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# Decision Tree-Based Expert System Planning To Support Temporary Housing Design Decision Making After Earthquake Disasters In Indonesia

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***Abstract:*** *Indonesia is one of the countries with a high level of vulnerability to earthquake disasters, which has an impact on the urgent need for the provision of temporary housing that is fast, appropriate, and adaptive to local conditions. However, the determination of the design of Temporary Modular Shelter (TMS) so far is still reactive and lacks data-based, so it is often not in accordance with the capacity of the affected areas. This research aims to develop an expert system based on a decision tree algorithm to support the policy decision-making process in determining the design of post-earthquake TMS in Indonesia. The method used is a quantitative approach with a classification system design based on three main variables: the availability of human resources (HR), the availability of local materials, and the affordability of the location. The research instrument was tested through two trial stages with a total of 15 respondents from across earthquake-prone areas. The results of the validity test showed that all items had a Pearson correlation of > 0.900 (p < 0.001), and very high reliability with Cronbach's Alpha values of 0.975 (HR), 0.981 (local materials), and 0.984 (location). The expert system successfully mapped 27 combination conditions into 27 TMS design alternatives that were tailored to local capacity and visualized in the form of an easy-to-interpret decision tree. The conclusion of this study shows that the decision tree is an effective and practical approach to support a more contextual and standardized TMS design policy. It is recommended that this system be further developed into a GIS-based digital platform and tested for implementation in national disaster management policies.*
***Keywords:*** *Temporary Modular Shelter, expert system, decision tree, earthquake, decision making, temporary housing design.*

## 1. INTRODUCTION

Indonesia, as a country located between the three main tectonic plates of Eurasia, Indo-Australia, and the Pacific, is one of the most prone regions to earthquake disasters in the world. Every year, thousands of earthquakes occur in various regions of Indonesia, causing infrastructure damage, casualties, and large numbers of population displacement. In the context of emergency response, the provision of Temporary Modular Shelter (TMS) is a crucial aspect to ensure the safety and comfort of disaster victims. However, limited resources, time, and local characteristics are often obstacles in the planning and construction process of an appropriate and adaptive TMS.In practice, the implementation of TMS in post-earthquake Indonesia still faces several problems, including designs that are not by local conditions, limited skilled manpower, and materials that are not available at disaster sites. In addition, TMS design decisions are still reactive, inconsistent across regions, and highly dependent on the subjective decisions of stakeholders. As a result, TMS often do not meet standards of convenience, sustainability, and structural safety. In answering these problems, there is a need for a systematic and data-driven approach to support the decision-making process in TMS planning that considers critical factors such as the availability of local materials, human resource capacity, and the geographical characteristics of the affected areas.Research on the provision of post-disaster Temporary Modular Shelter (TMS) has been conducted through various multidisciplinary approaches. In general, the studies highlight the importance of TMS design that is sustainable, affordable, and appropriate to the local context. For example, Perrucci (2016) emphasizes that TMS needs to be designed to be adaptive to local cultural norms and geographical conditions. This research provides a strong conceptual framework in a global context, but has not touched in depth the socio-topographic complexity that is typical of Indonesia.In terms of technical design, Nekooie and Tofighi (2020) developed a TMS system based on the Industrialized Building System (IBS) for emergency conditions. They identified three key critical success factors, namely reduced mortar use, interconnectedness between modular structures, and construction time efficiency. The results of the study showed that the symmetrical orthogonal design was effective in explosion resistance tests. However, the model has not taken into account local limitations such as the availability of materials and labor in earthquake-affected areas in Indonesia.

At the national level, Christian and Feriadi (2022) explored the use of local materials such as wood and bamboo in TMS design in Hargotirto Village. This approach successfully improves cost efficiency and environmental sustainability. However, the research has not been equipped with a decision support system framework that can assess the feasibility of the design comprehensively and systematically. Meanwhile, a study by Sari, Winarno, et al. (2024) used an Artificial Neural Network (ANN) algorithm to identify TMS design indicators based on the perception of disaster victims, such as structural strength, comfort, and ease of construction. While it is capable of capturing user preferences, the model is still limited to identifying indicators without leading to integration in expert policies or systems.

In terms of decision-making, Bakhshi Lomer et al. (2023) proposed a Large Group Decision-Making (LGDM) and Ordered Weighted Average (OWA) model for the selection of shelter locations based on earthquake risk maps. This approach excels spatially and quantitatively, but does not consider the physical design aspects of TMS and the social needs of the affected communities. Several other methods, such as TOPSIS, VIKOR, and fuzzy MCDM, have also been used in site optimization studies and material selection, but they often result in complex analytical processes and are less accessible to local policymakers in the field.

Considering the limitations of previous studies, it can be concluded that there is still a research gap in the development of simple, adaptive, and local context-based decision-making systems for post-earthquake TMS design in Indonesia. There is no system yet that specifically integrates Decision Tree algorithms into an expert system framework designed to support practical and standardized policy decision-making.

For this reason, this research offers a new approach through the development of a Decision Tree-based expert system that can formulate alternative decisions in a logical, transparent, and easy-to-understand manner. By integrating field data, expert input, and local characteristics such as human resource capacity, material availability, and geographical conditions, this system is expected to be able to provide contextual and appropriate TMS design recommendations. This approach has advantages in terms of logical clarity, interpretability of results, and its ability to be applied by policymakers at various levels of government and disaster-affected areas.

This research aims to develop a decision tree-based expert system to support policy decision-making in determining the design of post-earthquake Temporary Modular Shelter (TMS) in Indonesia. The system is designed to produce TMS design recommendations that are precise, efficient, and by local conditions, taking into account key variables such as human resource (HR) capacity, local material availability, and the geographical characteristics of the affected areas. Through a data- and rule-based approach, this system is expected to provide a consistent and standardized basis in the policy decision-making process related to the provision of adaptive and sustainable TMS.

The urgency of this research is based on the high number of earthquakes in Indonesia and the weak response system related to the provision of TMS. Inefficiencies in determining the appropriate TMS design not only slow down the recovery process but also increase secondary risks such as disease spread, social conflict, and long-term economic losses. By designing a decision tree-based decision-making system, this research contributes directly to efforts to increase national disaster resilience, data-based policy formulation, and improve the quality of life of people affected by disasters. This model also has the potential to be replicated in other countries with similar disaster risks.

## 1. METHOD

### 2.1 Research Design/Design and Research Place

This research is a quantitative-descriptive-based applied research, which aims to design a Decision Tree-based expert system to support policy decision-making in determining the design of post-earthquake Temporary Modular Shelter (TMS). This research has not been carried out in the form of direct implementation, but has resulted in a system design that is ready to be tested in earthquake-prone areas. The data used is a combination of the results of document studies, limited field data (questionnaire trials), and the results of simulative modeling.

### 2.2 Population, Samples, and Sampling Techniques

The research population consists of stakeholders in the planning and implementation of TMS, namely:

1. Field practitioners (craftsmen, technicians, project managers)
2. Representatives of government agencies (BNPB, BPBD)
3. Academics
4. Affected communities

Samples were taken by purposive sampling, which is selection based on roles and direct involvement. The number of respondents at the instrument trial stage was 15 people, consisting of:

1. 3 affected communities (East Java, West Sumatra, DIY)
2. 6 field practitioners (West Java, East Java, DIY)
3. 4 from BNPB
4. 3 from BPBD

### 2.3 Research Instruments

The research instrument was developed in the form of **a 1–5 scale questionnaire**, consisting of three main groups of indicators:

1. HR Availability
2. Availability of Local Materials
3. Location Affordability

Each indicator was tested for validity (Pearson's r) and reliability (Cronbach's Alpha) in two stages of the trial. The results of the second trial showed that all indicators in all three groups of factors were valid and reliable, with Cronbach's Alpha value > 0.98, indicating high consistency between items.

2.4 Research Procedure

The procedure for conducting the research includes:

1. Literature Study and Indicator Formulation

Based on regulations such as Permenaker No. 5/2012, SKKNI Jasa Konstruksi, and technical references BLK and PUPR.

2. Instrument Setup and Test

The questionnaire was designed, tested for validity and reliability on 15 respondents across backgrounds.

3. Data Processing & Score Assessment

Determination of the total score per category (High, Medium, Low) for each factor (HR, Material, Location).

4. Expert System Planning

The inputs from the score results are classified using **the Decision Tree algorithm** (classification method).

5. TMS Design Recommendation Simulation

Each combination of inputs results in 1 of 27 TMS design alternatives, complete with technical specifications, HR needs, and logistics methods.

1.5 Data Analysis Techniques

1. Validity and Reliability Analysis

The validity test used Pearson's correlation, reliability with Cronbach's Alpha:

1) All indicators are valid ($r > 0.3$, $p < 0.001$)
2) Cronbach's Alpha whole factor > 0.98

2. Instrument Validity and Reliability Test

1) Validity Test

Validity indicates the extent to which an instrument can measure what it should measure. In this study, validity was tested using Pearson's product-moment correlation, with the following formula:

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{\left[n\sum x^2 - \sum(x)^2\right]\left[n\sum y^2 - \sum(y)^2\right]}}$$

**Information:**

Rr: Pearson's correlation coefficient

XX: Item Score

yy: total score

NN: Number of respondents

**Validity criteria:**

If r>rtabelr is > r_tabel (at a significance level of 0.05), then the item is declared valid.

In this study, all items in the questionnaire had an RR value greater than the critical value, indicating that all instrument items were valid.

2) Reliability Test

Reliability is used to measure internal consistency between items in a questionnaire. This test is performed using Cronbach's Alpha formula, as follows:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum \sigma_i^2}{\sigma_t^2}\right)$$

**Information:**

$\alpha$: reliability coefficient (Cronbach's Alpha)

K: Number of items

$\sigma_i^2$: variance of each item

$\sigma_t^2$: total score variance

**Interpretation:**

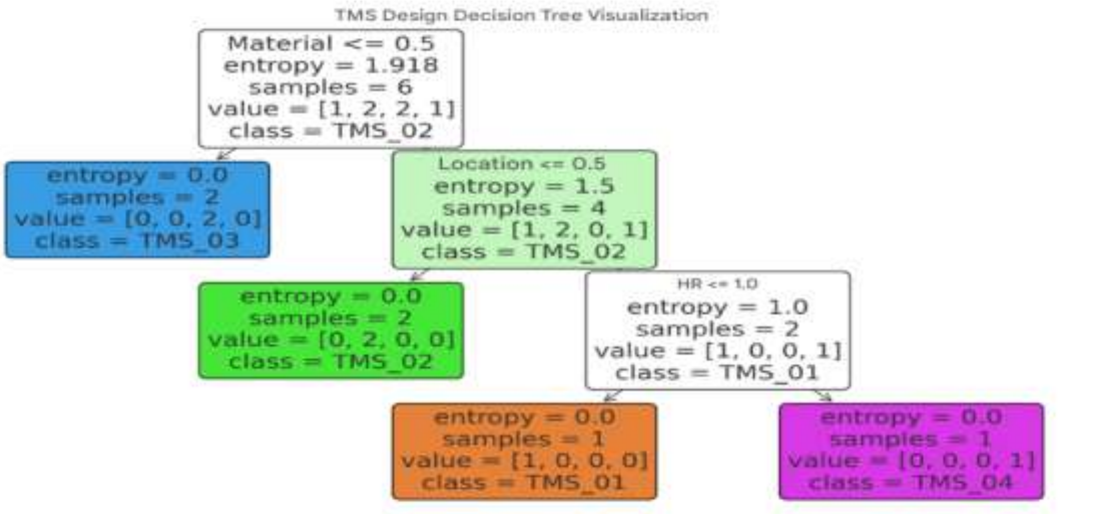
$\alpha > 0.70$: Good reliability

$\alpha > 0.90$: very high reliability

1.6 Output Visualization and Interpretation

Each combination results in a specific TMS design (TMS-01 to TMS-27) that contains:

1. Concept name
2. Building size
3. Main material
4. Assembly technology
5. HR Needs
6. Transportation methods




This tree shows the classification logic flow to determine the type of Temporary Modular Shelter (TMS) design based on a combination of category values (Low, Medium, High) of the three factors.

## 2. FINDINGS AND DISCUSSIONS

3.1 Instrument Validation: A Phased Test Process

This study uses a quantitative approach with validity and reliability tests to ensure that the measurement instruments of the three main variables of human resource availability, local material availability, and location affordability truly represent field conditions in the context of post-earthquake Temporary Modular Shelter (TMS) planning.

3.2 Trial Stage 1 (Preliminary Draft of the Instrument)

1. Number of respondents: 15 people (field practitioners, affected residents, BNPB, and BPBD personnel from Java, Sumatra, and DIY).
2. Preliminary findings:
1) Many indicators are invalid (Pearson correlation value < 0.3).
2) Reliability values are very low and even negative, for example:
   Cronbach's Alpha for HR factor = −0.419
   Cronbach's Alpha for local material = −2,608
   Cronbach's Alpha for location = −0.457

3.3 Trial Phase 2 (Instrument Revision)

After the improvement of the concept and redaction of the indicators, a retest was carried out:

1. All indicators in the three variables passed the validity test:
   Pearson correlation > 0.9 with p-value < 0.001
2. Very high reliability:
   Cronbach's Alpha for all variables is above 0.97
   Demonstrates excellent internal consistency and stability of the measuring instrument

3.4 Classification Results & Evaluation Categories

Each variable has 5 indicators, each of which is scored 1–5. The total score is then classified into three categories:

| Variable | Total Score Range | Category | Interpretation |
|---|---|---|---|
| HR Availability | 21–25 | High | Highly skilled, independent human resources build TMS |
| | 15–20 | Medium | A well-rounded team of experts needs technical guidance. |
| | ≤ 14 | Low | Teachers need additional training. |
| Material Availability | 21–25 | High | Complete materials, easy to obtain |
| | 15–20 | Medium | Materials are available but limited |
| | ≤ 14 | Low | Scarce/expensive materials, need an external supply |
| Location Affordability | 25–30 | High | Very easy to reach location |
| | 18–24 | Medium | Sufficient access needs additional support |

| | | | |
|---|---|---|---|
| | ≤ 17 | Low | Location is difficult to reach, and needs a special logistics strategy |

3.5 Implementation of Decision Tree Algorithm

After classification, the Decision Tree algorithm-based expert system is built. This algorithm maps 27 combination conditions ($3^3$) into 27 TMS designs tailored to local capacity. Example mapping:

1. TMS-01 (High-HR, High-Location, High-Material) → High-Tech Modular Unit
2. TMS-27 (Low all) → Ultra-Low Input Shelter

Each design has specifications:

1. Size & shape of the shelter
2. Main material
3. How to assemble
4. Required HR Profiles
5. How to ship materials

The decision tree is compiled by considering the order of decision-making that is most critical to the success of implementation in the field.

3.6 Findings Excellence

1. This system is based on transparent rules, allowing agencies such as BNPB, PUPR, and BPBD to make consistent, efficient, and contextual decisions.
2. The integration of social and technical factors makes the system more adaptive than purely spatial models.
3. Tree-shaped visualizations facilitate training for field officers and simulations in geographic information systems (GIS).

3.7 Analysis of Value Change from Trial 1 to Trial 2

The difference in results between the first and second trials showed a significant improvement in the quality of the research instruments, both in terms of validity and reliability.

3.8 Test Results 1: Indication of Conceptual Problems

In the initial trial, it was found that most of the indicators in all three main variables did not qualify for validity. This is indicated by the Pearson correlation value $< 0.3$, which means that the items are not sufficiently correlated with the total score, so they cannot represent the construct being measured.

In addition, the reliability value of Cronbach's Alpha is very low and even negative, namely:

1. SDM = –0.419
2. Local Materials = –2,608
3. Location = –0.457

This negative value indicates the existence of extreme inconsistencies between items, which are usually caused by:

1. Editorial of ambiguous indicators
2. Semantically inconsistent placement of items
3. Differences in respondents' interpretations

This problem is an indication that the instrument has not been standardized and is not suitable for use in systematic measurements.

3.9 Revision Action: Reformulation and Alignment of Indicators

Based on the findings of trial 1, a thorough revision was carried out on:

1. Editorial of the indicator statement
2. Inter-item logic arrangement
3. Sequence and consistency of question construction
4. Adding context or explanations to specific items

This process follows the principles of constructive validation and consultation with disaster experts, civil engineering, and field representatives.

3.10 Trial Result 2: Significant Improvement

After repairs, the second trial showed excellent results:

1. All items passed validity: Pearson correlation > 0.9 and significant ($p < 0.001$)
2. Cronbach's Alpha for all three variables:
   SD: > 0.97
   Local Material: > 0.98
   Location: > 0.98

This improvement indicates that each indicator in the measured variable has a high internal consistency, as well as being able to represent the constructed construct.

Comparison of trials showed that the validity and reliability of the instrument were highly dependent on the conceptual and technical quality of the question items. The change from a negative Alpha value to a value above 0.97 is evidence that the revision of the instrument has succeeded in improving the logical structure and strengthening the integrity of the data.

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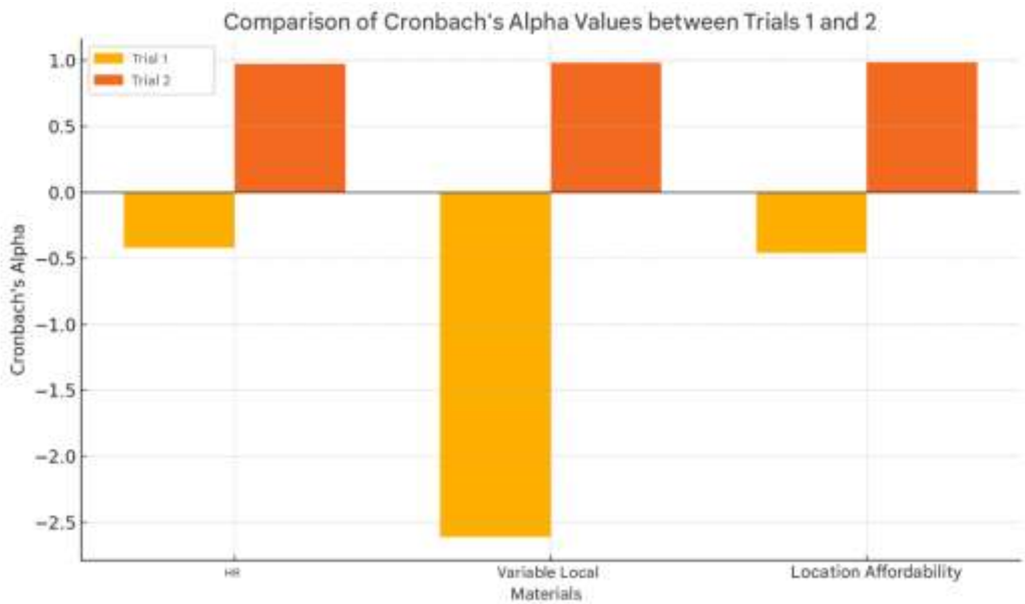
This success is an important foundation for classification accuracy in expert systems, as the quality of the input data directly affects the reliability of the results of TMS design recommendations in the Decision Tree model.

| Variable | Trial 1 | Trial 2 | Change |
|---|---|---|---|
| TBSP | -0.419 | 0.975 | 1.394 |
| Local Materials | -2.608 | 0.981 | 3.589 |
| Location Affordability | -0.457 | 0.984 | 1.441 |




### 3.11 Comparison with Previous Research

This study strengthens the indicator-based approach as carried out by Sari, Winarno, et al. (2024), who use Artificial Neural Network (ANN) to identify TMS design factors. In contrast to ANN, which is black-box, the Decision Tree model in this study is transparent and easy to understand by policymakers.

In addition, Christian and Feriadi (2022) emphasize the importance of using local materials in modular design. This research expands the approach through logical classification based on availability variables, allowing for policies to be more responsive to field conditions.

The spatial model of Bakhshi Lomer et al. (2023) in the selection of shelter locations has not touched on the technical design aspect. This research fills this gap by presenting a system that combines social, technical, and logistical aspects in TMS design.

### 3.12 Scientific Discussion and Integrated Approach

Recent disaster studies have broadly encouraged the need for an integrated approach in post-disaster shelter planning. Ahmed et al. (2018) emphasized that emergency housing design must simultaneously incorporate social, cultural, technical, and local capacity aspects so that it is not only functional but also sustainable.

Meanwhile, Shaw and Izumi (2014), through the Build Back Better approach, advocate that disaster response systems integrate local data, community input, and local government technical capabilities in one adaptive decision-making system.

This research addresses these challenges by developing a Decision Tree-based expert system that not only produces design recommendations but also provides a classification framework that can be understood by policymakers and the technical community, in line with the idea of a policy-relevant decision support system (UNDRR, 2015).

### 3.13 Follow-up on the Findings

These findings can be used as:

1. The basis for developing national policies for the provision of TMS based on locality.
2. Policy simulation tools in earthquake-prone areas, especially in the pre-disaster phase.
3. A digital-based prototype of an expert system, which can be developed in the form of a GIS dashboard or a mobile application for field teams.

### 3.14 Research Limitations

Some of the limitations noted in this study:

1. The sample size was relatively small (15 respondents) as the initial basis for model validation.
2. A real field implementation test has not been carried out.
3. Have not integrated cultural, gender, and psychosocial dimensions in the decision model.

These limitations form the basis for further development through:

1. Testing the system on real case studies in earthquake-affected areas.
2. Integration of expert systems with spatial data (GIS).
3. Enrichment of decision variables with social and demographic aspects.

## 4 CONCLUSION

The Decision Tree-based expert system developed in this study successfully classified a combination of local conditions into 27 Temporary Modular Shelter (TMS) design alternatives, based on three main variables: availability of human resources (HR), availability of local materials, and affordability of location. Each variable is categorized into three levels (Low, Medium, High), resulting in a logical combination that can be used as the basis for adaptive and data-driven policy decision-making. The validity of the instrument item showed a Pearson correlation of $> 0.900$ with a significance of $p < 0.001$, signaling a very strong relationship between the indicator and the construct being measured. Inter-item reliability is also very high, with Cronbach's Alpha values of 0.975 for HR variables, 0.981 for local materials, and 0.984 for location affordability, well beyond the minimum threshold of 0.70 for reliable instruments. A significant improvement from the results of the first test, showing a negative reliability value, confirms the success of the conceptual and technical improvements of the instrument. Overall, this expert system provides a logical, transparent, and easy-to-interpret approach to support the formulation of post-earthquake TMS provision policies in Indonesia, and has great potential to be widely applied in the context of locality-based disasters.

## REFERENCES

1.Ahmed, I., Seraj, T. M., & Chowdhury, M. R. (2018). Sustainable emergency shelter solutions: A holistic approach for post-disaster reconstruction. International Journal of Disaster Risk Reduction, 27, 55–63. https://doi.org/10.1016/j.ijdrr.2017.09.012

2. Bakhshi Lomer, K., Aghamohammadi, M., & Farhadi, H. (2023). A large-group decision-making approach using OWA and risk maps for temporary shelter site selection after earthquakes. Sustainable Cities and Society, 96, 104646. https://doi.org/10.1016/j.scs.2023.104646

3. Christian, R. & Feriadi, H. (2022). The use of local materials in the design of post-disaster modular housing: A case study of Hargotirto Village, Yogyakarta. Journal of Tropical Architecture, 10(1), 33–42.

4. Nekooie, M. A., & Tofighi, M. (2020). Design of blast-resistant modular buildings using Industrialized Building Systems (IBS): A sustainable approach. Engineering Structures, 216, 110698. https://doi.org/10.1016/j.engstruct.2020.110698

5. Perrucci, G. (2016). Temporary housing design: Towards culturally appropriate post-disaster shelters. Procedural Engineering, 161, 2080–2086. https://doi.org/10.1016/j.proeng.2016.08.763

6. Quinlan, J. R. (1993). C4.5: Programs for machine learning. Morgan Kaufmann.

**7.** Sari, S. N., Winarno, H., et al. (2024). Identify the main indicators of temporary housing based on the Artificial Neural Network (ANN) algorithm. Journal of Technology and Civil Engineering, 18(2), 112–125.
**8.** Shaw, R., & Izumi, T. (2014). Civil society organizations and disaster risk reduction. Springer.
**9.** Turban, E., Sharda, R., & Delen, D. (2011). Decision support and business intelligence systems (9th ed.). Pearson Education.
**10.** UNDRR. (2015). Sendai Framework for Disaster Risk Reduction 2015–2030. United Nations Office for Disaster Risk Reduction. https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030