ORIGINAL ARTICLE

Journal of Community Empowerment for Health (*JCOEMPH*) 2025, Volume 8, Number 2: 87-93
P-ISSN. 2655-0164, E-ISSN: 2654-8283

Strategic recovery and enhancement of natural resources and the environment post-Mount Semeru eruption in Lumajang Regency

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Submitted: 2024-07-25
Revised: 2024-09-23
Accepted: 2025-03-14

ABSTRACT

Introduction: Mount Semeru experienced a pyroclastic flow in 2021. Volcanic material was observed heading towards Lumajang Regency. Natural resources and the environment were significantly affected by the eruption of Mount Semeru. The eruption can have both short-term and long-term impacts on the surrounding natural resources and environment. In 2023, the National Disaster Management Authority (NDMA), in collaboration with the Master of Disaster Management, Postgraduate School of Universitas Airlangga (MDM PGS UNAIR) implemented the Assistance for Recovery and Productivity Improvement of Natural Resources and Environment (ARPINRE) program in the areas affected by the Mount Semeru eruption, namely Lumajang Regency, East Java Province. This article aims to report the results of the ARPINRE program in Lumajang Regency.

Methods: The disaster-prone area assistance was carried out based on various theories and approaches related to disaster management. These include Disaster Management, Water, Air, Sanitation, and Health (WASH), along with indicators from SPHERE.

Results: Before conducting the assessment, the team conducted a study of the inventory and prioritization of issues. Technical guidance activities were conducted as a follow-up to the established interventions. There were three technical guidance (I, II, III). Based on the results of pre-tests and post-tests distributed to technical guidance participants, as well as interviews with the self-sustaining community (SSC), it was concluded that there was an increase in public understanding of the importance of waste sorting and management through Integrated Waste Management Sites (IWMS) and the importance of biopores as a means of water conservation and composting. Stimulus provision, an integral part of this activity, was also carried out alongside technical guidance III. Evaluation results showed an increase in the average pre-test score from 52.67 to 65.33 in the post-test.

Conclusions: Despite this increase, the average score remained low. Continued socialization about solid waste management is necessary.

Keywords: Disaster management; environmental health; environmental recovery; mount eruption.
Cite This Article: Hargono, A., Prihatiningtyas, W., Prasasti, C.I., Kuncoro, E.P., Adriyani, R., Hartono, R., Kurnia, G.M. 2025. Strategic recovery and enhancement of natural resources and the environment post-Mount Semeru eruption in Lumajang Regency. *Journal of Community Empowerment for Health* 8(2): 87-93. DOI: 10.22146/jcoemph.98597

INTRODUCTION

Mount Semeru has a history of eruptions since 1941. On December 4th, 2021, Mount Semeru experienced a hot cloudburst. Volcanic material was observed to be directed towards the Pronojiwo District and the Candi Puro District, Lumajang Regency.[1] The report of the Volcano Observation Post (PPGA) officers on December 4th, 2022 at 12.00-18.00 WIB recorded 22 eruption earthquakes with an amplitude of 10-35 mm and an earthquake duration of 60-140 seconds.[2]

Various efforts were made to handle the impact of the Mount Semeru disaster. Law No. 24/2007 states that the implementation of disaster management is the responsibility of the government/regional government, together with the community.[3] The provisions of Article 56 and Article 75 of Government Regulation Number 21 Year 2008 state that the handling of post-disaster areas is in accordance with the implementation of rehabilitation and reconstruction activities in post-disaster areas.[4] Post-disaster area management activities include activities, including the restoration of facilities and infrastructure, economic, social, and environmental.[4]

Natural resources and environmental factors are among the factors affected by the eruption of Mount Semeru. The eruption can have short-term and long-term impacts on natural resources and the surrounding environment. Volcanic

eruptions can result in increased sedimentation in rivers and water bodies due to the deposition of ash and other volcanic materials [5] This sedimentation can affect water quality, reduce oxygen levels, and harm aquatic organisms.[5] Pyroclastic flows and lava flows can cause damage to natural habitats and disrupt ecosystems.[5] Vegetation and wildlife around the volcano could be significantly affected, potentially leading to changes in biodiversity.[6] Safety concerns related to the eruption and the temporary closure of hiking trails could affect the local economy, which relies on tourism revenue.[7]

Restoration of natural resources and the environment after a mountain eruption is one of the strategic efforts. Interventions on natural resources and the environment are expected to have potential in ecosystem restoration, soil fertility and productivity, water resources rehabilitation, biodiversity conservation, protection against erosion and landslides, and sustainable land use.[8] Efforts to deal with the post-disaster eruption of Mount Semeru on natural resources and the environment need to be supported by various sectors. The National Disaster Management Authority (NDMA) in 2023, in collaboration with Universitas Airlangga (UNAIR), especially the Master of Disaster Management Study Program, Postgraduate School of Universitas Airlangga (PGS UNAIR) carried out Assistance for Recovery and Productivity Improvement of Natural Resources and the Environment (ARPINRE) in the area affected by the eruption of Mount Semeru, namely in Lumajang Regency, East Java Province. This article aims to report on the ARPINRE program in Lumajang District.

METHOD

Efforts to assist disaster-prone areas are based on several theories and approaches related to disaster. These theories and approaches include Disaster Management, Water, Sanitation, and Health (WASH) and indicators contained in SPHERE. The Disaster Management approach includes activities carried out in pre-disaster, during disaster, and post-disaster. Important components of the SPHERE standard in the WASH program include water supply, sanitation, health promotion, and coordination and implementation. The ARPINRE steps are outlined in Figure 1 Evaluation was carried out in technical guidance II and III. Evaluation in technical guidance II aims to measure participants' understanding of the training material that has been delivered. The instruments used were pre-test and post-test questionnaires. Pre-test distributed before material presentation, while post-test distributed after material presentation. Evaluation in technical guidance III is an evaluation of domestic waste management and biopore assistance in disaster-affected community groups, using in-depth interviews methods. The evaluation is a follow-up to the training provided during technical guidance II. This article is derived from the outcomes of community service activities, thus ethical clearance is not required.

RESULTS

ARPINRE activities consist of six things, starting with coordination between UNAIR and the stakeholders involved. Then a situation analysis to determine the location of implementation and problem prioritization. Formation of community self-help groups. Formulation of program plan. Implementation of the program plan. Development of a sustainability plan. And monitoring and evaluation.

Coordination

The first coordination meeting was held offline in Bali Room, 4th floor, ASEEC Tower Building, Campus B Universitas Airlangga. The meeting was attended by Vice Director I PGS UNAIR, Vice Director III PGS UNAIR, Director of Recovery NDMA, UNAIR Assistance Team, and Support Staff. Further coordination was held on May 5, 2023 with relevant stakeholders, namely Regional Disaster Management Authority (RDMA), Health Office, and RDPA of Lumajang Regency, along with UNAIR Assistance Team. The meeting agenda included the delivery of the activity plan and mentoring process, information collection on the current condition of natural resources and the environment, and discussion of various alternative activities based on existing potential. Furthermore, further coordination was held on May 16-17, 2023, which focused on situation analysis as the basis for determining the location and intervention plan. This activity continued at the Bumi Semeru Damai (BSD) location.

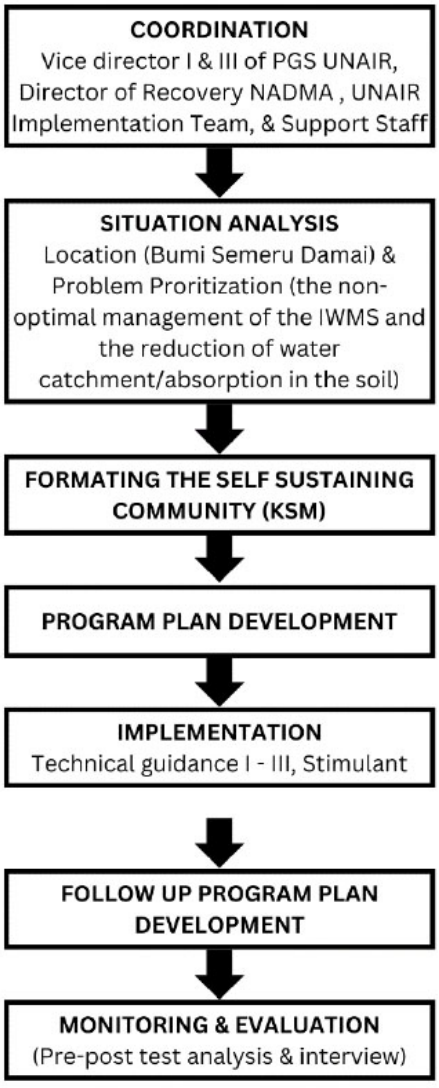


Figure 1. ARPINRE Implementation Steps.

Situation Analysis

The determination of the location was based on the suitability of the criteria in the Terms of Reference (TOR). Based on the mapping, it was agreed that the urgent location for assistance was BSD. BSD is a Semeru eruption relocation community that used to be residents of Sumberwuluh and Supiturang Villages, which are currently designated as red zones. Administratively, the population data of the BSD community is still in the process of transitioning to Sumbermujur Village.

Problem prioritization was determined

based on several considerations such as the magnitude of the problem, community perceptions, and the ability to solve the problem. Prioritization was done using the Reinke Method. The scoring results show that the priority focus of the problem in this assistance is the non-optimal management of the IWMS and the reduction of water catchment/absorption in the soil.

Formating the Self-Sustaining Community (SSC)

The SSC, which has been formed, has not been running well because there has been no special assistance and budget allocation for the management of the SSC. The SSC was formed based on the Decree of the Head of Sumberwuluh Village, Candipuro District, Lumajang Regency Number 52 of 2020 concerning the Establishment of SSC Bina Karya Semeru in Sumberwuluh Village, Candipuro District. SSC Bina Karya Semeru consists of residents of the temporary shelter/permanent housing affected by the 2018 Mount Semeru eruption, residents of Sumbermujur Village around the temporary shelter/permanent housing and environmentalists.

Program Plan Development

The intervention plan carried out to community groups is in the form of technical guidance and stimulants. Technical guidance was conducted 3 (three) times as follows:

1. Technical guidance I in the form of mapping the role of the community and related stakeholders.
2. Technical guidance II in the form of triggering the community, providing ToT (Training of Trainer) Training to the Head of the BSD Block Coordinator regarding domestic waste management and biopores in disaster-affected community groups.
3. Technical guidance III in the form of evaluation of domestic waste management assistance and biopores in disaster-affected community groups.

The stimulants provided are tools and materials for the community during technical guidance related to the sustainability of waste management activities and water reserves.

Implementation

Technical guidance I was held on July 20, 2023 and involved the BSD community, SSC Bina Karya Semeru, Sumbermujur village officials, and relevant local government authorities (LGA) such as Regional Development Planning Authority (RDPA), RDMA, Environmental Authority, Community and Village Empowerment Authority, and Lumajang District Health Office. The technical guidance discussed the triggering and mentoring strategies to be implemented. From the coordination, several priority issues were agreed upon for the next technical guidance, including:

1. The importance of community understanding of the waste segregation process.
2. The importance of community understanding of the function of IWMS.
3. The importance of biopores to store water reserves in the soil and for composting.

In addition, in the technical guidance there was also a division of roles which can be described in Table 1.

Technical guidance II was held in a triggering format for community members of BSD represented by the Coordinator of each Block for two consecutive days, on August 1-2, 2023. On the first day, the material was presented by several resource persons, namely:

1. UNAIR Assistance Team: Household Solid Waste Management
2. RDMA of Lumajang District: Disaster Profile in Lumajang District
3. Head of Lumajang District Environment Office: Waste Management and Biopores
4. Head of SSC Bina Karya Semeru: Waste Management at IWMS

On the second day, the material was presented by several resource persons, namely:

1. Material from the Health Office: Use of Personel Protective Equipment (PPE) and Health Risks of Waste Handlers
2. Waste processing training at IWMS
3. Training on making biopores

Before and after technical guidance II, pre-test and post-test were given to measure the participants' level of understanding of the material presented.

In technical guidance III, an evaluation of domestic waste management and biopore assistance to disaster-affected community groups was conducted. This

Table 1. Division of roles in technical guidance I

No	Division	Roles	
1	UNAIR Assistance Team	a)	Coordinate all implementation processes.
		b)	Delivering general materials related to WASH and biopores.
		c)	Coordinating the community to directly practice sorting waste at IWMS.
2	SSC Bina Karya Semeru	a)	Introducing IWMS to the community.
		b)	Explaining the waste management process at the IWMS.
		c)	Coordinate the practical process of waste sorting and processing at the IWMS.
3	Environmental Office	a)	Present materials related to waste and biopores.
		b)	Provide training for planting simple biopores in residents' homes.
4	RDPA	a)	Provide information on local government programs especially related to waste management in Lumajang district.
		b)	Trigger the community on the economic benefits of waste when managed properly.
5	Health Office	a)	Provide education on the correlation between waste and public health.
		b)	Trigger public awareness on the importance of proper waste management.
6	RDMA	a)	Explain the potential disasters in Lumajang district and how to prevent them.
		b)	Trigger the community to always be ready and responsive to potential disasters.

Table 2. Sustainability commitment/plan of the parties involved

No	Aspects	Sustainability Commitment/Plan
1	UNAIR Assistance Team	Committed to carrying out Tri Dharma of higher education related to disaster management, which includes teaching, research, and community service, especially helping the community in environmental management in BSD Sumbermujur, Lumajang.
2	Environmental Office	a) Facilitate socialization activities for BSD residents to dispose of and sort waste. b) Facilitate training activities for SSC Bina Karya Semeru and residents to recycle waste. c) Assisting in the promotion of recycled waste products produced by SSC Bina Karya Semeru as the manager of the Semeru Relocation IWMS to the community.
3	RDPA	Committed to assisting coordination with related LGAs, one of which is the Lumajang District Food Security and Agriculture Office (DKPP).
4	RDMA	Committed to conducting socialization to residents to be able to occupy houses and dispose of waste at the Semeru Relocation IWMS.
5	Candipuro Sub-district Apparatus	a) Facilitate and assist the SSC as the IWMS manager to conduct socialization on waste disposal at IWMS and waste segregation in community groups, schools, and public facilities. b) Initiate a movement related to waste segregation with gymnastics activities with the community, followed by cleaning the river around the *Huntara* periodically (every month).
6	Sumbermujur Village Apparatus	Committed to facilitating and conducting socialization to community members on waste disposal and sorting with the head of the community coordinator in the BSD Sumbermujur neighborhood, Lumajang.

evaluation is a follow-up to the training provided at technical guidance II. The results of interviews with members of SSC Bina Karya Semeru showed some positive changes after technical guidance. Changes in SSC Bina Karya Semeru include: 1) Clearer division of roles and main tasks and functions related to IWMS management; 2) The process of collecting waste from the community becomes easier.

Changes in the community include 1) An increase in the number of families willing to pay retribution for waste management at the IWMS; 2) Decreased activities of dumping waste out of place; 3) Waste segregation has started to be carried out independently at home, with the separation of organic and inorganic waste which facilitates the waste collection process.

Changes in the school environment include 1) Madrasah Aliyah (MA) and Madrasah Tsanawiyah (MTs) which were previously accustomed to burning waste, have now taken the initiative to communicate with SSC to get education on waste segregation; 2) The school also requested the help of SSC to assist in the process of transporting the waste generated.

In this mentoring activity, there was also a handover of stimulants from the Chief Executive of the ARPINRE Activity to the Head of the SSC Bina Karya Semeru. Stimulants are given to SSCs not individually, in the form of goods, namely equipment, equipment, and materials to support technical guidance.

Follow Up Program Plan Development

The results of ARPINRE mentoring activities are expected to be socialized to a wider audience. Dissemination of activities is carried out to convey the results of activities to related parties as well as discuss the sustainability of the program. The dissemination activity took place at the Semeru Relocation IWMS, BSD, Sumbermujur village, Lumajang district, East Java. Invited parties included the Implementation Team for ARPINRE of Universitas Airlangga, SSC Bina Karya Semeru, and related LGAs. Each party agreed to support the sustainability of ARPINRE activities shown in Table 2.

Monitoring and Evaluation

Monitoring was carried out periodically, starting from the implementation of coordination to planning for program sustainability. Evaluation was carried out to see the achievements of the program, consisting of outputs (Table 3) and outcomes on behavioral and environmental changes. Behavioral changes were obtained from the results of changes in knowledge of participants who participated in the technical guidance, the impact of socialization on the IWMS program, making biopores in temporary shelter/permanent housing, and satisfaction with the mentoring activities carried out.

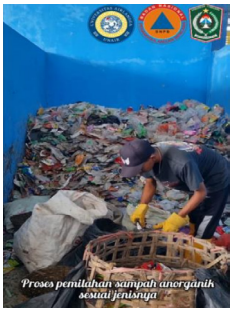
Changes in knowledge were measured through analysis of pre-test and post-test scores for technical guidance participants. The test was filled in by 32 participants, after cleaning the remaining 30 data. Data cleaning was carried out in the form of removing participants who had not filled in their names and only filled in one of the tests. The average pre-test and post-test scores are presented in Table 4.

Table 4 shows that there was an increase in the average pre-test and post-test scores. The average pre-test score of 52.67 increased during the post-test to 65.33. Although there is an increase, the average value is still relatively small. The significance of changes in knowledge was tested through statistical testing using the Paired-Samples T-Test. The results of the analysis are presented in Table 5.

The analysis showed a significance value of 0.000. This figure shows that there is a significant difference in the participants' test scores. Output impact is also analyzed through changes that occur in the waste management process at the IWMS. Information on changes in waste management at IWMS was obtained through qualitative data collection in the form of interviews with 4 SSC members. The results of the interview showed that SSC felt there were positive changes related to waste management at the IWMS obtained from the results of this activity.

> *"In terms of the SSC itself, there are job desk arrangements for each person... as well as ease of waste collection in the community..." - (informant 2)*
>
> *"For me, it's the same as Mr. Kancil... job desk is more efficient." - (informant 1)*

Table 3. ARPINRE activity output

No	Media	Description	Preview
1	Household Waste Management Module	Module containing materials for technical guidance. Contains the definition of solid waste and household waste sorting steps.	
2	Video of waste management flow at IWMS	The video contains the stages of solid waste management carried out at the IWMS, which includes sorting organic and inorganic waste. Organic waste management includes composting and shredding of organic waste. Inorganic waste management includes hydrogel management.	
3	Video of biopore making	The video contains the stages in making biopores	
4	Total attendance of technical guidance	The number of attendees of TECHNICAL GUIDANCE I - III who were invited was 20 people each, but in its implementation there were 32 participants who came (consisting of invitees and their colleagues). Participants who attended included: a. community self-help groups, b. people who will become cadres, c. village officials d. Representatives of related LGAs. (RDMA, Lumajang District Health Office, Community Health Center, and Environment Office)	  

The impact of this activity is not only felt by SSCs, but also by the community.

"As for the community... after the training yesterday, many people have started to realize by throwing garbage in the bins provided... it can be seen from the past few weeks that the volume of garbage has increased more than usual... also the addition of people who join the retribution or subscription" - (informant 2)

The impact of the activities is also felt by schools in the area of temporary shelter/permanent housing. Schools and MTS have coordinated with SSCs for waste management.

"From the school, yes there is... so initially they burned the waste and buried it... but now because it is active again and there are more students finally maybe the school is overwhelmed... finally contacted one of the SSC to how to subscribe to the retribution" - (informant 2)

The mentoring activities are expected to make the waste management process at IWMS more organized and effective and efficient. In addition, it also opens up opportunities to increase socialization and cooperation with several parties around temporary shelter/permanent housing. These parties include schools and shops that produce relatively more waste than households. The more cooperation carried out will potentially increase retribution participants and the volume of waste in the IWMS. Waste collected at IWMS can be managed to produce products that provide economic value to SSCs.

DISCUSSION

WASH stands for Water, Sanitation, and Hygiene programs and WASH initiatives aim to improve access to clean water, proper sanitation facilities, and good hygiene practices.[9] In terms of sanitation, good solid waste management prevents the accumulation of waste that can be a source of disease, minimizes the risk of spreading disease through vectors such as flies and rats, and reduces waste piles in the surrounding environment.[10-12] Biopores play a role in rainwater management to prevent stagnant water that can harbor mosquitoes that cause diseases such as dengue fever, and help decompose organic waste to reduce the volume of waste.[13,14] In terms of water, biopores enhance water infiltration into the soil, reduce the risk of flooding, and help conserve clean groundwater.[15,16]

Sphere is an international initiative aimed at improving the quality of humanitarian aid and the accountability of organizations providing assistance.[17] Known for "The Sphere Handbook," which is the primary guide in humanitarian aid, Sphere sets standards for solid waste management to prevent disease and maintain environmental cleanliness.[17] Waste management at the IWMS SSC BSD is an essential part of effective waste management, in accordance with Sphere standards for sanitation and waste management. Proper waste processing prevents environmental and water source pollution, protects public health, and safeguards and restores the environment in humanitarian responses. Sphere also sets standards for occupational health and safety for workers in humanitarian situations, where the use of PPE protects waste workers from health risks and prevents the spread of disease.[17]

Training in waste processing and biopores ensures that both staff and the community understand how to properly manage waste, in line with Sphere standards for sanitation and waste management, and enhances local capacity for sustainable waste management. Biopores support Sphere standards for water and sanitation management by ensuring good rainwater infiltration, reducing the risk of flooding, and replenishing groundwater, while also supporting environmental preservation by managing organic waste and improving soil fertility.[15,17]

All these activities contribute to achieving Sphere standards by improving sanitation, hygiene, and water management in communities affected by disasters. Through effective waste management, training, and the use of PPE, these initiatives help protect the health and dignity of the community, in line with the humanitarian principles set out in the Sphere Handbook.

The limitation of this study is that the evaluation limited to pre- and post-test in technical guidance II and interview after technical guidance III. Further evaluation needs to be done to ensure that the target participants carry out activities and apply the material that has been learned in a sustainable manner, as well as to see the commitment of relevant stakeholders in facilitating and socializing to community members about waste disposal and sorting.

CONCLUSION

The ARPINRE activities in Lumajang were organized by the MDM PGS UNAIR Assistance Team in collaboration with NDMA and relevant LGA, carried out in the relocation areas of temporary shelter/permanent housing, close to the villages affected by the Mount Semeru eruption. Technical guidance activities have been conducted as a follow-up to the previously determined interventions. There were three technical guidance activities: technical guidance I, technical guidance II, and technical guidance III. Based on the results of pre-tests and post-tests distributed to technical guidance

Table 4. Results of analysis of average pre-test and post-test scores

	Mean	N	Std. Deviation	Std. Error Mean
Score Pre-Test	52.67	30	18.182	3.320
Score Post-Test	65.33	30	12.521	2.286

Table 5. Significance analysis of changes in knowledge about solid waste management (paired samples test)

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1	Score pre – Score post	-12.667	10.148	1.853	-16.456	-8.877	29	.000

participants, and interviews with SSC, it can be concluded that there has been an increase in community understanding of the importance of waste separation and management through IWMS, as well as the importance of biopores as a means of water storage and composting. The distribution of stimulants, as an integral part of this activity, was also carried out simultaneously with the implementation of technical guidance III. Monitoring and evaluation of the sustainability of this activity still need to be carried out by involving relevant LGA within the Lumajang Regency Government. The Sumbermujur Village Government can be more actively involved in the management of IWMS once the population administration process of the community in the BSD area is completed.

ACKNOWLEDGMENT

Gratitude is extended to NDMA East Java and MDM PGS UNAIR for their assistance in coordinating the ARPINRE initiatives in the areas affected by disaster in Lumajang Regency, East Java Province.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

RESEARCH FUNDING

The ARPINRE activities in the post-disaster areas of Lumajang Regency, East Java Province, are funded by NDMA East Java for the fiscal year 2023.

AUTHOR CONTRIBUTION

All authors contribute in concepting; designing; defining the intellectual content; literature search; data acquisition; data analysis; statistical analysis; manuscript preparation; manuscript editing; manuscript review; and guarantor of the article.

ABBREVIATIONS

1. ARPINRE: Assitance for Recovery and Productivity Improvement of Natural Resources and Environment
2. ASEEC: Airlangga Sharia & Entrepreneurship Education Center
3. BSD: Bumi Semeru Damai
4. DKPP: District Food Security and Agriculture Office
5. IWMS: Integrated Waste Management Sites
6. LGA: Local Government Authorities
7. MA: Madrasah Aliyah
8. MDM: Master of Disaster Management,
9. MTs: Madrasah Tsanawiyah
10. NDMA: National Disaster Management Authority
11. PGS: Postgraduate School
12. RDMA: Regional Disaster Management Authority
13. RDPA: Regional Development Planning Authority
14. SSC: Self-Sustaining Community
15. TOR: Terms of Reference
16. ToT: Training of Trainer
17. UNAIR: Universitas Airlangga
18. WASH: Water, Air, Sanitation, and Health

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