Conceptual modeling of resilience measurement during natural disasters for SMEs

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Abstract. This study focuses on how to generate resilience information services to natural disasters for SMEs. The information in this study was using software or application developed based on a conceptual model formed as a framework for SMEs’ managers in dealing with natural disasters. The conceptual model was shaped based on actual data from SMEs’ owners and leaders, as well as stakeholders in four regencies in the Madura Island, Indonesia, namely Bangkalan, Sampang, Pamekasan and Sumenep, by identifying the variables or dimensions of SMEs’ resilience to natural disasters. The conceptual model was produced using sequence and use case diagrams to identify the relationship between risk and resilience dimensions to measure the level of resilience of SMEs. The level SMEs’ resilience to natural disasters was the basis of information received by SMEs’ owners and leaders. This study is expected to help SMEs to determine the level of SMEs’ resilience to the risk of natural disasters to minimize the existing risks.

1. Introduction

SMEs are very potential in Indonesia because Indonesia is the largest archipelagic country in the world with 13,466 islands and a sea area of 3,257,483 km², as well as a land area of 1,922,570 km² [1]. SMEs can help to improve the welfare and economy of the community as well as multiplying the regional economy by providing new jobs, producing goods and services, and paying taxes [2,3]. The SME operational process cannot be separated from the presence of several roles of the elements, including the SME owners and leaders, traders, government, environment, and location [2,4]. Indonesia, a nation with thousands of islands, is prone to natural disasters. The magnitude of the potential natural disasters causes human powerlessness due to the impact of after natural disasters, including the emergence of problems for SME owners and leaders and industries, such as not optimal production and marketing processes in SMEs. Internal and external factors of SMEs consist of six points, which are the quality of human resources and natural resources, production system, financial system, marketing strategy, partnership system, and infrastructure and regulation quality. SMEs can operate and develops if these six points can be formed and implemented well [5]. The occurrence of natural disasters is undeniable that the points above will experience an extraordinary reduction if the level of SMEs’ resilience is extremely weak against natural disasters. Thus, the problem that arises is how SMEs can find out the level of resilience of their SMEs to anticipate the impacts of natural disasters and increase the resilience against the impacts. Therefore, a model that can help SME managers in measuring the level of resilience of SMEs in dealing with natural disasters is required [6,7].

This research presents a conceptual model of an information system that can be used as a framework for generating an information system for an online resilience measurement system. The conceptual model is created using social and technical perspectives and will be used as a basis in the establishment of software or applications for measuring SMEs’ resilience to deal with natural disasters. The model needs to be formed to analyze the elements of a real system and further build a logic model that contains...
logical relationships between system elements and variables that affect the system, which are programming algorithm flowcharts that are then developed in a computer program [8].

SMEs are one of the business sectors that provide a significant contribution to the economic growth, which include small businesses with the household scale that have less than 20 employees and medium-sized businesses with less than 100 employees. The main problem in SMEs is in the sector of exposure, where the level of marketing effectiveness is influenced by two factors, including internal and external factors [4]. Internal factors are related to the aspects of production, human resources, natural resources, and SMEs operating practices, while external factors deal with the aspects of marketing, competitor, and environment [2]. Both internal and external factors must be considered carefully by the management of SMEs because these two factors are highly influential in the continuation of SMEs. SMEs’ owners and leaders need local governments’ attention to support the SME netting process, such as training and public facilities [9].

Natural disasters are events caused by the interaction of nature on environmental conditions that have major impacts on humans, disrupting humans’ life patterns and causing them to fall into helplessness and suffer, and in these conditions, humans ultimately need adequate food, clothing and others [6]. Natural disasters certainly have effects, one of which is the decline in the economy of the community or the local government, for example, causing the nets of SMEs and other businesses to become less optimal and even stop [10]. The impacts of natural disasters are extremely detrimental to humans, and therefore, special attention needs to be given and anticipating action is necessary to be made in various ways, one of which is always monitoring natural phenomena that can potentially lead to natural disasters and even impose limits on the public, especially to large industries, to stop activities that cause damage to nature [11].

The conceptual model is a diagram that consists of a set of relationships between factors or elements that are believed to have an impact on a target or goal [7]. A good conceptual model must describe a system of thought that is easily understood and logically bring up the relationship between factors or elements with more effective outputs [8]. Modeling is essential to support research activities, especially in the development of information and analysis systems [12].

The process of building a conceptual model includes two general stages. The first stage involves creating an initial conceptual model that shows what is happening at the project site before starting the project. This model explains the condition of the target location, underlying factors and initial relationship to start the project. The second stage comprises placing the initial conceptual model as a basis and then adding project activities to be carried out to achieve the goals and objectives. After completing the second stage, a complete project conceptual model is successfully created that shows the expectation toward the project to affect the situation at the project site [7,8].

2. Methodology
2.1. Data Collection
Data in this study were collected through both field and literature studies. The field study was carried out by directly visiting the locations of fifty SMEs in four regencies, including Bangkalan, Sampang, Pamekasan and Sumenep, in the island of Madura, to acquire and find out the production and marketing processes of SMEs’ products, stakeholders playing a role in the businesses, the risks faced by SMEs during natural disasters and mitigation efforts undertaken by SMEs. Literature studies were useful to support the formation of conceptual models to identify problems and their solutions based on previous research, journals, scientific publications, or related theories. In modeling a complex system, the elements of the system, covering variables or dimensions of resilience, were identified. The conceptual model was then formed using sequences and case diagrams to spot the relationship between risk and resilience to measure the level of resilience of SMEs.

2.2. Sequence Diagrams
A sequence diagram depicts the interaction between objects and indicates the communication between these objects to identify the extent of the relationship between objects [13,14]. In this study, the sequence
diagram was used to portray the behaviors in scenarios and describe how entities and systems interacted, including messages used during the interactions in sequential order of execution [15,16]. A sequence diagram is closely linked to the use case diagram, in which for one case, a sequence diagram will be formed [17].

2.3. Use Case Diagram
The use case diagram is a UML diagram model that is utilized to describe the desired functional requirements of a system [18]. A use case diagram is beneficial in briefly defining who uses a system and what the system can do [19]. This type of diagram was used in this research to model and express the functional units or services provided by the system to the user. It does not explain its use in detail but gives a brief description of the relationship between the actors and the system [17].

3. Results and Discussion
The conceptual model was formed as an information system that could provide services to measure the level of resilience of an SME to natural disasters.

3.1. Results of Use Case Diagram
This diagram explains how SMEs’ actors or users accessed the menus in the SMEs’ Resilience Measurement Information System for Natural Disasters.

![Use Case Diagram](image)

*Figure 1. Use case diagram in the SMEs’ resilience measurement information system for natural disasters.*

Figure 1 communicates that the Service menu has a Resilience Measurement Submenu, which contains a page with survey points and an explanation of how to complete the survey. The About Us menu contains pages that describe researchers and their research on the level of resilience of an SME to natural disasters. The News covers various news about the resilience of SMEs to natural disasters. The Contact Us menu comprises contact information that can be accessed to submit questions, suggestions, feedback, or reports about the resilience of SMEs to natural disasters.

3.2. Results of Sequence Diagram
This diagram explains how the users carried out the resilience measurement process by filling out a survey and the responses were later sent to the users’ emails.
Figure 2. Sequence diagram in the SME resilience measurement information system for natural disasters.

Figure 2 demonstrates that SMEs or Users accessed the Resilience Measurement submenu in the Service menu displaying a screen containing the survey form. The survey form contains 25 points, responded according to the levels of the provided responses. After the survey was submitted, the final step was entering an email address used to receive the result of the measurement in the form of a score of an SME’s resilience against natural disasters and some suggestions for improving the resilience of the SME.

3.3. Flowchart Diagram
Figure 3 presents the process flow of measuring the resilience of SMEs to natural disasters in four regencies in Madura Island, Indonesia, in which the initial step was taken in measuring the resilience of SMEs using surveys for data collection. The survey was conducted by making use of software or application that has been developed, with access to survey forms for measuring resilience. The data obtained from the survey were then inputted via email for submission. When the submission process was successful, the responses later proceeded to the calculation stage. However, when the submission process failed, the data inputting process had to be repeated. The results of the calculation were displayed as information by sending via email to the SMEs’ manager.
4. Conclusion
This study concludes that a conceptual model can be used as one approach to help solve problems in a system. The conceptual model in this study was formed through several stages with the use case diagram and sequence diagram. The model formed was later translated into a computer model to produce an information system about measuring SMEs’ resilience to natural disasters.

References
[1] National Disaster Management Agency of the Republic of Indonesia. Risiko Bencana Indonesia (Indonesia's Disaster Risk). 2016. http://inarisk.bnpb.go.id/pdf/Buku RBI_Final_low.pdf
[2] Iborra M, Safón V, Dolz C. What explains resilience of SMEs? Ambidexterity capability and strategic consistency. Long Range Plann. 2019;101947. doi.org/10.1016/j.lrp.2019.101947
[3] Günerergin M, Penbek Ş, Zaptıçoğlu D. Exploring the Problems and Advantages of Turkish SMEs for Sustainability. Procedia - Soc Behav Sci. 2012;58:244–51.
[4] Albats E, Alexander A, Mahdad M, Miller K, Post G. Stakeholder management in SME open innovation: Interdependences and strategic actions. J Bus Res. 2019;(April 2018):1–11. doi.org/10.1016/j.jbusres.2019.07.038
[5] Ansori N, Sutalaksana IZ, Widyanti A. Comparison Between Key Success Factors in Safety Behavior in Small- and Medium-Sized Enterprises (SMEs) and Large Industries, and Development of a Hypothetic Model for Safety Behavior in Indonesian SMEs. KneE Life Sci. 2018;4(5):582.
[6] Henneman A, Thornby KA, Rosario N, Latif J. Evaluation of pharmacy resident perceived
impact of natural disaster on stress during pharmacy residency training. *Curr Pharm Teach Learn.* 2020;12(2):147–55. doi.org/10.1016/j.cptl.2019.11.008

[7] Kalkhoven JT, Watsford ML, Impellizzeri FM. A conceptual model and detailed framework for stress-related, strain-related, and overuse athletic injury. *J Sci Med Sport.* 2020. doi.org/10.1016/j.jsams.2020.02.002

[8] Bianchi Janetti E, Guadagnini L, Riva M, Guadagnini A. Global sensitivity analyses of multiple conceptual models with uncertain parameters driving groundwater flow in a regional-scale sedimentary aquifer. *J Hydrol.* 2019;574(April):544–56. doi.org/10.1016/j.jhydrol.2019.04.035

[9] Leckel A, Veilleux S, Dana LP. Local Open Innovation: A means for public policy to increase collaboration for innovation in SMEs. *Technol Forecast Soc Change.* 2020. doi.org/10.1016/j.techfore.2019.119891

[10] Boudreaux CJ, Escaleras MP, Skidmore M. Natural disasters and entrepreneurship activity. *Econ Lett.* 2019;182:82–5. doi.org/10.1016/j.econlet.2019.06.010

[11] Murray M, Watson PK. Adoption of natural disaster preparedness and risk reduction measures by business organisations in Small Island Developing States - A Caribbean case study. *Int J Disaster Risk Reduct.* 2019;39(November 2018):101115. doi.org/10.1016/j.ijdr.2019.101115

[12] Verdonck M, Gailly F, Pergl R, Guizzardi G, Martins B, Pastor O. Comparing traditional conceptual modeling with ontology-driven conceptual modeling: An empirical study. *Inf Syst.* 2019;81:92–103. doi.org/10.1016/j.is.2018.11.009

[13] Baidada C, Bouziane EM, Jakimi A. A New Approach for Recovering High-Level Sequence Diagrams from Object-Oriented Applications Using Petri Nets. *Procedia Comput Sci.* 2019;148:323–32. doi.org/10.1016/j.procs.2019.01.040

[14] Campean F, Yildirim U. Enhanced Sequence Diagram for Function Modelling of Complex Systems. *Procedia CIRP.* 2017;60:273–8. doi.org/10.1016/j.procir.2017.01.053

[15] Refsdal A, Runde RK, Stolen K. Stepwise refinement of sequence diagrams with soft real-time constraints. *J Comput Syst Sci.* 2015;81(7):1221–51. doi.org/10.1016/j.jcss.2015.03.003

[16] Sellami A, Hakim H, Abran A, Ben-Abdallah H. A measurement method for sizing the structure of UML sequence diagrams. *Inf Softw Technol.* 2015;59:222–32. doi.org/10.1016/j.infsof.2014.11.002

[17] Arora PK, Bhatia R. Agent-Based Regression Test Case Generation using Class Diagram, Use cases and Activity Diagram. *Procedia Comput Sci.* 2018;125:747–53.

[18] El-Attar M. Evaluating and empirically improving the visual syntax of use case diagrams. *J Syst Softw.* 2019;156:136–63. doi.org/10.1016/j.jss.2019.06.096

[19] Skersys T, Danenas P, Butleris R. Extracting SBVR business vocabularies and business rules from UML use case diagrams. *J Syst Softw.* 2018;141:111–30. doi.org/10.1016/j.jss.2018.03.061