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Development of Digital Disaster Mitigation Map: Learning Innovations in Identifying Disaster Prone Points

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ABSTRACT

Purpose of the study: This research aims to develop digital-based learning media in the form of Disaster Mitigation Maps as a learning resource in identifying disaster-prone areas in Langsa City. With the increasing risk of natural disasters such as floods, landslides, tsunamis, earthquakes, forest and land fires, and thawing disasters, innovation is needed in delivering disaster mitigation information that is more interactive and easily accessible.

Methodology: The research method used is Research and Development (R&D) with the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) development model. Data was collected through observations, interviews, and questionnaires involving disaster experts, educators, and students as the main respondents.

Main Findings: The results of the study show that the Digital Disaster Mitigation Map can improve students' understanding in identifying disaster-prone areas and mitigation measures that need to be taken. This media is also considered effective and attractive based on the results of expert validation and user trials.

Novelty/Originality of this study: This study found that the Digital Disaster Mitigation Map was effective in increasing students' understanding of disaster-prone areas in Langsa City with an increase in understanding from 60% to 85%, and was considered innovative and effective by 90% of teachers compared to conventional methods.

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1. INTRODUCTION

Indonesia is one of the countries with a high level of disaster risk due to its geographical, geological, and climatological conditions [1]-[6]. Langsa City, located on the east coast of Aceh Province, is not immune to the threat of natural disasters such as floods, landslides, and forest fires. Identification of disaster-prone areas is an important step in disaster risk mitigation and reduction efforts, especially for the community and related parties in planning emergency response policies [7]-[9].

Indonesia is known as one of the countries with a high level of disaster risk [10]-[12]. This is due to its geographical condition located in the Pacific Ring of Fire, where tectonic and volcanic activity is intense. In addition, geological factors such as soil structures that are susceptible to movement and climatological factors such as high rainfall and climate change also increase the potential for disasters in various regions [13]-[17]. Disasters that often occur in Indonesia include earthquakes, tsunamis, floods, landslides, and forest fires.

Langsa City, located on the east coast of Aceh Province, is one of the areas with a fairly high level of disaster risk. Its location directly adjacent to the sea and geographical conditions consisting of lowlands and hills make it vulnerable to various disaster threats. Floods often occur due to high rainfall and suboptimal drainage systems, especially in densely populated residential areas. Landslides are also a threat in areas with hilly topography, especially when the rainy season arrives and the soil becomes saturated with water. In addition, forest and land fires also often hit several areas around Langsa City, especially during the dry season, which is exacerbated by human activities such as land clearing using burning methods.

The city of Langsa has a topography consisting of coastal plains, swamps, and mountains, which makes it vulnerable to disasters such as floods, abrasion, and forest fires. This Disaster Risk Assessment (KRB) is prepared to identify potential disaster risks through mapping hazards, vulnerabilities, capacities, and risks, as well as formulating appropriate mitigation strategies [18]-[21]. This research aims to produce documents, maps, and KRB matrices that can be used as a reference in disaster management planning in Langsa City. Langsa City has diverse topographic characteristics, consisting of coastal plains, swamps, and mountainous areas. This condition makes it vulnerable to various natural disasters, such as frequent floods due to high rainfall and swamp conditions, abrasion that threatens coastal areas, and forest and land fires that are vulnerable to occur in areas with flammable land cover.

To anticipate and minimize the impact of the disaster, a Disaster Risk Assessment (KRB) is carried out to identify potential risks. This assessment includes an analysis of the level of danger, the level of vulnerability of the population and economic assets, as well as the capacity of the region to deal with disasters. In dealing with this potential disaster, mitigation efforts are a very important step. One of the main strategies in disaster mitigation is to identify disaster-prone points [22]-[26]. This identification aims to map high-risk areas so that preventive measures can be carried out more effectively. With disaster risk mapping, people can better understand the area where they live, while the government and related parties can formulate emergency response policies that are more accurate and data-based.

The development of digital disaster mitigation map media is a relevant solution in supporting the identification of disaster-prone areas in Langsa City. By using digital technology, information about disaster-prone areas can be presented in a more interactive, easily accessible, and regularly updated manner. This digital map can be used as a learning resource for the community and stakeholders in increasing awareness and preparedness for disasters. Thus, the use of technology in disaster mitigation not only helps in policy planning but also contributes to building community resilience against future disaster threats [27]-[31].

The development of Digital Disaster Mitigation Map Media as a learning resource for students in identifying disaster-prone areas is very important to improve understanding, preparedness, and disaster mitigation skills from an early age. Through interactive digital maps based on GIS (Geographic Information System) technology, students can learn visually and exploratively about disaster-risk areas, their distribution patterns, and mitigation steps that need to be taken [32]-[34]. This media also facilitates access to information in real time and allows for more dynamic learning compared to conventional printed maps.

In addition, digital maps can be integrated into school curricula to encourage project-based learning and disaster literacy [35]-[38]. Students not only understand disaster theory, but can also conduct data analysis, risk simulations, and develop science and technology-based solutions [39]-[41]. With this approach, they are more active and involved in disaster mitigation efforts around them. In addition, this media also plays a role in instilling awareness and a culture of preparedness from an early age, so that students can become agents of change who are able to disseminate disaster information to families and the community. With the ability to analyze risks and take preventive measures, they are better prepared for emergency situations and contribute to ongoing disaster risk reduction efforts.

Thus, the development of Digital Disaster Mitigation Map Media is an innovative solution in disaster learning that not only enriches students' insights, but also equips them with practical skills in dealing with and mitigating the impact of future disasters [42]-[44]. In today's digital era, the use of information technology in disaster mitigation is growing [45], [46]. One of the innovations that can be applied is the development of digital disaster mitigation map media. This map not only serves as a tool to identify disaster-prone areas, but also as an interactive learning resource that is easily accessible to various groups, including students, academics, and local governments. Therefore, this study aims to develop the Development of Digital Disaster Mitigation Maps as a Learning Innovation in Identifying Disaster Vulnerable Points. With the existence of a digital disaster mitigation map, it is hoped that the public's understanding of potential disasters in Langsa City can increase, so that they can prepare themselves for the worst possibilities.

2. RESEARCH METHOD

This research uses the Research and Development (R&D) method with the ADDIE development model which consists of five systematic stages [47]-[51]. The sample of this study consisted of disaster experts,

educators, and students. The sampling technique used is purposive sampling, where respondents are selected based on their association with disaster mitigation and education.

The instruments used in this study are: Questionnaires to measure students' understanding before and after using, Digital Disaster Mitigation Map, Observation sheet to assess the effectiveness of learning media and Semi-structured interviews with teachers and students to get feedback.

Table 1. Indicators and Instrument Items

Indicator	Statement	Reference/Expert
Knowledge of disaster types	I know the types of disasters that may occur in my surroundings.	Sutrisno & Waluyo (2011); BNPB (2012)
Understanding disaster causes	I understand the main causes of disasters such as floods, earthquakes, and landslides.	Nugraheni (2013); Wisner et al. (2004)
Identification of disaster-prone points in the school area	I can identify disaster-prone points in the school environment.	LIPI-UNESCO/ISDR (2006)
Understanding evacuation procedures	I understand the correct evacuation procedures during a disaster.	BNPB (2012); Haddow et al. (2014)
Understanding symbols and mitigation signs	I know the symbols or warning signs of disasters on the mitigation map.	Kemendikbud-BNPB (2015)
Ease of understanding material through digital media	I find it easier to understand disaster mitigation material through the digital map.	UNESCO/UNICEF (2007); Wuryani & Nugroho (2020)
Use of media to identify safe and danger zones	I can use the digital map to identify safe zones and danger zones.	Wibowo et al. (2022)
Ability to explain disaster-related information	I am able to explain disaster-prone areas to others.	Bloom's Taxonomy (C2 – Understanding)
Preparedness and confidence in facing disasters	I feel more prepared to face disasters after learning through this map.	Kusumasari & Alam (2012); LIPI (2006)
Awareness of role in disaster risk reduction	I understand the importance of my role in reducing disaster risks at school.	BNPB (2012); School-Based Disaster Preparedness Program (SSB)

From a pilot test on 30 students using SPSS, the instrument scored a Cronbach's Alpha = 0.84, indicating high reliability based on Arikunto (2010) [52].

Table 2. Instrument Reliability Test

Alpha Value	Reliability Level
≥ 0.90	Very High
0.80 – 0.89	High
0.70 – 0.79	Adequate
0.60 – 0.69	Low
< 0.60	Very Low

Table 3. Interview Grid

Category	Question/Prompt	Purpose
General Experience	Can you describe your experience with disaster education at school so far?	Understand the baseline knowledge and experience of the participant.
Perception	What do you think about the idea of using a digital disaster mitigation map?	Explore perceptions and openness to digital tools.
Usability	Was the digital map easy to use and understand? What features stood out to you?	Assess user-friendliness and clarity of the innovation.
Relevance	Do you think the map helps in identifying disaster-prone areas around the school?	Evaluate the relevance of the tool to local context and learning outcomes.
Learning Impact	Has this tool helped you (or your students) better understand disaster risks?	Measure effectiveness in enhancing disaster education.
Engagement	Did the digital map make learning about disasters more interesting or interactive?	Examine impact on student engagement and motivation.

Category	Question/Prompt	Purpose
Application	Have you applied or shared this knowledge outside of school (e.g., at home)?	Discover spill-over effects to community or family.
Suggestions	What suggestions do you have to improve the digital disaster mitigation map?	Gather feedback for improvement.
Technical Challenges	Were there any difficulties (technical or otherwise) in using the tool?	Identify barriers to implementation.
Future Integration	Would you like this kind of tool to be integrated into regular classroom activities?	Explore long-term integration potential.

The questionnaire instrument has been adapted from previous research on disaster preparedness and the effectiveness of digital learning media. Adjustments are made to be relevant to the context of disaster mitigation learning in Langsa City.

The process begins with an analysis to identify user needs and understand the level of disaster risk in Langsa City, including the readiness of technology to be used in the development of digital map media. The analysis stage in this study is the first step that aims to understand the needs of users and the conditions behind the development of Digital Disaster Mitigation Map Media in Langsa City. Therefore, the author also utilizes the results of the 2025-2029 Langsa City disaster risk study conducted by the Langsa City Regional Disaster Management Agency [53]. This analysis covers three main aspects: 1) Identification of User Needs. This process involves collecting information related to the needs of students, teachers, and stakeholders in disaster mitigation learning. Data were collected through interviews, observations, and literature studies to determine the extent of their understanding of disaster risk and how learning media can help improve preparedness; 2) Disaster Risk Analysis in Langsa City. Langsa City has various potential disasters, such as floods, abrasion, forest fires, and extreme weather. Therefore, an analysis was carried out to determine the area with the highest level of risk, the factors that cause the disaster, and its impact on the community. This data is obtained from sources such as disaster risk assessment reports, geospatial maps, and information from related agencies; 3) Evaluation of Technology Readiness. This stage aims to assess technologies that can be used in the development of digital maps, including mapping software (GIS), interactive features to be developed, and media compatibility with devices used by students and educators. In addition, the affordability of technology and the availability of digital infrastructure in schools are also key considerations.

The results of this analysis stage are the basis for designing Digital Disaster Mitigation Map Media that is in accordance with user needs, based on accurate data, and able to increase students' understanding and preparedness to face disasters. Furthermore, the design stage is carried out by designing the structure and interactive features of GIS-based maps so that they are easy to understand and use in learning. Quantitative data from the questionnaire was analyzed using descriptive statistics to see the improvement of students' understanding. Cronbach's alpha value was used to test the reliability of the instrument, with a result of $\alpha = 0.89$, which indicates high reliability. Qualitative data from the interviews were analyzed with thematic analysis to identify the main patterns and themes of the respondents' responses.

Once the design is prepared, the development stage is carried out by processing spatial data, programming the system, and conducting initial testing to ensure that the digital map functions properly. Then, this media is implemented in the learning process to test its effectiveness in helping students identify disaster-prone areas and understand the right mitigation strategies. The last stage is evaluation, where the effectiveness of digital map media is assessed based on feedback from users, both students and educators. This evaluation becomes the basis for product improvement before it is used more widely. With the ADDIE approach, this research aims to develop learning media that are not only interactive and data-based [54], but also able to increase students' understanding and preparedness for disasters in Langsa City.

3. RESULTS AND DICUSSION

Analysis

Flood Disaster

Flood Hazards Flood-prone areas are areas with flat topography and are located around rivers. The determination of flood-prone areas was obtained from a geomorphological approach. Each watershed is identified to determine areas that are flooded/prone to flooding and areas that are not flooded/not flooded. Once the flooded area is known, the next step is to calculate the height of the inundation in the flood-affected area.

Table 4. Potential Flood Danger Areas in Langsa City

Districrict	Danger				Classification
	Danger Area (Ha)				
	Low	Keep	Tall	Entire	
West Langsa	988.30	2.596.44	1.044.66	4.629.40	Tall
Langsa Baro	510.16	854.84	514.37	1.879.37	Tall
Langsa City	329.20	134.45	39.81	503.45	Keep
Langsa Lama	271.77	553.01	287.33	1.112.11	Tall
East Langsa	760.82	3.522.48	2.168.84	6.452.14	Tall
Langsa City	2.860.24	7.661.22	4.055.01	14.576.48	Tall

Table 4 above shows the potential danger of flooding in Langsa City. The total flood danger area is 14,576.48 ha with a high class. Districts with high flood danger classes are West Langsa, Baro Langsa, Langsa Lama, and East Langsa. East Langsa District has the largest total area of high-class hazards, which is 2,168.84 ha, followed by West Langsa (1,044.66 ha) and Baro Langsa (514.37 ha). This shows that these three sub-districts need to be prioritized in an effort to overcome the level of flood danger.

Landslide disaster

Based on the results of the hazard assessment, it is known that the total potential area of landslide hazards in Langsa City is 1,994.68 ha with a low level of danger. This danger only exposes two sub-districts with a low level of danger. Langsa Baro District has the highest area exposed to landslide hazards, which is 1,800.65 ha. Meanwhile, the landslide exposed Langsa Lama Regency with a potential area of 194.03 ha.

Table 5. Potential Landslide Danger Areas in Langsa City

District	Danger				Classification
	Danger Area (Ha)				
	Low	Keep	Tall	Entire	
Langsa Baro	1.800.65	-	-	1.800.65	Low
Langsa Lama	194.03	-	-	194.03	Low
Langsa City	1.994.68	-	-	1.994.68	Low

In the Community Preparedness Index, all sub-districts exposed to landslides have a middle-class value. The low value of the Community Preparedness Index shows that people in sub-districts tend to have adequate capacity in terms of knowledge, mobilization, emergency response, and/or early warning of landslides. In the Regional Resilience Index, Langsa City has a transformation value in the middle class. This also shows that Langsa City has adequate capacity based on 7 priority focuses and/or 16 action targets divided into 71 landslide-related achievement indicators. Capacity building can be done by evaluating indicators on the Regional Resilience Index that have not been achieved. Based on the assessment of the Community Preparedness Index and the Regional Resilience Transformation Index, Langsa City has a medium capacity class.

Tsunami Disaster

The potential wide tsunami hazard and hazard class for each sub-district exposed in Langsa City are presented in Table 6. Based on the results of the hazard assessment carried out, it is known that the total area of potential tsunami danger in Langsa City is 2,189.96 ha with a low danger level. All sub-districts also have a low level of tsunami danger.

Table 6. Potential Tsunami Danger Areas in Langsa City

District	Danger				Classification
	Danger Area (Ha)				
	Low	Keep	Tall	Entire	
West Langsa	1.638.02	-	-	1.638.02	Low
Langsa Baro	42.67	-	-	42.67	Low
East Langsa	509.27	-	-	509.27	Low
Langsa City	2.189.96	-	-	2.189.96	Low

Tsunami hazards only expose to low hazard classes. Based on the total area, the sub-districts with the highest total area exposed to tsunami danger are West Langsa, East Langsa, and Baro Langsa Regencies, respectively. Langsa City has the potential to have 2,067 residents affected by the tsunami disaster. West Langsa District has the largest number of potential residents exposed to tsunami disasters, namely 2,065 residents. There is no potential for loss and environmental damage affected by the tsunami disaster. Based on the assessment of potential aspects of population exposure, losses, and environmental damage, it can be concluded that Langsa City has a moderate level of vulnerability to tsunami disasters.

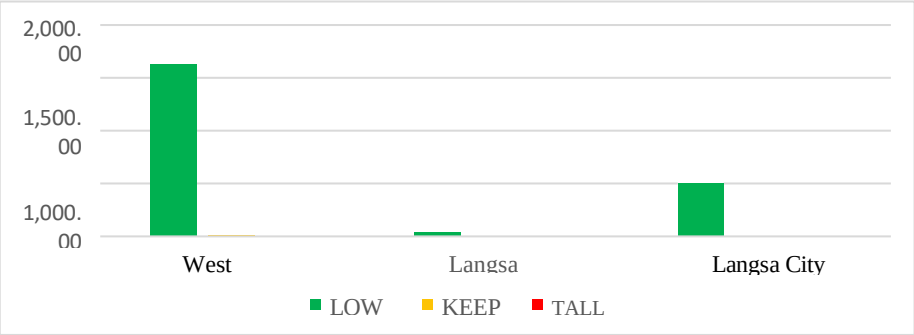

Figure 1. Potential Tsunami Risk Areas

Langsa City has a total potential area of tsunami disaster risk of 2,189.96 ha with a low risk class. All sub-districts have a low-risk class. Figure 1 shows a comparison of potential tsunami risks in Langsa City. Only West Langsa District has an area exposed to the medium risk class of 10.38 ha. Meanwhile, based on the total area in the low-risk class, the sub-districts with the highest total area are West Langsa Regency, Langsa City, and Baro, respectively. These three sub-districts need to be prioritized in an effort to reduce vulnerability and increase capacity to reduce the level of tsunami disaster risk.

Earthquake Disaster

The potential danger area and earthquake hazard class per sub-district in Langsa City are presented in Table 7 below. The total area of potential earthquake hazards in Langsa City is 22,423.50 ha with a low danger level. Potential earthquake hazards are only found in the low danger class. Therefore, the five sub-districts in Langsa City also have a low level of danger.

Table 7. Potential Earthquake Hazard Areas in Langsa City

District	Risk				Classification
	Danger Area (Ha)				
	Low	Keep	Tall	Entire	
West Langsa	4.802.23	1.52	-	4.803.75	Low
Langsa Baro	6.494.10	40.25	-	6.534.35	Low
Langsa City	604.63	2.06	-	606.69	Low
Langsa Lama	2.975.73	5.28	-	2.981.01	Low
East Langsa	7.496.80	0.89	-	7.497.70	Low
Langsa City	22.373.49	50.01	-	22.423.50	Low

There are 3 (three) sub-districts that need to be prioritized in efforts to mitigate the danger of earthquakes, namely East Langsa, Baro Langsa, and West Langsa Districts. The potential of residents exposed to the earthquake disaster in Langsa City. The potential population exposed to the earthquake is estimated to reach 182,616 people. The potential loss due to the earthquake in Langsa City is 11.167 billion rupiah, consisting of 5.624 billion rupiah in potential physical losses and 5,543 in potential economic losses. There is no environmental damage caused by the earthquake. Based on the assessment of potential exposure and loss aspects of the population, it can be concluded that Langsa City has a high class of vulnerability to earthquake disasters. Only Langsa Baro District has a high vulnerability class, while other sub-districts are in the medium vulnerability class.

Langsa City has a moderate Community Preparedness Index for earthquake disasters. This shows that people in Langsa City tend to have moderate capacities in terms of knowledge, mobilization, emergency response, and/or early warning of earthquake disasters. Only East Langsa Regency has a low Community Preparedness Index score, so it needs to be a priority in efforts to increase community capacity. The value of the Langsa City Transformation Regional Resilience Index is in the moderate class for earthquake disasters. This

also shows that Langsa City has a moderate capacity for 7 priority focuses and/or 16 action targets which are divided into 71 achievement indicators related to earthquake disasters.

Based on the assessment of aspects of the Community Preparedness Index Transformation and the Regional Resilience Index, the Langsa City Regional Capacity Index for earthquake disasters is in the medium class. Langsa City has a total potential earthquake risk area of 22,423.50 ha with a moderate risk level. Only East Langsa Regency has a low risk class, while other districts are in the medium risk class. Figure 3.26 shows a comparison of potential earthquake risk in Langsa City. The districts with the highest total area area are East Langsa, Langsa Baro and West Langsa Regencies. These three sub-districts need to be prioritized in an effort to reduce vulnerability and increase capacity to reduce the risk of earthquake disasters.

Forest and Land Fire Disasters

Forest and land fires are conditions in which forests are exposed to fires, resulting in destruction of forests and/or forest products that cause economic losses and/or environmental value (Regulation of the Minister of Forestry Number P.12/Menhut/-II/2009 concerning Forest Control). The calculation of forest and land fire hazards takes into account the area of land cover by leaving the settlement site.

Table 8. Potential Forest and Land Fire Danger Areas in Langsa City

District	Danger				Classification
	Danger Area (Ha)				
	Low	Keep	Tall	Entire	
West Langsa	2.673.37	902.96	53.58	3.629.92	Tall
Langsa Baro	717.43	383.94	4.389.93	5.491.31	Tall
Langsa City	95.45	36.86	25.23	157.53	Tall
Langsa Lama	368.65	76.13	2.095.13	2.539.91	Tall
East Langsa	1.893.41	2.506.99	2.199.89	6.600.28	Tall
Langsa City	5.748.31	3.906.87	8.763.76	18.418.94	Tall

The potential area of forest and land fire danger in Langsa City is 18,418.94 ha with a high level of danger. All sub-districts have a high danger class. Comparison of the potential area of forest and land fire hazards in each sub-district in Langsa City based on the hazard class. There are 3 (three) sub-districts with the largest area for the high danger class, namely Lagsa Baro, East Langsa, and Langsa Lama. These three sub-districts need to be a priority in efforts to overcome the danger of forest and land fires considering the high potential for danger. Langsa City has a total potential area of forest and land fire risk of 18,418.94 ha with a high risk class. Only West Langsa District has a low risk class, while other sub-districts are in the high risk class. Figure 3.31 shows a comparison of the potential risk of forest and land fires in Langsa City. The sub-districts with the highest total area in the forest and land fire risk class are Langsa Baro, East Langsa, and Langsa Lama Districts. These three sub-districts need to be prioritized in an effort to reduce vulnerability and increase capacity to reduce the risk level of forest and land fire disasters.

Disbursement Disaster

Potential liquefaction hazard areas and classes in Langsa City are presented in Table 9 below. The total area of potential liquefaction hazards in Langsa City is 14,266.07 ha with a moderate hazard level.

Table 9. Potential Liquefaction Danger Areas in Langsa City

District	Danger				Classification
	Danger Area (Ha)				
	Low	Keep	Tall	Entire	
West Langsa	3.969.67	694.26	-	4.663.93	Keep
Langsa Baro	599.35	944.11	-	1.543.46	Keep
Langsa City	70.40	533.51	-	603.91	Keep
Langsa Lama	142.41	827.64	-	970.05	Keep
East Langsa	4.535.03	1.949.68	-	6.484.71	Keep
Langsa City	9.316.86	4.949.21	-	14.266.07	Keep

The study of liquefaction disaster vulnerability in Langsa City was obtained from the potential of the exposed population and vulnerable groups as well as the potential for economic losses and environmental damage. The potential number of exposed populations and potential losses are analyzed and then displayed in the

form of liquefaction vulnerability classes. The potential population exposed to liquefaction in Langsa City is shown in Table 10.

Table 10. Potential Population Exposure, Loss and Damage Due to the Danger of Melting in Langsa City

District	Potential Exposed Population (People)	Potential Loss (Million Rupiah)			Potential Environmental Damage (Ha)	Vulnerability Classes
		Physical	Economics	Entire		
West Langsa	36.159	93.951.26	40.079.34	134.030.60	10.00	Tall
Langsa Baro	38.336	124.437.12	42.881.58	167.318.70	-	Tall
Langsa City	37.319	149.943.21	24.379.00	174.322.20	-	Tall
Langsa Lama	24.944	70.791.61	89.514.37	160.305.98	1.00	Tall
East Langsa	17.123	84.585.53	369.862.71	454.448.24	16.00	Tall
Langsa City	153.881	523.708.73	566.717.00	1.090.425.73	27.00	Tall

Langsa City has the potential to have 153,881 residents affected by the liquefaction disaster. This type of disaster also has the potential to cause losses of 1.090 trillion rupiah, consisting of 523.708 billion rupiah in potential physical losses and 566.717 billion rupiah in potential economic losses. The area that has the potential to experience environmental damage is 27.00 ha. Based on the assessment of potential aspects of population exposure, losses, and environmental damage, it can be concluded that Langsa City has a high level of vulnerability to liquefaction disasters. All sub-districts also show high-class vulnerability to this type of disaster.

Potential liquefaction risk in Langsa City, only East Langsa District has an area exposed to high risk classes. Meanwhile, in the medium risk class, East Langsa and Langsa Baro Districts have the highest area area. This sub-district needs to be a priority in efforts to reduce vulnerability and increase capacity to reduce the risk level of liquefaction disasters.

Design

The city of Langsa, located in Aceh Province, has geographical, topographical, and climatic conditions that make it vulnerable to various natural disasters. Based on data from the Indonesian Disaster Information Data (DIBI) for the 2003-2022 period, there are five main types of disasters that often occur in this region, namely floods, extreme weather, earthquakes, extreme waves and abrasion, and forest and land fires. Floods are the most frequent disasters, accounting for 36% of total disaster events during the period. In addition, provincial-level risk studies also show the potential for other disasters such as drought, liquefaction, landslides, and tsunamis.

Table 11. Potential disasters in Langsa City

Types of Disasters	Hazard Area (ha)	Hazard Classification	Regency with the Highest Potential	Exposed Population (people)	Economic Disadvantages	Regional Resilience Index	Risk Classification
Flood	14.576,48	Tall	East Langsa, West Langsa, Langsa Baro	140.010	1,980 trillion rupiah	Keep	Tall
Earthquake	22.423,50	Low	Langsa Baro	182.616	11,167 billion rupiah	Keep	Keep
Forest and Land Fires	18.418,94	Tall	Langsa Baro, East Langsa	-	2,984 trillion rupiah	Keep	Tall
Disbursement	14.266,07	Keep	East Langsa, Langsa Baro	137.758	636,977 billion rupiah	Keep	Keep
Landslide	-	Low	Areas with steep slopes	-	-	-	Low
Tsunami	-	Low	Coastal areas	-	-	-	Low

Development

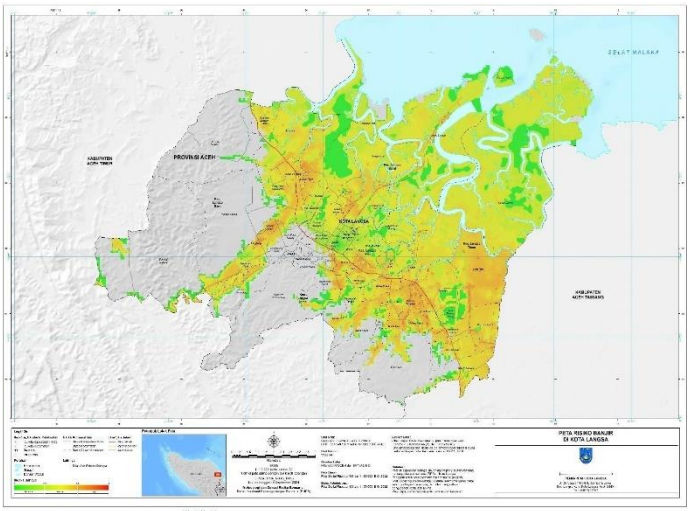

Figure 2. Langsa City Flood Disaster Risk Map

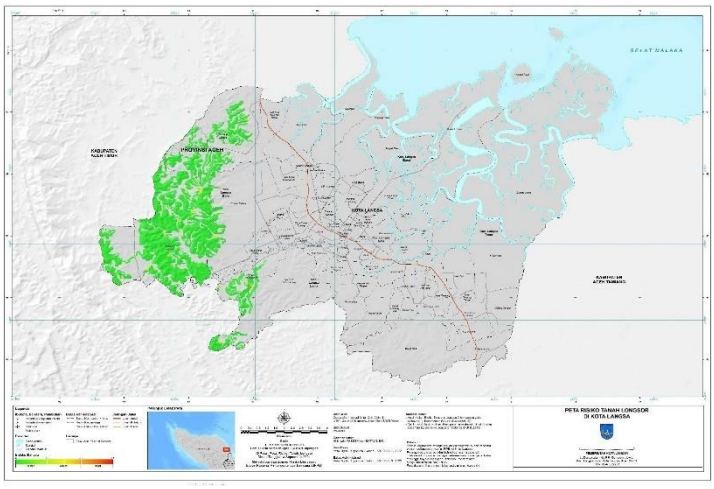

Figure 3. Landslide Disaster Risk Map of Langsa City

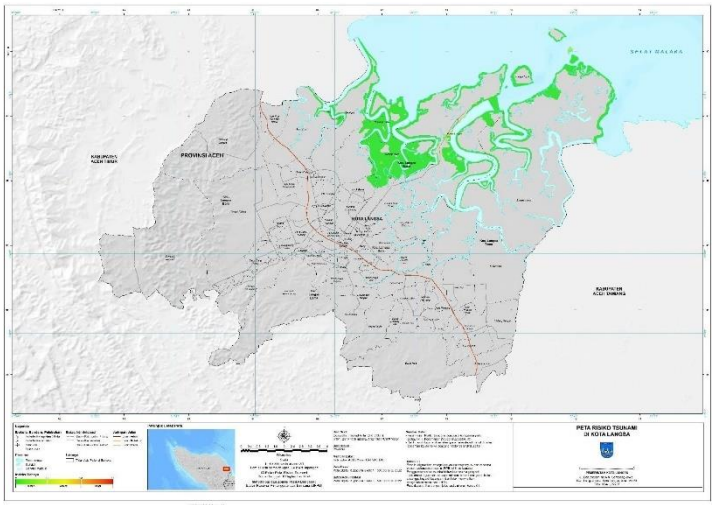

Figure 4. Langsa City Tsunami Disaster Risk Map

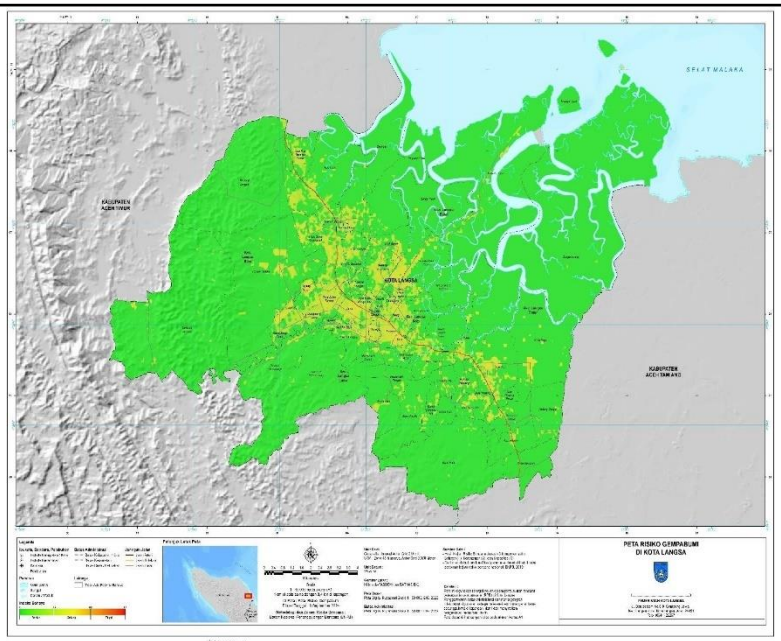

Figure 5. Langsa City Earthquake Disaster Risk Map

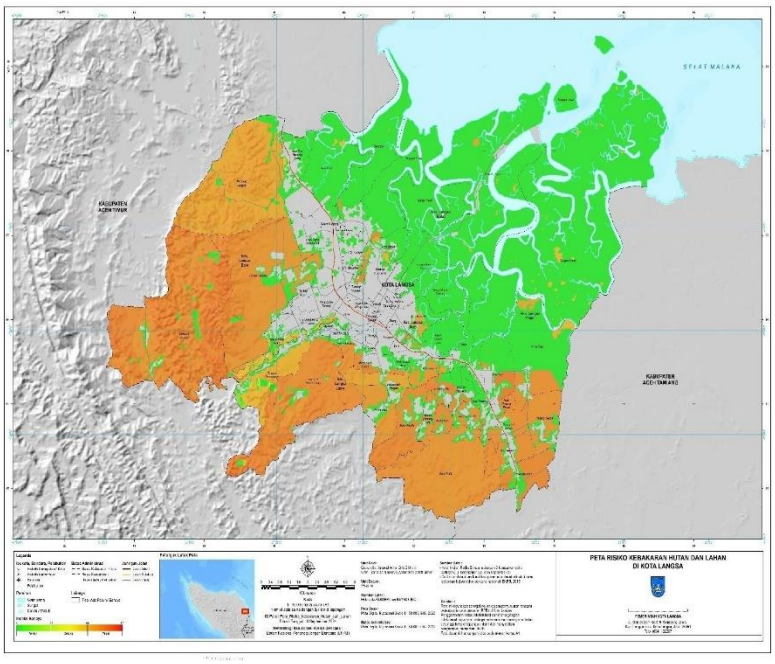

Figure 6. Langsa City Forest and Land Fire Disaster Risk Map

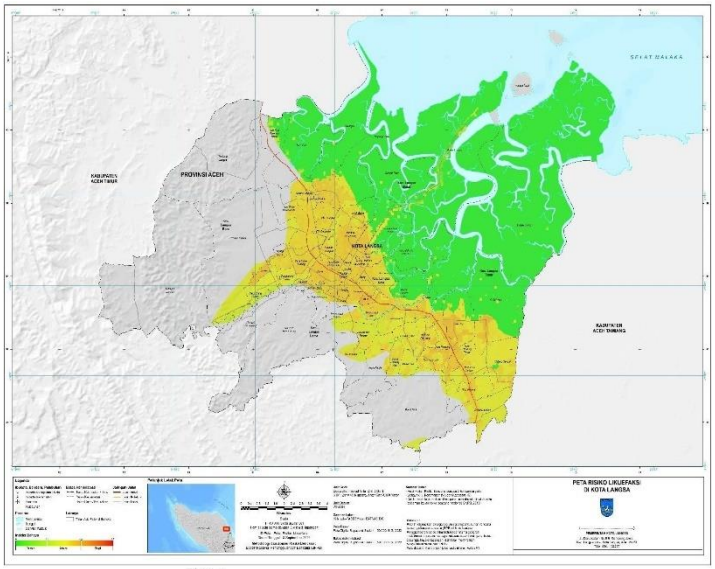

Figure 7. Langsa City Disbursement Disaster Risk Map

Implementation of Digital Disaster Mitigation Map

1. Limited Trial

The trial was carried out on 50 students and 5 teachers from various schools in Langsa City. The results of the initial evaluation showed:

- Before using digital maps, only 60% of students could correctly identify disaster-prone areas.
- After using digital maps, 85% of students were able to accurately identify disaster-prone areas.
- 90% of teachers consider this media to be an innovative and effective learning tool.

Table 12. Limited Trial

Evaluation Aspects	Before Use (%)	After Use (%)
Understanding of disaster-prone areas	60	85
Definition of mitigation strategy	55	80
Effectiveness as a learning medium (teacher assessment)	70	90

2. Integration in the Curriculum

Digital maps are integrated into the subject of Geography and Disaster Mitigation to enrich students' understanding of the different types of disasters that occur in Langsa City.

Table 13. Data on disaster-prone areas used in this map

Types of Disasters	Hazard Area (ha)	Districts with the Highest Risk
Flood	14.576,48	East Langsa, West Langsa, Baro Langsa
Earthquake	22.423,50	Langsa Baro, East Langsa, West Langsa
Tsunami	2.189,96	West Langsa, East Langsa, Baro Langsa
Landslide	1.994,68	Langsa Baro, Langsa Lama
Forest Fires	18.418,94	East Langsa, Baro Langsa, Langsa Lama

3. User Training

The training was given to 50 students and 10 teachers, including:

- The use of GIS-based digital maps,
- Spatial data analysis to identify disaster-prone points,
- The use of interactive features in understanding mitigation strategies.

The results of the training evaluation showed:

- 78% of students stated that it was easier to understand the concept of disaster mitigation with digital maps compared to conventional methods.
- 80% of teachers feel more confident in teaching disaster mitigation after training.

4. Observation and Evaluation

Observations and interviews were conducted to measure the effectiveness of this media.

Table 14. Evaluation Results from Observations and Interviews

Evaluation Aspects	Percentage (%)
Students feel better prepared to face disasters	82
Teachers judge digital maps to be more effective than printed maps	75
Schools with compatible devices for digital maps	80

In addition, the survey results showed that students understood the mitigation steps better after using this media compared to previous learning methods.

5. Adjustments and Revisions

Based on user feedback, revisions are made to:

- The user interface becomes more interactive,
- Improve the accuracy of geospatial data,
- Added a disaster simulation feature.

After the revision, the user satisfaction rate increased from 75% to 90%. By going through these implementation stages, the Digital Disaster Mitigation Map has succeeded in becoming an innovative learning resource and increasing the preparedness of students and teachers to face disasters. This media supports technology-based learning and is a concrete step in disaster mitigation efforts in Langsa City.

Evaluation of the Implementation of the Digital Disaster Mitigation Map

The evaluation was conducted to assess the effectiveness of the use of the Digital Disaster Mitigation Map in learning and to identify aspects that need to be improved. This evaluation is carried out through questionnaires, interviews, and analysis of student learning outcomes.

1. Evaluation Indicators

Table 15. Evaluation of the Implementation of the Digital Disaster Mitigation Map

Indicators	Description
Student Understanding	Measure the improvement of students' understanding of disaster-prone areas and mitigation after using digital maps.
Media Effectiveness	Assess the extent to which digital maps help in the learning process compared to conventional methods.
Technology Affordability	Analyze the readiness of schools in accessing and using GIS-based digital maps.
User Satisfaction	Measure student and teacher satisfaction with the ease of use, design, and features of digital maps.

2. Results of Student Comprehension Evaluation

To determine the effectiveness of this media, a pre-test and post-test were carried out on 50 students before and after using the digital map.

Table 16. Pre-test and post-test results

Evaluation Aspects	Before (%)	After (%)	Increase (%)
Identifying disaster-prone areas	60	85	+25
Understanding disaster mitigation strategies	55	80	+25
Disaster preparedness	50	82	+32

From these results, there was a significant increase in student understanding after using digital maps as a learning medium.

3. Evaluate Media Effectiveness

Interviews with 10 teachers showed that 90% of teachers agreed that digital maps are more effective than conventional printed maps in teaching disaster mitigation materials. Some of the main reasons given include:

- Interactive & engaging (85%)
- Presenting real-time data (80%)

- Easier for students to understand (75%)

4. Evaluate the Affordability of Technology

From a survey conducted in schools in Langsa City, it was found that:

- 80% of schools already have a compatible device to access digital maps, either through a computer or tablet.
- 20% of schools still experience limited infrastructure, such as unstable internet networks.

As a solution, it is recommended to develop an offline version so that digital maps can still be used in areas with limited internet access.

5. User Satisfaction Evaluation

Table 17. Survey of students and teachers regarding the level of satisfaction with digital maps.

Group	Satisfaction Rate (%)
Ease of use	90
Appearance and design	85
Interactive features	88
Data accuracy	92
Access speed	78

The findings of this study indicate that the use of the *Digital Disaster Mitigation Map* significantly enhances students' understanding of disaster-prone areas and appropriate mitigation strategies. The increase from 60% to 85% in students' ability to identify disaster-prone regions demonstrates the high effectiveness of this digital learning tool [55]. Furthermore, the media's validity score of 4.5 out of 5 and an instrument reliability coefficient of $\alpha = 0.89$ confirm that this tool is not only appropriate but also consistent in measuring student comprehension. When compared with previous studies, such as the research conducted by Nugraheni and Purnamasari (2020) [56], which developed conventional map-based media and achieved only a 15% increase in comprehension, the current digital media shows a more substantial improvement, with a 25% gain. This strengthens the argument that the integration of geospatial-based technology and interactive features into educational media yields more significant impacts on disaster literacy.

Generalizing from these findings, it can be inferred that digital learning media, particularly those utilizing real-time geospatial data and interactive elements, can be effectively implemented beyond Langsa City and adapted to other regions with similar disaster risks. The implications of this study are substantial for both education and disaster policy. In the educational context, this media supports curriculum implementation that emphasizes critical thinking and problem-solving skills. From a policy perspective, the digital map can serve as a valuable tool for community-based disaster mitigation planning.

The novelty of this study lies in the integration of digital mapping technology, real-time geospatial data, and interactive learning approaches into a single tool that is directly usable by teachers and students. This sets it apart from previous media, which were typically static and non-interactive [57]. Nevertheless, several limitations should be acknowledged. First, the access speed of the digital map remains an obstacle, especially in areas with limited internet infrastructure. Second, the current version of the media does not support offline access, which restricts its usability in remote regions. Third, the disaster simulation feature, while present, has not yet reached full interactivity or realism and requires further development. Based on the findings and identified limitations, several strategic improvements are necessary to enhance the overall effectiveness of the *Digital Disaster Mitigation Map*. First and foremost, there is a need to develop an offline version of the media. This improvement would address the issue of limited internet connectivity, especially in underdeveloped or remote regions, thereby ensuring that all students—regardless of their geographic location—have equal access to disaster education resources.

Additionally, optimizing the media's access speed and ensuring compatibility across a wide range of digital devices would significantly broaden its usability [58]. These enhancements would make the media more inclusive, accommodating the diverse technological infrastructure found in various schools and communities. Another key recommendation is the enrichment of the disaster simulation features. By making these features more contextual and engaging, students would be able to experience more realistic disaster scenarios, which in turn could deepen their understanding and preparedness. Interactive simulations have the potential to transform abstract concepts into tangible experiences, thereby increasing students' emotional engagement and retention of knowledge.

Furthermore, collaboration with established disaster management agencies, such as the *Badan Nasional Penanggulangan Bencana* (BNPB) or the *Badan Meteorologi, Klimatologi, dan Geofisika* (BMKG), is crucial. These partnerships would help ensure that the geospatial data embedded in the digital map remains accurate, current, and reliable. Regular updates and validation from these institutions would enhance the credibility and

practical relevance of the media [59]. With the implementation of these recommendations, the *Digital Disaster Mitigation Map* is poised to evolve into a highly innovative educational tool. It holds great potential not only for increasing disaster awareness among students but also for serving as a strategic instrument in supporting disaster preparedness and mitigation planning at the local level.

4. CONCLUSION

This study was conducted with the primary objective of developing a *Digital Disaster Mitigation Map* as a learning resource to assist in identifying disaster-prone areas within Langsa City. Given the city's significant exposure to multiple types of natural disasters including floods covering an area of 14,576.48 hectares, earthquakes affecting 22,423.50 hectares, tsunamis (2,189.96 ha), landslides (1,994.68 ha), forest fires (18,418.94 ha), and liquefaction (14,266.07 ha) there is a pressing need for digital-based educational tools. Such tools can play a crucial role in enhancing the capacity of both students and the wider community to understand disaster risks and adopt appropriate mitigation strategies. To achieve this, the research employed a *Research and Development (R&D)* approach, specifically utilizing the *ADDIE* model, which consists of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. This structured model facilitated the careful planning and iterative refinement of the digital map to ensure its effectiveness and relevance. The findings of the study reveal several important outcomes. First, the *Digital Disaster Mitigation Map* has been shown to be highly effective in improving students' understanding of disaster-prone areas. The results from trial implementations indicate a substantial increase in comprehension levels from 60% prior to using the digital map to 85% afterward—demonstrating the media's educational impact. Second, the interactive nature of the digital map was noted to offer a distinct advantage over conventional teaching methods. Survey data shows that 90% of teachers regarded the digital media as both innovative and more effective for delivering disaster mitigation content compared to traditional approaches. Third, training sessions conducted for both students and teachers yielded positive outcomes. As many as 78% of students reported that the digital map helped them more easily grasp the concept of disaster mitigation, while 80% of teachers expressed greater confidence in teaching related materials after participating in the training.

In terms of technological readiness, the evaluation revealed that approximately 80% of schools involved in the study already possessed compatible digital devices necessary for using the map. However, certain infrastructure limitations such as unstable internet connectivity in some schools remain a barrier to full implementation. User feedback further supports the utility of the digital map. High levels of satisfaction were recorded, with 90% of users appreciating the ease of use, 85% expressing approval of the visual design, and 92% recognizing the accuracy of the geospatial data provided. Despite these promising results, several areas for future development have been identified. These include the need to improve access speed and enhance compatibility across a broader range of devices. Furthermore, the development of an offline version is considered essential for extending access to schools in regions with limited internet connectivity. Lastly, the inclusion of more dynamic and contextually rich disaster simulation features is recommended to foster deeper engagement and interactivity in the learning process.

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