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E261

An Application of Combined Fuzzy MCDM Techniques in Structuring Disaster Resilience Indicators for Small and Medium Enterprises: A Case Study

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An Application of Combined Fuzzy MCDM Techniques in Structuring Disaster Resilience Indicators for Small and Medium Enterprises: A Case Study

by Dicky Fatrias

An Application of Combined Fuzzy MCDM Techniques in Structuring Disaster Resilience Indicators for Small and Medium Enterprises: A Case Study

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Abstract—**As a small business unit characterized by a high vulnerability to disaster disruption, Small and Medium Enterprises (SMEs) becomes those that are impacted most by disaster disruption. This research proposes to structure disaster resilience indicators by developing methodology utilizing fuzzy Delphi techniques and fuzzy Best-worst method (fuzzy-BWM) to identify and prioritize the relevant disaster resilience indicators for SMEs. A real data application is conducted for SMEs in Padang City. Through gathering experts' opinion, we obtained final list consisting of 26 suitable disaster resilience indicators grouped in four resilience dimensions. We revealed that the "building utility", "evacuation access" and "shelter facilities" are ranked the highest. Physical resilience was found to be the most crucial dimension since five out of its six indicators are placed in the top ten ranks. This result may reveal that physical infrastructures of SMEs in Padang city are considered as a main concern by the five experts to be developed to realize resilient capability against disaster disruption. This result can be used as the basis for interested parties to prioritize the effort to improve SMEs' capability in avoiding or mitigating future disaster disruption, especially in facing earthquake and tsunami.**

Keywords - disaster resilience, SMEs, fuzzy delphi, fuzzy-BWM

I. INTRODUCTION

The issue of disaster resilience has become the interest of many researchers in many years. In addition to its impact on people and the environment, disaster also have tremendous effects on business continuity in the aftermath of disaster. Business disruptions that are not coped effectively can come at a huge financial impact because of disrupted relation with partner, revenue losses, sales opportunity losses, etc. Getting back to business after disaster is not an easy task, but a complex arrangement on the critical process that consumes considerably amount of resources and time. Resilience is one of the key strengths for business to gain back its business function as prior to disaster. In disaster management domain, resilience has been an inclusion to apply as a framework for focusing on the priority of risk identification and reduction, culture of safety development, and strengthening preparedness and response capabilities [1]. Resilience is described as essential resources and characteristics that can help maintain or regain pre-disaster levels of operations function and realize successful adaptation [2].

In literatures, disaster resilience is defined from different point of view. From community perspective, Mayunga [3] mentioned that disaster resilience is the capacity or ability of a community to anticipate, prepare, respond and recover quickly from impacts of disaster. In organizational and business continuity perspective, Mitroff [4] defines resilience as a continuously moving target that enhances performance of business both in normal and disruptive situation. Seville et al. [5] mentioned that resilience as an ability/capacity of organization to survive, and even thrive, in times of crisis and emergencies. A resilient business provides competitive advantage and is used as a measure of business's health [6].

Small and medium enterprises (SMEs) are business units that are highly vulnerable to disaster risk. SMEs are those that are impacted most by disaster disruption. They are less likely to have inadequate capacity to respond and recover back after disasters, as most of them is not or less engaged in disaster risk reduction effort. They usually do not have the ability to absorb risks and the impacts of disasters, since they often operate with a few employees and are unable to spread and transfer their risks [7]. SMEs, especially in developing countries, also do not have the necessary concern and knowledge of their vulnerability to develop and implement business continuity plans [8].

This research attempts to explore disaster preparedness of SMEs in Padang city, West Sumatera - Indonesia, by studying its resiliency against disaster risk. Our work is motivated by the impact of the 2009 earthquake hit West Sumatera which damaged thousands of SMEs in Padang City resulting in the closure of businesses. After nine years of such big disaster and since there is an increasing caution of forthcoming megathrust earthquake predicted to occur in this area, it is become increasingly important to examine the current resilience of SMEs to disaster risk.

Research on SMEs resilience against disaster disruption is quite limited. Most researches in disaster resilience topic focus on proposing a framework of resilience models as well as conducting resilience evaluation on community perspective [9-11]. Although several researches attempt to address such issue in SMEs context, they possess some drawback in terms of measurement scope of evaluation. Furthermore, most of them are conducted in developed countries and those focus on such issues in developing countries are still scarce [12]. This study tries to fill this gap. The purpose of this study is to propose suitable indicators for resilient SMEs in Padang city. This research is the first step toward our advanced studies on evaluation of disaster risk reduction efforts in this city. Structuring disaster resilience indicators is carried out by identifying and prioritizing resilience indicators that could be used as the basis for government and interested parties to prioritize the effort to improve SMEs' capability in avoiding or mitigating future disaster disruption, especially in facing earthquake and tsunami.

Through gathering experts' opinion we propose to adopt a fuzzy Delphi technique to identify the relevant disaster resilience indicators of SMEs. The fuzzy Delphi has been widely used in numerous management science field to achieve a consensus among a group of people where vagueness and uncertainty in the decision-making are often occurs [13]. The fuzzy BWM, which is known as a novel and efficient pairwise comparison method [14], is then applied to gain the ranking of indicators that could help the stakeholders and policy maker to focus and prioritize the effort designed toward disaster risk reduction.

II. THE PROPOSED METHODOLOGY

A. *Survey Questionaires*

We conducted survey research in which rating scales questionnaires are used to gather expert opinion by eliciting judgment on the degree of importance of each resilience indicators applied to SMEs context. For this purpose, fuzzy linguistic scales are provided as shown in Table 1. This rating scales questionnaire establishes the relevant disaster resilience indicators from the initial list identified from current literatures.

B. *Respondents*

The number of experts assigned to fill the questionnaire is decided not to be necessarily high. This rule relies on the fact that in group decision making there is no strong correlation between the number of experts and the quality of judgment [13]. Even involving more experts who may have inadequate experiences may results in weak decision accuracy [15]. In this research, we arrange the qualification of experts to: (1) have theoretical and practical experience of working in disaster management field; (2) have at least five years' professional experience in SMEs development domain; (3) have experience in facilitating or organizing projects or activities geared towards disaster relief operation. Based on this qualification, five experts are chosen which includes academician with strong background in disaster management research, Head of Cooperatives and Small and Medium Enterprise office West Sumatera Province, Head of Regional Disaster Management Agency, and Disaster -NGO representatives.

C. *Data Collection*

First, the data of resilience indicators were gathered from literature review of nine research papers. A total of 202 resilience indicators were collected based on the type of disruption (man-made and natural disruption) and the context to where they were measured (community and organization). Redundancy check is then carried out which generates initial draft of 26 disaster resilience indicators of SMEs. This draft was then submitted to the experts for verification. The last step was done through a survey where questionnaires were distributed to the experts personally utilizing fuzzy Delphi techniques and BWM. The flow of methodology is shown in Fig. 1.

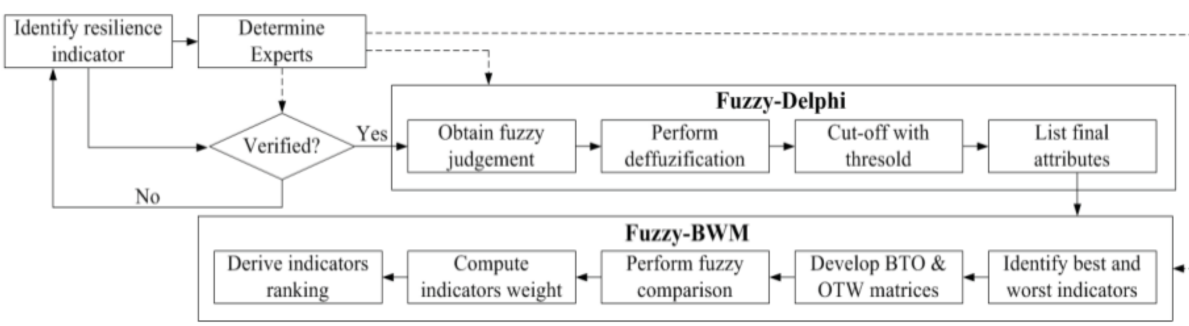

Figure 1. Flowchart of Methodology.

D. *Computational Procedures*

In general, the procedure of structuring disaster resilience indicators of SMEs at Padang city is itemized as follow:

- Review the main literatures which proposes resilience indicators, examine the indicators which relates to disaster disruption and filter them for redundancy.
- Ask the experts to examine the relevancy of indicators to the context of SMEs. The indicators which are not relevant are discarded from the initial draft list.

TABLE I. FUZZY INTENSITY OF IMPORTANCE

Linguistic variables	Fuzzy Preference Number (Triangular Fuzzy Number)
Very low important	(0.0, 0.1, 0.3)
Low important	(0.1, 0.3, 0.5)
Medium important	(0.3, 0.5, 0.7)
High important	(0.5, 0.7, 0.9)
Very high important	(0.7, 0.9, 1.0)

TABLE II. FUZZY PAIRWISE COMPARISON

Linguistic Preferences	**Fuzzy Preference Number (Triangular Fuzzy Number)**
Equal important	(1, 1, 1)
Weakly important	(0.6, 1, 1.5)
Fairly important	(1.5, 2, 2.5)
Very important	(2.5, 3, 3.5)
Absolutely important	(3.5, 4, 4.5)

TABLE III. DISASTER RESILIENT INDICATORS

Dimension	Indicators	
Physical Resilience (PR)	Building utility	PR1
	Housing type	PR2
	Evacuation access	PR3
	Housing age	PR4
	Shelter facilities	PR5
	Transportation facilities	PR6
Organizational Resilience (OR)	Leadership	OR1
	Staff engagement	OR2
	Informed decision making	OR3
	Innovation and creativity	OR4
	Unity of purpose	OR5
	Leveraging of knowledge	OR6
	Management structure	OR7
	Proactive posture	OR8
Social Resilience (SR)	Connectivity awareness	SR1
	Information exchange	SR2
	Community engagement	SR3
	Comprehensive partnership	SR4
	Cooperation with local community	SR5
Economic Resilience (ER)	Dependency on external funds	ER1
	Diversified business	ER2
	Business size	ER3
	Access to market	ER4
	Insured business asset	ER5
	Disaster management budget	ER6
	Access to credit	ER7

- Gather data from the experts through rating scales questionnaires for judgement of importance of each disaster resilience indicators using linguistic scale in Table I. Let $\tilde{b}_i^k = \left(b_{il}^k, b_{im}^k, b_{iu}^k\right)$ denotes the importance in triangular fuzzy number (TFN) of attribute i set by expert k, then the aggregate TFN, $\tilde{b}_i$, is stated as

$$\tilde{b}_i = (b_{il}, b_{im}, b_{iu}) = \left(\min_k b_{il}^k, (1/K)\sum_{k=1}^{K} b_{im}^k, \max_k b_{iu}^k\right) \quad (1)$$

- Defuzzify $\tilde{b}_i$ using the center of gravity method as

$$b_i = (b_{il} + b_{im} + b_{iu})/3 \quad (2)$$

- Set a desired value of α [0, 1]. If $b_i \geqslant \alpha$, include the indicators i in the indicators final list. Otherwise, discard the indicators.
- Ask the experts to choose the best (e.g. most desirable, most important) and the worst (e.g. least desirable, least important) indicators from a set of decision n indicators $\{a_1, a_2, ..., a_n\}$ from the indicators final list.
- Using Table II, perform fuzzy pairwise comparison which obtains fuzzy best-to-others (BTO) vector, $\tilde{A}_B = (\tilde{a}_{B1}, \tilde{a}_{B2}, ..., \tilde{a}_{Bn})$, and fuzzy others-to-worst (OTW) vector, $\tilde{A}_W = (\tilde{a}_{1W}, \tilde{a}_{2W}, ..., \tilde{a}_{nW})$, where $\tilde{a}_{Bj}$ is the fuzzy preference of the best criterion c_B over criterion j and $\tilde{a}_{jW}$ is the fuzzy preference of criterion j over the worst criterion c_W; $j = 1, 2, ..., n$.

TABLE IV. AGREGATE FUZZY JUDGMENT AND DECISION ON INDICATORS

Indicators	Expert 1				Expert 2				Expert 3				Expert 4				Expert 5				crisp b_i	Decision (Acc./ Rej.)
	Ra-ting	TFN			Ra-ting	TFN			Ra-ting	TFN			Ra-ting	TFN			Ra-ting	TFN				
		l	m	u		l	m	u		l	m	u		l	m	u		l	m	u		
PR1	SS	0.7	0.9	1	SS	0.7	0.9	1	SS	0.7	0.9	1	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.787	Acc.
PR2	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.587	Acc.
PR3	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	SS	0.7	0.9	1	SS	0.7	0.9	1	SS	0.7	0.9	1	0.613	Acc.
PR4	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	SS	0.7	0.9	1	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.600	Acc.
PR5	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	SS	0.7	0.9	1	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.600	Acc.
PR6	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	SS	0.7	0.9	1	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.600	Acc.
OR1	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	SS	0.7	0.9	1	SS	0.7	0.9	1	SS	0.7	0.9	1	0.613	Acc.
OR2	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	SS	0.7	0.9	1	SS	0.7	0.9	1	SS	0.7	0.9	1	0.613	Acc.
OR3	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
OR4	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	SS	0.7	0.9	1	0.760	Acc.
OR5	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
OR6	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
OR7	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.587	Acc.
OR8	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
SR1	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
SR2	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
SR3	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	SS	0.7	0.9	1	0.760	Acc.
SR4	S	0.5	0.7	0.9	N	0.3	0.5	0.7	N	0.3	0.5	0.7	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.653	Acc.

SR5	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
ER1	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	S	0.5	0.7	0.9	0.513	Acc.
ER2	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
ER3	S	0.5	0.7	0.9	S	0.5	0.7	0.9	N	0.3	0.5	0.7	N	0.3	0.5	0.7	SS	0.7	0.9	1	0.653	Acc.
ER4	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
ER5	SS	0.7	0.9	1	N	0.3	0.5	0.7	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.587	Acc.
ER6	SS	0.7	0.9	1	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	SS	0.7	0.9	1	0.773	Acc.
ER7	S	0.5	0.7	0.9	S	0.5	0.7	0.9	N	0.3	0.5	0.7	N	0.3	0.5	0.7	SS	0.7	0.9	1	0.653	Acc.

- Compute the fuzzy weights $(\tilde{\omega}_1^*, \tilde{\omega}_2^*, ..., \tilde{\omega}_n^*)$. The optimal fuzzy weight for each attribute is obtained when $\tilde{\omega}_B / \tilde{\omega}_j = \tilde{a}_{Bj}$ and $\tilde{\omega}_j / \tilde{\omega}_W = \tilde{a}_{jW}$ where $\tilde{\omega}_B, \tilde{\omega}_j, \tilde{\omega}_W$, $\tilde{a}_{Bj}$ and $\tilde{a}_{jW}$ are TFN and are given as $\tilde{\omega}_B = (l_B^\omega, m_B^\omega, u_B^\omega)$, $\tilde{\omega}_j = (l_j^\omega, m_j^\omega, u_j^\omega)$, $\tilde{\omega}_W = (l_W^\omega, m_W^\omega, u_W^\omega)$, $\tilde{a}_{Bj} = (l_{Bj}, m_{Bj}, u_{Bj})$ and $\tilde{a}_{jW} = (l_{jW}, m_{jW}, u_{jW})$. The below equivalent nonlinearly constrained model is formulated to find fuzzy weights [14]:

$$\text{Min } \tilde{\varphi} \tag{3}$$

s.t.:

$$\left|\tilde{\omega}_B / \tilde{\omega}_j - \tilde{a}_{Bj}\right| \le \tilde{\varphi}$$

$$\left|\tilde{\omega}_j / \tilde{\omega}_W - \tilde{a}_{jW}\right| \le \tilde{\varphi}$$

$$\sum_{j=1}^{n} R(\tilde{\omega}_j) = 1, \quad l_j^\omega \le m_j^\omega \le u_j^\omega$$

$$l_j^\omega \ge 0; \; j = 1, 2, ..., n \text{ and } \tilde{\varphi} = (l^\varphi, m^\varphi, u^\varphi).$$

By assuming $\tilde{\varphi}^* = (k^*, k^*, k^*)$, $k^* \le l^\varphi$, the Eq. (3) can be converted to Eq. (4) below.

$$\min \; \tilde{\varphi}^* \tag{4}$$

s.t.:

$$\left|\frac{(l_B^\omega, m_B^\omega, u_B^\omega)}{(l_j^\omega, m_j^\omega, u_j^\omega)} - (l_{Bj}, m_{Bj}, u_{Bj})\right| \le (k^*, k^*, k^*)$$

$$\left|\frac{(l_j^\omega, m_j^\omega, u_j^\omega)}{(l_W^\omega, m_W^\omega, u_W^\omega)} - (l_{jW}, m_{jW}, u_{jW})\right| \le (k^*, k^*, k^*)$$

$$\sum_{j=1}^{n} R(\tilde{\omega}_j) = 1$$

$$l_j^\omega \le m_j^\omega \le u_j^\omega; \quad l_j^\omega \ge 0$$

$$j = 1, 2, \dots, n$$

Then, the above nonlinearly constrained optimization problem in (4) can be solved by presenting it in concrete numbers (please see [14] for more details).

- Defuzzify the fuzzy weight of indicators to crisp weight using the graded mean integration representation (GMIR) method as below:

$$R(\tilde{a}_i) = (l_i + 4m_i + u_i)/6 \tag{5}$$

- Rank the indicators from the highest weight to the lowest.

TABLE V. RESILIENT INDICATOR RANKING

Resilience Dimension	Dimensions weight		Avrg.	Indica-tors	Indicators weight					Avrg.	Global weight	Rank-ing
					Exp.1	Exp.2	Exp.3	Exp.4	Exp.5			
Physical	Exp.1	0.325	0.323	PR1	0.251	0.219	0.239	0.244	0.224	0.235	0.076	1
	Exp.2	0.408		PR2	0.161	0.304	0.060	0.132	0.157	0.163	0.053	4
	Exp.3	0.317		PR3	0.165	0.143	0.217	0.183	0.238	0.189	0.061	2
	Exp.4	0.248		PR4	0.102	0.132	0.143	0.183	0.157	0.143	0.046	7
	Exp.5	0.313		PR5	0.161	0.109	0.219	0.183	0.157	0.166	0.053	3
				PR6	0.161	0.092	0.122	0.074	0.066	0.103	0.033	15
Organizational	Exp.1	0.167	0.221	OR1	0.199	0.229	0.195	0.122	0.162	0.182	0.040	11
	Exp.2	0.262		OR2	0.065	0.052	0.112	0.152	0.125	0.101	0.022	25
	Exp.3	0.228		OR3	0.126	0.128	0.129	0.092	0.079	0.111	0.024	23
	Exp.4	0.308		OR4	0.263	0.120	0.079	0.092	0.125	0.135	0.030	19
	Exp.5	0.139		OR5	0.097	0.108	0.102	0.064	0.119	0.098	0.022	26
				OR6	0.099	0.053	0.193	0.152	0.219	0.143	0.032	17
				OR7	0.050	0.137	0.043	0.175	0.124	0.106	0.023	24
				OR8	0.099	0.173	0.145	0.152	0.047	0.123	0.027	22
Social	Exp.1	0.091	0.181	SR1	0.196	0.358	0.131	0.213	0.293	0.238	0.043	9
	Exp.2	0.162		SR2	0.294	0.153	0.124	0.096	0.110	0.155	0.028	21
	Exp.3	0.369		SR3	0.193	0.103	0.237	0.264	0.314	0.222	0.041	10
	Exp.4	0.112		SR4	0.123	0.234	0.103	0.213	0.181	0.171	0.031	18
	Exp.5	0.169		SR5	0.194	0.153	0.406	0.213	0.102	0.213	0.038	13

Economic	Exp.1	0.416	0.276	ER1	0.131	0.180	0.058	0.111	0.056	0.107	0.029	20
	Exp.2	0.168		ER2	0.119	0.106	0.278	0.111	0.166	0.156	0.043	8
	Exp.3	0.086		ER3	0.171	0.169	0.105	0.111	0.051	0.122	0.033	14
	Exp.4	0.332		ER4	0.280	0.069	0.122	0.196	0.255	0.184	0.051	5
	Exp.5	0.377		ER5	0.157	0.176	0.154	0.111	0.115	0.142	0.039	12
				ER6	0.046	0.176	0.128	0.248	0.255	0.171	0.047	6
				ER7	0.095	0.123	0.154	0.111	0.104	0.117	0.032	16

III. Result and Discussion

There were 202 candidates of resilience indicators generated from literatures. After redundancy check and validation, the number of candidates were reduced to the final list of 26 indicators which is considered suitable as disaster resilience indicators of SMEs in Padang city. The final list is shown in Table III where the indicators are grouped into four different resilience dimension i.e., physical, organizational, social, and economic resilience. Using fuzzy intensity scale in Table I, experts opinion are gathered to determine the importance of each indicators. After coverting experts opinion into TFN, the TFNs were aggregated using (1) to obtain an aggregates $\tilde{b}_i$ (Table IV). The aggregates $\tilde{b}_i$ were then defuzzified using (2) in order to obtain the crisp scores b_i. The next step is obtaining the value of α as a thresold value of decision as explained in previous section. For this data, all experts provided the same value i.e., $\alpha = 0.4$. As stated earlier, if $b_i \geqslant \alpha$, then the final indicators i is included in the final list of disaster resilience indicators. The result shows that all attibutes are accepted (Table IV).

Best and worst dimension as well as indicators within each dimension were selected by each expert, and after that all preference rating used for BTO and OTW vectors are determined. Using (3-4), the dimension weights and attibutes weights are calculated, and by averaging these value the mean weights are obtained. The rank of indicators are derived by obatining indicators global weight by which each indicators weight is multiplied with the weight of their correspoding dimension. Table V shows that the highest ranked indicators are "building utility", followed by "evacuation access" and "shelter facilities" at the second and the third ranked, respectively. Physical resilience was found to be the most crucial dimension since its weight are the highest, and five out of its six indicators are placed in the top ten ranks. This result may reveal that physical infrastructures of SMEs in Padang city are considered as a main concern by the experts to be developed further in order to be resilient against disaster disruption such as earthquake and tsunami.

IV. Conclusion

This paper attempts to structure disaster resilience indicators of SMEs in Padang city. From 202 resilience indicators identified through the extensive literatures review, it was narrowed down to be suitable disaster resilience indicators for SMEs in Padang city. The significant reduction is due to the number of resilience indicators that are not related or weakly related to disaster resilience and SME context. Using fuzzy Delphi method, the final list of disaster resilience indicators comprises 26 indicators and the indicators rank were obtained by employing fuzzy BWM method. These 26 indicators are now can be used as representatives of the interests of the different stakeholders (i.e., policy-makers, academics and disaster NGO) who are high-level decision-makers to prioritize and focus on their effort to improve the SMEs resiliency against future disaster disruption, especially earthquakes and tsunami.

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An Application of Combined Fuzzy MCDM Techniques in Structuring Disaster Resilience Indicators for Small and Medium Enterprises: A Case Study

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An Application of Combined Fuzzy MCDM Techniques in Structuring Disaster Resilience Indicators for Small and Medium Enterprises: A Case Study

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***Abstract*—As a small business unit characterized by a high vulnerability to disaster disruption, Small and Medium Enterprises (SMEs) becomes those that are impacted most by disaster disruption. This research proposes to structure disaster resilience indicators by developing methodology utilizing fuzzy Delphi techniques and fuzzy Best-worst method (fuzzy-BWM) to identify and prioritize the relevant disaster resilience indicators for SMEs. A real data application is conducted for SMEs in Padang City. Through gathering experts' opinion, we obtained final list consisting of 26 suitable disaster resilience indicators grouped in four resilience dimensions. We revealed that the "building utility", "evacuation access" and "shelter facilities" are ranked the highest. Physical resilience was found to be the most crucial dimension since five out of its six indicators are placed in the top ten ranks. This result may reveal that physical infrastructures of SMEs in Padang city are considered as a main concern by the five experts to be developed to realize resilient capability against disaster disruption. This result can be used as the basis for interested parties to prioritize the effort to improve SMEs' capability in avoiding or mitigating future disaster disruption, especially in facing earthquake and tsunami.**

Keywords - disaster resilience, SMEs, fuzzy delphi, fuzzy-BWM

I. INTRODUCTION

The issue of disaster resilience has become the interest of many researchers in many years. In addition to its impact on people and the environment, disaster also have tremendous effects on business continuity in the aftermath of disaster. Business disruptions that are not coped effectively can come at a huge financial impact because of disrupted relation with partner, revenue losses, sales opportunity losses, etc. Getting back to business after disaster is not an easy task, but a complex arrangement on the critical process that consumes considerably amount of resources and time. Resilience is one of the key strengths for business to gain back its business function as prior to disaster. In disaster management domain, resilience has been an inclusion to apply as a framework for focusing on the priority of risk identification and reduction, culture of safety development, and strengthening preparedness and response capabilities [1]. Resilience is described as essential resources and characteristics that can help maintain or regain pre-disaster levels of operations function and realize successful adaptation [2].

In literatures, disaster resilience is defined from different point of view. From community perspective, Mayunga [3] mentioned that disaster resilience is the capacity or ability of a community to anticipate, prepare, respond and recover quickly from impacts of disaster. In organizational and business continuity perspective, Mitroff [4] defines resilience as a continuously moving target that enhances performance of business both in normal and disruptive situation. Seville et al. [5] mentioned that resilience as an ability/capacity of organization to survive, and even thrive, in times of crisis and emergencies. A resilient business provides competitive advantage and is used as a measure of business's health [6].

Small and medium enterprises (SMEs) are business units that are highly vulnerable to disaster risk. SMEs are those that are impacted most by disaster disruption. They are less likely to have inadequate capacity to respond and recover back after disasters, as most of them is not or less engaged in disaster risk reduction effort. They usually do not have the ability to absorb risks and the impacts of disasters, since they often operate with a few employees and are unable to spread and transfer their risks [7]. SMEs, especially in developing countries, also do not have the necessary concern and knowledge of their vulnerability to develop and implement business continuity plans [8].

This research attempts to explore disaster preparedness of SMEs in Padang city, West Sumatera - Indonesia, by studying its resiliency against disaster risk. Our work is motivated by the impact of the 2009 earthquake hit West Sumatera which damaged thousands of SMEs in Padang City resulting in the closure of businesses. After nine years of such big disaster and since there is an increasing caution of forthcoming megathrust earthquake predicted to occur in this area, it is become increasingly important to examine the current resilience of SMEs to disaster risk.

Research on SMEs resilience against disaster disruption is quite limited. Most researches in disaster resilience topic focus on proposing a framework of resilience models as well as conducting resilience evaluation on community perspective [9-11]. Although several researches attempt to address such issue in SMEs context, they possess some drawback in terms of measurement scope of evaluation. Furthermore, most of them are conducted in developed countries and those focus on such issues in developing countries are still scarce [12]. This study tries to fill this gap. The purpose of this study is to propose suitable indicators for resilient SMEs in Padang city. This research is the first step toward our advanced studies on evaluation of disaster risk reduction efforts in this city. Structuring disaster resilience indicators is carried out by identifying and prioritizing resilience indicators that could be used as the basis for government and interested parties to prioritize the effort to improve SMEs' capability in avoiding or mitigating future disaster disruption, especially in facing earthquake and tsunami.

Through gathering experts' opinion we propose to adopt a fuzzy Delphi technique to identify the relevant disaster resilience indicators of SMEs. The fuzzy Delphi has been widely used in numerous management science field to achieve a consensus among a group of people where vagueness and uncertainty in the decision-making are often occurs [13]. The fuzzy BWM, which is known as a novel and efficient pairwise comparison method [14], is then applied to gain the ranking of indicators that could help the stakeholders and policy maker to focus and prioritize the effort designed toward disaster risk reduction.

II. THE PROPOSED METHODOLOGY

A. *Survey Questionaires*

We conducted survey research in which rating scales questionnaires are used to gather expert opinion by eliciting judgment on the degree of importance of each resilience indicators applied to SMEs context. For this purpose, fuzzy linguistic scales are provided as shown in Table 1. This rating scales questionnaire establishes the relevant disaster resilience indicators from the initial list identified from current literatures.

B. *Respondents*

The number of experts assigned to fill the questionnaire is decided not to be necessarily high. This rule relies on the fact that in group decision making there is no strong correlation between the number of experts and the quality of judgment [13]. Even involving more experts who may have inadequate experiences may results in weak decision accuracy [15]. In this research, we arrange the qualification of experts to: (1) have theoretical and practical experience of working in disaster management field; (2) have at least five years' professional experience in SMEs development domain; (3) have experience in facilitating or organizing projects or activities geared towards disaster relief operation. Based on this qualification, five experts are chosen which includes academician with strong background in disaster management research, Head of Cooperatives and Small and Medium Enterprise office West Sumatera Province, Head of Regional Disaster Management Agency, and Disaster -NGO representatives.

C. *Data Collection*

First, the data of resilience indicators were gathered from literature review of nine research papers. A total of 202 resilience indicators were collected based on the type of disruption (man-made and natural disruption) and the context to where they were measured (community and organization). Redundancy check is then carried out which generates initial draft of 26 disaster resilience indicators of SMEs. This draft was then submitted to the experts for verification. The last step was done through a survey where questionnaires were distributed to the experts personally utilizing fuzzy Delphi techniques and BWM. The flow of methodology is shown in Fig. 1.

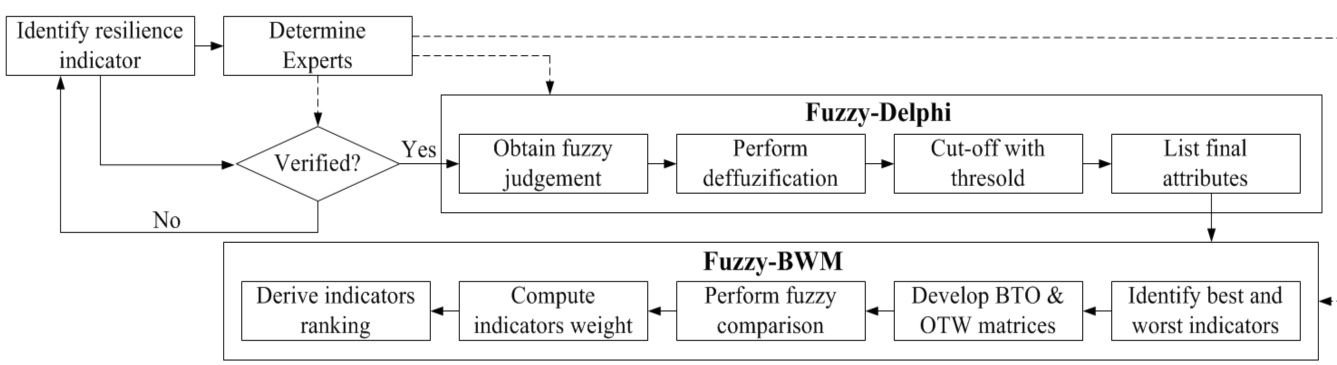

Figure 1. Flowchart of Methodology.

D. *Computational Procedures*

In general, the procedure of structuring disaster resilience indicators of SMEs at Padang city is itemized as follow:

- Review the main literatures which proposes resilience indicators, examine the indicators which relates to disaster disruption and filter them for redundancy.
- Ask the experts to examine the relevancy of indicators to the context of SMEs. The indicators which are not relevant are discarded from the initial draft list.

TABLE I. FUZZY INTENSITY OF IMPORTANCE

Linguistic variables	Fuzzy Preference Number (Triangular Fuzzy Number)
Very low important	(0.0, 0.1, 0.3)
Low important	(0.1, 0.3, 0.5)
Medium important	(0.3, 0.5, 0.7)
High important	(0.5, 0.7, 0.9)
Very high important	(0.7, 0.9, 1.0)

TABLE II. FUZZY PAIRWISE COMPARISON

Linguistic Preferences	**Fuzzy Preference Number (Triangular Fuzzy Number)**
Equal important	(1, 1, 1)
Weakly important	(0.6, 1, 1.5)
Fairly important	(1.5, 2, 2.5)
Very important	(2.5, 3, 3.5)
Absolutely important	(3.5, 4, 4.5)

TABLE III. DISASTER RESILIENT INDICATORS

Dimension	Indicators	
Physical Resilience (PR)	Building utility	PR1
	Housing type	PR2
	Evacuation access	PR3
	Housing age	PR4
	Shelter facilities	PR5
	Transportation facilities	PR6
Organizational Resilience (OR)	Leadership	OR1
	Staff engagement	OR2
	Informed decision making	OR3
	Innovation and creativity	OR4
	Unity of purpose	OR5
	Leveraging of knowledge	OR6
	Management structure	OR7
	Proactive posture	OR8
Social Resilience (SR)	Connectivity awareness	SR1
	Information exchange	SR2
	Community engagement	SR3
	Comprehensive partnership	SR4
	Cooperation with local community	SR5
Economic Resilience (ER)	Dependency on external funds	ER1
	Diversified business	ER2
	Business size	ER3
	Access to market	ER4
	Insured business asset	ER5
	Disaster management budget	ER6
	Access to credit	ER7

- Gather data from the experts through rating scales questionnaires for judgement of importance of each disaster resilience indicators using linguistic scale in Table I. Let $\tilde{b}_i^k = \left(b_{il}^k, b_{im}^k, b_{iu}^k\right)$ denotes the importance in triangular fuzzy number (TFN) of attribute i set by expert k, then the aggregate TFN, $\tilde{b}_i$, is stated as

$$\tilde{b}_i = (b_{il}, b_{im}, b_{iu}) = \left(\min_k b_{il}^k, (1/K)\sum_{k=1}^{K} b_{im}^k, \max_k b_{iu}^k \right) \quad (1)$$

- Defuzzify $\tilde{b}_i$ using the center of gravity method as

$$b_i = (b_{il} + b_{im} + b_{iu}) / 3 \quad (2)$$

- Set a desired value of α [0, 1]. If $b_i \geqslant \alpha$, include the indicators i in the indicators final list. Otherwise, discard the indicators.
- Ask the experts to choose the best (e.g. most desirable, most important) and the worst (e.g. least desirable, least important) indicators from a set of decision n indicators $\{a_1, a_2, ..., a_n\}$ from the indicators final list.
- Using Table II, perform fuzzy pairwise comparison which obtains fuzzy best-to-others (BTO) vector, $\tilde{A}_B = (\tilde{a}_{B1}, \tilde{a}_{B2}, ..., \tilde{a}_{Bn})$, and fuzzy others-to-worst (OTW) vector, $\tilde{A}_W = (\tilde{a}_{1W}, \tilde{a}_{2W}, ..., \tilde{a}_{nW})$, where $\tilde{a}_{Bj}$ is the fuzzy preference of the best criterion c_B over criterion j and $\tilde{a}_{jW}$ is the fuzzy preference of criterion j over the worst criterion c_W; $j = 1, 2, ..., n$.

TABLE IV. AGREGATE FUZZY JUDGMENT AND DECISION ON INDICATORS

Indicators	Expert 1				Expert 2				Expert 3				Expert 4				Expert 5				crisp b_i	Decision (Acc./ Rej.)
	Ra-ting	TFN			Ra-ting	TFN			Ra-ting	TFN			Ra-ting	TFN			Ra-ting	TFN				
		l	*m*	*u*		*l*	*m*	*u*		*l*	*m*	*u*		*l*	*m*	*u*		*l*	*m*	*u*		
PR1	SS	0.7	0.9	1	SS	0.7	0.9	1	SS	0.7	0.9	1	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.787	Acc.
PR2	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.587	Acc.
PR3	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	SS	0.7	0.9	1	SS	0.7	0.9	1	SS	0.7	0.9	1	0.613	Acc.
PR4	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	SS	0.7	0.9	1	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.600	Acc.
PR5	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	SS	0.7	0.9	1	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.600	Acc.
PR6	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	SS	0.7	0.9	1	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.600	Acc.
OR1	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	SS	0.7	0.9	1	SS	0.7	0.9	1	SS	0.7	0.9	1	0.613	Acc.
OR2	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	SS	0.7	0.9	1	SS	0.7	0.9	1	SS	0.7	0.9	1	0.613	Acc.
OR3	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
OR4	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	SS	0.7	0.9	1	0.760	Acc.
OR5	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
OR6	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
OR7	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.587	Acc.
OR8	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
SR1	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
SR2	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
SR3	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	SS	0.7	0.9	1	0.760	Acc.
SR4	S	0.5	0.7	0.9	N	0.3	0.5	0.7	N	0.3	0.5	0.7	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.653	Acc.

SR5	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
ER1	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	S	0.5	0.7	0.9	0.513	Acc.
ER2	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
ER3	S	0.5	0.7	0.9	S	0.5	0.7	0.9	N	0.3	0.5	0.7	N	0.3	0.5	0.7	SS	0.7	0.9	1	0.653	Acc.
ER4	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.747	Acc.
ER5	SS	0.7	0.9	1	N	0.3	0.5	0.7	TS	0.1	0.3	0.5	S	0.5	0.7	0.9	SS	0.7	0.9	1	0.587	Acc.
ER6	SS	0.7	0.9	1	S	0.5	0.7	0.9	S	0.5	0.7	0.9	SS	0.7	0.9	1	SS	0.7	0.9	1	0.773	Acc.
ER7	S	0.5	0.7	0.9	S	0.5	0.7	0.9	N	0.3	0.5	0.7	N	0.3	0.5	0.7	SS	0.7	0.9	1	0.653	Acc.

- Compute the fuzzy weights $(\tilde{\omega}_1^*, \tilde{\omega}_2^*, ..., \tilde{\omega}_n^*)$. The optimal fuzzy weight for each attribute is obtained when $\tilde{\omega}_B / \tilde{\omega}_j = \tilde{a}_{Bj}$ and $\tilde{\omega}_j / \tilde{\omega}_W = \tilde{a}_{jW}$ where $\tilde{\omega}_B, \tilde{\omega}_j, \tilde{\omega}_W$, $\tilde{a}_{Bj}$ and $\tilde{a}_{jW}$ are TFN and are given as $\tilde{\omega}_B = (l_B^\omega, m_B^\omega, u_B^\omega)$, $\tilde{\omega}_j = (l_j^\omega, m_j^\omega, u_j^\omega)$, $\tilde{\omega}_W = (l_W^\omega, m_W^\omega, u_W^\omega)$, $\tilde{a}_{Bj} = (l_{Bj}, m_{Bj}, u_{Bj})$ and $\tilde{a}_{jW} = (l_{jW}, m_{jW}, u_{jW})$. The below equivalent nonlinearly constrained model is formulated to find fuzzy weights [14]:

$$\text{Min } \tilde{\varphi} \tag{3}$$

s.t.:

$$\left|\tilde{\omega}_B / \tilde{\omega}_j - \tilde{a}_{Bj}\right| \le \tilde{\varphi}$$

$$\left|\tilde{\omega}_j / \tilde{\omega}_W - \tilde{a}_{jW}\right| \le \tilde{\varphi}$$

$$\sum_{j=1}^{n} R(\tilde{\omega}_j) = 1, \quad l_j^\omega \le m_j^\omega \le u_j^\omega$$

$$l_j^\omega \ge 0; \; j = 1, 2, ..., n \text{ and } \tilde{\varphi} = (l^\varphi, m^\varphi, u^\varphi).$$

By assuming $\tilde{\varphi}^* = (k^*, k^*, k^*)$, $k^* \le l^\varphi$, the Eq. (3) can be converted to Eq. (4) below.

$$\min \; \tilde{\varphi}^* \tag{4}$$

s.t.:

$$\left|\frac{(l_B^\omega, m_B^\omega, u_B^\omega)}{(l_j^\omega, m_j^\omega, u_j^\omega)} - (l_{Bj}, m_{Bj}, u_{Bj})\right| \le (k^*, k^*, k^*)$$

$$\left|\frac{(l_j^\omega, m_j^\omega, u_j^\omega)}{(l_W^\omega, m_W^\omega, u_W^\omega)} - (l_{jW}, m_{jW}, u_{jW})\right| \le (k^*, k^*, k^*)$$

$$\sum_{j=1}^{n} R(\tilde{\omega}_j) = 1$$

$$l_j^\omega \le m_j^\omega \le u_j^\omega; \quad l_j^\omega \ge 0$$

$$j = 1, 2, \dots, n$$

Then, the above nonlinearly constrained optimization problem in (4) can be solved by presenting it in concrete numbers (please see [14] for more details).

- Defuzzify the fuzzy weight of indicators to crisp weight using the graded mean integration representation (GMIR) method as below:

$$R(\tilde{a}_i) = (l_i + 4m_i + u_i) / 6 \tag{5}$$

- Rank the indicators from the highest weight to the lowest.

TABLE V. RESILIENT INDICATOR RANKING

Resilience Dimension	Dimensions weight		Avrg.	Indica-tors	Indicators weight					Avrg.	Global weight	Rank-ing
					Exp.1	Exp.2	Exp.3	Exp.4	Exp.5			
Physical	Exp.1	0.325	0.323	PR1	0.251	0.219	0.239	0.244	0.224	0.235	0.076	1
	Exp.2	0.408		PR2	0.161	0.304	0.060	0.132	0.157	0.163	0.053	4
	Exp.3	0.317		PR3	0.165	0.143	0.217	0.183	0.238	0.189	0.061	2
	Exp.4	0.248		PR4	0.102	0.132	0.143	0.183	0.157	0.143	0.046	7
	Exp.5	0.313		PR5	0.161	0.109	0.219	0.183	0.157	0.166	0.053	3
				PR6	0.161	0.092	0.122	0.074	0.066	0.103	0.033	15
Organizational	Exp.1	0.167	0.221	OR1	0.199	0.229	0.195	0.122	0.162	0.182	0.040	11
	Exp.2	0.262		OR2	0.065	0.052	0.112	0.152	0.125	0.101	0.022	25
	Exp.3	0.228		OR3	0.126	0.128	0.129	0.092	0.079	0.111	0.024	23
	Exp.4	0.308		OR4	0.263	0.120	0.079	0.092	0.125	0.135	0.030	19
	Exp.5	0.139		OR5	0.097	0.108	0.102	0.064	0.119	0.098	0.022	26
				OR6	0.099	0.053	0.193	0.152	0.219	0.143	0.032	17
				OR7	0.050	0.137	0.043	0.175	0.124	0.106	0.023	24
				OR8	0.099	0.173	0.145	0.152	0.047	0.123	0.027	22
Social	Exp.1	0.091	0.181	SR1	0.196	0.358	0.131	0.213	0.293	0.238	0.043	9
	Exp.2	0.162		SR2	0.294	0.153	0.124	0.096	0.110	0.155	0.028	21
	Exp.3	0.369		SR3	0.193	0.103	0.237	0.264	0.314	0.222	0.041	10
	Exp.4	0.112		SR4	0.123	0.234	0.103	0.213	0.181	0.171	0.031	18
	Exp.5	0.169		SR5	0.194	0.153	0.406	0.213	0.102	0.213	0.038	13

Economic	Exp.1	0,416	0.276	ER1	0.131	0.180	0.058	0.111	0.056	0.107	0.029	20
	Exp.2	0.168		ER2	0.119	0.106	0.278	0.111	0.166	0.156	0.043	8
	Exp.3	0.086		ER3	0.171	0.169	0.105	0.111	0.051	0.122	0.033	14
	Exp.4	0.332		ER4	0.280	0.069	0.122	0.196	0.255	0.184	0.051	5
	Exp.5	0.377		ER5	0.157	0.176	0.154	0.111	0.115	0.142	0.039	12
				ER6	0.046	0.176	0.128	0.248	0.255	0.171	0.047	6
				ER7	0.095	0.123	0.154	0.111	0.104	0.117	0.032	16

III. Result and Discussion

There were 202 candidates of resilience indicators generated from literatures. After redundancy check and validation, the number of candidates were reduced to the final list of 26 indicators which is considered suitable as disaster resilience indicators of SMEs in Padang city. The final list is shown in Table III where the indicators are grouped into four different resilience dimension i.e., physical, organizational, social, and economic resilience. Using fuzzy intensity scale in Table I, experts opinion are gathered to determine the importance of each indicators. After coverting experts opinion into TFN, the TFNs were aggregated using (1) to obtain an aggregates $\tilde{b}_i$ (Table IV). The aggregates $\tilde{b}_i$ were then defuzzified using (2) in order to obtain the crisp scores b_i. The next step is obtaining the value of α as a thresold value of decision as explained in previous section. For this data, all experts provided the same value i.e., $\alpha = 0.4$. As stated earlier, if $b_i \geqslant \alpha$, then the final indicators i is included in the final list of disaster resilience indicators. The result shows that all attibutes are accepted (Table IV).

Best and worst dimension as well as indicators within each dimension were selected by each expert, and after that all preference rating used for BTO and OTW vectors are determined. Using (3-4), the dimension weights and attibutes weights are calculated, and by averaging these value the mean weights are obtained. The rank of indicators are derived by obatining indicators global weight by which each indicators weight is multiplied with the weight of their correspoding dimension. Table V shows that the highest ranked indicators are “building utility”, followed by “evacuation access” and “shelter facilities” at the second and the third ranked, respectively. Physical resilience was found to be the most crucial dimension since its weight are the highest, and five out of its six indicators are placed in the top ten ranks. This result may reveal that physical infrastructures of SMEs in Padang city are considered as a main concern by the experts to be developed further in order to be resilient against disaster disruption such as earthquake and tsunami.

IV. Conclusion

This paper attempts to structure disaster resilience indicators of SMEs in Padang city. From 202 resilience indicators identified through the extensive literatures review, it was narrowed down to be suitable disaster resilience indicators for SMEs in Padang city. The significant reduction is due to the number of resilience indicators that are not related or weakly related to disaster resilience and SME context. Using fuzzy Delphi method, the final list of disaster resilience indicators comprises 26 indicators and the indicators rank were obtained by employing fuzzy BWM method. These 26 indicators are now can be used as representatives of the interests of the different stakeholders (i.e., policy-makers, academics and disaster NGO) who are high-level decision-makers to prioritize and focus on their effort to improve the SMEs resiliency against future disaster disruption, especially earthquakes and tsunami.

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