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Strategies for Ensuring Safe, Accessible, and Resilient Schools in Developing Countries: A Focus on Disaster Mitigation

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A B S T R A C T

The problem of equal quality education still occurs in several developing countries such as Indonesia. Educational infrastructure is one factor that influences the quality of learning provided in schools and students' motivation to learn. Accessibility problems such as the location of the school far from settlements and the inadequate physical condition of the roads mean that students must take a long time to arrive at school. This affected the decrease in motivation and enthusiasm of students to study at school. The occurrence of damage to school infrastructure and the safety of students threatened by disasters also affect student performance in learning.
Additionally, environmental factors such as air pollution and traffic noise cause inconvenience to students and teachers and decrease students' concentration and comprehension in class. Through systematic review methods from journals and related literature, several strategies have been developed to strengthen multi-disaster resilience in schools that are integrated with environmental conditions and the comfort of the teaching and learning process as a priority. Accessibility, disaster mitigation, and convenience must be considered in realizing environmentally sound, safe, and quality schools in achieving Sustainable Development Goals.

Keywords: Accessibility, Resilience, Sustainable School

INTRODUCTION

In order to build a better community and meet human needs, education is a crucial component. Through receiving a high-quality education, one can develop skills such as those required for navigating life's problems and making decisions, as well as social and creative abilities (Bhardwaj, 2016). Because education plays such a significant role in enhancing each person's welfare, it should be given top priority in all efforts to implement development and address its difficulties. These limitations include the lack of resources and expertise adjusting to new learning methods, the uneven distribution of internet facilities across the country, and the placement of schools in areas that do not fit the fundamental criteria for constructing a school (Kristiansen, 2006). The Indonesian government, particularly the Ministry of Education and Culture, has improved several indices of educational and cultural development in 2020, including enrollment rates, equitable distribution of educational quality, and educational relevance. However, there are still many issues with education in Indonesia, one of which is the regional disparity in the quality of the educational infrastructure. Other developing nations face similar issues with geography, such as accessibility, which is why the United Nations has made decent education one of the aims of the Sustainable Development Goals or sustainable development. Since ensuring access to education is a long-term investment in achieving development and high-quality human resources, there must be a program or solution. Schools must fulfill several standards as the foundational element of the educational infrastructure in order to be freely accessible to all societal levels. Schools are required to satisfy community demands and must balance their development with societal conditions or the pace of population increase to achieve the state's aims, namely the country's intellectual life. To realize this goal, infrastructure such as schools requires good accessibility to make it easier for someone to travel the distance and time to receive services (Li et al.,2015). Creating schools using a geographical framework makes them more accessible and considerably aids students who graduate from high school in pursuing further education (Bilgiç et al.,2020).

Several factors must be considered in addition to accessibility when determining how educational infrastructure will be distributed and set up. Disaster resilience characteristics, including both natural and man-made risks, must be taken into consideration in a developing nation like Indonesia, where the population is constantly growing, and the country is geographically located in a disaster-prone area. These many catastrophes might endanger the safety and security of the continuity of teaching and learning activities in schools if they are not considered in spatial planning while building educational infrastructure (Reichenbach,2014). Additionally, the comfort of students while learning at school is a factor that must be taken into account when planning the distribution of educational infrastructure because deteriorating environmental issues like air pollution and traffic noise can interfere with students' comfort while learning, potentially causing respiratory conditions and impairing their comprehension in class (Chithra & Narendra, 2012). As a result, creating

parameters as part of a plan is required to choose the best site for the school. These criteria may be used for the spatial planning of educational facilities and as a guide for enhancing already-existing school facilities. A safe and sustainable school approach must include accessibility, multi-disaster resilience, and convenience, as shown by systematic review research from related publications.

RESEARCH METHODS

This study uses a search engine with Google Scholar to investigate several factors used to design a plan to build safe, disaster-resilient, and sustainable schools. Based on analysis of published papers from journals with a Scopus index that has been chosen using systematic literature results. It is believed that this approach would help identify sustainable school-building strategies

Table 1. Research Articles

No	Article Title, Author, Year	Database
1	**School Location** Analysis by Integrating **Accessibility, Natural and Biological Hazards** to Support Equal Access to Education (Sakti et al.,2021)	MDPI
2	Improving the **Accessibility** to Public Schools in Urban Areas of Developing Countries Through a Location Model and an Analytical Framework (de Armas et al.,2022)	PLOS ONE
3	Exploring Safety in **Disaster**-Induced Displacement Relocation Site Schools in Tokwe-Mukosi, Zimbabwe (Chidarikire et al.,2021)	Journal of Disaster Risk Studies
4	**Disaster** Risk Management Insight on School Emergency Preparedness-a case study of Khyber, Pakhtunkhwa, Pakistan (Shah et al.,2020)	Elsevier
5	From Rapid Visual Survey to **Multi-Hazard Risk** Prioritisation and Numerical Fragility of **School Buildings.** (Gentile et al.,2019)	Copernicus
6	Public Transport and **School Location** Impacts on Educational Inequalities: insight from Sao Paulo (Moreno et al.,2017)	Elsevier
7	**Schools** and Neighbourhood Crime: The Effects of Dropouts and High-performing Schools on Juvenile Crime (Gerlinger & Hipp, 2020)	UC Irvine

8	**Air Quality** Around Schools: Part I – A Comprehensive Literature Review across high-income countries (Osborne et al.,2021)	Elsevier
9	How to Protect School Children from The Neurodevelopmental Harms of **Air Pollution** by Interventions in the **School Environment** in the Urban Context (Rivas et al.,2018)	Elsevier
10	Children Environmental Exposure to Particulate Matter and Polycyclic Aromatic Hydrocarbons and Biomonitoring in **School Environments**: A Review on Indoor and Outdoor Exposure Levels, Major Sources and Health Impacts (Oliveira et al.,2019)	Elsevier

Numerous articles may be included in a comprehensive evaluation of the literature. Five procedures are employed in a systematic literature review to gather high-caliber research papers: Keyword and concept research, article discovery, quality assessment, data extraction, and data synthesis are the other four steps. The initial step in a systematic literature review is identifying the keywords and search terms discovered during the theoretical review. Finding articles in the specified database is the second stage. The exact keywords and terms are used in each database search, with any required revisions made to keep within the keyword term ranges. The third stage, which only applies to academic journal publications examined and indexed by Scopus, is the appraisal of paper quality. Data extraction comes in at stage four, while data synthesis comes in at stage five.

Using the terms school location, accessibility, disaster, and words related to environmental issues impacting school activities, this study selected the databases from Elsevier, MDPI, PLOS ONE, UC Irvine, Copernicus, and Journal of Disaster Risk Study. Ten papers utilized and published between 2017 and 2022 are shown in Table 1. This study's publications are organized into groups based on factors including the publication year, journal name, focus nation, article categorization, technique, findings, and theory.

RESULTS & DISCUSSION

Parameters Related to School Development. Schools as an educational infrastructure need to implement a geographic perspective and concentrate on disaster mitigation in their spatial planning due to the significance of schools as the primary formal educational facilities. This will promote the development of sustainable and high-quality education (Ye et al., 2018). In addition to using spatial techniques and technology, various additional factors should be considered while designing the spatial planning of educational infrastructure.

Accessibility. Accessibility to a location is essential in spatial planning because it is measured based on service quality and how far and long it takes to reach that location (Lima et al.,

2019). Schools are public institutions crucial to society's growth and development. As such, they must be easily accessible so the targeted groups can feel the advantages at all societal levels. The placement of schools, particularly elementary schools, significantly impacts urban areas in emerging nations. Therefore accessibility must be taken into account throughout development. A population's education level rises due to easy access to schools, which affects how an area develops. Access to education is impacted by where a school is located, particularly in underdeveloped nations with few alternatives for private or public transportation and where adequate roads have inconsistent physical qualities (Moreno et al., 2018). Due to the significance of accessibility, factors like population growth, the level of public investment in community-based issues like the distribution of diverse populations, and taking into account the spatial distribution of students, the maximum walking distance between students and schools, among other things, are taken into consideration when planning the location of schools (de Armas et al.,2022). Schools that are too far from populated areas may significantly increase the distance, travel time, and transportation costs that students must endure. Additionally, the accessibility of children to schools is impacted by the high expense of public transportation and their safety and comfort.

Based on the results obtained from the process of reviewing these journals, there are two main points in terms of accessibility, namely the distance between the center of the settlement and the school and the condition of the road that students must pass on their way to school. The following table shows the indicators and values that must be met in the accessibility parameter in education infrastructure spatial planning.

Table 2. Accessibility Parameter

Parameter	Indicator	Score
Accessibility	The school is located at a radius of 3-5 km from settlements	3
	Road Condition (Asphalt = 3) (Road = 2) (Waterway = 1)	3

Description: 1 – 2 = Bad; 3 – 4 = Enough ;5 – 6 = Good

The distance between the school and the nearest settlement, which is a radius of 3 to 5 km, is the first indicator on the accessibility criterion for spatial planning of educational infrastructure. The ideal distance between schools and settlements is 3-5 km due to the fact that the infrastructure for schools is located both in urban and rural locations. Schools that are too faraway from populated areas may require students to travel long distances, spend a lot of time traveling, and pay expensive transportation fees. Additionally, the high expense of public transportation, as well as kids' comfort and safety when traveling to school, have an impact on how easily accessible schools are for pupils.

The physical state of the roads that must be travelled affects accessibility to school in addition to the cost of transportation from home to school. The result is that schools are still difficult to access and unable to properly serve the target community because of the poor state of the roads. The cost of attending school, the length of time it takes to get there, the possibility of being late, and the difficulties attending school presents reduce students' motivation to learn.

Multi-Disaster Resilient. People can also create catastrophes, or they can be referred to as man-made dangers, such as war, criminal activity, etc. Disasters do not just include natural disasters**.** The quality of student learning at school is significantly influenced by the safety of teaching and learning activities. Schools safeguard students against hazards, including natural and man-made calamities. Because catastrophes can impede attempts to achieve sustainable development, particularly in the education sector, disaster risk reduction measures must be performed using various strategies, making them urgent for schools**.** In order to increase school safety and create a safe atmosphere for kids to learn, disaster preparation must first be built in disaster-safe school settings. Schools can be built to be robust to several calamities through a variety of means. If it is decided to manage natural disasters, the first action that can be made is to create a disaster-prone map in the area to determine the distribution of places that are most vulnerable to safe from natural disasters (Sakti et al.,2021). Areas that are safe from disasters will be simpler to identify so that they may be used to create safe, educational infrastructure with the aid of a disaster-prone area distribution map tailored to the region's geographical features. In order to make schools more resilient to disasters, the government, schools, and other connected organizations must work together and coordinate. The government can play a part in establishing a safe environment around schools as well as in safety training workshops and awareness programs, the involvement of all school personnel, and other initiatives (Gentile et al.,2019). Man-made disasters, as was already established, can have a detrimental effect on school-aged children. Numerous research shows a link between students' learning processes and the communities with the highest crime rates. As a result, maintaining social security and preventing crimes in and around schools requires cooperation between the schools and the local community (Gerlinger & Hipp, 2020). Schools must develop ways to construct settings that are disaster-safe and have an extensive disaster risk management program. The following are multi-disaster factors that should be taken into consideration while planning educational infrastructure. The instances of flood and landslide indicators that frequently occur in several places of Indonesia are provided below. These indicators are subject to change and adaptation based on local environmental factors and prospective disasters.

Table 3. Multi-Disaster Resilient Parameter

Parameter	Indicator	Score
Natural Disaster	Soil Texture (Sand = 3) (Loamy Sand = 2) (Clay = 1)	3

	Land Slope (0 – 3% = flat)	3
	Elevation (50-100 m = 3) (10-50 m = 2) (<10 = 1)	3
	Soil Type (Regosol, Litosol Organosol = 3) (Andosol, Podsol, Grumusol = 2) (Latosol, Mediteran = 1)	3
Man-made Disaster	5 – 15 minutes from security facility	3
	5 – 15 minutes from medical facility	3

Description: 1 – 6 = Bad; 7 – 12 = Enough; 13 – 18 = Good

Natural disasters are the first sub-parameter on the multi-disaster resilience aspect. Natural disasters are catastrophes that are brought on by natural forces and may also be impacted by forces related to human activities. Because the geographical conditions in each place vary, so do the types of catastrophes that are likely to occur. Because of this, the natural catastrophe sub-parameters are dynamic and can change based on the location of the school. The construction of more resilient educational infrastructure can reduce school spending on infrastructure development when schools are located in disaster-safe zones. By using a geographical method to decide where to locate schools or by making improvements to existing schools by following disaster mitigation rules, schools can increase the safety of teachers and children.

Disasters can also be brought on by human activity, such as war and criminal activity. Even though students generally feel safe at school, both inside and outside of the school, criminal activity can sometimes occur. Therefore, when creating a spatial plan for the educational infrastructure, man-made hazards or disasters caused by human treatment must be taken into account as part of resistance to multiple disasters. Student safety is a top priority, especially when it comes to first aid for students who are ill or have accidents at school, in addition to prevention and attempts to lessen the impact of criminal activities in schools. Not all schools have fully equipped health departments. It is essential to have easy access to medical facilities like hospitals or health centers in order for first aid in schools to be effective. This condition can worsen things if it takes more than 15 minutes to go to security and medical facilities, especially in an emergency, therefore it is important to take this into account.

Convenience. When developing educational infrastructure, convenience criteria must be considered to reduce environmental concerns like air pollution and road noise that can be uncomfortable. Environmental issues are intimately tied to uncomfortable conditions like air pollution, making breathing hard and creating a warm climate. This undoubtedly influences whether some activities, including the teaching and learning process at school, are conducive. Due to exposure to air pollution, children live in a society predisposed to respiratory illnesses. Children are exposed to the most pollution during their walk to school, at the school's entrance, and on the playgrounds, where nearby traffic causes the pollution (Osborne et al.,2021). The high level of transportation also adds to the number of pollutants in the air, which is related to air pollution.

In addition, the noise created by the movement of cars on congested roadways might interfere with daily activities. There is no doubt that this issue needs to be handled using a variety of tactics that the government and the school can implement. Some actions can be taken to lessen the effects of exposure to airborne populations on children, such as developing green infrastructure-based projects in schools and the areas around them. Green Infrastructure affects the environment's air quality and can help lessen traffic noise (Rivas et al.,2018). Another suggestion to lessen schoolchildren's exposure to air pollution is to choose school settings that are conscious of air quality. (Oliveira et al.,2019). The location of schools must consider the concentration of air pollution focused on congested highways. The following is a table showing the comfort parameters along with their indicators and values.

Table 4. Convenience Parameter

Parameter	Indicator	Score
Convenience	NAB $\mathbf{PM_{2.5}}$ = <65 µgram/m^3 = 3	3
	NAB $\mathbf{PM_{2.5}}$ = 65 µgram/m^3 = 2	
	NAB $\mathbf{PM_{2.5}}$ = >65 µgram/m^3 = 1	
	Noise Level= <55 dBA = 3	3
	Noise Level= 55 dBA = 2	
	Noise Level= >55 dBA = 1	

Description: 1 – 2 = Bad 3 – 4 = Enough 5 – 6 = Good

When developing educational infrastructure, two indications make up the convenience factor: traffic noise level, which is measured in decibels, and air pollution, which is determined by the amount of PM 2.5 in the surrounding air. These two factors are linked, and when there are more vehicles on the road, both the amount of noise they make and the amount of pollutants they discharge into the air rise. In order to determine the best location for the development of educational infrastructure in terms of accessibility, multi-disaster resilience, and convenience, the three spatial planning characteristics for educational infrastructure are combined to yield a total score for each parameter. The parameters of the education infrastructure listed in Table 5's summary score are as follows.

Table 5. Total Score of Education Infrastructure Parameters

Parameter	Indicator	Score	Total
Accessibility	The school is located at a radius of 3-5 km from settlements	3	6
	Road Condition (Asphalt = 3) (Road = 2) (Waterway = 1)	3	
Natural Disaster	Soil Texture (Sand = 3) (Loamy Sand = 2) (Clay = 1)	3	18
	Land Slope (0 – 3% = flat)	3	

	Elevation (50-100 m = 3) (10-50 m = 2) (<10 = 1)	3	
	Soil Type (Regosol, Litosol Organosol = 3) (Andosol, Podsol, Grumusol = 2) (Latosol, Mediteran = 1)	3	
Man-made Disaster	5 – 15 minutes from security facility	3	
	5 – 15 minutes from medical facility	3	
Convenience	NAB **$PM_{2.5}$** = <65 µgram/m^3 = 3 NAB **$PM_{2.5}$** = 65 µgram/m^3 = 2 NAB **$PM_{2.5}$** = >65 µgram/m^3 = 1	3	6
	Noise Level= <55 dBA = 3 Noise Level= 55 dBA = 2 Noise Level= >55 dBA = 1	3	

Description: 0 – 10 = Bad; 11 – 20 = Enough; 21 – 30 = Good

The following factors must be taken into account while planning the physical layout of educational infrastructure: comfort, accessibility, and multi-disaster resilience. As for several indicators in the parameters of natural catastrophes, they are subject to change and adaptation depending on the geographic circumstances of an area. The location of educational infrastructure has an impact on the continuation of the teaching and learning process in the classroom, according to the analysis that has been given. Schools that are simple to go to can keep students' motivation and excitement for learning, save money, and successfully serve society, especially children. In addition to accessibility, security and safety of students and teachers are important priorities in the development of educational infrastructure, thus the idea of disaster mitigation during the building and restoration of schools must be taken into account. The ease of the school's location also has an impact on how well teachers and students perform during the teaching and learning process. Students' levels of focus and comprehension in class will decline in schools located in places with poor air quality and traffic noise that exceeds the permitted levels.

CONCLUSION & SUGGESTION

An effort that may be made to actualize inclusive quality education in reaching the Sustainable Development Goals is ensuring equitable education for all facets of society. Every component, including catastrophe mitigation, must be considered due to the problem of educational fairness, which is complex and frequently affects developing nations. The ideal site of a school should consider factors including accessibility, resilience to many calamities, and convenience connected to environmental issues. Furthermore, existing schools can use these criteria to pinpoint any areas that need strengthening or enhancements to raise the quality of their infrastructure. Optimal school locations and sustainable infrastructure can create a conducive, safe, and comfortable teaching and learning process for school residents. The findings of future research have significance for both education and geographical

planning. The creation of school administration that is easily accessible, sustainable, and adequate for the teaching and learning process might theoretically take into account factors such as accessibility, resilience to many calamities, and the convenience of students and teachers. Practical terms, the findings of this study can be used as suggestions and recommendations for school administration to enhance school infrastructure, as well as suggestions for the government to create sustainable and safe school zones. The multi-disaster resilience parameters described in this study only take into account disasters and landslides, so it is necessary to modify the multi-disaster resilience indicators if the area in question is shown to be vulnerable to other disasters, such as earthquakes and other natural disasters. Future research can examine indicators of multi-disaster resilience with different types of disasters. Existing parameters can be developed and arranged in a digital map based on an overlay technique that represents the data for each parameter to identify the most suitable zone for constructing school buildings.

In order to solve the challenges of equitable distribution of high-quality education, the approach for achieving sustainable schools based on disaster mitigation and convenience is anticipated to be a component of spatial planning for educational infrastructure. For a strategy to operate successfully and accomplish the desired goals, it needs the cooperation and assistance of many stakeholders.

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