Measuring post-disaster resilience perception in small island: Lessons from 2018 Lombok Island earthquakes in Indonesia

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Abstract. Disasters expose small islands to heightened risks, which their unique natural conditions and limited economic capabilities further amplify. Malaka Village, located on Lombok Island in West Nusa Tenggara Province, Indonesia, experienced several destructive sequential earthquakes in 2018, providing valuable lessons four years later. A community-based quantitative household survey measures the local community's perceptions of resilience and their correlation with recovery efforts. Local volunteers participated in measuring their community using the local language based on a designed stratified sampling quantitative study employing a five-component framework. This framework assessed access to basic services, regulations and policies in disaster management, prevention and mitigation, emergency preparedness, and recovery readiness. The study finds that Malaka Village is more resilient four years after the 2018 earthquakes, despite a perceived hamlet resilience of 69.9% and a perceived local government resilience of 59.3%. Perceived family or household resilience is higher at 75.6%, which is also concerning, as a quarter of people do not think they are ready to face another disaster. This study recommends ten actions to improve community resilience and identifies the key lessons to enhance community resilience, including access to basic services, understanding disaster risk, and housing recovery capacity.

1 Introduction

Disasters profoundly impact human lives and ways of living, necessitating immense efforts to recover from the devastation and rebuild what was lost. However, post-disaster rebuilding should not only aim to return to a pre-disaster state, but also to create a stronger and better community that can anticipate and mitigate future disaster risks.

The 2018 Lombok Island earthquakes in Indonesia resulted in 481 deaths and US$ 69 million in loss, devastating lives and houses built through years of hard work [1]. We conducted a household study in 2022 with the research question: Is Malaka Village in Lombok Island, Indonesia, resilient four years after the 2018 earthquakes? Resilience measurement is a complex effort and is often focused on the pre-disaster stage. There is a need for a simple resilience measurement and especially in post-disaster situation. Most importantly is to provide a snapshot of resilience perspectives of Malaka Village with improvements opportunities moving forward in the recovery process. This research provides an opportunity for a simple 25-question household survey to be replicated in many locations.

1.1 Disaster resilience

Disasters impacted humans, economies, and the environment significantly, with over 0.7 million lives lost, 1.4 million injured, and 23 million became homeless between 2005 and 2015 alone [2, 3]. Resilience may result in behaviours and approaches in resources management and qualitative capacity to absorb and accommodate events in the future. In contrast, over 70 definitions of Resilience exist across the scientific literature in various fields [4].

Disaster resilience is a priority concern of the Sustainable Development Goals (SDGs), where understanding how people think and respond to risk can contribute to effective policies. Resilience perception can change over time, necessitating further research for mitigation measures [5].

1.2 Urban resilience

Cities have been destroyed, but in most cases, they were rebuilt and rose again. The Rockefeller Foundation selected 100 Resilient Cities in a coordinated effort to implement resilience in cities, primarily focusing on wealthier countries and lacking engagement with marginalized communities [5]. The City Resilience Index, with 12 goals and 52 indicators, encompasses four dimensions: health and wellbeing, economy and society, infrastructure and environment, and leadership and strategy [6].

However, most resilience indicators and assessment frameworks have not been truly satisfactory for households [7]. Resilience measurement remains a

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challenge, as it should encompass social, economic, institutional, infrastructure, and community capacities [8].

Systems, institutions, and policies are the primary focus for these resilience frameworks, but not on the individual's access to available resources. Resilience consists of the physical, social, and economics of a household's capacity to withstand disaster's adverse effects and the ability to recover back to its original conditions [9].

1.3 Rural resilience

Synergizing rural assets, diversity, and dynamism can build rural resilience to overcome place-based inequities, fostering inclusive, vibrant, and connected rural places [10]. Disasters provide an opportunity to raise awareness and motivate stakeholders' engagement in resilience planning.

Policymakers must approach community resilience cautiously through sound planning, with citizen participation and community decentralization, to reduce potential conflicts among residents, as well as between residents and nature, thereby helping to prevent future disasters. Measuring resilience can be different across countries and communities and, most importantly, needs a participatory approach to building skills, capacity, and experience [11].

Citizen engagement and a whole-community approach in resilience building depend on local resources, expertise, skills, services, governance, economic and employment opportunities, culture, disaster preparedness, and emergency planning, while food security is a crucial aspect of household resilience [12].

1.4 Village resilience in Indonesia

Located on *the Pacific Ring of Fire*, Indonesia has over 53,000 villages with high disaster risk, 70.6% of total villages, prompting Badan National Penanggulangan Bencana (National Disaster Management Organization) to initiate Desa Tangguh Bencana (Disaster Resilient Village) program, also called Destana, with focus on legislation, institutional, funding, capacity development, and disaster management implementation [13].

Destana's assessment has 56 questions on access to basic services, 20 questions on regulation and policies in disaster management, 11 questions on prevention and mitigation, 24 questions on emergency preparedness, and 16 questions on recovery readiness [14]. Destana offers skills improvement for community members in managing disaster risk [15].

Resilience measurement is no simple task, with a robust literature to support the purpose or population in making informed judgments. However, individuals can recover better from disasters in the presence of resilience factors, as it provides a survival stimulus and helps them overcome stress or trauma.

1.5 Household resilience

The guideline to evaluate Destana is a tool comprising 128 questions, divided into five components: basic services access, regulation and policy in disaster management, prevention and mitigation, emergency preparedness, and recovery readiness [14]. This study measures household resilience, which is slightly different from Destana.

We develop a 25-question household survey to increase household and community awareness of improving household resilience. This study examines equity, social justice, readiness, and preparedness at the household and hamlet levels, utilizing inferential analysis that can inform future policy formulation to address deficiencies in community resilience building for disaster prevention.

2 Methods

This quantitative study employs an observational, cross-sectional study design with a 25-question household interview survey for inferential statistical analysis in Malaka Village, Pemenang sub-district, North Lombok District, Nusa Tenggara Barat Province, Indonesia (Fig. 1). We conducted a household survey in the local language and Bahasa Indonesia, using random cluster sampling for all 12 hamlets in Malaka village.

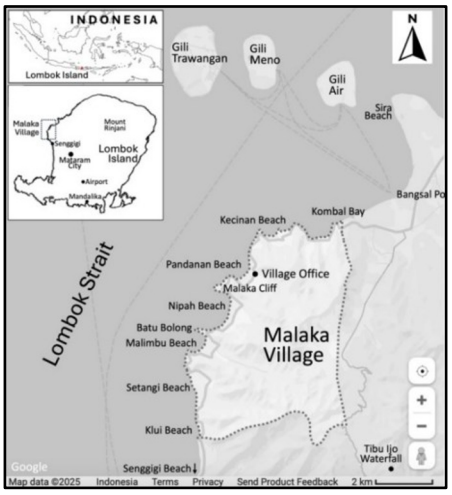

Fig. 1. Map of Malaka Village in Lombok Island, Indonesia.

We targeted 340 families out of the 2,893 households, roughly 30 households per hamlet, to achieve a 95% confidence level and a 5% margin of error. The analytical methods used include the t-test, correlation test, chi-square test of independence, and multiple regression analysis. This study employs a measurement framework comprising five components, adapted from Destana's Assessment Guide [14], as described below, followed by a series of questions after the ten demographic questions.

2.1 Basic services access

Two questions explore whether the community has access to basic services. In times of disasters, access to food, water, health, and other essential resources is crucial for survival and is a good indicator of resilience.

2.2 Regulation & policy in disaster management

Two questions explore the preparedness for disasters ahead of time to prevent loss of life and property and

whether the community has necessary disaster management policies and implementations, a sign of resilience.

2.3 Prevention and mitigation

Three questions explore whether a community takes actions to prevent and mitigate identified disaster risks.

2.4 Emergency preparedness

Four questions explore whether families are better prepared to face future disasters and examine readiness perspectives at the village and local government levels.

2.5 Recovery readiness

Three questions explore whether families have a recovery plan in the event of a disaster striking.

Table 1. Twenty-five questions in the survey.

No	Questions	Framework
1.	What is your name?	demographic
2.	What is your gender?	demographic
3.	What is the name of your hamlet?	demographic
4.	How old are you?	demographic
5.	What is your total monthly household income?	demographic
6.	What is your marital status	demographic
7.	How many people are dependent on your income?	demographic
8.	Does your household members have disability or vulnerability?	demographic
9.	How bad was your house damage/destroyed by earthquake 4 yrs. ago?	demographic
10.	After 4 years, how many percentages of your house rebuilt now?	demographic
11.	Compared to 4 years ago, do you now have better knowledge how to access basic services (water, health, food, transport, shelter)?	1
12.	Who will help the vulnerable individual (if any) in your house when a disaster come?	1
13.	How well do you understand local disaster risks and hazard?	2
14.	Did your house/hamlet practice/simulate for a disaster in the last year?	2
15.	What local community group do you belong to?	3
16.	What has your family done in mitigating disaster risk in the last 4 years?	3
17.	Do you have a household contingency plan for a disaster now?	4
18.	What disaster early warning system does your community have now?	4
19.	How many days can you survive a disaster with your food supplies in the house now?	5
20.	Where is the best way to evacuate from your house in a disaster?	4
21.	How confident your financial saving level can help you in disaster now?	5
22.	Is your house rebuilt better in facing earthquake like 2018?	5
23.	Is your family more disaster resilient today?	4
24.	Do you think your hamlet is ready to face another disaster compared to 4 years ago?	4
25.	Do you think your local government is ready to face another disaster?	3

The twenty-five questions are designed for short or multiple-choice answers, as listed in Table 1, along with a signed consent form from the respondent, witness, and interviewer. All volunteer interviewers received a briefing to ensure the reliability of data collection. Questionnaire forms are stored safely and destroyed after the data has been input into an Excel computer file. Collected data were integrated into a Microsoft Excel matrix with anonymity for privacy. After the data cleaning, the data were analysed using SPSS tool for test of hypothesis. The analysis started with a descriptive analysis (mean, median, standard deviation, standard error, range) followed by the inferential analysis (p-value, probability function, pH value, PLG likelihood ratio test, chi-square test of independence, correlation test, and multi-linear correlation test).

3 Results and discussions

3.1 Hypothesis

Our Null Hypothesis is that Malaka Village is not disaster resilient after the earthquakes 4 years ago. We aim to test and analyse whether this null hypothesis can be rejected based on the collected data, thereby confirming that the village is disaster-resilient.

3.2 Descriptive analysis

3.2.1 Volunteer involvement

Twenty-three local unpaid community volunteers received a briefing on the interview protocol with the permission of local village and community leaders. The Household Survey, conducted between September 28 and October 21, 2022, had 354 participants (67.5% had a witness). The median number of interviews per volunteer was 18 (SD = 7.75, Range 1-23).

3.2.2 Demography

The mean respondent age is 40.6, with a median of 38.0 (SD = 12.8, Range = 17-79). The respondent gender is 52.8% female, while the provincial female ratio is 50.1%, with no respondents disclosing a non-binary gender type. The Volunteers covered ten hamlets (83%), while two of the hamlets could not participate because of their remote locations.

The monthly income mode is below 500,000 rupiahs (36.2%), with 74.1% earning below 1 million rupiahs (US$ 64.12) monthly. Meanwhile, low membership in *Perkumpulan Kesejahteraan Keluarga* (Family Welfare Association) is a concern (9.9%).

3.2.3 Disaster risk reduction (DRR)

Most of the participants took DRR actions (81%), with 33.3% house reinforcement, 18.5% hazardous household items relocation, 13.9% family preparedness plan development, 1.5% outward-opening door construction, 4.8% survival bag placement in the house, 2.1% duck-cover-hold technique learning, and 6.4% combinations of various DRR techniques above while 19% take no DRR measures.

3.2.4 Financial survivability

Most of the volunteers have enough savings to survive for a week in the event of a disaster (63.4%), while the rest (29.4%) are vulnerable with only one day's worth of savings.

3.3 Inferential analysis

3.3.1 Gender relationship

There is mostly no significant relationship between gender and their answers. A few notable gender-based statistics analyzed include expressed higher income from males compared to females, more reported widows than widowers (633%), more multiple dependences by males than females (400%), and disaster understanding in males than females.

3.3.2 Resilience perception

No significant correlation was found between age and perceived family resilience (r (339) =0.026, p=0.643, > .05), between monthly income and perceived family resilience level (r (336) = -0.022, p= 0.688, > 0.05), and between number of dependances to perceived family resilience (r (335) = -0.070, p= 0.199, > 0.05). A significant correlation exists between housing recovery and perceived family resilience (r (338) = 0.130, p = 0.017, p < 0.05) and between having a family disaster contingency plan and perceived family resilience (r (335) = 0.176, p = 0.001, p < 0.05).

3.4 Analytical framework test

3.4.1 Access to basic services

Access to basic services is significantly correlated (r (103) = 0.196) with housing recovery (p < 0.001, p < 0.05) or the presence of vulnerable individuals (p = 0.039, p < 0.05). In building community resilience, ensuring access to basic services (such as water and food) is crucial for preparing communities to survive a disaster better and recover more quickly, as shown in Fig. 2.

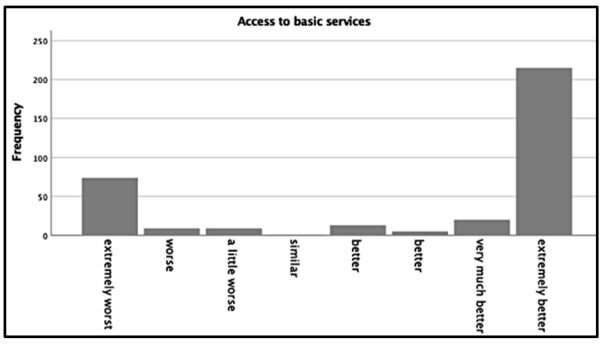

Fig. 2. Access to basic services four years after earthquakes.

3.4.2 Disaster risk understanding

Understanding of disaster is not significantly correlated (r (101) = 0.081) with housing recovery (p = 0.165, p> 0.05), having vulnerable individuals (p = 0.135, p> 0.05), or income (p = 0.122, p> 0.05). Understanding disaster is important for a community to prepare and reduce its disaster risk. Despite no significant correlation, it is essential to enhance the community's understanding of disaster risk. Figure 3 illustrates that most of the community lacks an understanding of disaster risks.

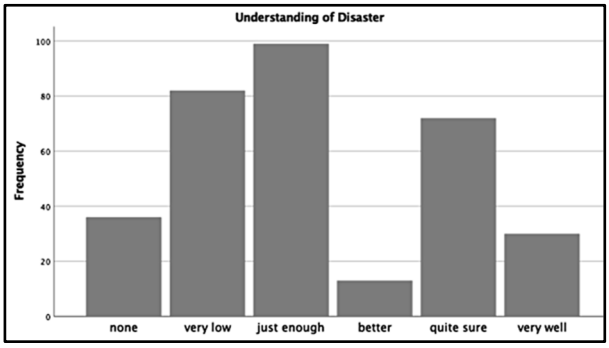

Fig. 3. Understanding of disasters four years after earthquakes.

3.4.3 Prevention and mitigation measures

Preventive and mitigative DRR Actions are not correlated (r (101) = 0.053) to housing damage (p= 0.862, > 0.05), housing recovery (p= 0.429, >0.05) or having vulnerable individuals (p=0.204, > 0.05). DRR measures taken to reduce disaster risk are variative but very low (Fig. 4). Communities should be educated, encouraged, and incentivized to reduce risks.

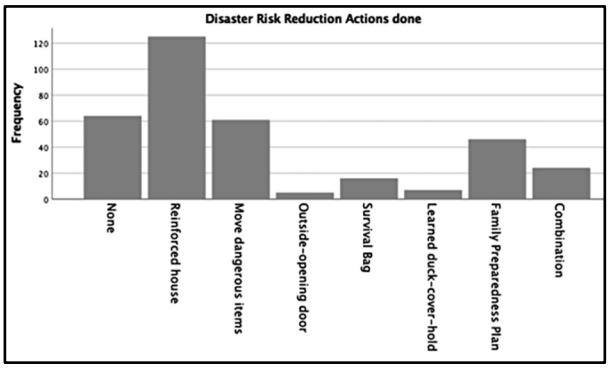

Fig. 4. DRR measures taken four years after earthquakes.

3.4.4 Housing recovery

The housing recovery correlates with recovery capacity (r (100) = 0.262, p < 0.001, p < 0.05). The primary concern in rebuilding capacity is stronger house rebuilding, as shown in Fig. 5. In any disaster, rebuilding houses should be the main priority as early as possible. However, the need for stronger house building is most important in preventing future disaster impacts.

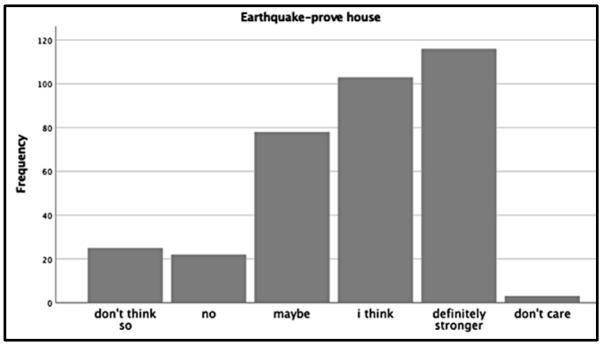

Fig. 5. Housing earthquake-proofing perception four years after.

3.4.5 Resilience perception

The study reveals low *perceived local government resilience* (59.3%), *perceived hamlet resilience* (69.9%), and *perceived family resilience* (75.6%). In a nutshell, a quarter of the population do not think they are resilient enough to face the next disaster. However, controllable family resilience is considered better and more important than the resilience of hamlets and local governments (Fig. 6-8).

Family resilience ($r(99)= 0.066$, > 0.05), hamlet resilience ($r(98)= 0.003$, < 0.05), and local government resilience ($r(102)= 0.071$, > 0.05) is not correlated to monthly income ($pF= 0.731$, $pH= 0.665$, $pLG= 0.857$, > 0.05), housing recovery ($pF= 0.090$, $pH= 0.828$, $pLG= 0.015$, > 0.05), household having vulnerable individuals ($pF= 0.559$, $pH= 0.756$, $pLG=182$, > 0.05), and access to basic services ($pF= 0.281$, $pH= 0.956$, $pLG=204$, >0.05).

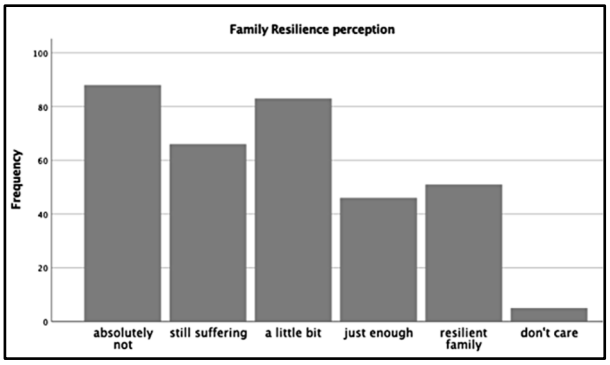

Fig. 6. Perceived family resilience four years after 2018 earthquakes.

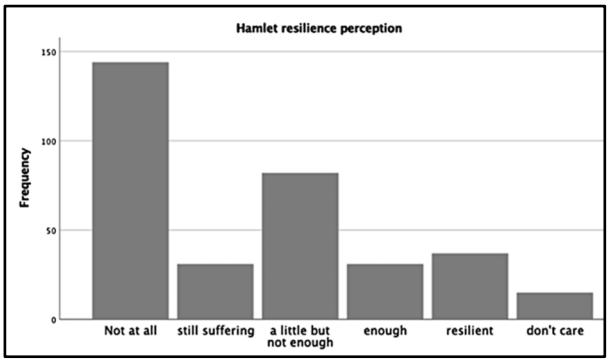

Fig. 7. Perceived hamlet resilience four years after 2018 earthquakes.

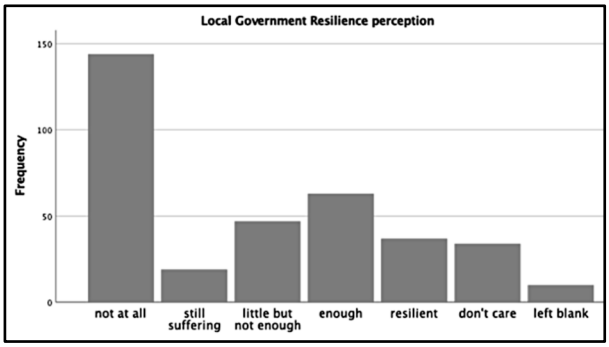

Fig. 8. Perceived local government resilience four years after 2018 earthquakes.

The low resilience perception at all levels, as seen in Figures 6-8, prompts a need for improvements and further participatory and inclusive studies on specific issues to address.

3.5 Hypothesis test

H_0: Malaka Village is not disaster resilient after 2018 earthquakes.

H_A: Malaka Village is disaster resilient after 2018 earthquakes.

As the housing recovery correlates with perceived family resilience, our multilinear regression analysis test concluded that, based on housing recovery, Malaka Village is significantly more resilient than in 2018 ($p= 0.017$, < 0.05), with 81.3% experiencing at least 75% house recovery or 62.8% total recovery or better, as shown in Table 2.

Table 2. Housing recovery four years after 2018 earthquakes.

Housing Recovery Level	N	Percentage
None	22	6.2 %
Below 25 %	3	0.8 %
25 %-50 %	6	1.7 %
50 % - 75 %	32	9.0 %
75 % - 100 %	66	18.6 %
100 %	197	55.6 %
Better than before	25	7.1 %
Missing/left blank	3	0.8 %

3.6 Limitation of study

We acknowledge that this research only scratches the surface and provides limited in-depth details. A further study should be conducted to collect and analyze more detailed data.

4 Conclusion

4.1 Recommendations for Malaka Village

Our study has several recommendations for Malaka Village, as follows:

- Identify more detailed data variables to measure the in-depth resilience level.
- Improve local policies to increase resilience at the family, hamlet, and local government levels.
- Complete the housing recovery to rebuild the community after the 2018 disaster.
- Improve DRR measures, early warnings, simulations, and community group participation.
- Prioritize income improvement to increase preparedness and survivability.
- Involve the younger generation in community planning.
- Set up community resilience hubs and a food bank for disaster preparedness.
- Include remote or far-flung hamlets in village participatory planning actions.
- Empower vulnerable widows and the elderly.
- Local government should invest financially to increase community resilience.

4.2 Key variables correlate to resilience

This study reveals that three main issues characterize the resilience of post-disaster small island communities. First is access to basic services, second is understanding disaster risk, and finally, housing recovery capacity.

4.3 Conclusion

Community building and household resilience is a continuous process that occurs both before and after disasters. Lombok Island shows us that small islands face increased risks due to their insularity, natural challenges, and limited economic capacity.

This study concludes that the Malaka Village is significantly more resilient than in 2018 ($p = 0.017$, < 0.05), with 81.3% experiencing at least 75% house recovery or 62.8% total recovery or better.

This study also statistically confirms that policy improvements are necessary to enhance access to basic services, disaster risk awareness, and housing recovery capabilities. However, Lombok Island should complete the reconstruction of unrecovered houses from the 2018 earthquakes and retrofit weak houses to manage its disaster risks.

Despite a 69.9% perceived hamlet resilience and a 59.3% perceived local government resilience, the perceived family or household resilience is higher at 75.6%, which is also concerning, as a quarter of people do not think they are ready to face another disaster. Policymakers should adopt the lessons learned and seriously consider equipping communities to reduce their disaster risks, especially by empowering families and households, as well as local hamlets, as disaster survivability is essentially a family and neighbourhood approach.

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References

1. B. Setyogroho, D. Muslim, M.S. Sadewo, G.O. Muslim, S. Burhanuddin, and H. Hendarmawan, Correlation between building damages and losses with microzonation map of Mataram - Case Study: Lombok Earthquake 2018, Indonesia. Sustainability, **14**(4), 2008 (2022). https://doi.org/10.3390/su14042028
2. M. Moy de Vitry and J.P. Leit˜ao, The potential of proxy water level measurements for calibrating urban pluvial flood models. Water Res. **175**, 115669 (2020). https://doi.org/10.1016/j.watres.2020.115669
3. United Nations. Transforming our world: The 2030 agenda for sustainable development (United Nations, New York, 2015).
4. L. Fisher, More than 70 ways to show resilience. Nat., **518**(7537) (2015). https://doi.org/10.1038/518035a
5. J. Fitzgibbons and C.L. Mitchell. Just urban futures? Exploring equity in "100 resilient cities". World Dev., **122,** 648-659 (2018). https://doi.org/10.1016/j.worlddev.2019.06.021
6. The Rockefeller Foundation, City resilience index: Understanding and measuring city resilience (ARUP, London, 2014).
7. L. Jones, E. Samman, and P. Vinck, Subjective measures of household resilience to climate variability and change: Insights from a nationally representative survey of Tanzania. Ecol. Soc., **23** (2018). https://doi.org/10.5751/ES-09840-230109
8. S.L. Cutter, C.G. Burton, and C.T. Emrich, Disaster resilience indicators for benchmarking baseline conditions, JHSEM, **7**, 1 (2010). https://doi.org/10.2202/1547-7355.1732
9. J. Leandro, K.-F. Chen, R.R. Wood, R. Ludwig. A scalable flood-resilience-index for measuring climate change adaptation: Munich city. Water Res. **173**, 115502 (2020). https://doi.org/10.1016/j.watres.2020.115502
10. H. Love and M. Powe, Building resilient rural places: Strategies from local leaders to strengthen rural assets, diversity, and dynamism. (Brooking Report, Washington D.C, 2020).
11. A.K. Ahmed, S. Tighe, R. Jackson, A. Stein, C.A. Courtney, A. White, P. Rubinoff, and D. McKinnie, Coastal community resilience in the Indian Ocean region: A unifying framework, assessment, and lessons learned. in Proceedings of Solutions to Coastal Disasters 2008, Oahu, Hawaii, USA, April 13-16. 990–1001 (2008). https://doi.org/10.1061/40968(312)88
12. M. Browne, G.F. Ortmann, and S.L. Hendriks, Developing a resilience indicator for food security monitoring and evaluation: Index construction and household classification for six African countries. Agrekon, **53**(3), 31-56 (2014).

https://doiorg/10.1080/03031853.2014.929011

13. R.S. Oktari, S. Kamaruzzaman, F. Fatimahsyam, S. Sofia, and D.K. Sari, Gender mainstreaming in disaster-resilient village programme in Aceh Province, Indonesia: Towards disaster preparedness enhancement via an equal opportunity policy. IJDRR, **52**, 101974 (2021). https://doi.org/10.1016/j.ijdrr.2020.101974
14. Badan Nasional Penanggulangan Bencana. *Panduan: Penilaian ketangguhan desa/kelurahan. (Direktorat Kesiapsiagaan, Deputi Pencegahan, Badan Nasional Penanggulangan Bencana*, Jakarta, 2021).
15. E.T. Paripurno. *Panduan fasilitator desa tangguh bencana. (Badan Nasional Penanggulangan Bencana*, Jakarta, 2015).