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The utilisation of education as a means of mitigating the impact of natural disasters

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Abstract

In the 21st century, there has been a notable increase in the frequency and intensity of natural disasters. Such phenomena have the potential to inflict human suffering, cause economic damage and precipitate changes to the environment. The most commonly cited types of natural disasters in the literature are as follows: windstorms, floods, extreme temperatures, droughts, wildfires, earthquakes, tsunamis, volcanism, mass movements, epidemics, and pest infestations. Education can be employed as a means of mitigating the impact of such phenomena by focusing on the following concepts: emergency management, disaster policy, disaster risk management, disaster risk reduction, event-related policy change, hazard protection, and natural disasters policy. The application of education in the mitigation of the consequences of natural disasters is typically focused on two key areas: the dissemination of knowledge to the inhabitants of regions prone to such occurrences and the training of prospective emergency personnel and urban planners. While the aim is to mitigate the negative effects, it is also essential to recognise that natural disasters can, on occasion, result in beneficial outcomes. Furthermore, human activities can disrupt the natural ecosystems in which natural disasters occur, subsequently increasing the risk of such events.

Keywords: teaching and education, health and welfare, environment and sustainable development, flood, storm, drought
Jel codes: F52, H12, H56, I18, I20, Q01

1. Introduction

In the 21st century, there has been a notable increase in the frequency and intensity of natural disasters. A disaster is defined as an event that causes human suffering, economic damage and changes to the environment. Such events frequently exceed the capacity of local authorities, thereby necessitating external assistance at the national or international level. The most commonly distinguished natural disasters are earthquakes, tsunamis, volcanism, mass movements, windstorms, floods, extreme temperatures, droughts, wildfires, epidemics and pest infestations (Abbott, 2009; Piepiora, 2010; Piepiora, 2012).

The prevailing view is that natural disasters are unavoidable. However, some can be prevented, others can be adapted to or their effects can be mitigated (Piepiora, 2010; Piepiora, 2012). Various institutions are responsible for preventing the effects of such phenomena, based on concepts such as:

- disaster management (also called 'emergency management') (Alexander, 1993);
- disaster policy (Platt and Rubin, 1999);
- disaster risk management (Garatwa and Bollin, 2002);
- disaster risk reduction (also called 'disaster reduction') (UN/ISDR, 2009).
- event-related policy change (Birkland, 2007);
- hazard protection (Grocki 2003);
- natural disasters policy (Piepiora, 2010; Piepiora, 2012).

These initiatives have a common objective, namely to utilise education as a means of mitigating the impact of natural disasters. The following section will present an overview of the various types of natural disasters and illustrate how education can be employed to mitigate their adverse effects (Piepiora, 2010; Piepiora, 2012).

2. Data & Methodology

The issues raised justified the use of the evidential research method. The research process was divided into two stages – analysis with deductive reasoning and synthesis with inductive reasoning. The document examination method was used to collect source materials. An important source of information was the EM-DAT database on the occurrence of natural disasters in the world and their consequences. The structure of the article was subordinated to the formulated research problem (EM-DAT, 2024; Piepiora, 2019).

3. The usage examples of education as a means of mitigating the impact of natural disasters

The initial category of natural disasters is volcanism. This phenomenon is frequently accompanied by a range of other effects, including severe volcanic ash falls, lava outpourings, ejections of pyroclastic materials, earthquakes, landslides and shifts, mud and water flows (lahars), and global weather changes. A recent example of volcanism is the eruption of the 'Lewotobi Laki-Laki' volcano in Indonesia in November 2024. This eruption resulted in 10 fatalities, 66 injuries, and approximately 11,500 individuals being affected. The ash from the volcanic eruption led to the cancellation of flights to Bali (Cegła et al., 2022; EM-DAT, 2024; Piepiora, 2010; Piepiora, 2012).

The primary objective of teaching the counter effects of volcanism is to highlight the necessity of avoiding the construction of human settlements in areas characterised by high seismic activity. In practice, however, more than half a billion people currently reside in close proximity to active volcanoes, primarily in the Philippines, Indonesia, Japan, Mexico, the United States, and Italy. The scarcity of land, high population density, favourable climatic conditions, fertile soils and scenic beauty are driving an increase in the number of people living in proximity to volcanoes that are often perceived as extinct (Del Negro, 2019; Piepiora, 2010; Piepiora, 2012).

The inability to resettle such a large population necessitates the implementation of alternative strategies to mitigate the effects of volcanic eruptions. These strategies include the training of emergency services on enhanced warning and evacuation procedures, as well as the dissemination of information to at-risk populations regarding the characteristics, consequences, and potential insurance options associated with volcanic eruptions (Penatas, 2024; Piepiora, 2010; Piepiora, 2012).

The seismic activity that occurs in conjunction with volcanic eruptions can result in casualties and extensive damage to property. Furthermore, they can result in substantial alterations to the topography of the land, with the potential for flooding as a consequence of the obstruction of water runoff by large landslides, which dam the riverbed and lead to an increase or decrease in groundwater levels. Seismic shocks can also give rise to the formation of giant tsunamis, which have the potential to extend considerable distances inland over low-lying coastal regions. The rupture of power cables or gas lines is a common consequence of earthquakes occurring in densely built-up areas, which often result in fires. In November 2024, an earthquake of this type occurred in Cuba. Approximately 6,000 individuals were impacted, and infrastructure was severely damaged (EM-DAT, 2024; Pawłuszek and Borkowski, 2017; Piepiora, 2010; Piepiora, 2012).

The education of future space planners, emergency workers and the population living in areas at risk of such phenomena includes the prevention of the negative consequences of earthquakes. Education in appropriate urban spatial planning allows for (Kudłacik et al., 2019; Piepiora, 2010; Piepiora, 2012; Yani et al., 2024):

- avoiding the construction of human settlements in areas of high seismic activity,
- avoiding decorating the facades of buildings with protrusions, balconies, cornices that pose a risk to people evacuating the buildings,
- building on flat land with stabilised soils;
- locating buildings away from unstable slopes, and avoiding building on loose soil;
- providing the city with ample space occupied by parks, which ensure opportunities for residents to evacuate and are places where fire is difficult to spread;
- implementing a seamless urban transport system.

The provision of adequate training to emergency services personnel, including the fire brigade, ambulance service, police and other relevant agencies, enables the enhancement of their operational capabilities. This is particularly evident in the context of activities pertaining to the issuance of warnings and the evacuation of local populations (Palm and Ramsell, 2007; Piepiora, 2010; Piepiora, 2012).

The provision of adequate education to those residing in areas prone to seismic activity enables the development of the capacity to evacuate in a timely manner when tremors are anticipated, as well as instilling a sense of confidence in the reliability of catastrophic forecasts, despite the inherent limitations in their accuracy. It is crucial that information regarding the risks associated with earthquakes is disseminated not only to the students being instructed, but also to their parents or legal guardians, who should possess a comprehensive understanding of the nature of the phenomenon and its potential consequences (Kotsis and Elefthiera, 2024; Piepiora, 2010; Piepiora, 2012).

Tsunamis are caused by a rapid change in the shape of the seabed, which is often the result of an earthquake. The rapid lowering or raising of a section of the seabed causes the movement of the column of seawater from the surface to the ocean or sea floor. This phenomenon has the potential to cause significant disruption along coastlines, resulting in the destruction of a vast array of structures and, in some cases, the loss of human life. A notable example is the tsunami that followed the 2009 Oceania earthquake (EM-DAT, 2024; Okai et al., 2010; Piepiora, 2010; Piepiora, 2012).

The education of the general public on the limitations of construction on coastlines will not provide adequate protection against tsunamis, which often penetrate far inland. Education is based on the training of emergency services to warn and evacuate the population before an approaching wave. In addition, large-scale public education programmes for both the inhabitants of tsunami-hit areas and tourists travelling to these areas are of great importance. These programmes should include an examination of the nature and effects of the tsunami and the potential for insurance coverage against its consequences. Evacuation is also a key aspect of tsunami preparedness. It is often the case that only those who live in coastal areas that are prone to tsunamis are aware that, in the minutes or so before a wave arrives, the sea retreats from the shore to below the lowest tide level(Cels et al., 2023; Piepiora, 2010; Piepiora, 2012).

It has been observed that more than half of tsunamis are preceded by a rapid lowering of the water table at the shoreline, which can last up to several minutes and reach a depth of one to a few metres. This allows for a rapid evacuation to higher ground. Additionally, the initial wave may be relatively small in height, providing a greater window of opportunity for those fleeing. Following the initial wave, there is a subsequent lowering of the water level and a period of relative calm. It is only later that a significantly larger wave arrives (Piepiora, 2010; Piepiora, 2012; Suwaryo et al., 2024).

One of the most pervasive phenomena responsible for natural disasters on Earth is the occurrence of mass movements, often in conjunction with earthquakes. These processes and phenomena are characterised by the destruction of the ground structure, which is their common feature. It is characterised by a pronounced displacement and deformation under the influence of gravity. The term ‘mass movements’ encompasses a range of phenomena, including rockfall, ground avalanches, snow avalanches, and collapse. Mass movements encompass both rapid and slow movement of rock masses, as well as various types of runoffs and slides. They can be caused by a multitude of factors, including geophysical, meteorological, and hydrological phenomena. In September 2024, a mudslide triggered by heavy rainfall struck Mexico, resulting in 16 fatalities and affecting over 100 individuals (EM-DAT, 2024; Permana, 2023; Piepiora, 2010; Piepiora, 2012).

The education of future space planners, emergency workers and the population living in areas at risk of mass movements is similar to that of earthquakes. It is designed to equip these groups with the knowledge and skills required to mitigate the effects of mass movements. Education in appropriate spatial planning allows human

habitats to be located away from potentially hazardous areas, on flat terrain or on slopes with a slight gradient (Piepiora, 2010; Piepiora, 2012; Ronggowulan et al., 2024).

The training of mountain rescuers enhances the monitoring and anticipation of the risks associated with the recurrent occurrence of mass movements, which tend to utilise the same transport routes, river valleys or slopes. Furthermore, it is the responsibility of the rescuers to alert the local population and tourists to the potential risks posed by mass movements and to provide assistance to those affected. The efficacy of their actions is contingent upon the enhancement of data collection, transmission and processing procedures, the introduction of contemporary forecasting techniques, and the dissemination of warnings and messages to decision-making centres and the public (Piepiora, 2010; Piepiora, 2012; Wang et al., 2024).

The teaching of the population living in areas at risk of mass movements involves the familiarisation of the public with the nature and effects of surface mass movements, the dissemination of information regarding the issuance of warnings against avalanches in mountainous regions, the explanation of the five-level scale adopted in the global system for categorising avalanche danger, the presentation of evacuation methods and the dissemination of information regarding insurance options against the unfortunate consequences of their occurrence (Piepiora, 2010; Piepiora, 2012; Tim et al., 2024).

Extreme temperatures represent another category of natural disaster. They encompass heatwaves, cold waves, and extreme winter conditions, as exemplified by those that recently affected the US in November 2024. The primary objective of educational initiatives in this context is to raise public awareness of the potential for insuring against the consequences of extreme temperatures and to influence behaviours that prepare for adverse weather forecasts (EM-DAT, 2024; Piepiora, 2010; Piepiora, 2012; Marin et al., 2024).

Prolonged extremes of temperature and lack of rainfall cause droughts, which result in significant agricultural and economic losses. These conditions lead to insufficient moisture for the water needs of plants, water deficits for the maintenance of live-stock, normal farming and human functioning, including economically. Additionally, droughts contribute to the spread of deserts. In 2024, a severe drought impacted the southern part of Africa (Dąbrowska et al., 2023; EM-DAT, 2024; Piepiora, 2010; Piepiora, 2012; Piepiora et al., 2017).

The education of the public on the causes of desertification and the means of their elimination is a key aspect of counteracting the effects of droughts. This encompasses a range of human-related factors, including over-irrigation, agricultural activities, live-stock farming, logging and forest fires, as well as other, less directly related factors such as spontaneous fires and erosion (Kalbarczyk and Kalbarczyk, 2022; Piepiora, 2010; Piepiora, 2012).

The occurrence of wildfires in forests, peatlands, scrublands and grasslands results in considerable losses. Furthermore, these fires result in significant atmospheric emissions of gases and dust, which contribute to soil erosion and global and local changes in water and climate conditions. In addition to forests, they also destroy fauna and flora. This type of disaster can also spread to human settlements or landfills, leading to additional damage. For instance, in 2024, a series of devastating fires hit the forests of the Amazon (EM-DAT, 2024; Kuta et al., 2023; Piepiora, 2010; Piepiora, 2012).

Education in counteracting the effects of spontaneous fires is based on the implementation of forest fire prevention activities, including the prohibition of public access to forests during periods of elevated fire risk and the provision of training for forest and emergency services personnel (Piepiora, 2010; Piepiora, 2012; Restaino et al., 2024).

The occurrence of spontaneous fires can be intensified by windstorms. Storms are among the natural disasters that can cause enormous damage, with the destructive factors being wind, violent lightning and heavy rain and tidal surge. For example, the series of typhoons that hit the Philippines in 2024 (EM-DAT, 2024; Piepiora, 2010; Piepiora, 2012; Szewrański et al., 2018) demonstrated the potential for significant destruction.

Education in the mitigation of the effects of windstorms entails the training of emergency services and the dissemination of information to the general public regarding the importance of personal insurance and the construction of shelters or reinforced sections of buildings for use in the event of an emergency. This is particularly relevant for residents situated in areas prone to tornadoes ('tornado alleys') (Lee et al., 2020; Piepiora, 2010; Piepiora, 2012).

Storms are a frequent cause of flooding. The losses incurred as a result of flooding are typically considerable, given that people have, for centuries, established themselves along rivers that provide convenient transport routes. For instance, the low-pressure area associated with the Genoese storm Boris in September 2024 led to flooding across Europe (Jarynowski et al., 2025; Olearczyk and Stodolak, 2015; Piepiora, 2010; Piepiora, 2012).

The primary objective of flood prevention education is to highlight the necessity of avoiding the construction of human settlements in natural floodplains and the reduction of human activities that can exacerbate the impact and frequency of such disasters. The severity of flooding is exacerbated by agricultural activities that result in soil erosion, poorly planned settlements that contribute to soil hardening, and the clearance of forests, which serve as natural flood mitigators (Ancheta et al., 2020; Piepiora, 2010; Piepiora, 2012; Piepiora, 2019; Szewrański et al., 2015; Wieczorek et al., 2024).

It is also important to consider the impact of epidemics as a further type of natural disaster. It is evident that epidemics, which can be categorised as diseases of viral, bacterial, parasitic, fungal or prionic origin, have frequently exerted a profound influence on world history. The occurrence of epidemics has resulted in significant alterations to the geographical, economic and religious aspects of numerous countries. The ramifications of epidemics, which can lead to threats to life and health, economic stagnation, substantial social and economic losses, and the potential for public disorder due to the risk of panic, are undoubtedly detrimental. This was exemplified by the advent of the SARS-CoV-2 pandemic(Levine et al., 2023; Perwenis and Szewrański, 2022; Piepiora, 2010; Piepiora, 2012).

The teaching of methods to counteract the effects of epidemics involves the dissemination of information to the public regarding the utilisation of appropriate vaccinations. Frequently, each variety of infection necessitates the implementation of a bespoke control strategy, typically associated with the requirement for individuals to utilise appropriate protective clothing and restrictions on trade, transport and tourism (Aslanoğlu et al., 2025; Piepiora, 2010; Piepiora, 2012).

As with epidemics, insect infestations have a detrimental impact on humans, plants and animals. Such infestations can pose significant risks to life and health, as well as substantial social and economic losses and threats to public order, particularly in the context of panic. For instance, in 2019, a plague of locusts affected the eastern part of Africa. In addition to locusts occurring in flocks, infestations of mosquitoes, wasps, ladybirds, ticks, or other insects can also cause considerable damage (Dancewicz et al., 2023; EM-DAT, 2024; Piepiora, 2010; Piepiora, 2012).

Education pertaining to the mitigation of the adverse effects of pest infestations encompasses the training of emergency services in preparedness for such occurrences and disseminating knowledge about the feasibility of insuring against losses incurred due to a range of infestations (Fageer and Ahmed, 2010; Piepiora, 2010; Piepiora, 2012).

An increase in educational activities may contribute to a reduction in the tendency for people to act in a convenient and thoughtless manner. The level of awareness among the general public with regard to the risks associated with natural disasters can be enhanced through a variety of means, including the education and study system, printed and digital informational materials such as brochures, books, articles in local press outlets, television programmes, educational films, radio programmes, training materials, competitions for children and young people, social media platforms, and the use of augmented reality and artificial intelligence. The educational system offers a variety of avenues for imparting knowledge about the risk of natural disasters. These include subjects such as Defence Preparation, Geography, Biology or Physics at the secondary level, while at the university level, the focus is on security-related subjects. The dissemination of information via social media posts or brochures allows for the conveyance of data tailored to specific local threats, as is also the case with articles in the local press. At the same time, more general information can be included in books. Popular science educational programmes and films can attract a greater number of viewers than books, prompting associations with reports from locations affected by natural disasters in news broadcasts on radio, television and the Internet. Training materials facilitate the dissemination of knowledge primarily among personnel in public administration and emergency services, while competitions promote natural disaster risk issues among children and young people (Piepiora, 2010; Piepiora, 2012).

In the context of natural disasters, it is important to recognise that, while these events often result in significant losses, they can also bring about benefits (Piepiora, 2010; Piepiora, 2012). For instance, some natural disasters, rather than deterring tourists(Kulczyk-Dynowska et al., 2025), may actually lead to increased tourist traffic. However, it is unfortunate that, in many instances, disaster tourists tend to limit themselves to photographing the sites of natural disasters, thereby risking their own lives and those of others, including the emergency services.

Spontaneous fires can also have beneficial effects, for example by allowing the proliferation of beneficial species such as the lodgepole pine. Furthermore, droughts can also confer advantages, as they result in a reduction of the water level in rivers and lakes, thereby creating conditions conducive to the discovery of archaeological sites. In contrast, the occurrence of floods allows the germination of cottonseed, which in turn increases the population of numerous fish species. The occurrence of frequent minor floods has been observed to result in increased drainage of larger river channels, thus reducing the threat of major floods. Additionally, the rushing river waters

have been found to carry a significant amount of sediment, which, upon deposition, creates fertile soils that are highly conducive to agricultural activities (Piepiora, 2010; Piepiora, 2012). Furthermore, it is often the case that humans interfere with the ecosystem of which natural disasters are a part, subsequently becoming affected by them.

4. Conclusions

As a result of the analysis, the following conclusions can be drawn.

1. Education can be used as a means of mitigating the impact of natural disasters in the following concepts: disaster management, disaster policy, disaster risk management, disaster risk reduction, event-related policy change, hazard protection, natural disasters policy.

2. The use of education in mitigating the impact of natural disasters is most often based on the education of future space planners, emergency workers and the population living in areas at risk of such phenomena.

3. When using education as a means of mitigating the impact of natural disasters, it should be remembered that natural disasters, generally causing significant losses, sometimes also bring benefits.

4. It should also be emphasized that it is often the case that humans interfere with the ecosystem of which natural disasters are a part, becoming later affected by them."

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