for boosting preparedness and resilience.

Policymakers, educators, and other stakeholders could benefit from knowledge about how natural hazards affect student enrollment in higher education programs. This information could be used to help develop policies and initiatives to lessen the impact of major disasters on educational systems to ensure the continuation and stability of higher education in impacted areas. The socioeconomic ramifications of natural disasters, such as their long-term consequences on economic growth, the creation of human capital, and employment outcomes, can be better understood by understanding how these events affect student enrollment.

Many recent studies have focused on the adverse effects of natural disasters on higher education [8–12]. These studies examine the direct and indirect consequences on institutions, infrastructure, and academic activities. Smith et al. [13], for instance, provided a detailed analysis of the Hurricane Katrina-related university recovery and reconstruction process, highlighting the necessity of institutional resilience and adaptation in the face of such disasters. Farris and McCreight [8] recommended disaster preparedness is a best practice for emergency management in higher education institutes. Novella and Zanuso [14], when investigating how the 2010 Haiti earthquake affected households, argued that nearly three years post-shock, investments in children's human capital were negatively impacted due to vulnerabilities present at the time of the earthquake, increasing the likelihood that the household would remain in poverty. Kato et al. [15] explored the long-term effects of natural disasters on university students in Japan, identifying factors that could heighten psychological stress in response to such catastrophes. Additionally, some studies have examined how technology might help higher education institutions be more resilient and adaptable in the face of calamities [16–19]. Segarra-Almística et al. [20] studied how educational outcomes, particularly for vulnerable populations, were impacted by school service interruptions connected to Hurricane Maria and the 2020 earthquake sequence. They discovered that teenagers who reside in locations where the storm caused significant damage or whose schools were closed down permanently as a result are more likely to experience a deterioration in their academic performance and, in some circumstances, to quit attending school entirely. Yet, no studies directly focus on the holistic aspects of the impact of natural disasters on the various phases of student enrollments, its challenges, and possible solutions.

In addition to these narrowly focused studies, several review articles have compiled knowledge on how natural disasters affect higher education. Notably, Co et al. [21] performed a comprehensive analysis of 12 studies, looking at how natural disasters affect many facets of higher education, and emphasized the need for adopting a principle-based strategy by higher education institutions to actively enhance students' coping skills by raising their self-efficacy, involvement, and resilience while lowering anxiety. Similarly, Borazon and Chuang [6] analyzed 707 documents to assess the factors of educational resilience and highlighted the role of the environment, individual experiences and background, and educational institution's programs as enablers of resilience-building. Consequently, only a few studies have specifically examined how natural disasters impact students' enrollment in higher education programs, despite the fact that a sizable body of research has been done on the various effects of natural disasters on higher education. This paper aims to fill this research gap by thoroughly examining the connection between natural disasters and student enrollment, taking into account both the direct and indirect effects of these occurrences on enrollment dynamics.

Although there is an expanding body of research on how natural disasters influence higher education, little is known about how these calamities affect student enrollment. This gap in research may stem from the complexity of the issue, as the impact of natural disasters on enrollment is probably dependent on a number of variables, such as the scope and severity of the disaster [22], the preparedness and resilience of the affected institutions [23], and the socioeconomic conditions of the affected areas [24]. Furthermore, empirical investigations into this issue have been impeded by the lack of thorough and trustworthy data on student enrollment in the aftermath of natural disasters. Existing research has highlighted the impact of natural disasters on the infrastructure of educational institutions [25–27], academic functions [10,28,29], and students and staff's mental health [12,30–33]. Thus, a comprehensive understanding of the adverse impact of natural disasters on student enrollment is required to face future education resilience.

This study addresses the knowledge gap through in-depth research. The literature can benefit from this study in several ways. First, it provides a thorough and fact-based explanation of the connection between natural disasters and student enrollment provided by a systematic review, enabling researchers to summarize the body of material already available. Second, it provides important insights into the direct and indirect effects of natural disasters on enrollment patterns and the variables that may affect the resilience or vulnerability of higher education institutions in the face of disasters. Third, this study also points out areas where more study is required and uncovers gaps in the existing body of knowledge. Fourth, few studies particularly examine how natural disasters affect student enrollment in higher education programs, as previously discussed. This study elucidates the extent and nature of these research gaps, which can also inform the formation of policies and initiatives to solve the problem. Fifth, a thorough analysis can aid in creating measures and policies grounded in fact to lessen the negative effects of natural disasters on the enrollment of students in higher education. Finally, this offers the necessary information to develop targeted and context-specific approaches to addressing this important

issue by synthesizing the existing research and identifying the most efficient strategies for enhancing institutional resilience and preparedness.

The study aims to address the following research questions: (a) How do natural disasters affect students' enrolment in higher education programs? (b) What variables affect the link between natural disasters and enrollment in schools? And (c) What are the proper measures that can enhance resilience of students and institutions? Hence, the primary goal of this study is to investigate how natural disasters affect student enrollment in higher education programs in different areas and contexts. The study's specific objectives are to (a) Examine the direct and indirect effects of natural disasters on student enrollment in higher education programs; (b) Identify the factors that determine how resilient or vulnerable higher education institutions and their student populations are to natural disasters; (c) Offer policy recommendations for enhancing the preparedness and resilience of higher education institutions and the student enrollment process.

By focusing on student enrollment, this study contributes to the body of information on how natural disasters affect higher education. Prior research has often overlooked this aspect. This study examines the direct and indirect impacts of natural disasters on enrollment patterns to better understand the wider repercussions of such calamities on higher education institutions. This research is innovative in integrating the issue, incorporating ideas from several fields like socio-economic analysis, disaster risk reduction, and education policy. This research can be useful in helping policymakers, educators, and stakeholders to develop effective strategies for reducing the impact of natural disasters on higher education programs and ensuring the continuity and stability of these systems in the face of an increasingly uncertain global environment.

2. Methods

2.1. Research approach

Investigating the effect of natural disasters on student enrollment in higher education programs necessitated a thorough study of the literature. A systematic review is an exacting and open approach for locating, analyzing, and putting together the evidence that is currently accessible on a certain subject. This study adopted a mixed method approach comprising Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) for identifying the most pertinent documents and a narrative review approach for explaining the extracted contents [34]. The systematic review was conducted following the PRISMA approach [35] to guarantee the openness and thoroughness of the review process (Supplementary S1. PRISMA checklists [36]).

2.2. Study protocol

The PRISMA standards were used to design the research protocol (Table 1). The study topic, the inclusion and exclusion criteria, the search strategy, the data extraction techniques, the quality evaluation standards, and the data synthesis techniques were included in the protocol.

2.3. Search strategy

A combination of terms relating to natural disasters, student enrollment, and higher education programs were used to create the search string. A number of databases, including Web of Science, and Scopus, were searched. The Web of Science and Scopus databases were chosen as sources for this investigation because of their rigorous selection of quality articles. These databases are highly acceptable among the myriad of existing databases. They are widely recognized for their quality control. Not all databases maintain the same level of recognition or reputation. The stringent selection criteria of Web of Science and Scopus ensure that not all articles indexed in other databases are included. However, both these databases index only high-quality papers. Studies written in English and published between January 2000 and February 2023 were included in the search.

Table 1
Research protocol.

Items	Description
Research question	How natural disasters influence student enrollment in higher education programs?
Database	Web of Science and Scopus
Document	Only peer-reviewed articles
Language	English
Publication period	From January 2000 to February 2023
Search terms	Natural disasters, natural hazards, natural calamities, student enrollment, and higher education
Search fields	Title, abstract, and keywords
Inclusion criteria	Natural disaster, natural hazards, natural calamities, student enrollment, and higher education should be focused in the study.
Exclusion criteria	Inaccessibility of full text, duplication, and non-English articles. Furthermore, articles not focusing on students' enrollment and natural disasters are ignored.

2.4. Inclusion and exclusion criteria

The inclusion criteria were: (a) articles were published in English; (b) articles addressed how natural disasters affect students' enrollment in higher education programs; (c) articles having quantitative data; (d) published in peer-reviewed journals, (e) published between January 1, 2000, and February 28, 2023. The following were the exclusion criteria: (a) Papers that did not concentrate on how natural disasters affected students' enrollment in higher education programs; (b) papers that contained only qualitative information; (c) papers that were not published in peer-reviewed journals; and (d) papers that were published before January 1, 2000.

2.5. Quality assessment

All the studies incorporated in this study underwent quality evaluation using one of two recognized methods. Firstly, the qualitative selection criteria focusing on study design, sampling, data gathering, relevant data, and data triangulation, along with the reliability of the outcomes and the absence of bias in the research procedure. Secondly, the research foundation, sampling approach, sample size, interpretation, variables used, and study validity were all assessed for quantitative samples.

2.6. Data extraction and synthesis

Information was taken from the included studies using a standardized data extraction form. Author(s), year of publication, country of study, study design, sample size, kind of higher education program, enrollment data (pre-disaster and post-disaster), and study findings were taken from each study. A narrative synthesis method was used to combine the data.

3. Results

3.1. Document identification

The PRISMA approach was used to choose the papers that would be analyzed [35]. In the identification phase, the study's main databases yielded 76 documents, and 5 more were obtained from secondary sources (Fig. 1). In the screening phase, 30 papers were considered unnecessary and eliminated. Most of these papers were excluded because they were irrelevant to the investigation and lacked a focused issue. In the eligibility phase, the PRISMA approach determined which papers were suitable for inclusion based on their coverage of topics, such as natural disaster, student enrollment, and higher education. Out of the remaining 51 papers, 18 were disqualified for various reasons, and 22 documents were chosen for detailed analysis (Supplementary S2. Selected documents).

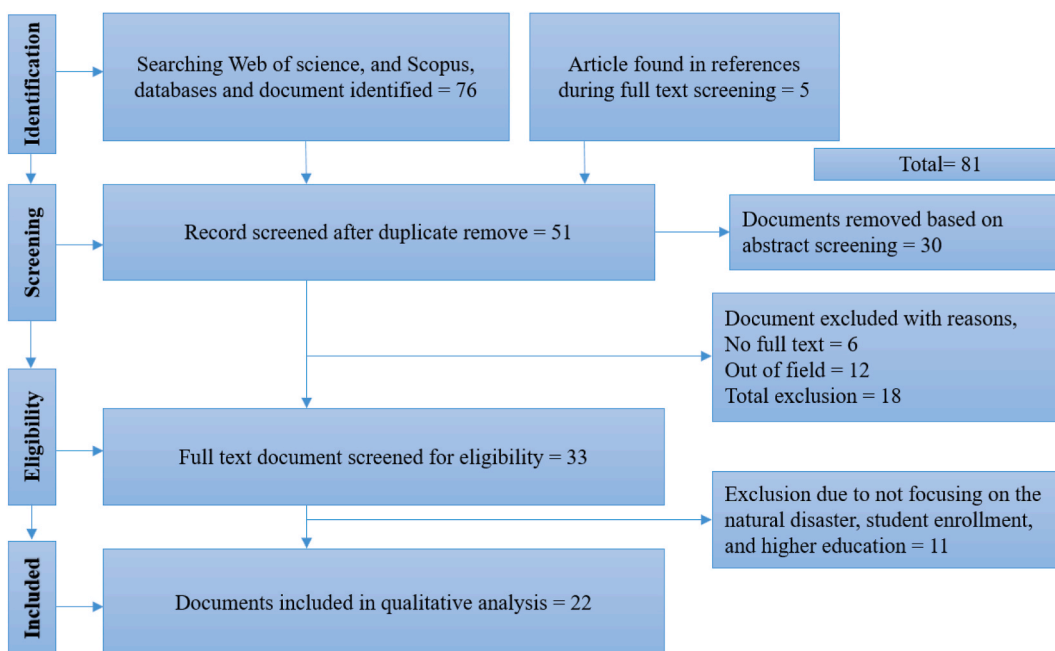


Fig. 1. Document selection for analysis.

3.2. Analytical results

3.2.1. Phases of disruption and impact on student enrollment

The findings indicate a decrease in the number of applications due to natural hazards, which has impacted the ability of potential students to apply and the capacity of institutions to handle these applications. This study also reveals the effects of natural disasters on graduation rates, difficulties in sustaining attendance and retention, and delays in the registration and acceptance procedures. In this study, we also assessed the various stages of enrollment interruption brought on by natural hazards. The four main stages are applications for admission, acceptance and registration, attendance and retention, and graduation. Our findings highlight the possible repercussions for student achievement and higher education institutions by revealing the degree to which natural disasters have impacted each stage. Applications for enrollment are the first step in determining how natural disasters affect student enrollment [37]. We investigate how these occurrences may affect the volume of applications higher education institutions receive and the general demand for higher education. We also examine how natural disasters may impact schools' ability to admit and register students before delving into the acceptance and registration procedure [38]. Understanding the accessibility of higher education after a natural disaster depends on this step. The attendance and retention stage investigates how natural disasters affect students' capacity to show up for class and continue to be enrolled in their respective programs [39]. This stage is crucial for determining how these incidents affect students' academic development and perseverance. The review also assesses the overall consequences of degree completion and potential long-term repercussions for students and institutions. Finally, it examines how natural disasters affect graduation rates [1]. This study clarifies the extensive effects of these events on higher education institutions and the students they serve by looking at each stage of the enrollment process (Table 2).

3.2.2. Influential factors related to disasters on student enrollment

We comprehensively examine the numerous effects of natural disasters on the number of students enrolled in higher education institutions. We have identified several crucial factors that influence the enrollment process, such as physical infrastructure deterioration, economic and psychological consequences, resource limitations, and disturbances to social support networks and academic programs in the aftermath of natural disasters (Table 3).

3.2.3. Resilience enhancement measures

Our research indicates that numerous actions may be taken to improve students' resilience in higher education programs. These include adopting online learning platforms, providing financial assistance, adopting flexible policies, offering mental health support, conducting disaster preparation training, developing robust infrastructure, and establishing collaborative programs. An overview of these strategies is given so that educational institutions, decision-makers, and stakeholders can use them to lessen the effects of natural disasters on student enrolment. The outcomes are arranged into the following categories: online learning platforms, financial aid, flexible enrollment policies, mental health support, training for disaster preparedness, resilient infrastructure, and collaborative programs with other institutions. By implementing these initiatives, institutions can increase their ability to assist students and sustain educational access and quality during and after natural disasters (Table 4).

3.2.4. Overall impact of natural disasters on student enrollment

Several key impacts of natural disasters on all stages of student enrolment have been revealed. The major outcomes are arranged into the following categories: decline in enrollment rates, financial restrictions, disrupted access to education, psychological stress, a shift to online learning, inequities in recovery, and changes in academic emphasis [13,30]. Policymakers, educational institutions, and stakeholders can benefit greatly from analyzing these results as they devise policies and initiatives to lessen the impact of natural disasters on higher education enrolment (Table 5).

4. Discussion

The findings show that natural disasters can disrupt several stages of the student enrollment process. The precise steps of student enrolment, disaster contexts, resilience measures, and outcomes are discussed in this section and presented in Fig. 2.

Table 2
Impact of disasters on different phases of student enrollment.

Phases of disruption	Description	Sources
Enrollment applications	The enrollment process may be hampered by natural disasters, making it challenging for students to submit applications and for schools to handle them.	[37,40]
Acceptance and registration	Natural disasters may cause delays in the registration and acceptance processes, making it difficult for institutions to process applications or send out acceptance letters on schedule.	[38,41]
Attendance and retention	Due to safety concerns or the impact of the disaster on the transportation infrastructure, natural disasters might influence student attendance. Natural disasters can also significantly affect student retention rates, especially for students from underprivileged backgrounds.	[39,42]
Graduation	Natural disasters can also impact students' graduation rates, causing program completion delays due to the disaster's effects on academic resources or the requirement that students take time off from school.	[1,40]

Table 3
Influential factors impacting on different phases of student enrollment.

Influential factors	Description	Sources
Physical infrastructure	<ul style="list-style-type: none"> •Flooding, earthquakes, or storm damage to dormitories or school buildings. •Road and bridge closures make it challenging for students to get to and from school. •Power outages, which reduce the supply of electricity and internet connectivity. 	[25,42]
Economic impact	<ul style="list-style-type: none"> •The disaster caused job losses for families, making paying for tuition and other education-related costs challenging. •Decreased government financing for higher education institutions in disaster-affected areas, which results in increased expenses for schools to repair and replace destroyed infrastructure and raises tuition for students. 	[39,43]
Psychological impact	<ul style="list-style-type: none"> •Students facing anxiety, despair, and other mental health concerns as a result of the trauma of a natural disaster. •Difficulty focusing and learning as a result of chronic stress and emotional difficulties. •A reluctance to return to school due to fear of natural disasters in the future or a repeat of the same disaster. 	[15,41,44]
Resource constraints	<ul style="list-style-type: none"> •Funding cuts for educational resources including computers and textbooks resulting from the disaster. •Reduced availability of student services including counseling and academic advising due to reduced budget and personnel availability. 	[37,43] [45]
Social support networks	<ul style="list-style-type: none"> •Limited faculty and staff availability due to displacement or difficulty commuting to the university. •The disaster's disruption of social networks results in a lack of support for students who could be having a hard time dealing with the fallout. •Difficulty sustaining social ties as a result of moving or losing one's community and home. •Inability to obtain social support services, such as counseling and mental health care, as a result of the disaster's effects on the healthcare system's infrastructure. 	[44,46]
Research and academic programs	<ul style="list-style-type: none"> •The interruption of research projects results from equipment or lab facility damage. •Decreased quality of education due to less availability of faculty and staff or restrictions in course offerings and programming. •Reduced availability of academic resources like libraries and databases owing to power outages or internet connectivity issues. 	[47–49]

Table 4
Resilience enhancement measures of higher education student.

Measures for resilience	Possible indicators	Effective ways of implementation	Sources
Online learning platforms	Increased student enrollment and engagement.	Create and install user-friendly learning management systems, and give the necessary training to teachers and students.	[50,51]
Financial assistance	Accommodate more students for scholarships, grants, or loans.	Create special funding and resources for students affected by natural disasters, and simplify the application process.	[46,50]
Flexible enrollment policies	Higher retention and enrollment rates among students impacted by disasters.	Admissions procedures and deadlines should be modified to accommodate students impacted by natural disasters. Deferred enrollment options should also be made available.	[52,53]
Mental health support	Increased utilization of counseling services and improved mental wellbeing.	Provide counseling services to students affected by a disaster by specialist, and put mental health initiatives in place to promote resilience.	[15,44]
Disaster preparedness training	Improved student and faculty awareness and preparedness.	Include lessons on disaster preparedness in the curriculum and schedule frequent faculty and student training sessions.	[54,55] [23]
Infrastructure resilience	Minimal disruption of educational facilities after a disaster.	Build and renovate educational facilities that can endure natural calamities and maintain them properly.	[27,42]
Collaborative programs with other institutions	Increased number of students participating in an exchange or collaborative programs.	Form alliances with other organizations to offer students to other learning opportunities.	[56] [23,57]

Table 5
Overall impact of natural disasters on student enrollment.

Possible impacts	Possible indicators	Cited sources
Decline in enrollment rates	<ul style="list-style-type: none"> • Reduced number of applications. •Lower percentage of enrollments. 	[13,30] [20,58]
Financial constraints	<ul style="list-style-type: none"> •Increased student loan burden. •Higher dropout rates 	[52,59] [44,46]
Disrupted access to education	<ul style="list-style-type: none"> •School closures •Loss of physical infrastructure 	[40,42] [25,42]
Psychological distress	<ul style="list-style-type: none"> •Increased mental health issues •Lower academic performance 	[15,44] [41]
Shift to online learning	<ul style="list-style-type: none"> •Rapid adoption of remote learning •Changes in pedagogical strategies 	[50,59] [55,60]
Disparities in recovery	<ul style="list-style-type: none"> •Unequal access to resources •Longer recovery times for certain student populations. 	[56,58] [37,61]
Changes in academic priorities	<ul style="list-style-type: none"> •Shift in program/course choices. •Delayed graduation. 	[13,50] [62]

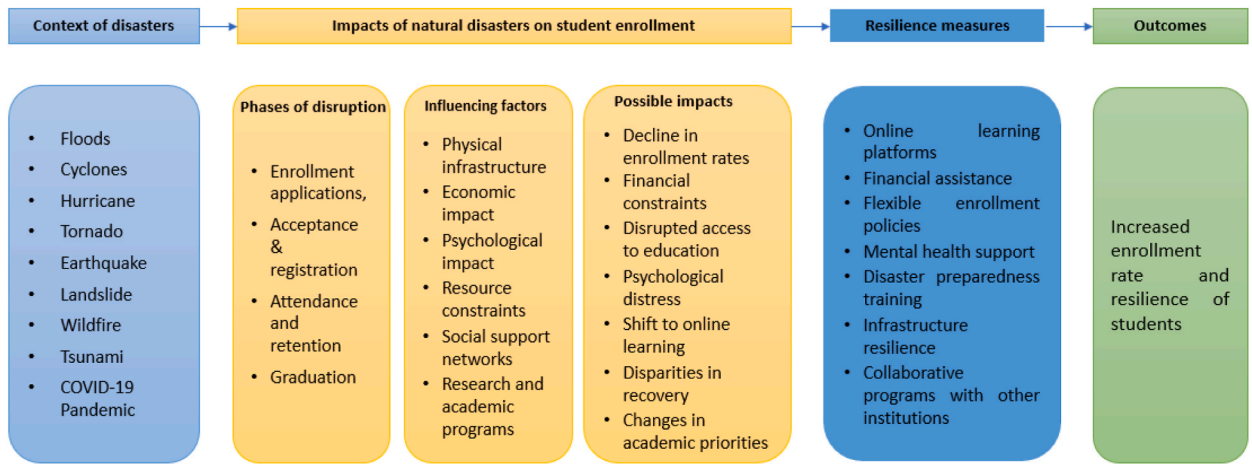


Fig. 2. Various phases of a disaster’s impact and resilience measures in higher education.

4.1. Phases of disruption and the disaster’s impact on student enrollment

4.1.1. Enrollment applications

Natural hazards may significantly impact applications to higher education institutions. They affect enrollment application volume, as seen by a decline in applications. This can be attributed to several factors, including the unavailability of students to submit applications owing to house damage or being evicted from the disaster area [37]. Prospective students may be discouraged from pursuing higher education or forced to postpone their plans due to the uncertainty and instability brought on by these occurrences. It may be challenging for institutions to assess and react to applications on time if campus facilities are closed and they cannot process applications [40]. Additionally, it could be challenging for students to acquire information about programs and application procedures and submit applications on time if communication services and physical infrastructure are disrupted. Institutions can consider alternative application submission methods, such as online applications, and extend deadlines to accommodate students affected by natural disasters to manage this period of interruption.

4.1.2. Acceptance and registration

The acceptance and registration processes may be delayed due to natural disasters, which may affect the start of the academic session. This may result from several factors, including the requirement for schools to evaluate the harm done to campus buildings and allocate appropriate funding for repairs [38]. Due to interruptions in administrative processes, institutions may struggle to process applications and inform applicants of their admission status. In addition, accepted students could experience difficulties with their finances or other factors that prevent them from enrolling in classes and finding accommodation, which lowers enrollment rates [41]. Institutions may also need to concentrate on offering affected students support services before the start of the academic session. Institutions may consider giving students impacted by this disruption phase flexible start dates, remote learning choices, and support services.

4.1.3. Attendance and retention

The capacity of students to attend lessons and maintain their enrollment in their programs can be affected by natural hazards. It could be challenging for students to regularly attend lessons if there are problems with the transit system, they lose their homes, or there is property damage to the school [39]. Furthermore, students’ academic performance and general wellbeing may be harmed by the stress and trauma connected with natural disasters, increasing the likelihood that they will drop of their programs [42]. By offering online courses, extending due dates for assignments and exams, and offering affected student’s intellectual and emotional assistance, institutions can combat this phase of disruption.

4.1.4. Graduation

It could be more challenging for students to meet their degree requirements on time if there are natural calamities. This may result from several factors, including the need to repeat classes, the need to take time off from school to concentrate on recovery, or the inability to complete necessary internships or research projects [1]. The capacity of students to finish their degrees and graduate may be negatively impacted for some time after natural disasters. Long-term changes in academic priorities or interruptions to educational services may cause students to take longer to complete their degree requirements [40]. Financial limitations or continued difficulties with disaster recovery could also cause students to take longer to graduate. Offering flexible graduation requirements, academic support programs for impacted students, and expanding financial aid alternatives can help institutions deal with this phase of disruption.

Policymakers, educational institutions, and stakeholders can better develop and implement targeted interventions to support

students and minimize the negative effects of these events on higher education enrollment by understanding the various phases of student enrollment disrupted by natural disasters.

4.2. Influential factors of disasters and impact on student enrollment

The study highlights multiple facets of this complicated issue. This section describes the influence's numerous facets, such as its physical infrastructure, economic impact, psychological impact, resource limitations, social support systems, and academic and research programs.

4.2.1. Physical infrastructure

The physical infrastructure of higher education institutions can significantly impact student enrollment during and after natural disasters. Campuses that have suffered damage might not be able to provide students with a secure environment for studying. Additionally, institutions might be unable to fit all enrolled students if classrooms and other facilities are unusable, resulting in overcrowding or the requirement to postpone lessons [25]. The physical infrastructure of educational institutions, including classrooms, libraries, dorms, and other facilities, can sustain significant damage due to natural disasters [42]. This harm could prevent institutions from operating normally, prevent students from accessing educational resources, and make maintaining a supportive learning environment difficult, which could harm student enrollment and retention. Institutions can concentrate on infrastructure reconstruction and invest in disaster-resilient infrastructure to address these issues. This can entail implementing sustainable building techniques, bolstering current structures, and creating backup plans for campus closures.

4.2.2. Economic impacts

Natural disasters' economic impacts may greatly impact how many students enroll in higher education. Due to financial difficulty brought on by a loss of income or property, students may find it challenging to pay for tuition and other costs [39]. Institutions might also have to pay more for the costs of reconstruction and restoration. Financial limitations brought on by the disaster may result in higher student loan debt loads, fewer scholarships or other forms of financial aid, and higher dropout rates. These elements may eventually restrict access to higher education and have a detrimental impact on enrollment rates [43]. Institutions can respond by providing emergency grants and loans, scholarships, and exemptions for tuition and fees to impacted students in order to help them financially. Institutions can create disaster preparedness plans that include measures for preserving financial stability in emergencies to address institutional expenses.

4.2.3. Psychological impacts

Students who have experienced natural disasters may experience substantial psychological impacts that may affect their decision to enroll in or remain in higher education programs [15]. These experiences of stress and trauma may lead to more mental health problems, poorer academic performance, and decreased enthusiasm to pursue educational goals [41,44]. Institutions can address this impact by offering affected person's therapy and mental health services. This could include counseling on an individual or group basis, crisis intervention, and other assistance. Institutions can also support faculty and staff members' mental health and wellness through awareness campaigns, training sessions, and other activities.

4.2.4. Resource constraints

Natural disasters frequently limit resources, affecting students and educational institutions. Due to decreased financing or personnel, institutions may struggle to maintain the quality of their academic programs [37], while students may encounter difficulties getting access to the materials they require for their studies, such as textbooks, computers, and other resources. Institutions might be unable to accommodate all students' needs if campuses are destroyed or shut down [43]. This could involve issues with the availability of academics and academic staff, technological and academic resources, etc. [45]. By investing on disaster preparedness plans that include techniques for resource sharing across institutions and forging alliances with community organizations, institutions can address this effect. Institutions can ensure that students have access to the tools they need to succeed academically by taking this action.

4.2.5. Social support networks

Social support networks are essential for helping students overcome the difficulties brought on by natural disasters [44]. The loss of family members, friends, or community support can exacerbate students' difficulties in accessing and succeeding in higher education, particularly for those who rely on these networks for financial, emotional, or logistical support [46]. When these incidents affect students' personal lives, they could struggle to juggle academic obligations with personal recovery efforts. Institutions can address this dimension of impact by providing support services and resources to affected students, including access to community organizations, housing and food assistance, and transportation. Additionally, institutions can build partnerships with community organizations to ensure students' access to necessary support networks.

4.2.6. Research and academic programs

Finally, the research and academic programs that higher education institutions offer might be affected by natural disasters [47]. Disruptions to ongoing research projects, shifts in academic priorities, or changes in faculty availability may alter the courses and programs offered, further affecting student enrollment and retention [48,49]. Institutions can address this impact dimension by

offering flexible academic requirements and supporting alternative forms of academic engagement, such as online research and internships. Authorities can also support academics and students conducting disaster-related research with resources and assistance, allowing them to contribute to the recovery.

Policymakers, educational institutions, and stakeholders can better understand the difficulties faced by students and work toward developing successful strategies and interventions to mitigate these effects by looking at the various aspects of how natural disasters affect student enrollment in higher education.

4.3. Overall impact of disasters on different phases of student enrollment

From initial enrollment to graduation, natural disasters substantially impact all stages of student enrollment. Reducing enrollment numbers, financial restrictions, disrupted access to education, psychological suffering, a move to online learning, inequities in recovery, and changes in academic priorities are just a few ways these catastrophes' overall effects can be recognized.

4.3.1. Decline in enrollment rates

Natural disasters can cause declining enrollment rates due to fewer applications, lower acceptance rates, and fewer registrations [13,30]. The uncertainties of the disasters may discourage prospective students from pursuing higher education or force them to delay their plans until things stabilize. Natural disasters have a major and wide-ranging effect on student enrollment [20,58]. The drop in enrollment rates is one of the most obvious effects. This reduction may be caused by infrastructure damage, student displacement, and financial difficulty.

Furthermore, students who experience a crisis might not put their education first in the immediate aftermath. Institutions can lessen this impact by providing flexible academic requirements, financial aid, and online learning options. They can assist impacted students in continuing their education and maintaining their academic progress.

4.3.2. Financial constraints

Natural disasters' financial effects can greatly impact students' capacity to start or finish higher education programs [59]. Students may experience financial hardship due to lost family incomes, property damage, and rising living costs [52]. This can result in many difficulties, including trouble financing needs like tuition, books, and food [44]. Students may be forced to postpone or give up their academic goals due to lost income, rising costs, and diminished access to financial help or scholarships [46]. Institutions can lessen this effect by offering emergency grants, loans, and scholarships to impacted students. Institutions can lessen some of the stress and difficulties students face by offering financial support.

4.3.3. Disrupted access to education

Another substantial effect of natural disasters on student enrollment is disrupted access to education. Students might not be able to attend classes, get access to academic resources, or finish academic obligations when campuses are damaged or shut down [40]. As a result, students may make slower academic progress, experience more stress and worry, and feel cut off from the academic community [42]. Natural disasters can prevent people from getting access to education by destroying physical infrastructure, disrupting transportation, and depleting resources [25]. These elements may make it challenging for students to attend class, access reading materials, and maintain a positive learning environment. Institutions might lessen this impact by providing online learning opportunities, pooling resources among institutions, and forming alliances with neighborhood organizations. In times of disruption, they can do this to support students in maintaining their academic progress and a sense of community.

4.3.4. Psychological distress

Students also face a psychological distress due to natural disasters. These events' related trauma and stress can affect students' academic and mental health [15]. This may manifest in various ways, such as trouble concentrating, diminished motivation, and heightened anxiety and depressive symptoms [44]. Natural disaster-related psychological distress can negatively influence students' motivation, academic performance, and mental health, which may impact how many students enroll in and stay in higher education programs [41]. Additional assistance and resources may be needed to help students cope with the stress and trauma of these occurrences and achieve academic success. Institutions might decrease this impact by providing counseling and mental health services to affected students and promoting mental wellbeing. By paying attention to their students' mental health and welfare, institutions may help students overcome the challenges brought on by natural disasters and preserve their academic achievement.

4.3.5. Shift to online learning

After a natural disaster, switching to online education may aid in preserving students' access to education. Online learning can be a useful resource for students who cannot attend classes in person, but it can also be difficult for those who lack access to the required equipment or academic materials [50,59]. This may widen already existing gaps in academic success and performance. A shortage of digital infrastructure, unequal access to technology, and changes in pedagogical practices that can affect student enrollment are a few of the difficulties that may arise from the rapid adoption of remote learning [55,60]. Institutions can lessen this effect by providing resources and assistance for online learning, such as technology loans, online tutoring, and online study groups.

4.3.6. Disparities in recovery

Natural disasters considerably impact student enrollment, as do disparities in recovery. Depending on their access to services and

support, there may be differences in recovery and academic achievement among students [58]. This can be especially difficult for students from historically oppressed communities who may already be experiencing institutional impediments to academic success [56]. Different student populations may not have equal access to resources and support due to differences in the recovery after natural disasters [37]. This disparity may widen educational achievement differences and make it more difficult for at-risk students to participate in higher education programs [61]. Institutions can lessen this effect by offering resources and support to all impacted students, regardless of their circumstances or background. Institutions may ensure that all students get the support they need to overcome the difficulties posed by natural disasters by prioritizing equity and inclusion.

4.3.7. *Changes in academic priorities*

Natural disasters can also have an impact on students' academic priorities. Some may decide to change their programs or courses as a result of the disaster's negative consequences on their future prospects or quality of life [13,50]. This may be a challenging opportunity for institutions to engage with their communities and assist disaster response and recovery activities for students who might feel overwhelmed or unsure of how to contribute. The delays caused by these occurrences may also prevent certain students from graduating on time [62]. Institutions can lessen this effect by promoting alternative modes of academic engagement and research, such as online research and internships, and by ensuring access to resources and assistance faculty and staff members working on disaster-related projects. By doing so, they may ensure that students can participate in their academic community and meaningfully contribute to disaster response and recovery activities.

Policymakers, educational institutions, and stakeholders can establish targeted interventions and measures to reduce these effects and promote students' access to and success in higher education by analyzing the overall impact of natural disasters on various phases of student enrollment.

4.4. *Resilience measures to overcome natural disaster effects*

4.4.1. *Online learning platforms*

Online learning offers students a flexible and accessible alternative to completing their education even when physical access to schools and classrooms is impeded. Students affected by natural disasters may still have access to education by deploying online learning platforms [50]. Educational institutions can ensure continuity in instruction and adjust to the changing requirements of students during and after disasters by providing remote learning options [51]. Institutions might invest in online learning infrastructure, platforms, and technologies to support remote instruction and sustain academic continuity during and after natural disasters. Additionally, distance learning can aid students who might not otherwise have access to higher education by bridging geographic divides.

4.4.2. *Financial assistance*

Students and their families may experience severe financial hardship due to natural disasters, resulting in property damage, lost income, and increased costs for recovery and reconstruction. Lagmay and Rodrigo [63] reported that extreme weather occurrences cause physical and financial harm, which negatively affects academic success. Young children from economically challenged households have less parental involvement and financial support for their schooling, which leads to a performance difference that widens with time. O'Shea et al. [55] argued that higher education institutions (HEIs) provided various forms of financial assistance based on the requirements of the students and the available funding. These benefits included tuition fees, extra scholarships, money for research, travel, and help with leaving university.

4.4.3. *Flexible enrollment policies*

Students who are impacted by natural disasters can be accommodated with the use of flexible enrollment policies, such as extended application deadlines, alternate admission requirements, or postponed enrollment options [52]. These regulations may give students more time and assistance as they negotiate the difficulties caused by the disaster and choose their educational paths. Institutions can accommodate students requiring more time to finish their coursework due to natural disasters by offering deferred enrollment, flexible timetables, and extended deadlines [53]. This can ensure that students don't suffer consequences for events out of their control and can keep progressing in their academic objectives.

4.4.4. *Mental health support*

Affected students require mental health support to cope with the psychological strain brought on by natural disasters. Students can handle stress, anxiety, and trauma using counseling services, support groups, and other mental health resources, enhancing their well-being and academic performance [15]. Institutions can help students deal with the psychological effects of natural disasters by providing counseling services, mental health resources, and support groups [44]. Institutions can aid students in overcoming trauma and advancing their academic careers by offering a safe and encouraging atmosphere for them to process their experiences.

4.4.5. *Disaster preparedness training*

Incorporating disaster preparedness training in curricula can assist students in acquiring the abilities and information needed to survive and recover from natural disasters [54]. Courses on emergency preparedness, community resilience, and disaster risk reduction may be included in this training to help students become more resilient to disasters in the future [55,64]. Institutions can provide faculty, staff, and students with tools and training to help them be prepared for and respond to natural hazards. This can involve

emergency planning, evacuation protocols, and communication techniques to keep everyone safe and informed during a disaster [23].

4.4.6. Infrastructure resilience

Resilient infrastructure can assist educational institutions in withstanding the physical effects of calamities while preserving a positive learning environment for students [27]. This can involve renovating existing structures, designing new construction to be more disaster-resistant, and creating backup plans for keeping vital services running in an emergency [42]. Institutions can lower the risk of damaging and disrupting campus facilities by enhancing physical infrastructure's resilience to natural disasters [65]. This can involve upgrading structures, setting up backup generators, and taking other actions to guarantee that crucial services continue to be provided during and after natural disasters.

4.4.7. Collaborative programs with other institutions

Collaboration with other universities can help create programs that give students affected by natural disasters more resources and support [23]. These connections can be exchange programs, co-degree programs, or research projects that let students continue their studies while their home institutions rebuild from the catastrophe [56]. To pool resources and expertise, coordinate relief efforts, and offer a more extensive network of support for impacted students, schools can collaborate with other institutions of higher education, non-profit groups, and governmental organizations [57].

5. Conclusion

Natural disasters provide serious obstacles to the operation of institutions of higher learning and may negatively impact all facets of student enrollment, from application through graduation. This study aimed to provide policymakers, academic institutions, and stakeholders with useful insights by synthesizing the relevant literature.

This study aimed to find ways to reduce the effects of natural disasters on student enrollment in higher education programs and to offer a thorough understanding of the impact of such effects. This study demonstrates that natural disasters negatively impacted student enrollment via various channels, including relocation, infrastructure destruction, financial hardship, and psychological stress. These effects disproportionately negatively impacted disadvantaged and vulnerable individuals, aggravating existing disparities in access to higher education. This study emphasizes the need for comprehensive, context-specific disaster management plans that account for immediate and long-term educational needs. The findings have substantial practical ramifications for higher education organizations, decision-makers, and stakeholders. These stakeholders may establish targeted interventions and policies to support students and sustain educational access and quality during and after disasters.

Our findings suggest that policymakers should allocate resources for financial assistance programs and support the development of online learning platforms to ensure the continuity of education during and after natural disasters. Higher education institutions should invest in disaster preparedness and resilience, provide mental health support to affected students, adopt flexible enrollment policies, and explore partnerships with other institutions.

Limitations of the research

This study's limitations should be considered when evaluating the results. First, this study is solely dependent on the available relevant published journal articles. Due to publication bias, the influence of natural disasters on student enrollment or the efficiency of mitigation measures may be overestimated. Second, leaving out studies written in languages other than English may restrict the review's reach and leave out studies from various geographical and cultural contexts. This restriction might limit the applicability of our findings and leave out important information from non-English literature. Third, the comparative validity and synthesis of the results may be constrained by the variability of the included research in terms of methodology, geographical regions, and types of natural disasters. This variety may also make it difficult for us to come to firm conclusions regarding the overall effect of natural disasters on student enrollment or the efficacy of particular interventions in various contexts. Fourth, the quality of included studies can vary, with some perhaps having methodological flaws or limitations on presenting their findings. These problems might compromise the validity and dependability of the inferences made from our systematic review. Finally, despite our thorough search approach, it's possible that not all of the pertinent literature on the subject was included in our evaluation. An incomplete picture of the present state of knowledge about the effects of natural disasters on student enrollment in higher education programs and potential mitigation techniques may have resulted from the absence of recent publications, grey literature, or unpublished studies.

Despite these drawbacks, the systematic review gives insightful analysis into the complex effects of natural catastrophes on student enrollment and useful suggestions for dealing with these issues. However, care should be taken when generalizing the results to various contexts, and more study is required to address the gaps and limitations noted in this analysis.

Future research directions

Future studies can overcome the review's shortcomings and delve deeper into the complex connection between natural disasters and student enrollment. Comparative studies can illuminate the elements that lead to resilience and recovery in various situations, whereas longitudinal studies are necessary to understand further the long-term effects of these events on enrollment patterns. Additionally, studies on the efficiency of particular interventions and regulations can help guide best practices for assisting students and preserving educational access and standards during and after natural disasters.

CRedit authorship contribution statement

Jing Wang: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2024.e27705>.

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