Doctoral Thesis

Shibaura Institute of Technology

The Transformative Capacity of Disaster Awareness for Governing Resilient Community in Merapi Volcano, Indonesia

2022/ September

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ABSTRACT

The threat of disasters is a constant reminder that society must find alternatives to address communal uncertainty and complex living situations. Therefore, to fully evaluate the vulnerability and risk through contextual and cultural lenses, Disaster Risk Reduction (DRR) programs need to address a variety of issues, strengthen links between various practices, and explore the potential adaptive processes and transformations required to reduce risks when disasters strike. However, transformative DRR (TDRR), which combines disaster governance in a development context with a resilience framework, has not yet been widely discussed. This study revealed the transformative capacities of disaster awareness programs and initiatives. The Merapi volcano community in Indonesia, which is constantly exposed to the possibility of volcanic eruptions, is an excellent example of a post-disaster community with a long history. This community is now faced with additional exposure from increasing urbanization, and is expected to be a suitable disaster awareness transformation example. A combined qualitative and quantitative mixed-method case study approach was employed to accommodate the disaster resilience governance complexities. By focusing on the transformative capacity elements, such as (1) community participation and people-centered program designs, (2) co-creation and collaboration, (3) reflective learning-experienced-based approaches, and (4) innovative embedding; it was observed that the community had transformative capacity, particularly in the community participation, co-creation, and collaborative elements. However, insufficient evidence was obtained for the reflective learning element in the community. The findings implied that in practice, transformative capacity can accommodate changes in certain system functions, is an alternative approach to understanding the relationships between disaster governance and people's everyday lives, and can result in sustainable functional economic and human capital systems. These results indicate that resilient TDRR support programs can be embedded in economic and human capital programs and initiatives that are seeking to resolve pre-event social situations, such as poverty and lack of equality.

Keywords: community resilience, disaster awareness, disaster governance, disaster in society, Merapi volcano, transformative capacity, transformative disaster risk reduction

ACKNOWLEDGEMENT

When I was composing for this study, I met many people who contributed to my knowledge exploration and establishment. In particular, I would like to express my sincere appreciation to Professor Hitoshi Nakamura, my supervisor, for his full support and guidance throughout this study. This research would not be finished without his continued support and interest. I also thank the co-supervisor, Professor Yukihiro Masuda, for the reviews and valuable feedback. I very much appreciate Dr. Yasmin Bhattacharya's support and constructive criticism during the research and papers writings. I want to extend my gratitude to all the reviewers, Professor Shunji Suzuki, Professor Tomoko Iwata, and Dr. Akito Murayama for their valuable feedback and suggestions. My sincere gratitude also applies to all my colleagues and others who have, on various occasions, provided assistance. Their insights and help are indeed helpful. I owe much to the Shibaura Institute of Technology and the MEXT Japan, which funded my research and doctoral degree. Not to be forgotten, the Merapi volcano community participated in this research during the Covid 19 pandemic; thank you.

ABBREVIATION

BAPPEDA	: Badan Perencanaan Pembangunan Daerah – Local/Regional Planning and Development Agency
BAPPENAS	: Badan Perencanaan Pembangunan Nasional – National Planning and Development Agency
BNPB	: Badan Nasional Penanggulangan Bencana – National Disaster Management Agency
BPBD	: Badan Penanggulangan Bencana Daerah – Local Disaster Management Agency
BPPTKG	: Balai Penyelidikan dan Pengembangan Teknologi Kebencanaan Geologi - Geological Disaster Technology Research and Development Center *(en)*
CBDRM	: Community – based Disaster Risk Management
CSO	: Civil Society Organization
CVGHM	: Center for Volcanology and Geological Hazard Mitigation – PVMBG in English
DMMT	: Disaster management mandatory training
DPA	: Disaster Prone Area/ Hazard zone
DRR	: Disaster Risk Reduction
DRV	: Disaster Resilience Village
IDP	: Internally Displaced People
IDR	: Indonesian rupiahs
JALIN Merapi	: Jaringan Informasi Lintas Merapi. A community-based information network in Merapi
MEMR	: Ministry of Energy and Mineral Resources of the Republic of Indonesia
NGO/INGO	: Non – governmental organisastion/ International Non – governmental organisastion
PASAG Merapi	: Paguyuban Siaga Merapi (Merapi Preparedness Community)
PVMBG	: Pusat Vulkanologi dan Mitigasi Bencana Geologi – CVGHM in Indonesian
SDGs	: Sustainable Development Goals
SFDRR	: Sendai Framework for Disaster Risk Reduction
SSL	: Safe school learning *(en)* – Satuan Pendidikan Aman Bencana (SPAB) *(id)*
TDRR	: Transformative Disaster Risk Reduction
UN	: United Nations
UNDRR	: United Nations Office for Disaster Risk Reduction
UNISDR	: United Nations International Strategy for Disaster. Reduction (previous name of UNDRR)
USD	: US dollars
WLPB	: Wajib Latih Penanggulangan Bencana. DMMT in Indonesian

GLOSSARY

district	: 4th level of government in Indonesia
province/provincial	: 2nd level of government in Indonesia
regency/city/municipality	: 3rd level of government in Indonesia
village	: 5th level of government in Indonesia (administratively)
slow-onset disaster	: a disaster type that emerges gradually over time. Slow-onset disasters could be associated with, e.g., drought, desertification, sea-level rise, and epidemic disease.
rapid-onset disaster	: a disaster type triggered by a hazardous event that emerges quickly or unexpectedly. Rapid/sudden-onset disasters could be associated with, e.g., earthquakes, volcanic eruptions, flash floods, chemical explosions, critical infrastructure failure, or transport accidents.
urban kampong	: a village in the city. An area initially grew from a rural community that migrated to an urban area—commonly used in the Southeast Asian region, such as Indonesia, Singapore, and Malaysia.
gotong royong	: mutual assistance in the community.

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INTRODUCTION

1.1. Background

The threat of disaster is a continuous reminder that society must find alternative means of dealing with communal uncertainty and increasingly complex life situations. Disasters are enormous obstacles to sustained development and progress, posing challenges to the well-being of communities worldwide [1–5]. In 2020 alone, in addition to the COVID-19 pandemic, there were 389 disasters recorded worldwide, resulting in 15,080 deaths, 98.4 million people affected, and an economic loss of at least 171.3 billion USD [6]. Most disasters are attributable to natural phenomena, but many are rooted in or worsened by mismanagement and or inappropriate policy implementation [7]. A disaster is a combination of technical faults and a failure of social systems made up of technical, social, organizational, and institutional factors [8], primarily induced by human activities [9–11].

After a disaster, communities experience changes on various scales, for residents who already recognized that they lived in a disaster-prone area (DPA) before the disaster and those who did not. In many previous cases of disaster, the affected community has experienced displacement, either temporarily (evacuation) or permanently (relocation). Additionally, some recovery projects may include attempts to relocate disaster victims implemented unsuccessfully. Such failures leave people still living in high-vulnerability areas and, adding to the problem, experiencing conflict with others' land utilization. Moreover, not all disasters are rapid-onset, such as cyclones, earthquakes, and volcanic eruptions. Slow-onset disasters, such as drought, environmental degradation, and climate change, where the effects may not be recognized at once, also occur. It cannot be denied

that a disaster could be a transformative catalyst for certain geographic areas and communities [12]

Although, within the past few decades, disaster management has transformed its focus from the post-disaster to the pre-disaster phase [13], the complexity and uncertainty of disasters have also prompted a transformation in disaster governance. Disaster destroys assets and undoes development gains [12]. At a certain level, disaster management, including disaster risk reduction (DRR) in the pre-event context, and unsustainable development must be re-understood as messy, wicked, and complex problems [14]. For instance, community members may be confused about how a hazard map is translated into the real context of their neighborhood setting. Some recovery projects have challenges that remain unsolved despite the passing of more than 10 years since the disaster occurrence. This raises the question of whether the concepts of *Building Back Better* and *Linking Relief, Rehabilitation, and Development* can contribute toward solutions for post-disaster communities. Based on having experienced a disaster, post-disaster communities must determine whether they will seek to transfer risk over to the government entirely or pursue transformative learning and emerge capable of self-help.

Looking beyond this, as part of an effort to comprehend the silo debates in both theory and practice, DRR should be seen in the wider context of development issues [14,15], where sustainable development agenda is part of it. Thus, discussing DRR with cross-cutting issues enables an understanding of vulnerability and risk through a contextual and cultural lens, strengthening linkages between different communities of practice and exploring potential adaptive processes and transformations [16]. Transformative disaster risk reduction (TDRR) develops ideas for combining disaster governance in a development context. This combination is understood to form a step in finding unsolved root problems. TDRR does not offer a utopian outcome but instead creates a continuous learning process [17]. A part of this that continues to be challenging is disaster awareness, which is focused on identifying knowledge of disaster risk in communities. This approach is not part of the community cultural setting yet, where people take it as part of their way of life. Such a situation may occur when the hazard threat has not appeared recently or has never happened, such as in landslides, flash floods, or the eruption of a dormant volcano.

In disaster governance, experience is a key part of the means that communities and stakeholders can draw upon to develop a more sustainable and resilient governance. Experience informs community resilience and sustainable disaster management. However, past experiences have not yet been analyzed sufficiently to clarify how local communities

can prepare for future hazard possibilities, which are more complex, uncertain, and urbanized, in the contemporary context of high population mobility. For example, some areas feature natural hazard vulnerability that functionally connects with other areas concerning ecosystem- or activity-based hazards, such as volcanoes or coastal areas. Volcanoes have been magnets for civilization throughout recorded history due to their fertile soil and water resources [18]. At the same time, however, they pose a complex case of natural hazard. This study provides an example of an enabling environment model for TDRR to demonstrate how local initiatives and programs can lead to disaster governance transformation.

1.1.1. Transformative capacity and why it matters for disaster resilience

Transformation remains an abstract concept in transforming development and DRR policy and practice [14]. Within disaster governance, the transformation can be defined as a fundamental, qualitative change or a change in composition or structure, often associated with changes in goals, perspectives, governance regimes, or initial conditions concerning a risk management status quo [14]. Pelling [19] also indicates that transformation is "the deepest form of adaptation indicated by reform in overarching political-economy regimes and associated cultural discourses on development, security, and risk." These various regimes define transformation in terms of fundamental changes. Further, transformation centers not only on the results or outputs, such as changes to a particular form but also on the process.

In the discussion on transformation and DRR, it is impossible to ignore the environmental setting. That is: the neighborhood around the hazard epicenter is not a static entity without dynamic change to either the source of the hazard itself, such as a volcano or a tectonic fault, or the broader environment around the disaster's epicenter, including the growth of human activities that lead to the urbanization of the area or other alterations. Additionally, it must be noted that urbanization, as it approaches DPAs, comes with problems that are felt in the urban area and beyond. Urbanization in its current form entails significant changes in land use and land cover, energy demand, biodiversity, and lifestyles, and it raises questions regarding how cities are contributing to global environmental changes, including climate change, biodiversity loss, and resource depletion [20].

Although the definition of UNISDR indicates that resilience accommodates processes and outputs, because disaster governance is complex and uncertain, transformative change is needed to accommodate wider movement. In this study, resilience

and transformation are seen more as continuous processes than as expected outputs. According to resilience theory and TDRR, capacity plays a role in making this change. Specifically, during the transformation of systems and processes, transformative capacity in disaster governance describes the capacity to make an intentional change to stop or reduce the drivers of risk, vulnerability, and inequality and ensure more equitable risk-sharing [21]. This becomes necessary because resilience relates to survival in unjust contexts or adaptation to whatever is coming and inclusive development.

Additionally, transformative capacity creates and enables embedding novelties [22]. In this context, localization and tailor-made development are beneficial for transformative governance. When these are linked to the context of resilience, the transformative capacity relates more to experimentation and leadership [23]. It can also be interpreted as an alternative that accommodates more complex needs.

In this study, localization focuses on how community-based DRR programs provide an overview of how local communities can be empowered to participate in disaster management. Some concepts, such as those of a sister village working together in an emergency, emerged from a bottom-up setting. Mainstreaming innovation indicates room to innovate and learn internally by the community and external stakeholders, and this learning opportunity is expected to provide more space to accommodate those needs. This study illustrates how a disaster awareness program can be implemented as part of knowledge internalization and how DRR can create a space devoted to learning, a process through which stakeholders seek to improve their leadership capacity.

1.1.2. Natural hazards, place-shaping, and spatial transformation: Complexity shaping transformative capacity in disaster resilience

Disasters, whether or not a natural hazard triggers them, play the role of a catalyst in transformation at the disaster site [12], with either good or bad connotations. A disaster can serve as a wake-up call for stakeholders to strengthen their disaster risk governance, or a post-disaster area may become a dead zone with no activity. People adapt to the susceptibility about the settings in which they live. For instance, even though they live in DPAs, they tend to have strong attachments to their residence [24–27]. Whether cultural reasons drive them, legacy factors, or an inability to access resources, their adaptability is fundamentally a strategy they develop to survive. This adaptation is communicated very slowly by affected residents in slow-onset disasters such as coastal flooding, drought, or other consequences of climate change. This is done until the afflicted community's state

prevents them from accessing resources and compels them to migrate or relocate, as happened in the case of a tidal flood on Java's north coast, Indonesia [28,29].

The situation differs from rapid-onset disasters, such as earthquakes, tsunamis, volcanic eruptions, typhoons/hurricanes, landslides, or debris avalanches, which can have a sudden impact that often forces affected residents to move from their homes. In such cases, the relocation process poses problems for affected residents, dragged on for as long as 10 years post-recovery or longer. A conflict of interest may arise in relation to the resident's unwillingness to relocate, lack of understanding of the recovery process, legal issues, access to basic infrastructure, or social and cultural shock. Moreover, place attachment has a different influence on groups affected by rapid-onset disasters versus slow-onset disasters [30,31]; therefore, different responses are needed. For example, during the COVID-19 pandemic, one coping mechanism was hidden gated communities on a local or regional scale adopted based on rapid- and slow-onset cases. The lockdown phenomenon and the need for open space, online transactions, contactless interactions, and big data mobility were other key adaptations [32].

Issues do not merely relate to where the affected people live, and other problems arise in the neighborhood settings of the DPAs. Often areas containing threat centers such as volcanoes, coastal areas, or riverbanks develop into growth magnets due to their ease of access to sources of livelihood [33–35]. For example, areas near volcanoes have fertile soil and often have accessible water sources, riverbank areas enable access to mobility and resources, and a fast-growing region in a coastal area may benefit from trade activities both now and in the past. The settings of such spaces often grow rapidly in complexity as the surrounding areas grow.

In some instances, other economic developments, such as educational facilities and manufacturing industries, act as additional growth magnets for these areas or function as the capitals of the countries and regions. The changes that occur are often quite complex. For example, settlements near volcanoes, which may function as a protected area, may only accommodate specific activities. In DPAs, activities are limited by existing policies. However, uncontrollable activities often appear outside these areas, affecting the hazard zone area. Whether a rule accompanies a certain land designation related to disaster risk has been provided to people who live near the DPA but are not included on the hazard map can be uncertain because of the dynamics of natural factors, such as volcanic geodynamics.

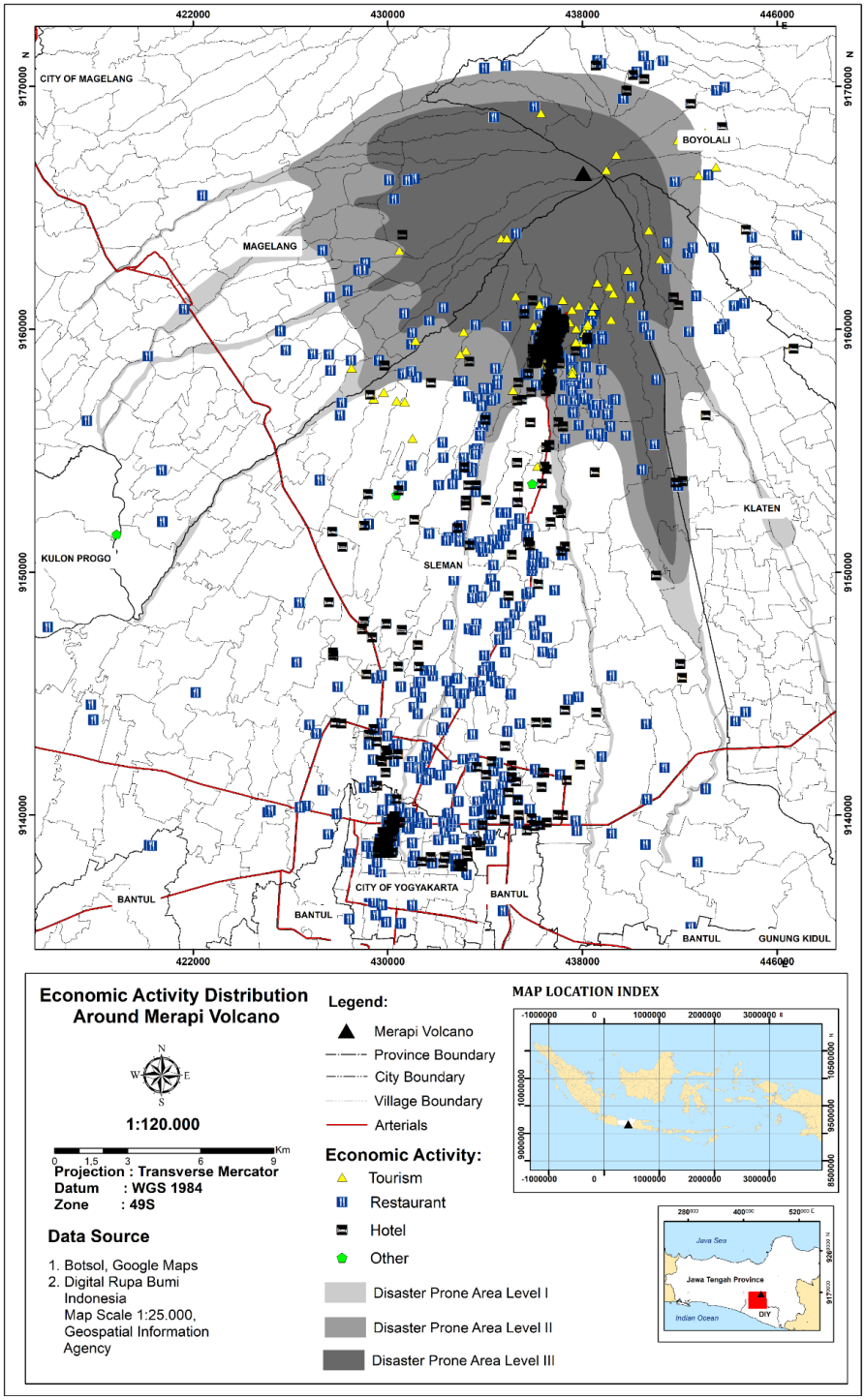


Figure 1.1 The figures represent the ways that Merapi has developed linearly from an urban area to Merapi Volcano through the road: distribution of hotels and accommodation, restaurants, and food and beverage business

Source: Author, 2022.

Data resources map: 1. Topographical map [36]; 2. Open street map [37], 3. Hazard map Merapi [38]; (4) Google map [39] data scrapping

The question of preparing people who have never experienced a disaster but live close to and work around DPAs is complex regarding allocating activities in specific spatial settings and preparing for the worst conditions. For example, areas around Merapi have experienced changes in land use. Additionally, Merapi's spatial setting, designated for specific activities (i.e., education, tourism, and intensive agriculture), is bustling. An examination of activity maps shows that the Merapi area has been growing linear toward urban Yogyakarta. This can be seen from the distribution of economic facilities, especially in relation to the accommodation and tourism support sectors (see **Fig. 1.1**). Such activities are allowed for DPA in Merapi. Thus, understanding the risk context among people around Merapi, both those who are residents and those who work/visit the area, is important.

Disaster risk governance should provide an answer to this question due to the need to integrate disaster management in all cycles and development planning. That is, how a disaster risk-sensitive plan can be embedded in spatial planning to manage the complexities of disaster management is a matter that must be resolved in the future.

1.1.3. Disaster awareness, community DRR activities, and transformative capacity: a narrative transformative learning framework for building a resilient community

As TDRR is developed, disaster management programs can be integrated into development programs for involvement in spatial planning concepts[40]. This concept can use contingency and spatial plans for disaster emergencies [40]. To begin this transformative process, a public awareness-raising program can be implemented that embraces people living around the epicenter of potential disaster, either measured in relation to the activities of the hazard activity (e.g., an earthquake or volcano epicenter) or based on proximity and includes visitors who come to the area for work, leisure activities, or pursuing other goals.

Public awareness is a key factor in preparing for the worst-case scenario of a disaster threat due to the spatial setting and other capacities in relation to the pre-event context, as well as the speed and quality of response through the recovery stage. An increased level of awareness can support the community and allow it to function properly following the shock of the disaster onset. In this context, knowledge of disaster and risk and preparation for an emergency will help strengthen resilience by design [40]. This requires that the community's capacity be prepared before the threat arrives. In Nias, where both earthquakes and tsunamis are possible, folklore passed down from the ancestors of the

population and preserved in song helped to save residents [41]. This information is available because the setting of the social system in the community does not stop at a given scale. However, this may not be the case in a community setting in New Zealand and Australia [41]. A social system not accommodating a similar cultural feature may experience a slower recovery.

In Merapi, although local wisdom is available in the community, disaster risk information in folklore form was not passed effectively, resulting in a death toll of above 350 people in the 2010 volcanic eruption. If such experiences become the ultimate factors in public awareness, high death tolls should be prevented. Merapi has seen volcanic eruptions every 4 or 5 years [42], and this gap is sufficient for people who experienced the previous eruption to provide a narrative regarding volcano risk in Merapi. Although in 2010, the scale of the Merapi eruption was Volcanic Explosivity Index (VEI) >3, this is not the first time that this scale of eruption has occurred, with the latest one being within the last 50 years [43]. Thus, the following question arises: how can written experiences and historical records, as well as the cultural setting, such as in Nias, save people and build capacity and awareness in the community in an environment with recurrent hazards?

Given these conditions, internalization is needed in relation to the role that knowledge plays in the awareness-raising process that influences DRR. As previously noted, the increasingly complex and uncertain future conditions require applying knowledge to develop a stronger setting. Local programs and initiatives can be used as tools to preserve this knowledge and to enable memories of experiences to be passed on from one generation to the next, with the expectation that, like Nias, the community will be safer and can restore their life functions more quickly, strengthening their resilience.

1.2. Background Context and Study Rationale

Merapi Volcano, located 25 km north of urban Yogyakarta, Indonesia, is home to approximately 1.6 million people [44–48]. Within 30 km of the volcano live more than 4 million people, making it one of the world's ten most densely populated areas around a volcano (**Table 1.1**) [49]. The region is famous for its pre-Islamic temples, especially Borobudur and Prambanan [50]. Merapi is one of the 127 active volcanoes in Indonesia, of which only 69 are monitored by the Center for Volcanology and Geological Hazard Mitigation [51]. Prior to the 2010 eruption, Merapi had an altitude of 2,987 m [52], and it has erupted at least 80 times since 1768, the most significant of which (VEI ≥3) were in

1768, 1822, 1849, 1872, 1930–1931, 2010, 2014, and 2018 [42,53]. The earlier eruptions had higher VEIs, but the 20th-century eruptions have been more frequent [53].

Table 1.1 Most Populated Volcanoes in the World

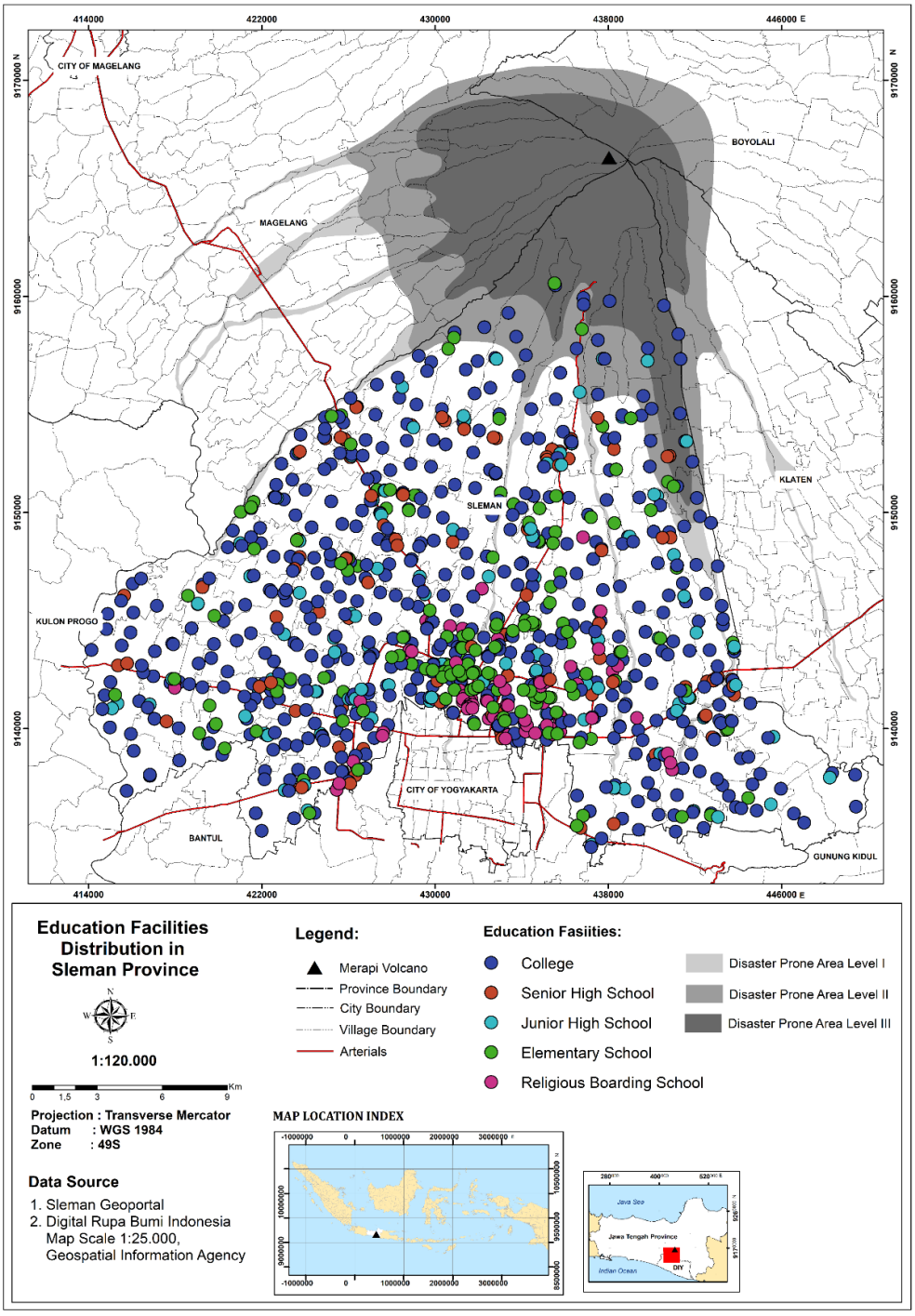
Volcano	Country	The population within 30 km	Last Eruption Year
Laguna Caldera	Philippines	7,073,814	Unknown
Tatun Volcanic Group	Taiwan	6,735,396	648 CE
Michoacan-Guanajuato	Mexico	5,783,287	1952 CE
Tangkuban Parahu	Indonesia	5,729,309	2019 CE
Penanggunan	Indonesia	4,605,710	Unknown
Ungaran	Indonesia	4,595,534	Unknown
Merapi	Indonesia	4,348,473	2021 CE
Arjuno-Welirang	Indonesia	4,143,137	1952 CE
Chichinautzin	Mexico	4,061,942	400 CE
Vesuvius	Italy	3,907,941	1944 CE

The 2010 eruption caused 367 fatalities and 277 injuries, displaced 410,388 people, destroyed 2,300 houses [44], and caused total losses of 256.4 million USD [54]. Prior to the 2010 eruption, the people of Merapi depended on nature for their livelihoods, drawing on land and the rivers, namely, the agricultural sector, mining, and community services. After the 2010 eruption, novel economic sectors emerged, such as trade, restaurants, lodging, and tourism services [24,50,55,56]. The Merapi Volcano community also depended on tourism sectors before the 2010 eruption and has since developed community-based tourism with an eco-tourism village concept. Other activities, such as lava tours, emerged following 2010 [57].

People in Merapi pursue various economic activities, dominated by agriculture, followed by trading, education services, manufacturing, and accommodations, including food and beverage services. In the figure, various types of landscapes around Merapi are visible, from rural areas with low population density to urban areas with high population density (**Fig. 1.2 and 1.3**). Within this landscape profile and activities, there are concerns about how to prepare the community for another possible eruption of the Merapi Volcano, either for the local or external community who conduct activities within or around it.

Figure 1.2 Merapi Volcano landscape profile

1. Suburban area of Yogyakarta that has rural ambiance (personal collection)
2. Urban River Kampong, which has an upstream area in Merapi, along Code River [58]
3. Merapi from urban Yogyakarta [59]
4. Merapi from urban Yogyakarta. The linear growth along the road. [60]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Education Facilities Distribution in Sleman Province
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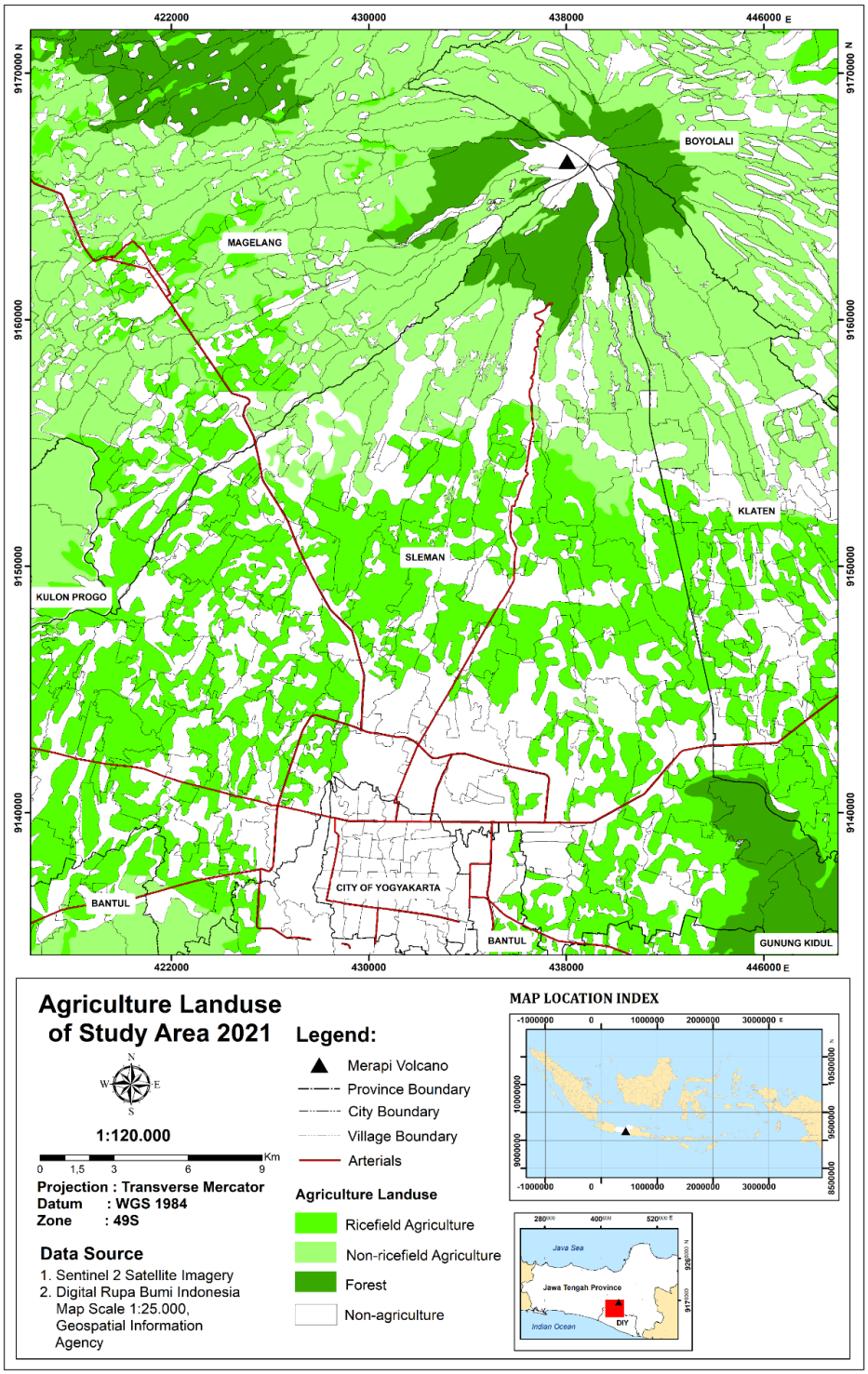
Projection : Transverse Mercator
Datum : WGS 1984
Zone : 49S
Data Source
1. Sleman Geoportal
2. Digital Rupa Bumi Indonesia Map Scale 1:25.000, Geospatial Information Agency
Legend:
Merapi Volcano
Province Boundary
City Boundary
Village Boundary
Arterials
Education Fasiities:
College
Senior High School
Junior High School
Elementary School
Religious Boarding School
Disaster Prone Area Level I
Disaster Prone Area Level II
Disaster Prone Area Level III
MAP LOCATION INDEX
Java Sea
Jawa Tengah Province
DIY
Indian Ocean

(a)



(b)

Figure 1.3 The figures represent that Merapi has developed (a) school facilities distribution and (b) agricultural land distribution).

Data resources map: (1) Topographical map [36]; (2) Open street map [37], (3) Hazard map Merapi [38]; (4) School facilities distribution in Sleman [61,62] (a); (5) Modified from topographical map (b). *Source: Author, 2022.*

Given their long experience with the volcanic hazard of Merapi, the local community has changed its perspective over time. However, high awareness of the volcanic hazard remains necessary because of the unpredictable characteristics of volcanic and geological-based hazards. Therefore, it is necessary to prepare the local or outer community members who engage in activities around the volcano for the hazard threat.

In Merapi, although some emphasis has been placed on the role of non-hazard-related socio-economic factors in shaping people's behavior in the case of an ongoing eruption, there is a lack of preparation for emergencies. Consequently, the Merapi community lacked disseminated information, resulting in a risk perception gap [63] even though they have relatively adequate risk knowledge [64]. Accessing means of livelihood is important for people to continue living; however, the community struggled with poverty even before the disaster. Aside from that, the culture of Merapi, which is the developed heart of the community [24], is characterized by high interdependencies between resources (e.g., water, sand and rock, forest, water, and landscape) and the people.

A decade after a catastrophic volcanic eruption in 2010, the Merapi Volcano community in Java, Indonesia, has been living with a high possibility of recurrent volcanic hazards. On 5 November 2020, the level of volcanic activities was raised [65], and, since then, there have been 16 eruptions [66,67], in response to which 836 people from vulnerable groups have had to be evacuated [66]. With the geodynamics of the volcano being uncertain [68], and the added complexity of local communities' reliance on the volcano, strengthening disaster resilience governance remains challenging. Some community members have experienced permanent displacement from their previous neighborhoods because of the 2010 eruption, and some new community members have also moved voluntarily after the 2010 eruption due to the urbanization in the south part of Merapi.

Yet, despite the uncertainties surrounding the spatial nature of the next volcanic eruption, due to limited resources, the government has been implementing disaster management mandatory training (DMMT) as DRR programs only for people living in DPAs. After the disaster training, local community members who filled out the post-training survey mentioned that they were confused about translating the concept of hazard map into reality [55,64,69,70]. During the 2010 eruption, people were confused when the government evacuation warning was issued with reference to the proximity (20 km distance) from Merapi Volcano rather than to the DPA identified by the existing hazard map based on magmatic activity and the volcano morphology. This call had been made to

be safer and to evacuate more people, given that the scale of the 2010 eruption was more extensive than assumed by the hazard map. However, it resulted in confusion among people who were outside the DPA and considered themselves safe from the risks. This implies that a wider area of implementation is needed for the DRR programs to educate the greater surrounding community about the risks and prepare for an emergency.

Such awareness would also help the community utilize their social networks and cooperate in evacuating themselves and their livestock to their sister villages (a sister village network is a network that connects the villages in Merapi as a DPA with buffer villages located in the Merapi safe zone [71,72]).

1.3. Problem Statement and Research Questions

Concerning the remaining challenges in the pre-event context towards hazard threat, the way to capacity-building needs to be transformed. One remaining challenge is raising public awareness, which is considered to play a key role in reducing disaster risk in transforming disaster governance. To this end, the government has implemented several practical programs and initiatives with the participation of the local community. However, gaps remain that have not been closed by these targeted programs due to the inability to resolve the question of the external members of the local community and its newer members, who do not have experience with the given disaster or the tailor-designed DRR program that includes drills and simulations. Moreover, this is not only valuable as an internal function as several other sites are also vulnerable to recurrent hazards, and residents of these areas may benefit from training as well. To a certain extent, the local community must collaborate with external members. Because of this gap, there is a need to evaluate the public awareness level to a certain extent to improve the public's disaster risk knowledge. Furthermore, this awareness could be converted into a narrative story that can be passed from generation to generation for disaster preparedness for "permanent" hazards such as volcanic hazards.

As human factors are a prominent issue in TDRR, understanding the socio-cultural background of the community becomes essential in achieving transformative governance. The pre-existing community profile affects residents' behavior toward hazards risks; for example, poverty results in unequal access to resources, hindering the community's level of preparedness. For some community groups, living in DPA is the result of their inability to access resources that can support their long-term life planning. In addition, conflicts caused by mandatory resettlement arise in several post-disaster recovery cases. In such

cases, the community understands the risks they might face. However, the choice of living in a DPA, even with the risk as they understand it, is better than living in a place where they do not understand how to survive [63]. Often, this group normalizes the risks that may be faced by living in DPA.

In addition, studies on risk knowledge, people behavior, and disaster preparedness focus on responding to changes caused by disasters with uncommon intensity and scale. These studies examine the emergency and recovery stages and long-term post-recovery situations. For example, it is critical to investigate the community situation 10 years after a disaster. This type of study would look back at what has been done, changed, and used as lessons learned to prepare for the future possibility of recurrent hazards. As volcanic hazards are likely to occur in the future, coupled with the complexity scale due to the growth of human activities or the threat of multi-hazards such as climate change, longitudinal studies are essential to disaster governance and community resilience study.

This study addresses the following research questions (RQs):

Table 1.2 Research Problem and Research Questions

Research Problem	Research Questions
The remaining challenge of disaster awareness where risk knowledge is unmatched with the disaster preparedness	**RQ1** How can disaster awareness programs be explained in terms of the DRR framework and its relationship between individual attributes in TDRR governance? 1. ***RQ1a*** How can disaster awareness programs be explained in terms of the DRR framework and enable the identification of the challenges of DRR? 2. ***RQ1b*** How is disaster awareness manifested in the relationship between individual attributes and DRR programs and initiatives to encounter recurrent hazard risk in TDRR governance?
There is a need to do long-term evaluations of for post-disaster areas and understand the changes, including people's behaviour toward disaster risk	**RQ2** How can disaster awareness be understood as a transformative capacity to achieve community resilience to recurrent natural hazards in spatially complex settings?

Source: Authors, 2022

1.4. Research Objectives

Based on the background, research problem, and RQs, this study investigated how the current DRR program and initiatives can be understood as transformative capacity through specially designed DRR programs and embedded knowledge as a component for enabling TDRR that leads to community resilience

1.5. Significance of the Research

From the RQs, the social and scientific relevance is described as follows:

1. Social significance

   This study provides practical insight with respect to global initiatives through Sustainable Development Goals (SDGs) [73], in particular with respect to reducing poverty (Goal 1), making cities and other settlements inclusive, safe, resilient, and sustainable (Goal 11) and fostering life in land by protecting, restoring, and promoting the sustainable use of the terrestrial ecosystem (Goal 15). Aside from the SDGs, this research provides a practical perspective concerning disaster governance through the Sendai Framework for DRR (SFDRR) [74] in terms of all priorities (understanding disaster risk; strengthening risk governance to manage disaster risk; investing in DRR for resilience; and enhancing disaster preparedness for effective response and to *Build Back Better (BBB)* in recovery, rehabilitation, and reconstruction). From an institutional perspective, represented by both SDGs and SFDRR, these initiatives deal with the current disaster governance challenges, which yet have no answer. Both show the importance of reducing the risk to achieve sustainable and resilient life, leaving a minimal impact on human beings and the environment, and more importantly, preparing in the pre-event period and working afterward. Aligned with that goal, this research also has implications for the pre-event understanding toward creating an enabling environment for better disaster governance by understanding the basics of DRR.

2. Scientific significance

   In addition to its social significance, this research contributes to the discussion on transformation research, especially regarding the context of disaster governance. Understanding disaster risk can increase public awareness, influencing how people prepare and respond. Further, developing the narrative story about disaster risk can help eventually and have a greater impact on the local community and external stakeholders called TDRR, which leads to a resilient community. While other research on transformative capacity focuses on urban settings with or without a disaster context (e.g., climate change), this research uses natural hazards and the possibility of a recurrent event (stated as a permanent threat) as the context of the discussion (see **Table 1.3**).

1.6. Structure

This study consists of 7 (seven) chapters, a references list, and an appendix.

Chapter 1 introduces the research topic and explains its importance.

Chapter 2 presents the theoretical concepts from previous research in theory and practice.

Chapter 3 elaborates on the research methodology from the concept, design, and implementation of this research

Chapter 4 discusses RQ1*a* on understanding disaster risk governance through the DRR program and initiatives in the Merapi Volcano community. This chapter consists of three parts: a review on DRR governance, a first case report on a case of education for DRR, and a second case report that discusses how to see DRR as an embedded program in community-based economic-driven activity through social learning approach. Moreover, it also addresses RQ2, namely, how disaster awareness develops into a transformative capacity to support resilience governance through the DRR program and initiatives in the Merapi Volcano community

Chapter 5 discusses RQ1*b* on the importance of involving the community in DRR, which could lead to a transformative capacity, strengthening disaster resilience governance. This chapter shows the relationship between individual attributes of the community living near hazards epicenter and DRR to understand the need for a people-centered design for disaster governance through capacity building

Chapter 6 discusses the research findings presented in chapters 4 and 5 and how mainstreaming in resilient governance.

Chapter 7 presents a conclusion and suggestions for further studies. The references list and appendix follow it.

Table 1.3 Similar Research with a Transformative Approach

No	Writer, Year, and Location	Approach	Research Topic	Transformative Capacity approach	Data	Result
1.	Wolfram (2019). South Korea [75]	Comparative case study	Urban regeneration and transformative capacity	Agency and interaction forms (C1–C3), development processes (C4–C8), and relational dimensions (C9–C10)	Qualitative	Preconditions that allow urban regeneration approaches to become transformative
2.	Holscher (2019). Rotterdam, the Netherlands, and New York City, USA.[22]	Comparative case study	Transforming urban climate governance	Enabling novelty creation, increasing visibility of novelty, and anchoring novelty in context	Qualitative	Explaining and evaluating urban climate governance
3.	Dwirahmadi, Febi, et al. (2019). Jakarta, Indonesia [76]	Mixed methods	Flood-resilient urban community	Disaster risk reduction (DRR), climate change adaptation (CCA), and development agency	Qualitative and quantitative	Elaborating operational concept of flood-resilient community
4.	Ziervogel (2019); South Africa [77]	Comparative case study	Transformative capacity for adaptation planning and implementation for the urban poor	Adopted from Transformative Capacity by Wolfram (C1) inclusive and multiform urban governance: (1) participation and inclusiveness, (2) sustained intermediaries and hybridization, (3) diverse governance modes and network forms	Qualitative	Exploring the inclusive governance between local government and the urban poor and the extent to which this has contributed to transformative development trajectories
5.	Räsänen, Aleksi, et al. (2019). Finlandia [78]	Multiple methods to analyze past and future-oriented data	Transformative capacity in river basin management transformations	Wolfram's framework of transformative capacity	Qualitative	Transformations and transformative capacity are not just about driving changes but more into a multidimensional relationship across spatial, administrative, and temporal scales.
6.	Mutiarni (2022); Merapi Volcano, Indonesia *(This research)*	Mixed methods case study	Transformative capacity in disaster awareness	Community participation (CP) and people-centered (PPC) programs design, co-creation (CCR) and collaboration (CLB), reflective and learning – experienced-based approach (RE), and innovation embedding (IE)	Qualitative and quantitative	Investigating DRR programs and initiatives as transformative capacity and enabling of TDRR that leads to community resilience

CHAPTER 2
LITERATURE REVIEW

2.1. Transformative Capacity and Designing Community Resilience

2.1.1. Defining community resilience and capacities

Resilience has been widely used to explain various sectors and fields. Originally, resilience was used in the ecology field and was focused on adaptation [79–81]. Within disaster governance, the concept of resilience has had two streams. The first stream has been focused on output, and the second has focused on continuous processes, which include the dynamic alternative called evolutionary resilience [82]. UNISDR [83] defined disaster resilience as the ability of a system, community, or society that is regularly exposed to hazards to resist, absorb, accommodate, adapt to, transform, and recover from hazard effects in a timely and efficient manner by preserving and restoring its essential basic structures and functions using risk management strategies. Therefore, resilience accommodates conservatives who seek to rebuild pre-existing areas as community memories and those who seek a transformation that embraces change [84,85] and flexibility [86]. This research focused on the second resilience approach to seize potential transformative opportunities for positive future outcomes [85]. However, both approaches can be used interchangeably.

Resilience is focused on ensuring a functional community system after a disaster shock [87]. Twigg claimed that community resilience was associated with a capacity to anticipate, minimize, and absorb potential stresses through adaptation or resistance, to

maintain essential functions and structures during disastrous events, and to recover after the event [88]. Imperiale and Vanclay claimed that it was important that social processes (cognitive and interactional) are collectively actioned by local people to enhance community wellbeing and address the adverse risks and impacts of common problems [89]. Therefore, resilience can be understood as the community process associated with the maintenance of functional systems [90].

To date, to reduce disaster impacts and enhance recovery, community disaster resilience research has emphasized the core importance of social capital [91] (see **Fig 2.1**). Pre-event disaster governance includes preparations for both emergencies and post-disaster recovery. With the support of spatial planning and development, the built environment emphasizes structural engineering focused on hazards. The social organization focuses on developing social community connectedness and networks that can assist individuals and organizations and a sharing of state resources that can improve the ability to adapt and cope with crises [91].

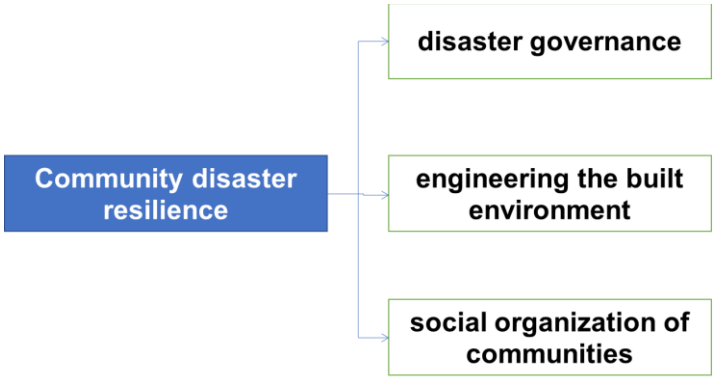


Figure 2.1 Community disaster resilience elements
Source: Mayer [91] *illustrated by the author*

However, when the focus of resilience shifts to a social approach, transformations may be required to build community disaster resilience [92]. These transformations bridge short-term community disaster resilience and long-term resilience development [93], which is referred to as transformative disaster risk reduction (TDRR) in this research. Even though disaster risk reduction (DRR) is generally focused on long-term development frameworks, the DRR terminology used in this research was specifically related to a community that lives with a permanent volcanic hazard. Disaster resilience focuses on community capacity building by gaining access to diverse resources, and community resilience development is focused on improving the community's self-determination [93]. While DRR programs can be embedded in community capacity building, generating information to understand the

spatial contexts in highly dynamic areas remains challenging. However, investment in technology and building institutional, cultural understanding and knowledge can overcome these challenges [90] by providing transformational experience-based problem-solving. The capacity to transform on a smaller scale is related to broader-scale resilience, as crises can be seen as opportunities to take advantage of experience and knowledge to develop innovative socio-ecological transitions [94].

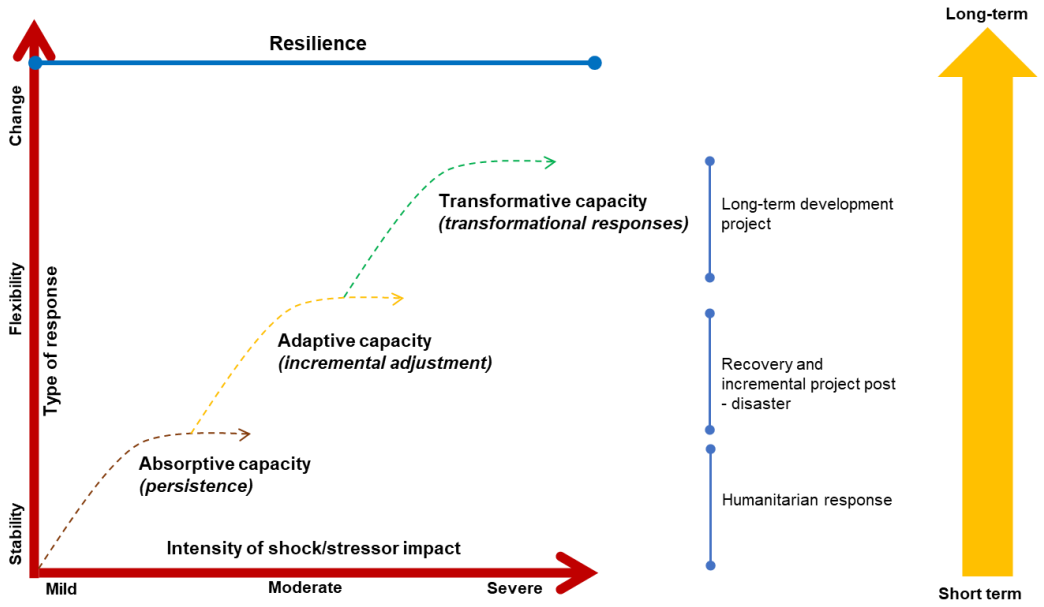


Figure 2.2 Resilience is a result of capacities interactions [95] and the relation to disaster risk reduction (DRR) [96] (adopted and re-drawn by the author)

To support disaster-resilient governance, absorptive, adaptive, and transformative capacities are needed [97]. In practice, even though these capacities have different functions, all need to harmonize to ensure effective implementation (see **Fig. 2.2**, **Table 2.1**) [17,96,98–100]. Transformative capacity in disaster governance refers to the development of an enabling environment that allows fundamental changes to be made to deal with the challenges, such as low disaster preparedness due to perceived risk knowledge, limited access to resources, including financial resources, and external factors, such as urbanization.

Table 2.1 Comparisons between absorptive, adaptive, and transformative capacity

Key words	Absorptive capacity	Adaptive capacity	Transformative capacity
Definition	The ability to persist and retain the functional system after shock	The ability to explore and adjust to change after a shock	The ability to alter and facilitate the system changes at a fundamental level
Time frame	Short term	Short to mid-term	Long term
Key features	▪ bonding social capital, ▪ informal safety nets, ▪ crop insurance, and ▪ conflict mitigation	▪ bridging/linking social capital, ▪ livelihood diversity, ▪ learning and innovation, ▪ diversity of assets, ▪ engagement across sectors, and ▪ access to financial services	▪ formal safety nets, ▪ improvements in communication, access to markets, ▪ improvement land tenure, ▪ government transparency and accountability
Example action	▪ the strengthening and maintenance of informal safety nets ▪ support for local peacebuilding, conflict ▪ mitigation and management of natural resources through informal governance structures ▪ the strengthening of risk education, risk mitigation, and risk coping mechanisms (community-based early warning, contingency plans, household savings) ▪ the strengthening of community organization and collective action capacities	▪ adoption of changed farming techniques ▪ the promotion of diverse livelihood strategies that protect against different risks ▪ the promotion of asset accumulation and diversification ▪ the expansion of aspirations ▪ improvements in human capital (health, education, nutrition) ▪ improved access to credit ▪ support for smallholder market linkages ▪ improvement in access to technologies ▪ a strengthening of the diverse social networks ▪ the promotion of gender empowerment ▪ support for healthy ecosystems (land, water, biodiversity)	▪ strengthening of governance functions, including formal and customary institutions ▪ the promotion of representativeness within governance structures ▪ improvements in infrastructure systems (roads, communications, market systems) ▪ effective support for social protection mechanisms (formal and informal safety nets) ▪ the promotion of social and economic policies that support resilience ▪ the provision of basic social services ▪ the development of institutional capacity: public management; accountability systems; technical skills in data collection, analysis, monitoring; early warning; risk analysis

Source: see paragraph before this table

2.1.2. Disaster in society: comprehension of community exposure and inequality when faced with the threat of hazards

Disaster risk analysis involves three domains: environmental changes and shocks, community-people exposure, and prevention and response systems. Understanding the human side of disaster research by examining people's capacity and vulnerability profiles can reveal how communities cope with environmental changes and shocks [101]. This involves examinations of community perceptions, socio-economic enablement, information provision, communication abilities, expectations, the risk culture, and social differentiation, such as age and gender [101]. Social differences can lead to varied individual and community vulnerabilities. For example, different gender and age groups could face different difficulties and require different aid during an emergency.

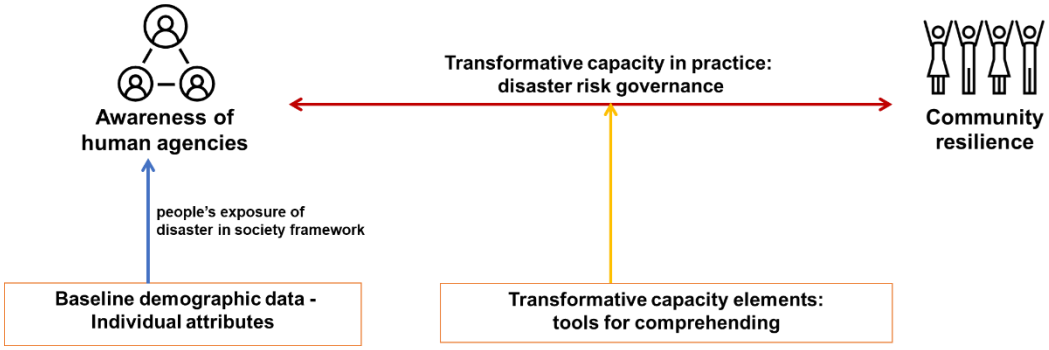


Figure 2.3 Disaster in society discussion: a correlation framework between transformative capacity and individual attributes
Source: Author, 2022

Although assessing local community disaster risk exposure is essential, many assessments have been conducted post-disaster in response to the disaster. As DRR involves a thoughtful response to complex and uncertain risks [102], to build transformative capacity, the people's social attributes in the pre-event context must be considered, especially in communities that have long disaster experiences or live with permanent hazards (see **Fig. 2.3**). Pre-event assessments can result in more people-centered DRR programs to deal with the complexity. Several indicators have been commonly used to measure people's exposure to disaster: (1) household structures (household headship, marital status, and type of family); (2) socio-economic status (income, wealth, political power, and education); (3) gender; (4) race and ethnicity; (5) age; (6) tenure; (7) urban or rural; (8) special needs population; (9) employment status; and (10) time spent living in the neighborhood [87,101,103].

2.1.3. Disaster awareness as transformative capacity: the role of knowledge and learning process

In disaster governance, awareness is closely related to building knowledge and changing attitudes (cognitive aspect) toward both pre-and post-disaster management cycles. Instead of excessive investment in post-disaster, reducing the risks pre-event would build greater resilience. Therefore, disaster awareness is essential in DRR to ensure better community preparedness.

Resilience thinking means being able to respond to complexity and learning to live with change, both of which are the basic norms for transformation [104]. To contribute to TDRR, disaster awareness, which is a transformation in knowledge, attitudes, and actions, involves continuous learning. Deepish [104] claimed that resilience was associated with different forms of knowledge, social learning, self-organization, and practical spatial planning and development, all of which are related to disaster governance and collaborative planning processes.

However, even though knowledge building is essential for sustainable communities, these learning processes have been the most neglected aspects in disaster governance studies [84], which has hindered transformative processes. Bridging this gap requires system changes that enable (a) a sharing of knowledge, technologies, resources, and responsibilities for the development and the achievement of the SDGs and (b) ensuring new inclusive, transparent, and accountable deliberative spaces within the locality and other socio-ecological governance changes [89]. Engaging with residents to understand the risks can develop their planning and preparation efficacies [105], that is, co-creating knowledge with the local community can benefit disaster governance by providing a narrative on the risks.

2.2. Understanding the Transformative Capacity of Disaster Awareness: The Elements

Transformative capacity has been discussed in relation to transformation and resilience. Several researchers, such as Wolfram [106,107], Ziervogel [77], and Räsänen et al. [78], have attempted to understand transformative capacity by examining urban resilience indicators. Holscher [22,108] introduced a different transformative capacity framework for urban climate governance. Although Wolfram's initial framework was also based in an urban environment, the introduction of indicators gave space to apply it to

broader ecosystem-based locations, as was proposed in Räsänen. et al.'s watershed governance research. Ziervogel also included a poor urban environment in their study. While Holscher's approach was more focused on the role of agencies, learning, and innovation in particular programs, Wolfram's framework was a complex, comprehensive approach to understanding transformative governance. Wolfram's indicators have also been partially used based on research goals, as in Ziervogel et al., whose case study introduced inclusiveness and inequality issues.

However, these two transformative capacity frameworks have not explicitly discussed community-based programs or community disaster governance in communities living with disaster risk. Therefore, this research proposes a transformative capacity measuring tool conceptualized at the community level. Community involvement in community disaster resilience frameworks can ensure short-term community equilibrium and long-term evolution in resilient community development [93]. This research focuses on building community resilience to bridge these two resilience contexts.

Transformation involves changes in community behaviors, interests, and knowledge. This approach enhances specific programs by introducing innovation at the core of the discussion. In SFDRR priority number 3, public and private investment in DRR enables the development of an environment that allows for innovation, structural and non-structural prevention measures, and an enhancement of economic, social, health, and cultural resilience [109]. Minor DRR changes and disaster awareness knowledge improvements can benefit both pre-event and post-disaster disaster governance.

Transformative capacity inclusion in structures, cultures, and practices enables innovations that give rise to the creation, dissemination, and embedding of novelties, such as new ways of organizing, producing, consuming, and thinking about social innovation, technology, and governance. To understand how transformative capacities could be better understood, Holscher suggested three sub-capacities [22,108]: enabling novelty creation; increasing novelty visibility; and empowering communities. The transformative capacity approaches in both Wolfram [106] and Holscher [22] emphasize the urgent need for innovation. Therefore, this research used this innovative terminology to shape the transformation process. Holscher [22,108] added that this transformative approach requires embedding creation into the learning process to provide an enabling environment for replication and upscaling. In this research, transformative capacity indicators were used in the framework to understand how the DRR programs and initiatives in the Merapi Volcano

community could create an enabling environment to transform the community's disaster risk governance.

This research proposes four conceptual elements to explore transformative capacity in practice (see **Table 2.2**):

1. **Community participation (CP) and people-centered (PPC) program design**
   People's pre-event, during, and post-event decisions and behaviors can dramatically affect the impact, vulnerability, recovery time, and resilience of individuals and communities [110,111]. The local communities living near a hazard must be aware of their risks [112,113], that is, local community involvement is a vital part of disaster governance. However, the community here is not limited to the people living close to the disaster epicenter. Nevertheless, it could be more comprehensive as the public could participate in aid processes managed by an authority. People-centered programs are tailored to the needs of those who benefit from such programs or initiatives. A people-centered approach enhances inclusivity by allowing the people to interact and participate in the designated programs.
2. **Co-creation (CCR) and collaboration (CLB)**
   Co-creation and collaboration are similar but different [114]. Co-creation involves the development of new programs, products, or initiatives [115], whereas collaboration enhances the relationships between the stakeholders in the program's implementation [116]. Transformative capacity enables co-creation and collaboration to create innovative solutions for unresolved problems and prepare for the future (preventive). Transdisciplinary and diverse stakeholder co-creation, which includes policymakers, focuses on various open process systems that consider the programs' end-users, such as local communities in disaster-prone areas. Collaboration is both exclusive and inclusive, that is, it involves a symbiotic mutualism, in which each partner contributes based on their role. Therefore, in practice, networks based on social cohesion are essential to enhance transformative capacity.
3. **Reflective and learning – experience-based approach (RE)**
   Enabling environments allow the community and stakeholders vertically (national to local) and horizontally (sectoral and agency-based) to track their performances and learn from the process. Reflective learning focuses on the process rather than the output and strongly emphasizes the creation of multiple alternatives, practices,

solutions, and path dependencies [78,106,117]. To ensure that the programs and initiatives are accountable, outputs and outcomes must be included; therefore, resilience and transformation must accommodate these elements.

Because DRR's primary aims are to transform behaviors, perceptions, and emotions through the four major learning perspectives of behaviorism; cognitivism, constructivism (cognitive and social), humanism, and connectivism; [118] DRR activities must involve both epistemological and ontological learning paradigms [119–126]. Therefore, for transformative disaster governance and resilience, DRR must be understood in a social learning context that embraces community experience-based learning. As social learning emphasizes that the community is the leading actor in understanding the knowledge, in this context, disaster risk knowledge could be gained through DRR programs and could embed learning in the local community's daily activities [127].

4. **Innovation embedding (IE)**

   Innovation is at the core of transformative capacity. The development of transformative capacity does not imply radical changes or different systems; rather, it is focused on light modifications so that the programs and initiatives reach a wider audience. Embedded innovation is not a utopian concept but should be merged into current and new future programs to ensure change; that is, transformative capacity embeds 'change' into current structures, cultures, and practices [22,106].

   To realize these aims, the programs and initiatives to achieve these goals need to be included in formal policies. If innovation is informal, resource allocations will not be adequate to mainstream the programs and initiatives. Therefore, the inclusion of narratives could fill this current gap. For example, while adjustments such as contingency planning could contribute to the development of disaster governance adaptive capacities, a transformative capacity building requires additional and incremental planning to focus on all community sectors and initiatives that enhance the narrative and inspire people to participate.

The previous discussion has conceptualized transformative capacity, its elements, and the positioning of the people's exposure to TDRR. **Fig. 2.4** shows the conceptual framework used in this research, in which transformative capacity building was employed to connect human agencies and build broader community resilience.

Table 2.2 Transformative capacity elements

No	Transformative capacity element	Description	Keywords	Satisfied when evidence perceived	Evidence/Data	Key reference(s)
TC1	Community participation (CP) and people-centered (PPC) programs design					
TC1.1	Empowered community of practice	Shows active participation of the local community in disaster governance in practice and formal settings (multiform and multimodality)	*Community involvement*	▪ Local community or civil society organizations participating directly in planning and or decision-making processes ▪ Embedding the different values of community empowerment into designed programs and initiatives	▪ Community involvement in designing programs and initiatives through various mechanisms such as participatory or collaborative planning, public consultation, or community-led initiatives. ▪ For example, contingency plans made by the community-based disaster risk management (CBDRM) organization	Wolfram [106] Broto, et.al [117] Gina, et.al. [128]
TC1.2	A people-centered oriented program designed	▪ Purposes to strategically design the program based on the people's needs and attributes of each group of community members ▪ The program is designed not only in the structured or physical aspect but also with new skills, training, and abilities, improved access to political processes, greater independence, and self-efficacy ▪ Explicit reference to inclusive planning-oriented programs that address vulnerable groups, women, and issues of social inequality	*People need inclusive planning, soft skill*	▪ Addressing or analyzing the social needs ▪ It gives a space for vulnerable groups, women's involvement, and addressing the social inequalities	▪ Allows the tailor-made programs based on people/group needs ▪ Addressing the vulnerable groups, women, and issues of inequality both in practice and regulation/documents	Wolfram [106] Broto, et.al [117] Gina, et.al. [128] Räsänen A. et al. [78]
TC2	Co-creation (CCR) and collaboration (CLB)					
TC2.1	Diversity and transdisciplinary co-production of knowledge/ program/ initiatives	Includes the involvement of diverse groups such as the local community, experts, external stakeholders, civil society, and other government authorities in	*Diverse stakeholders' involvement, creating knowledge/*	Involvement of various and multiple stakeholders in knowledge/ program/ initiatives production processes	Involvement of various actors/stakeholders in creating knowledge/ program/ initiatives	Wolfram [106] Broto, et.al [117]

No	Transformative capacity element	Description	Keywords	Satisfied when evidence perceived	Evidence/Data	Key reference(s)
		the production of knowledge/ program/ initiatives of disaster governance and related issues	*program/ initiatives*			Räsänen A. et.al [78]
TC2.2	Diverse governance modes and network forms for implementing the programs/ initiatives	▪ A variety of actors involved throughout the initiative(s) ▪ A strong sense of social cohesion manifested in strong various network forms ▪ Institutional development and capacity building in relation to building social capital, for example, by creating relationships of trust between stakeholders or developing formal communication channels for marginalized groups that could facilitate future collaboration	*Network* *Diverse stakeholders' involvement* *Program and initiatives implementation, capacity building*	▪ Different and various stakeholders are working together and building connections between sectors in different manners ▪ The existence of various network forms, in practice or formal settings. ▪ Reference for capacity building that enhances the future collaboration	▪ Involvement of various stakeholders to implement certain programs/ initiatives ▪ Existence of network forms such as village networks located near the volcano, networks for community-based disaster risk management (CBDRM), etc. ▪ Programs that support capacity building that enhances future collaboration	Wolfram [106] Broto, et.al [117] Gina, et.al. [128] Räsänen A. et al. [78]
TC3	Reflective and learning–experienced-based approach (RE)					
TC3.1	Enabling reflexivity and social learning	▪ Purpose of tracking performance through recording, assessing, monitoring, evaluating, and procedures ▪ They are considering how the project unfolds and if and how the project visions are met.	*Monitoring and evaluation; performance track*	▪ Stakeholders reflecting on the learning and capacity-building process ▪ Monitoring and evaluation processes with open discussions and critical dialogue on project development both in practice and formal setting	▪ Continuous learning process manifested on re-designed/revision of current programs/initiatives supporting with the regulatory framework in practice or formal setting ▪ For example, revision of guidelines managing community-based tourism, new contingency plan with considering several factors (making a new contingency plan in the volcanic community that meets the issues with global pandemic) ▪ Conducting monitoring and evaluation with a formal report	Wolfram [106] Broto, et.al [117] Räsänen A. et al. [78] Holscher [22]

No	Transformative capacity element	Description	Keywords	Satisfied when evidence perceived	Evidence/Data	Key reference(s)
TC3.2	Learning from tested solutions and practices	This includes formulating and evaluating multiple alternative solutions and practices that consider different possible development outcomes (path dependency) associated with different policies or environmental conditions	*Multiple alternatives practices and solutions, path dependency, Experience-based*	▪ Deliberate use of experiments or ideas that seek to challenge the established policies, technologies, or social practices ▪ Comparative scenarios that evaluate the mutual shaping of social, ecological, economic, and technological dimensions	▪ Creating multiple scenarios based on local profiles. For example: creating multiple contingency plans based on local community profiles and the risk levels	Wolfram [106] Broto, et.al [117] Räsänen A. et.al [78]
TC4	Innovation embedding (IE)					
TC4.1	Resources Access	▪ Consists of space and context for the innovation to be embedded into routines, institutions, legal norms, and practices by enabling access to basic resources: human, knowledge, time, financial, technical, and organizational resources	*Resources access; embedded innovation;*	▪ Sharing of lessons learned, knowledge and expertise through events, workshops, publications (printed or online) or offering direct advice and support to groups that could benefit from the expertise, including a new funding model,	▪ Creating an enabling environment that accommodates the innovation/ new norm by accessing the resources, such as new funding models, knowledge storage systems, new data systems with an IT approach, etc. For example: creating a web-based real-time information system for disasters at the local government level or creating waste management using a Public-Private Partnership scheme	Wolfram [106] Broto, et.al [117] Räsänen A. et.al [78] Holscher [22]
TC4.2	Mainstreaming the transformative action	▪ Replicating or applying the project itself or various processes, methods, components, or solutions in different settings and locations ▪ Projects leading to lasting change by being embedded in legal, regulatory, and policy frameworks	Generalization; replication; policy framework;	▪ Attempts to generalize the project operation or results beyond the initial application context ▪ Project stakeholders share resources for capacity development outside the project to disseminate and multiply results	▪ Reference to the legal framework to mainstream transformative action ▪ Dissemination of lessons learned to a broader platform. For example, involvement in sharing sessions at the tourism village management for open public lecture series	Wolfram [106] Broto, et.al [117] Räsänen A. et al. [78] Holscher [22]

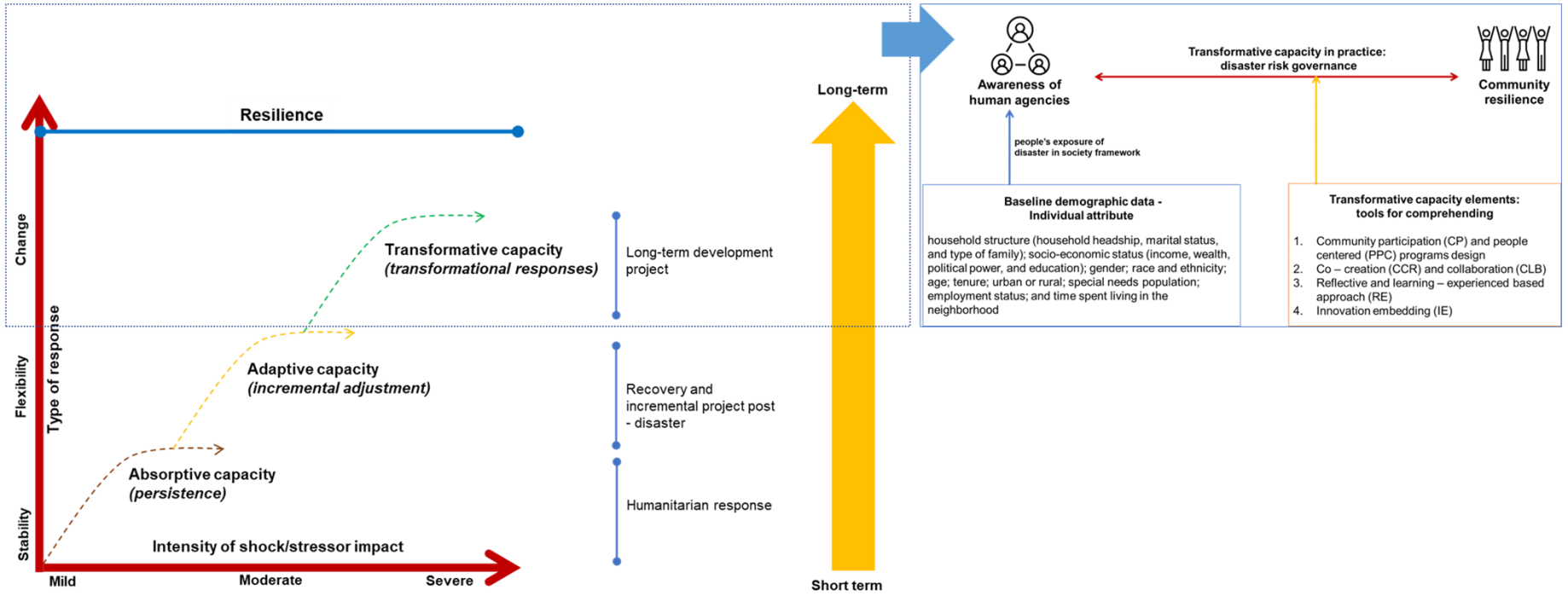


Figure 2.4 Conceptual Framework
Source: Author, 2022

CHAPTER 3
RESEARCH METHODOLOGY

3.1. Introduction

This chapter presents the approaches used for this study. It includes a description of the research design, study area, research methods, and data collection rationale.

3.2. Research Design

This study used a mixed-methods case study approach in recognition that the existing research gaps are caused by inadequate exploration through specific dimensions/indicators/points of view [129,130]. Specifically, the gaps to be filled are longitudinal study (10 years after the catastrophic disaster), discussing resilience from a specific capacity component (transformative capacity), and focusing on the human factors of disaster governance (socio-culture). Mixed methods allow for a combination of qualitative and quantitative methods to be used simultaneously and enable triangulation to clarify complexities that may arise during the research.

This study addresses disaster awareness as part of DRR as a transformative capacity to strengthen resilient communities within transformative disaster governance. This research collected and analyzed quantitative and qualitative data concurrently to support answering the RQs. The qualitative and quantitative data were collected and analyzed different sub-research questions within the first research question (RQ1) in the same phases, then the result from both sub-research questions was used to analyze the second RQ (RQ2) with additional tools of analysis. The qualitative data consisted of content

analysis for several sources of data and reports, including open data from the internet and observations that the researcher experienced during the previous time with the researcher and the community. The quantitative data comes from an online platform survey from a selected community based on the relationships within this research theme, a volcanic hazard. Both results of this RQ1 (RQ1*a* and RQ1*b*) are used in the next research stage, wherein RQ2 is answered using qualitative data. The reasons for using both forms of data (qualitative and quantitative) aim to understand the complex phenomena in this research theme.

3.3. Research Questions and Data Acquisition Methods

Chapter 3 presents the data collection methods used in this research (see **Table 3.1**). The methods include a combination of an online survey, past observation, and content analysis of various secondary data. The various data collections represent an attempt to answer the RQs with valid information. Observation data were available through the researcher's previous work with the community. Then, the documents or secondary data (data from secondary sources) used in this research were obtained from various resources such as academic journals, projects and government reports, open data, and macro data from several organizations.

The online survey was administered to people who either (1) lived within 20 km of Merapi, (2) experienced the Merapi eruption of 2010, or (3) were either temporarily or permanently displaced by the 2010 eruption. As this research aims to understand the public perception of people's exposure to Merapi Volcano, the survey did not specifically target residents who had participated in DMMT who lived at all levels of DPAs (see **Fig. 3.1)** since DMMT has been widely conducted in these areas since 2008 [64,69,131].

The survey was conducted using questionnaires through various streams, such as personal social media, public accounts, local influencers, and stakeholders' networks with whom the researcher previously worked. From a total population of 1.6 million near the Merapi Volcano, the online survey obtained 215 usable responses through a reach of 476 people who completed it between September and December 2020 on the online survey platform Survey Monkey. Since the online survey cannot ensure the adequate spatial distribution of respondents, nor control who completes it, it is acknowledged that the population profile can be biased. However, to reduce the unfit criteria of respondents, the survey required respondents to give their address information. Given the data saving and voluntary nature of participation in this research, the privacy statement, and consent

Table 3.1 Data Collection

	Research Question	Data Collection Method	Data Source	Expected Data	Type of data	Data Analysis	Data Output
1	**RQ1** How can disaster awareness programs be explained in terms of the DRR framework and its relationship between individual attributes in TDRR governance?						
	RQ1a How can disaster awareness programs be explained in terms of the DRR framework and enable the identification of the challenges of DRR?	Documents observation; field observation	Documents, field data (key person, community, activities)	Disaster awareness programs and initiatives	Secondary data; primary data	Descriptive, comparative	Description with table, diagram, and photo
	RQ1b How does disaster awareness manifest in the relationship between individual attributes and DRR programs and initiatives to encounter recurrent hazards in TDRR governance?	Online survey	Respondent (local community) s	DRR and the relation to individual attributes	Primary data	Statistical analysis	Statistical numeric data, table
		Documents observation	documents	Supporting data for survey methods	Secondary data	Descriptive	Description with table
2	**RQ2** How can disaster awareness be understood as a transformative capacity to achieve community resilience to recurrent natural hazards in spatially complex settings?	Documents observation	The previous result from RQ1 documents	Transformative capacity checked for disaster awareness programs and initiatives	Primary data	Descriptive evaluative	Description with table, diagram

Source: Analysis, 2022

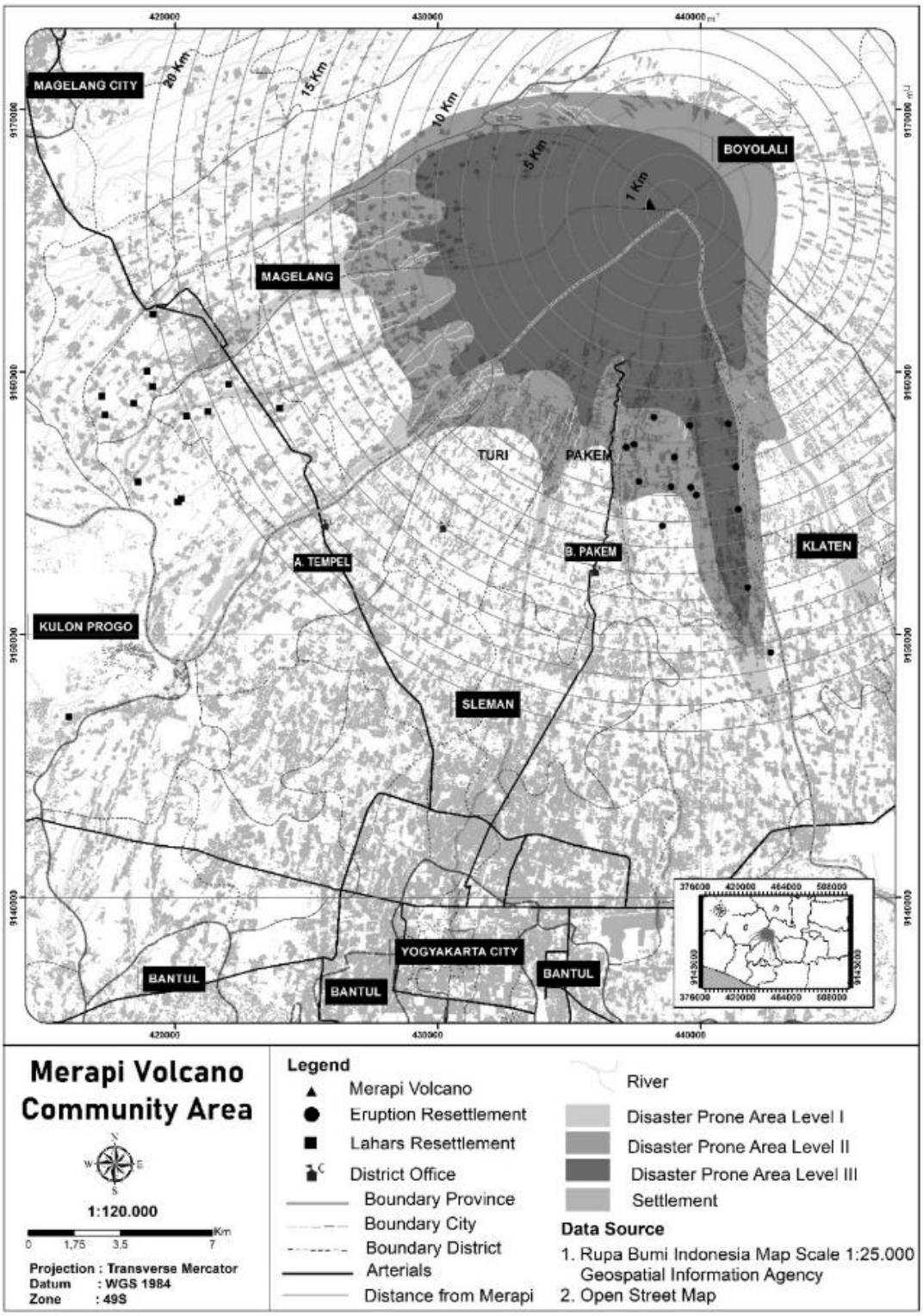


Figure 3.1 Merapi Volcano community area map
Source: Author, 2021
Data resources map: 1. Topographical map [36]; 2. Open street map [37], 3. Hazard map Merapi 2019 [38]

obtained in the online survey explained how the data are to be used and saved. With this, the respondents had the choice of filling out the survey or not.

3.4. Site Setting

Site selection was based on the research objectives. This research was conducted in the Merapi Volcano community, Indonesia. The Merapi Volcano community is defined as the community living in 20 km proximity to Merapi Volcano. This definition is influenced by the 2010 experience, which forced the community evacuation members within a 20 km radius of the volcano.

There are several rationales for choosing the Merapi Volcano community as the research study:

1. Merapi has experienced a long history of volcanic hazards and disasters. Since these are recognized as permanent hazards, people in Merapi have three choices: (a) keep the hazards away from the community, (b) keep people away from the hazards (permanently), or (c) live in harmony with the environment. Most of the people around Merapi choose the third option [132];
2. Within this extensive experience and exposure to volcanic hazards, there is a possibility of best practices from the local community to enable TDRR, for example, through applying local disaster knowledge.
3. Merapi is an example of permanent hazards with additional exposure to rapid urbanization near the volcano, extreme (spatial) changes in the risk after the eruption of 2010 (i.e., changing the lava dome in the south sectors), and a diverse community profile.

3.5. Tools, Material, and Research Instruments

This research applied two approaches, qualitative and quantitative; various tools and instruments were used, such as an online survey platform (Survey Monkey), stationery; and computer software, such as SPSS for statistical analysis numbers, word processing software (Microsoft Office either Microsoft Word or Microsoft Excel), and image processing software (i.e., ArcGIS and Adobe family).

3.6. Research Process and Stages

This research comprises three main parts (see **Fig. 3.2).** The first part aims at answering RQ1- *How can disaster awareness programs be explained in terms of the DRR framework and its relationship between individual attributes in TDRR governance?* This part consists of two sub-research questions, RQ1*a* - *How can disaster awareness programs be explained in terms of the DRR framework and enable the identification of the challenges of DRR?* and RQ1*b* - *How is disaster awareness manifested in the relationship between individual attributes and DRR programs and initiatives to encounter recurrent hazard risk in TDRR governance?* The next part aims to answer RQ2 - *How can disaster awareness be understood as a transformative capacity to achieve community resilience to recurrent natural hazards in spatially complex settings?* Thus, the last part is the interpretation and discussion part of this research, based on the data from the previous stages.

First, the discussion addresses three sub-themes (two case studies and one policy review) related to RQ1*a* and the theme of RQ1*b* related to the role of the community in DRR in transformative disaster governance (see **Fig 3.3**). The case study and policy review data collection involved document or secondary data observation, fieldwork observation, and qualitative data gathered from an online survey. The quantitative data for RQ1*b* were drawn from the online survey, complimentary with document/secondary data observations. In this part, data test analysis, descriptive analysis, comparative, evaluative, and even prescriptive approaches have been used within qualitative models. Statistics analysis and non-parametric and parametric methods were used for the quantitative data.

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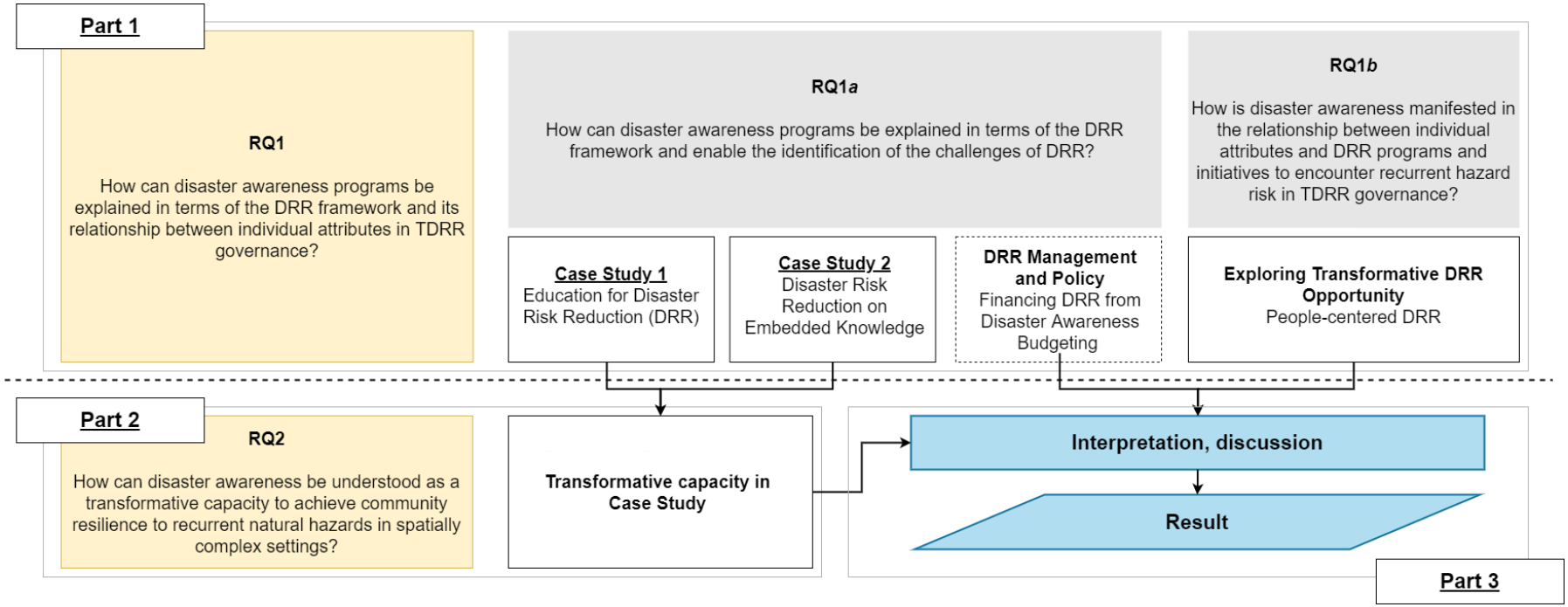


Figure 3.2 Research phases based on sub–research questions
Source: Author, 2022

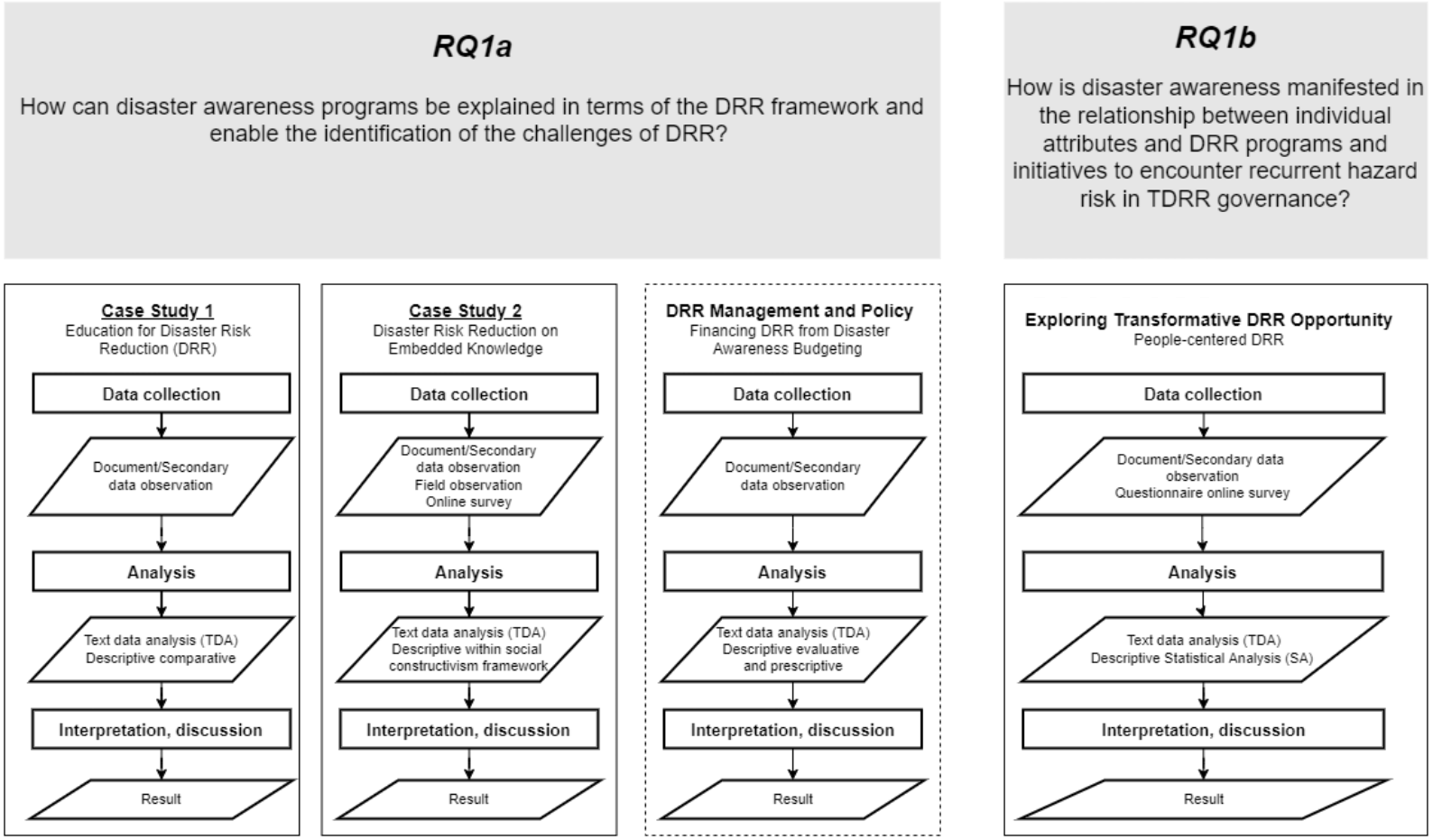


Figure 3.3 Research phase part 1: Answering research question 1 **(RQ1)**: *How can disaster awareness programs be explained in terms of the DRR framework and its relationship between individual attributes in TDRR governance?*
Source: Author, 2022

The second part of this research examined the case study results from the first part. An additional tool from conceptual transformative capacity developed in Chapter 2 was used to check and uncheck the indicators of each element (see **Fig 3.4** and **Table 3.2** for an example exercise). Next, a comparative model is made of the two cases. The last part of this research discusses the community role (RQ1*b*) and evaluates the transformative capacity (RQ2).

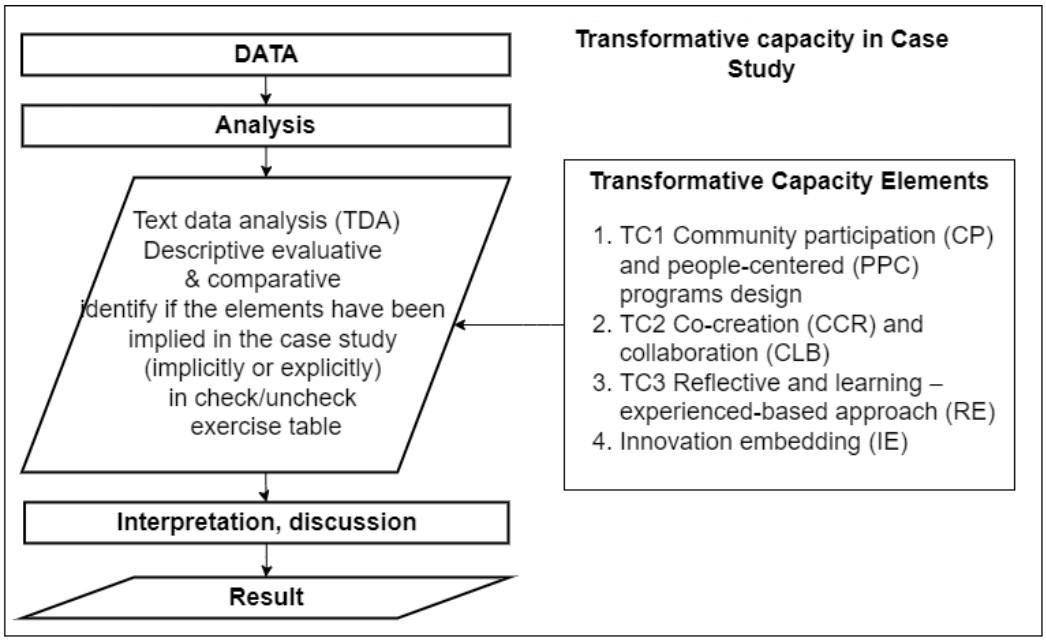


Figure 3.4 Research phase part 2: Answering research question 2 **(RQ2)**: *How can disaster awareness be understood as a transformative capacity to achieve community resilience to recurrent natural hazards in spatially complex settings?*
Source: Author, 2022

Table 3.2 Transformative Capacity Identification Exercise

No	Case Study	Theme	TC Elements/ Sub-elements	Evidence/ Rationale	Implementation/ best practice in Merapi Narration
1	*2*	*3*	*4*	*5*	*6*
Example.	Safe School Learning (SSL)	education, community	TC2	It aims to increase the school's capacity, students, teachers and staff, and the neighborhood around the school.	a. Disaster knowledge and capabilities are informed regularly and well organized b. Safety of the school

CHAPTER 4
TOWARDS RESILIENT COMMUNITY: UNDERSTANDING DISASTER RISK REDUCTION PROGRAMS AND INITIATIVES GOVERNANCE IN MERAPI

4.1. Revisiting Disaster Risk Reduction (DRR) Governance in Indonesia

This sub-chapter addresses three issues: (1) a study of disaster governance in Indonesia, with a focus on structural and policy support; (2) and (3) a review of DRR programs and policy in specialized disaster-preparedness programs, as well as embedded knowledge and practice.

4.1.1. Review of disaster risk management and policy: a volcano hazard

This section includes an overview of disaster governance in Indonesia, governance of volcanic disasters, and the financial implications of disaster risk reduction.

4.1.1.1. Natural hazard and disaster risk management policy in Indonesia

Indonesia's location along the Pacific ring of fire has high seismicity and volcanism. With an average annual rainfall of 2,000 mm and up to 6,000 mm annually, among the highest archipelago in the world, climate-induced disasters such as flooding, drought, and landslides are also quite common [133,134]. In 2021, BNPB recorded 3,092 disaster events, dominated by hydrometeorological disasters: 1,298 flood events, 804 extreme weather events, 632 landslides, 265 forest, and land fires, 45 coastal flood and abrasions, 32 earthquakes, 15 droughts, and one volcanic eruption [133]. From these disasters, 8,426,609 residents suffered and were evacuated, 14,116 were injured, 665 died, and 95 were missing,

and the total damage was recorded as 142,179 houses, 3,704 public facilities, 509 offices, and 438 bridges. The damage to houses was as follows: 19,163 houses were heavily damaged, 25,369 moderately damaged, and 97,647 lightly damaged. There were fewer disasters in 2021 than in the previous year. Based on the data, Indonesia's disaster occurrence considerably affects people and damage at a high cost **(Table 4.1, Fig. 4.1, and Fig. 4.2)** [135]**.**

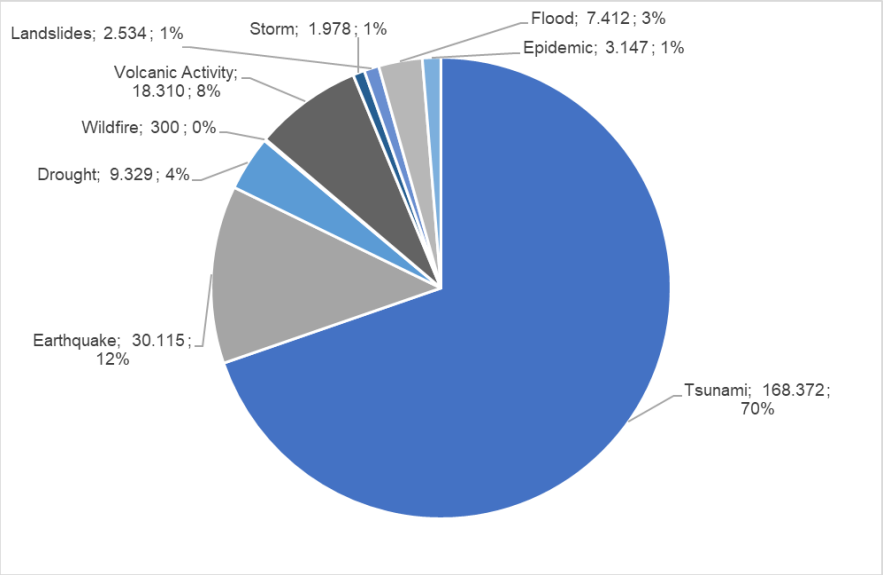


Figure 4.1 Total fatalities from natural disasters in Indonesia, 1900 – 2015

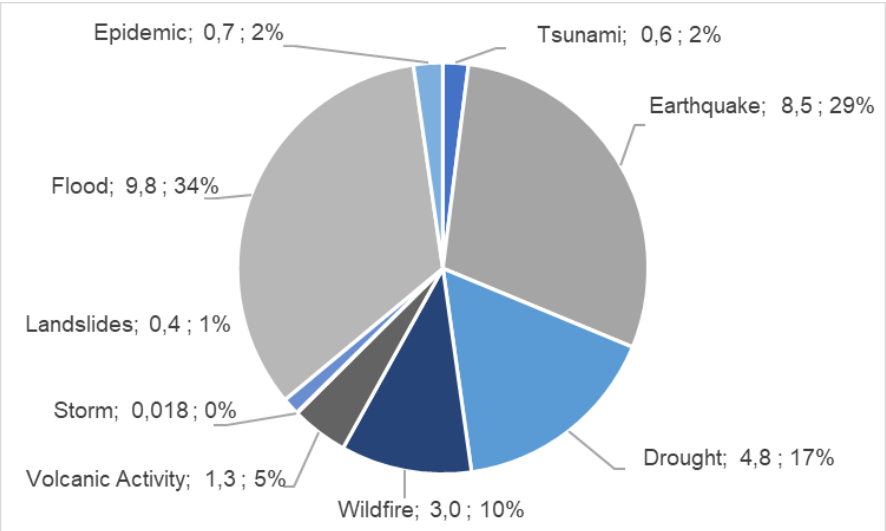


Figure 4.2 Total population affected by natural disasters in Indonesia, 1900 – 2015

Table 4.1 Impact of natural disasters in Indonesia, 1900 – 2015

Disaster Type	Disaster Subtype	Events Count	Total deaths	Total affected	Total damage (USD)
Drought	Drought	9	9,329	4,804,220	160,200,000
Earthquake	Tsunami	9	168,372	580,520	4,506,600,000
	Ground Movement	105	30,115	8,536,402	718,932,000
Epidemic	Bacterial Disease	15	744	38,030	0
	Viral disease	13	2,178	137,015	0
	Parasitic disease	3	225	504,000	0
Flood	Flash flood	32	2,037	1,236,455	247,500,000
	Riverine flood	85	2,708	6,054,476	6,318,909,000
	-	58	2,656	2,571,584	90,638,000
	Coastal flood	1	11	2,000	0
Landslides	Rockfall	1	12	55	0
	Landslide	52	2,522	397,792	121,745,000
Storm	Tropical cyclone	6	1,953	5,298	0
	Convective storm	3	25	12,950	1,000
Volcanic activity	Ash fall	57	18,310	1,333,828	530,390,000
Wildfire	Forest fire	9	300	3,034,478	9,329,000,000

Indonesia plays a critical role in disaster governance by coping with catastrophes through a well-developed disaster management system. In its current stage, Indonesia's disaster governance is shifting toward more polycentric and dual methods (local and international). This approach suggests change based on disaster management performance evaluation, considering the 2004 Aceh and Nias tsunami, culminating in Disaster Management Law No. 24 of 2007 [136]. Each level of disaster governance, national, provincial, and regency/municipal, consists of a disaster management organization, a policy framework, and a budgeting mechanism [137,138]. The governance level is related to the catastrophe magnitude, which may influence resource allocation. Indonesia has a comprehensive legal system framework to facilitate catastrophe management:

1. Disaster Management Law No. 24/2007: Principle of Disaster Management, Promptness & Precision, Priority, Coordinating & Integrity, Efficiency & Effectiveness, Transparency and Accountability, Partnership, Non-Discrimination, Non-Proselytization
2. Government Regulation No. 21/2008 Operation of Disaster Management
3. Government Regulation No. 22/2008 Funding and Managing in Disaster Assistance

4. Government Regulation No. 23/2008 Role of International Agencies and Foreign Non-Governmental Agencies in Disaster Management
5. Presidential Regulation No. 8/2008 Establishment of NADM

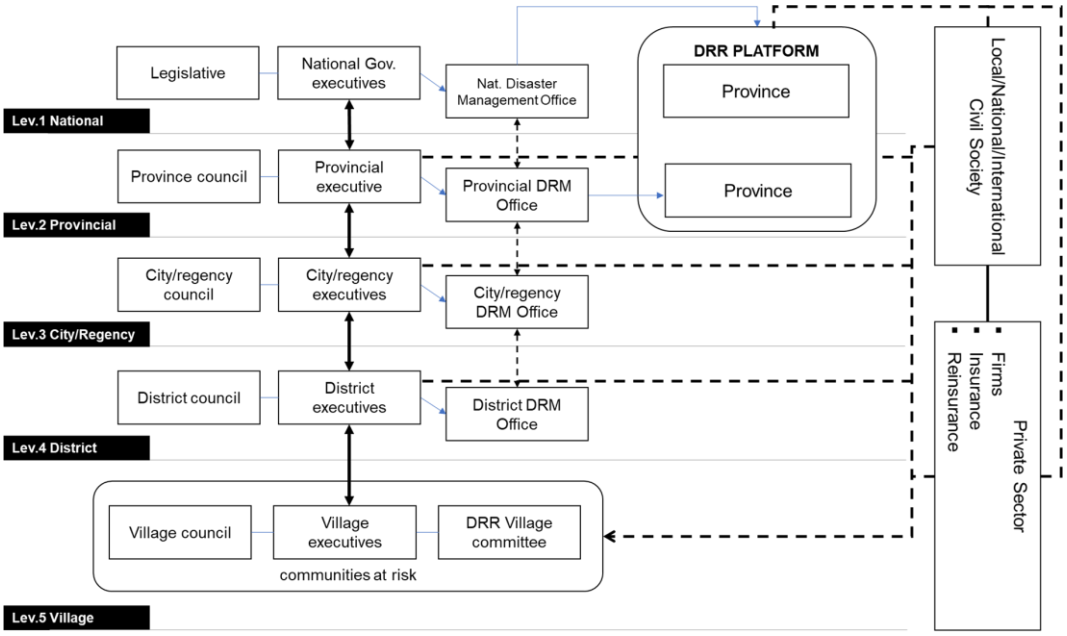


Figure 4.3 Structure of Disaster Risk Management (DRM) in Indonesia

Article 33 of Law No. 24/2007 stated that on an operational level, disaster relief organizations are divided into three stages: pre-disaster, emergency response period, and post-disaster[139]. Between 2005 and 2015, Indonesia achieved tremendous progress in mainstreaming disaster risk reduction into national and local development, with a significant effort at legislative, institutional, and regulatory levels, as well as program planning and implementation. Over 8% of districts and cities formed local disaster management agencies in 2015. Indonesia has also provided resources for disaster governance, including financial issues. Indonesia has also tried to address DRRs at the national and community levels (see **Fig. 4.3**) [140,141]. DRR is integrated into emergency preparedness through national and local contingency planning processes. The budget for DRR has increased significantly over the last ten years, with budget allocation for DRR in cross-sectoral ministries exceeding 1% of the national budget.

In addition, disaster governance in Indonesia acknowledges the use of networks and volunteerism in disaster management [138], such as consortiums on specific thematic issues, global humanitarian networks, disaster specialists, and civil society organization forums. Volunteering is deeply established in Indonesian society, and *gotong royong* (social movements) has become a way of life. These principles have been used in

catastrophe risk management. CSO groups concentrating on disaster resilience and youth movements for community-based disaster risk management assisted with the integration.

4.1.1.2. Volcano, hazard, and community resilience planning

People have been fascinated by the unpredictable natural forces created by geological occurrences that they have been unable to explain since ancient times. Many cultures have linked volcanoes and natural features such as hot springs, geysers, and hissing steam vents to the mythological underworld, where humanity was thought to suffer the eternal fires of hell. Volcanoes are one of the natural dangers that can have disastrous consequences for populations (see **Table 4.2**) [142].

As the human population grows, it is impossible to avoid the habitation of sites that expose them and make them susceptible, such as volcanoes. The challenge for disaster governance in this area is to involve the local community, which consists of persons who live or work in this area, in responding effectively to catastrophe risks and mitigating loss of life and livelihood.

Table 4.2 Ten (10) deadliest volcanic eruptions between 1900 and 2009

No	Volcano/Eruption	Death Reported	Percentage	Injured	Total Affected
1.	Mount Pele (Martinique, 1902)	30,000	29.3%	Not reported	Not reported
2.	Nevado del Ruiz (Colombia, 1985)	23,080	22.5%	10,000	12,700
3.	Santa Maria (Guatemala, 1902)	6,000	5.9%	Not reported	Not reported
4.	Semeru (Indonesia, 1909)	5,500	5.4%	Not reported	Not reported
5.	Kelut (Indonesia, 1919)	5,110	5.0%	Not reported	Not reported
6.	Santa Maria (Guatemala, 1929)	5,000	4.9%	Not reported	Not reported
7.	Lamington (Papua New Guinea, 1951)	3,000	2.9%	Not reported	Not reported
8.	El Chichon (Mexico, 1982)	1,879	1.8%	500	40,500
9.	Oku Volcanic Field (Cameroon, 1986)	1,746	1.7%	437	10,437
10.	Soufriere Hills (St. Vincent, 1902)	1,680	1.6%	Not reported	Not reported
Total		82,995	81.1%		

Notes: The table indicates the maximum number of deaths reported for the event. Percentages were calculated based on the maximum reported deaths in all volcanic events between 1900 and 2009

Table 4.3 Indonesian Volcanic Hazards Zoning Policy and Management

Description	I Normal *(Normal)*	II Alert *(Waspada)*	III Stand by *(Siaga)*	IV Emergency *(Awas)*
Indicators and threat	The results of visual and instrumental observations fluctuate but do not show an increase in activity	The results of visual and instrumental observations began to show symptoms of increased activity. Some volcanoes can erupt.	Visual and instrumental observations showed increased activity that was getting more real, or an eruption occurred.	The results of visual and instrumental observations observed an increase in activities that were increasingly real or could be in the form of eruptions
	The threat of danger in the form of toxic gases around the crater/dome (on certain volcanoes)	The threat of danger around the crater/dome	The threat can widely spread but does not threaten settlements	The threat of danger can be widespread and threaten the settlements of residents
Disaster-prone area I (Zone I)	People can carry out their daily activities	People can carry out their activities by increasing awareness	The community increases awareness by not carrying out activities around the river valley that have the upstream area of the volcano	The community immediately evacuated based on the instruction from the local government according to MEMR technical recommendations
Disaster-prone area II (Zone II)	People can carry out their daily activities	Communities can carry out their activities by increasing awareness of the threat	The community began evacuation preparation while waiting for instruction from the local government according to the technical recommendations of the MEMR	The community immediately evacuated based on the instruction from the local government according to MEMR technical recommendations
Disaster-prone area III (Zone III)	The community can carry out daily activities while still complying with the provisions of regulations from the local government according to technical recommendations from MEMR	People are recommended not to do activities around the crater/dome	Communities in threatened areas are not allowed to carry out activities and begin to prepare for evacuation	People in disaster-prone areas are not allowed to carry out activities and immediately evacuate

Source: Raden Sukhyar [143] Ministry Regulation of MEMR No. 11 [144]

Regarding volcanic disaster governance in Indonesia, the zoning system for volcanic risk in Indonesia is critical in affecting the vulnerability level, particularly during an emergency evacuation. Regarding volcanic risk, there are two types of zoning: (1) spatial zoning, which consists of three different levels in a DPA, DPA I (lowest risk), II, and III (highest risk), and (2) time zoning, which consists of four levels based on volcano activities, normal active (base), attention (advisory), pre-alarm (watch), and alarm (warning) [95,100,108] (see **Table 4.3** for detail description and recommendation activity). Considering the information path, the leading resources for the volcanic hazard and decision-making were in the Ministry of Energy and Mineral Resources (MEMR) of the Republic of Indonesia. Under the Geological Division, there is a sub-division called *Pusat Vulkanologi dan Mitigasi Bencana Geologi - PVMBG* or Centre of Vulcanology and Geological Hazard Mitigation - CVGHM *(en*). For Merapi volcano, considering the geological profile and activity, there is a technical unit called *Balai Penyelidikan dan Pengembangan Teknologi Kebencanaan Geologi (BPPTKG)* or Geological Disaster Technology Research and Development Center *(en)*. In Merapi disaster governance, the center of information is BPPTKG, as mandates the technical unit from the MEMR (see **Fig 4.4** to understand the information path).

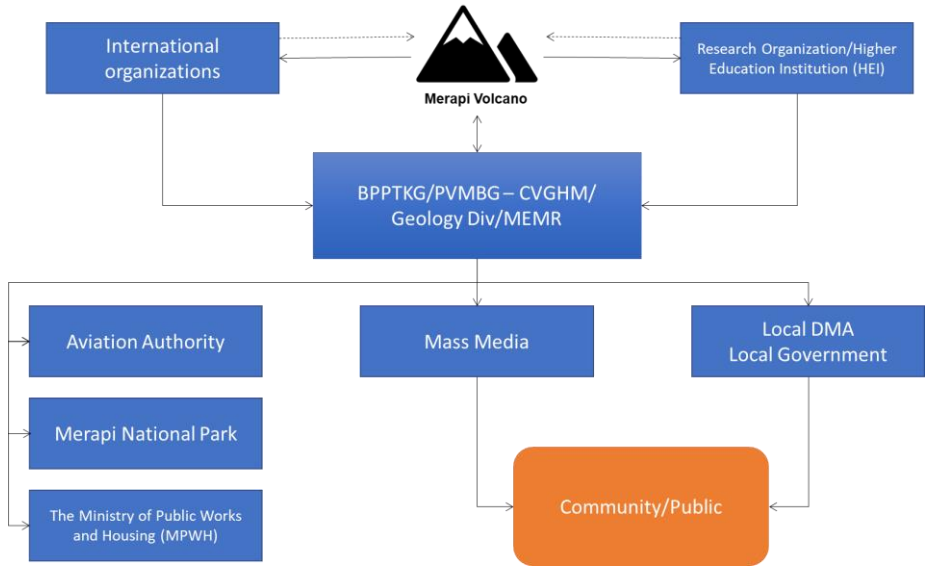


Figure 4.4 Merapi Volcanic information path
Source: Subandriyo [131]

Although the danger level system was implemented during the 2010 eruption, the DPAs had altered due to previous abrupt changes in Merapi's operations (see **Fig, 4.5)**. The public was unaware of these changes because to a lack of information channels and

emergency preparedness at the time, as well as the bigger eruption intensity compared to its history [100]. As a result, during the 2010 eruption, pyroclastic flows of up to 13 km from Merapi's crater compelled residents living in a radius of 17-20 km to flee.

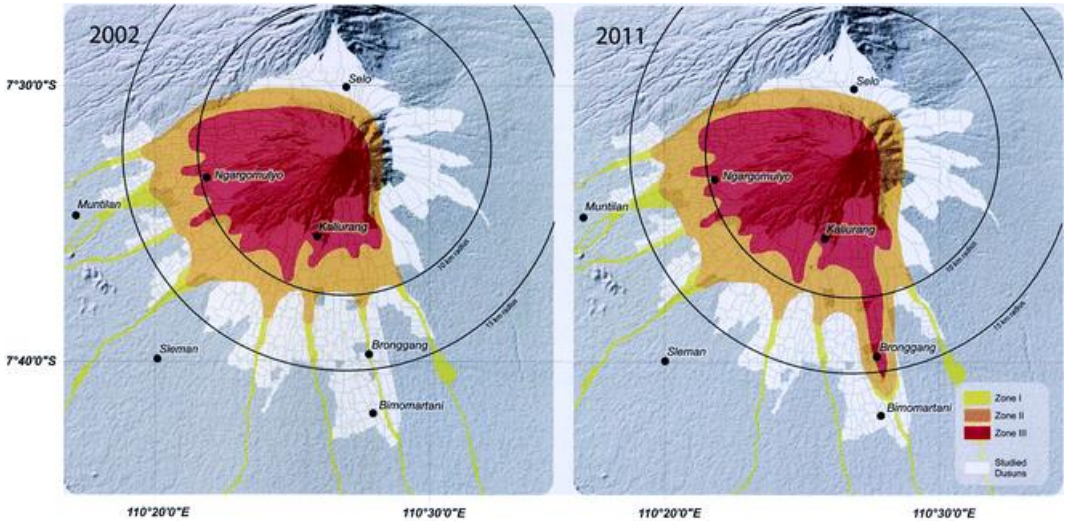


Figure 4.5 The Merapi volcano hazard map designed by the Indonesian Center of Volcanology and Geological Hazard Mitigation (CVGHM) in 2002 (left) and 2011 (right)
Source: Atlas Merapi [50]

The 2010 Merapi eruption, including secondary hazards (the lahars catastrophes), demonstrates that a good early warning system does not guarantee disaster mitigation success. Following the 2010 eruption, Merapi declared a permanent danger and provided the people with three options:

1. Keep the Merapi hazards away from the community.
2. Keep people (permanently) away from the Merapi hazards; or
3. Living in harmony with Merapi volcano.

Most people live beside the Merapi hazard, yet they must constantly be prepared to flee, as happened during the 2010 eruption. Because of this circumstance, developing and investigating a novel approach to these facts and failures is necessary.

4.1.1.3. Financing the DRR: the perspective of budget allocation for awareness programs in the Merapi Volcano community

The increasing number of disasters and excessive costs of damage highlight that financing is essential to managing community disaster response. As the most significant spending related to a disaster occurs after the disaster strikes, it can be challenging to know

how much this spending could be reduced through preparedness in disaster management. This paper discusses the budget allocation of ex-ante programs on disaster risk reduction, focusing on education, knowledge awareness, capacity building, and risk communication. Special attention is paid to budget management programs in the Merapi Volcano area. A literature review is conducted to create a profile of the budget allocation for awareness programs in the disaster management cycle. It is found that the budget allocation for such programs is 7% of the total budget of the rehabilitation and reconstruction project and 20%–30% of the annual budget of the Local Disaster Management Agency. The findings demonstrate a need for alternative budgeting for ex-ante programs on disaster risk reduction to accelerate the targeted outcomes.

Introduction

Financing disaster risk reduction (DRR) is essential, especially with the many disaster occurrences in the last 20 years [1–3,145]. With the growth rate of the population and their livelihood assets, security and relief funds are needed to safeguard against various levels of disaster risk. Education and awareness building is indispensable to reducing this population's disaster risk and vulnerability. However, financing DRR programs is complex due to the uncertainty of disaster occurrences [146]. The expenditure related to a disaster mostly takes place after the disaster strikes, as part of the emergency response, rehabilitation, and reconstruction, and only around 13% of the budget goes to ex-ante DRR programs [145]. Like other nations, Indonesia allocates around 10% of its total DRR budget for ex-ante programs, based on the High-Level Dialogue on Disaster Risk Financing and Insurance Indonesia [147].

Moreover, the World Bank [148,149] estimates that the annual economic impact of disaster (e.g., earthquake, floods, cyclone) in Indonesia is around 0.3% of Gross Domestic Product (GDP) and that cost of a major disaster could potentially exceed 3% of the GDP (about USD 30bn). Then, DRR has not been fully implemented in the government structures, including budgeting, especially on the local level [150]. Meanwhile, it is unclear how much budget allocation can be reduced from ex-post programs to assist ex-ante programs. Further, it argued that ex-ante programs have a limited budget [151]. For these reasons, this research examines the budgeting portion of ex-ante DRR programs and determines the reliability of preparing for the uncertain future with disaster risk. This discussion has focused on discussing the programs related to improving the awareness of vulnerable community members and the capacity building of stakeholders. Then, it points

out the need for alternative funding for accelerating ex-ante programs that could contribute to reducing loss after a disaster occurrence.

Methods

This research used an evaluative and prescriptive approach to explain the budget allocation for DRR programs (ex-ante), such as risk communication, disaster drill prevention, and disaster awareness-related institutional development. The data are from secondary sources such as reports from the local government (i.e., annual government performance report [152–161], project reports (i.e., Community-Based Settlement Rehabilitation and Reconstruction Project for Central and West Java and Yogyakarta Special Region, which describes the project of rehabilitation and reconstruction of several locations on Java Island following an earthquake and tsunami, and volcanic eruption [1,148,162], and relevant academic literature. The data were processed and discussed in a descriptive model focused on the budget allocation for ex-ante DRR programs, knowledge and capacity building, and risk communication. This research has some limitations in that the public access data are discussed on the level of the Sleman Regency, where the Merapi Volcano is located, and the impact of the 2010 eruption is the most salient.

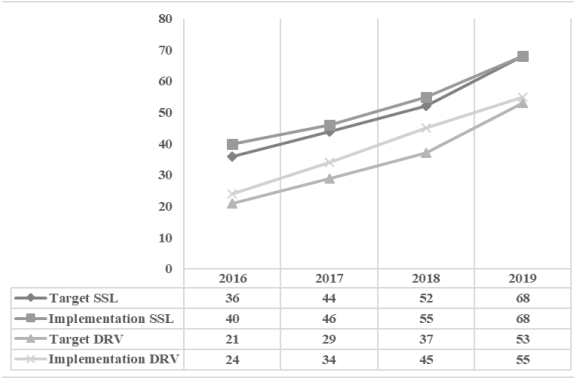
Analysis and Results

1. DRR Awareness Programs

The disaster governance system in Indonesia requires that disaster management-related programs at the regional level include, at minimum, the following three components: (a) risk communication to the public; (b) mitigation and preparedness; and (c) disaster response and evacuation [163,164]. Within these areas, some of the activities that relate to the process of DRR education and improving public awareness are (a) risk communication and education activities, (b) disaster mitigation and preparedness training for the communities, officers, and related stakeholders, (c) disaster prevention drills (desk or field simulations). Indicators for evaluating the success of ex-ante DRR programs primarily concerning education and building awareness are the number of Safe School Learning (SSL), number of Disaster Resilience Village (DRV), number of people who have participated in disaster training and drills, and risk communication through media.

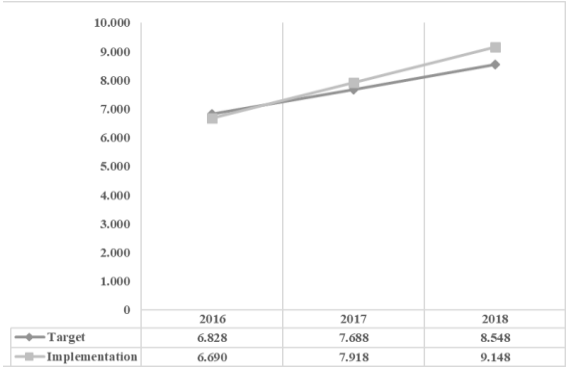
SSL is a collaborative concept in which the school aims to protect children's rights, security, and survival, including their right to obtain quality and sustainable education. Then, DRV is defined as a village that can independently adapt and respond to disaster

risks and recover from the disaster loss and damage [150,165]. In a DRV, the community, with assistance from the government, is expected to build its disaster-resilient capacity using local resources. A comparison of the targeted number and actual implementation of SSL and DRVs in Sleman **(Fig. 4.6)** [156–159] shows that the number of implementations exceeded the targets for most years. **Figure 4.7** shows that the number of participants has participated in the training, simulation, and disaster prevention drills have increased [156–158]. In 2019, there were slight changes in the indicators of these programs, which caused the number of participants to decrease from the previous year (3,840 participants) [159]. However, the activities have a more complex and integrated approach, such as field disaster drills and simulations for the community and school, community training on the management of evacuation areas, public kitchens and logistic support, and simple handyman training processes for providing support with the emergency, mitigation training for community-based early warning system management, trauma healing, emergency response teams, and, disaster volunteers [159].



	2016	2017	2018	2019
Target SSL	36	44	52	68
Implementation SSL	40	46	55	68
Target DRV	21	29	37	53
Implementation DRV	24	34	45	55

Figure 4.6 The number of SSL programs and DRVs in Sleman Regency, Yogyakarta from 2016-2019. Based on Government Performance Report Sleman Disaster Management Agency [156–159]



	2016	2017	2018
Target	6.828	7.688	8.548
Implementation	6.690	7.918	9.148

Figure 4.7 The number of participants in disaster training, simulation, and prevention drills from 2016-2018. Based on Government Performance Report Sleman Disaster Management Agency [156–159]

Another indicator of disaster risk awareness programs is risk communication through digital media, such as providing risk maps of various hazards, the regulations of the disaster relief fund, and information on evacuation routes and signs. The government has developed and written various news and content on the disaster agency website [166] and community websites hosted by disaster volunteers [167]. In 2019, these websites were accessed by a sum of138.344 visitors.

In addition, the local government also built an application called *'Lapor Bencana Sleman – Sleman Disaster Report'* in which community members can voluntarily report to the command center and access various materials about a disaster occurrence and

preparation. For example, one application feature called *'Jarak Aku dan Merapi* ("*The distance between Merapi and me")* provides information about Merapi, including safe distance, Merapi activities, and status updates. In 2019, 603 persons downloaded this application. The local government also used social media to disseminate information to the public. Overall, these programs for risk communication and the number of people utilizing them indicate that the public accesses risk communication contents, reflecting the success of awareness-raising.

2. Budget Allocation of Awareness Programs for Disaster Risk Reduction

Indonesia's budgeting system has several levels, from the national to the provincial, regency, sub-district, and village levels. Financial support for DRR often comes from this budgeting system with additional support from private organizations, community social responsibility, and donations from program participants. In this research, the budget allocation is discussed from the perspective of provincial and regency levels. Budget reports from Yogyakarta province and Sleman Regency, where Merapi is located, are analyzed to understand the allocation for education-related and ex-ante DRR programs. Several local bureaus and agencies at the provincial and regency levels manage the budget based on their programs and activities. These include the disaster management local bureau, social agency, development planning agency, spatial planning agency, and education bureau.

Budget planning, especially for DRR, should not focus solely on the availability of total annual funds but also consider the potential hazards' characteristics, including the risks and severity levels [168]. For example, in Sleman, Yogyakarta, several potential hazards could occur, both natural and human-made. These include tropical cyclones, landslides, volcano eruptions, floods, droughts, fires, and epidemics [152–155,160,161]. In 2017 and 2018, Sleman and Yogyakarta were hit by intense winds caused by Tropical Cyclone Cempaka, and this affected the subsequent budget planning for disaster response and management. As there were more cyclones in 2017 and 2018 compared to the previous year, the budget planning should allocate more resources to prepare for cyclones versus other types of disasters that occur less frequently.

The budget allocation for response and preparedness activities in Sleman Regency constitutes over 80% of the total budget for the local disaster management agency (DMA) **(Fig. 4.8)**. However, only 20% to 30% of this allocation is used for capacity building and DRR education (including simulation costs and community disaster drills and training).

The rest is reserved for a response to a disaster, rehabilitation, and physical reconstruction (not specifically for loss or damage caused by Merapi Volcano). Similar to the budget allocation managed by Sleman Regency, the disaster budget at the upper level of government is allocated toward structural mitigation, such as the construction of the Early Warning System and Fast Response Team (TRC) supporting systems, command center, and physical mitigations like dams or dykes [160,161].

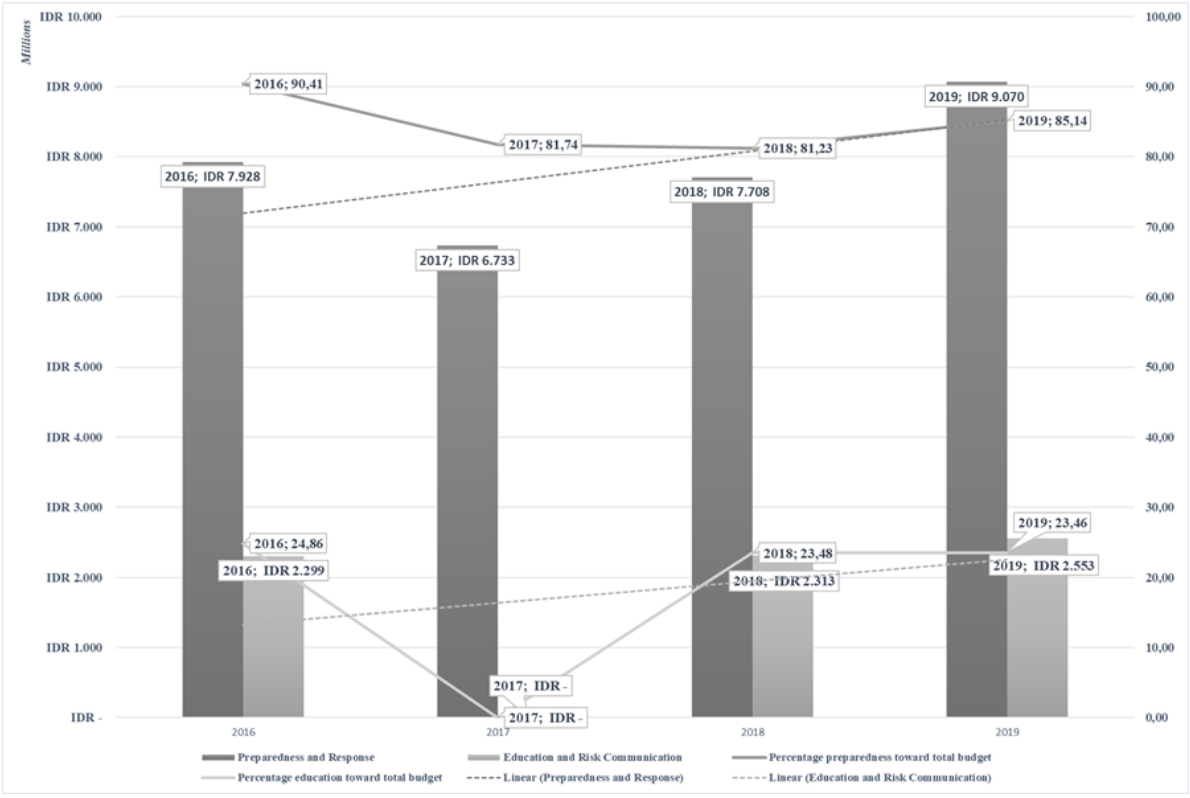


Figure 4.8 Budget allocation for disaster management in Sleman Regency, Yogyakarta, from 2016 to 2019

Note:
For 2017, there is no precise budget allocation data, especially concerning DRR education and risk communication. However, there are data on the total budget for disaster response (which commonly includes DRR education programs).

Furthermore, given the evaluation indicators for DRR programs, such as the number of SSL programs and DRVs, it is advisable to obtain additional funding from another budget category in addition to the budget allocation from the Local DMA. For example, in DRV-related programs, the DRR can be supported by other types of budgets, such as the Village Fund *(Dana Desa)*, which offers grants from the national government to each village in Indonesia in addition to the standard budget allocation [165]. This fund can be used for disaster response, including capacity building under the concept of the DRV.

Aside from this, especially in Yogyakarta, there is another budget provided by the national budget allocation called *Dana Keistimewaan* (Privilege Fund)[169]]. This fund allows disaster-related programs to acquire additional funds [169,170], as DRR matters fall into the five categories that can be funded with this privilege fund: (a) governance system of the governor and vice governor, (b) institutional affairs, (c) culture, (d) land, and (e) spatial affairs [169,171].

From the Merapi Volcano rehabilitation and reconstruction project, which reports as part of the Community-based Settlement Rehabilitation and Reconstruction Project for Central and West Java and Yogyakarta, it can be seen that most of the funds go to physical resources such as housing reconstruction and infrastructure investment [162]. Then, around 7% of the funds go to the education part of the project.

Among a total of 860 formal schools (primary, junior high, and high school) in Sleman [48], only 68 schools have SSL status (7.64%), excluding 48 higher education institutions that had 192,943 students in 2016 [172,173]. Among 86 villages in Sleman [48], only 61.63% of them have standards as DRVs. The current budget allocation from the local government can only sustain 9 SSL programs on average per year and ten villages a year with various levels of DRV standards. This points to the need for an alternative financing system and a collaborative policy so that all the formal schools and villages can achieve the standardization for SSL or DRV, respectively. From this description, it can be concluded that there is a need to fund programs that can accelerate the outcomes of DRR. Similarly, Djalante et al. [150], Fahlevi et al. [168], and Oktari et al. [151] said that Indonesia needs a more collaborative and accommodating policy system, with formal, informal, and non-formal for ex-ante programs. Ex-ante DRR programs can improve the community response to disaster occurrences, reducing the high ex-post disaster budget.

Conclusion

This research points out that the budget allocation for ex-ante DRR programs is only 7% of the total budget for rehabilitation and reconstruction projects and 20% – 30% of the annual budget of the Local DMA. Thus, compared with Indonesia's national budget for disaster education, which is 10% of the total budget [147], the local budget for disaster education has a greater allocation. In the budget profiles and programs in Sleman, Yogyakarta, and Indonesia, more disaster funding has been allocated for physical mitigation, rehabilitation, and reconstruction. The most important reason is that funding has been urgently needed for affected disaster communities undergoing recovery [2,149].

Moreover, because of the increasing number of disasters, victims and exposed communities are at a moderate to a prominent level of risk and therefore need larger emergency relief and recovery. Overall, non-physical awareness and preparedness are often less prioritized because of the limitations in budget allocation.

With this budget profile, there is a need to consider other types of financing for ex-post and ex-ante DRR programs. The current ex-post budgeting emphasizes physical matters. This research suggests that it will be helpful to develop an alternative financing model and collaborative system to prepare for possible disaster occurrences. For example, some communities have community social insurance, including securing their livestock and tangible assets [2]

4.1.2. Designated DRR Program and Initiatives

Merapi's DRR program is being developed and consolidated. Each phase of the disaster management cycle is addressed by a corresponding program, which includes risk assessment programs, spatial planning reviews, disaster preparedness schools (currently known as School Safe Learning or *Satuan Pendidikan Aman Bencana*), Disaster Preparedness Village, Disaster Resilient Villages, River Schools, infrastructure sector strengthening, and economic sector strengthening. These are carried out at many levels, from provinces to villages, through mandated disaster management training (DMMT) [174].

Several networks and community-based initiatives, such as sister villages, sister schools, a community-based risk reduction forum (PASAG Merapi), and a community-based communication network (JALIN Merapi), have also been developed through Merapi communities [55]. These activities and networks began before the 2010 eruption, as the Merapi community had already faced several disasters. For example, the risk reduction forum was established following the 1994 eruption. However, people in the Merapi community have established that their perceived risk is impacted by risk knowledge, socioeconomics, and cultural factors [24,55]. Aside from the rapid-onset risk of the eruption (lava, pyroclastic flows, and ash) in 2010, several community members could not get information on changes in the DPA during the disaster.

Similarly, some community members chose to remain in their neighborhoods because of previous volcanic eruptions. In addition, they had never experienced the DMMT program before the 2010 eruption. Due to the modification of DPA zoning following the 2010 eruption, they acknowledged the existence of DRR programs through DMMT

[64,69]. As a result, neighborhoods were frequently prepared to manage their resources and work with neighboring villages to survive the disaster.

4.1.2.1. Disaster Management Mandatory Training (DMMT) – Wajib *Latih Penanggulangan Bencana*

Disaster Management Mandatory Training (DMMT) – *Wajib Latih Penanggulangan Bencana (WLPB)* at Merapi is a follow-up program to the results of the 2007 Merapi Forum [69] that aims to develop a community culture that is resilient to volcanic hazards. This DMMT must be followed by those who reside in disaster-prone areas level III (the highest risk), even though there are no binding sanctions, participation is voluntary, and the curriculum and methodology are open. Since 2022, this program's focus has shifted from the community to the family. Each member of a family must have prior experience with this program. Utilizing a co-creation program mechanism, the DMMT can be implemented by relevant government agencies or qualified NGOs. The source of funding is the national/local government budget and other non-binding funds. Until 2018, 82 villages had been affected by DMMT, including nine villages in Sleman, 57 villages in Magelang, three villages in Boyolali, and thirteen villages in Klaten [69]. From 2012 to 2017, Magelang had the most significant number of DMMT participants with 1,569, followed by Sleman with 418, Klaten with 398, Boyolali with 176, and Yogyakarta (municipality) with 78. 2017 saw the highest number of DMMT participants, 1,725 [175].

This DMMT was held in two related villages, namely the village in the Merapi DPA and the buffer village, by combining other disaster risk reduction concepts, such as the sister village concept (the concept of sister village will be explained in another section). Sayudi [69] reports that the DMMT was held over three days with a different curriculum for disaster-prone and buffer villages (see **Table 4.4** and **Fig. 4.9**).

Table 4.4 Example of DMMT Curriculum and Schedule

Day	Time	IDP Origin Village	Buffer Village
1	09.00 –09.30	Introduction	
	09.30 –11.00	Merapi update from BPPTKG	
	11.00 –12.00	Disaster Management Policy from Local DMA	
	12.00 –13.00	Break	
	13.00 –15.00	Concept of volcanic hazard	
	15.00 –16.00	Understanding the hazards	Understanding hazards as a sister village
2	09.00 –10.00	Understanding disaster risk	Understanding disaster risk
	10.00 –12.00	Risk and vulnerability analysis	Introducing contingency plan, action and scenario planning, and decision
	12.00 –13.00	break	break

Day	Time	IDP Origin Village	Buffer Village
	13.00 –15.00	Village action plan making	Shelter planning
	15.00 –16.00	Mapping	Sectoral planning
3	09.00 –10.00	Early warning system	Need assessment
	10.00 –12.00	Designing SOP – a standard operational procedure	Gap analysis
	12.00 –13.00	break	break
	13.00 –15.00	Evacuation planning making	Tabletop exercise
	15.00 –16.00	Evaluation and closing	

Source: Sayudi [69]

The ideas of andragogy, the discovery approach, experiential learning, role actors, and field studies are all used in these DMMT activities, which combine indoor and outdoor training techniques [176]. However, it seems that DMMT causes behavioral adjustments in how people respond to threats and hazards, as well as several inputs regarding changes in the Merapi community following the 2010 eruption [69,162,176]. For instance, adjustments to social structures, patterns of communication, and the relocation of eruption dangers because of lava dome direction changes. Due to this shift in direction to the south sector, DMMT must be finished for all families in DPA level 3 (the highest danger). Additionally, modifications are needed in terms of curriculum design, participant selection, and engagement strategies.

Figure 4.9 Activities during DMMT
Source: Sayudi [69]

4.1.2.2. SSL (Safe School Learning) and Sister School

Safe school learning (SSL) is known as Satuan Pendidikan Aman Bencana (Disaster Safe Education Unit) in Indonesia (SPAB). This program was launched in 2008 because of government, business, and academic partnerships. More than 25,620 schools in Indonesia have implemented SSL with cooperation from government agencies and/or non-governmental organizations. This initiative is anticipated to establish the school as the epicenter of disaster risk reduction due to its high-quality physical building structure, community center, and emergency disaster facilities. This SSL program was built with the following factors in mind:

1. Reducing disruptions to educational processes ensures the health, safety, eligibility of children with disabilities, comfort, and security of schools and other educational facilities,
2. Safer learning environments enable the identification and support of humanitarian assistance for children in emergencies during rehabilitation and reconstruction phases,
3. Serving as a hub for community activities and the crucial social instrument in the fight against poverty, illiteracy, and health issues,
4. Coordination of community response and recovery following a disaster,
5. Serves as an emergency shelter to safeguard the school's population, educational facilities, and the surrounding neighborhood.

Further, in the implementation of this concept, three main pillars are targeted, namely:

1. Secure school buildings. It implies that the location of schools must be protected from disaster threats and built using proper design and construction methods. In addition, the old school was evaluated to establish retrofitting and infrastructure replacement objectives.

2. Disaster management in schools. Ensure SOP (Standard Operating Procedures) implementation in emergencies. This SOP must be accessible and correctly understood by the school community, including students, teachers, supporting staff, and neighboring residents, including parents and guardians.
3. Integrating disaster prevention and risk reduction into the learning process is the most significant aspect of the DRR education pillar. It is anticipated that this method will strengthen the resilience of students, teachers, and education workers, thereby contributing to individual and community disaster preparedness.

Indonesia provides enabling environments that facilitate SSL implementation in various forms [177]. For instance, the establishment of the National Secretariat of SSL and the collaborative SSL secretariat demonstrates systemic innovation to strengthen coordination, collaboration, and multi-stakeholder cooperation that encourages resource mobilization (in terms of funding, human resources, and equipment) as well as more structured efforts to build the capacity of school residents to adopt and implement the three pillars of SPAB [178]. This initiative also facilitates collaboration with external organizations that have worked in schools, such as the Boy Scouts, the Youth Red Cross, and the Youth movement for DRR.

CASE STUDY BOX

Sister School in Merapi Volcano

Sister school is an initiative that engages schools in the disaster-prone region of Merapi Volcano who have implemented the School Safe Learning (SSL) concept [179,180]. During an emergency, the sister school concept stresses the transfer of learning activities from a school in a disaster-prone location to a safer school, which may continue the phase of rehabilitation and reconstruction. The sister school concept strives to lessen the likelihood of delayed teaching and learning activities in schools caused by emergencies, such as when residents, including children, are obliged to evacuate due to heightened activity at Merapi Volcano. The idea of a sister school is founded on the following activities:

1. Team formation for disaster preparedness,
2. Examine hazards, vulnerabilities, capacity, and risks,
3. Plan for contingencies,
4. Socialisation and training,
5. Create an evacuation map and board,
6. Developing DRR communication, education, and information medium,
7. Conduct emergency simulations,
8. Include DRR in extracurricular activities.
9. Sign a memorandum of agreement between schools affected and schools providing help.

As a result of the destruction of numerous educational facilities during the 2010 eruption, students were unable to continue their education and had to transfer to a refugee camp before being allowed to return and/or being permanently relocated to safer locations. Instead of utilizing an emergency school, a sister school program was implemented to decrease the impact and danger of the education sector under this scenario. 20 disaster preparedness schools [181] were linked with 10 sister schools in Sleman in 2015 (see **Fig 4.10** and **Fig. 4.11**).

Figure 4.10 The sign of the sister school in Merapi
Source: Google map [39] *street-view accessed 6 June 2022, 6.23 am*

Implementing a sister school is inseparable from the agreement within the sister village program, equating to two schools and two villages. The sister village idea stipulates that a village in a disaster-prone location should be relocated to its designated sister village in the event of an emergency involving hazard-related activities. During this period, the residents evacuate not just themselves but also their livestock. Based on our conversation with Sukiman, a community leader from Deles, Klaten (in the east of the Merapi Volcano), people of his neighbourhood profited from their temporary relocation during the 2010 evacuation. In their sister village's refugee area, livestock has been successfully bred, and they have profited from sales during their departure during the 2010 eruption.

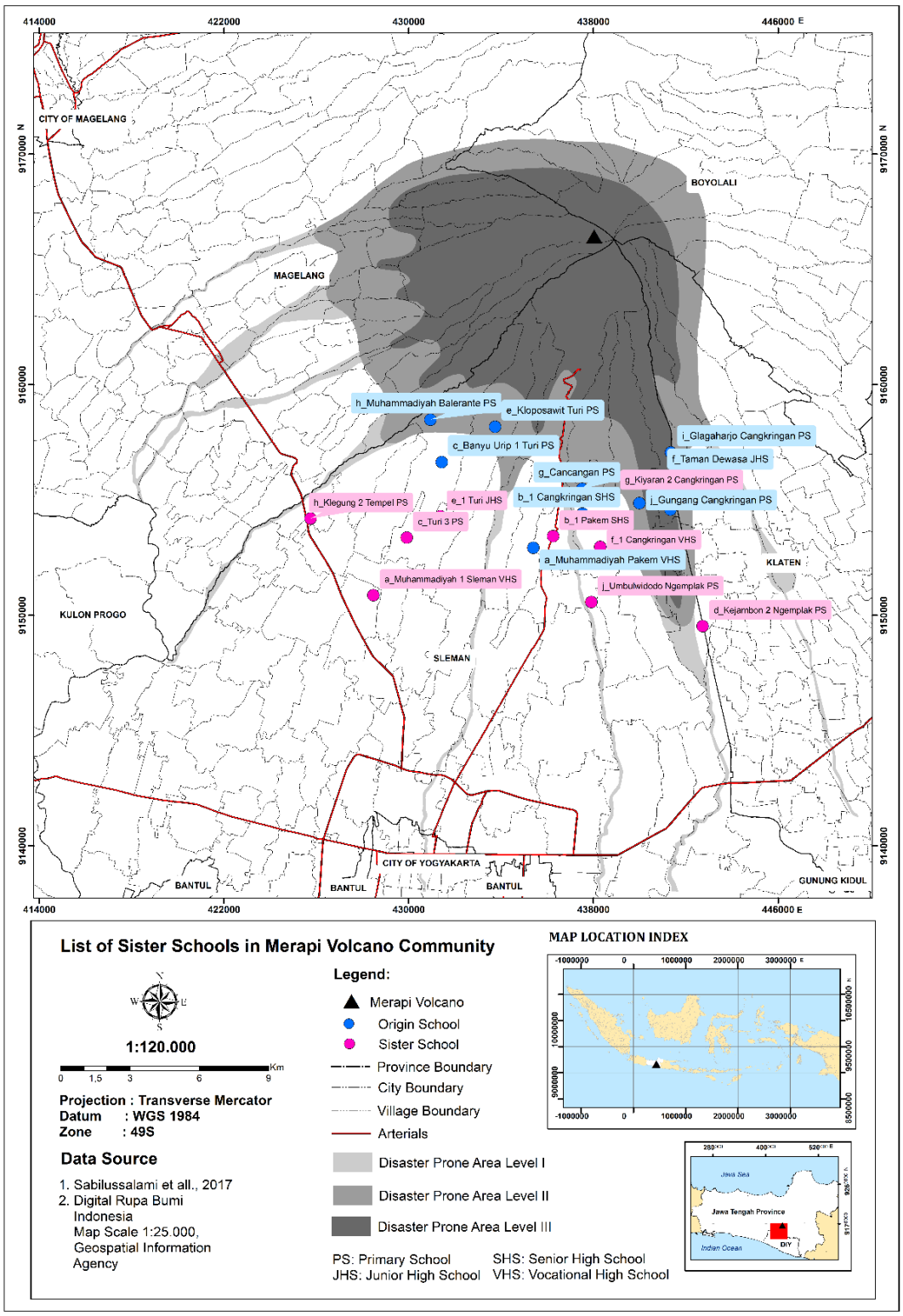


Figure 4.11 List of sister schools in the Merapi Volcano community
Source: (1) Topographic map [36]*; (2) Sabilussalami, et.al.* [182]

After 15 years of SSL deployment in Indonesia, numerous conclusions may be drawn [178]:

1. The output of the three pillars of SSL for each education type and level is unbalanced.

   This imbalance impacts the quality of human resources, teachers, and school administration. Most SSL programs have been introduced in public schools, particularly at the elementary level. SSL is implemented minimally in preschool, higher education, and vocational schools. Non-formal schools, such as religious-based schools, home-schooling, and community-based education, have not yet been widely adopted.
2. The national government and non-governmental organizations have initiated SSL, but the initiative originates from the schools.
3. Inclusivity has not been widely and consistently applied, such as for the issue of disability and the spatially disadvantaged in Indonesia (post-disaster areas and *3T – terdepan, terisolir, dan tertinggal* - frontmost, isolated, and left behind regions).

4.1.2.3. Network-based Disaster Programs and Initiatives: Jalin Merapi, PASAG Merapi, and Sister Village

Merapi spans four regencies (equivalent to a city). Hence this volcano encompasses a vast and extensive community. With this coverage, a network-based community-based organization is required to link the community in this area. Several thematic network-based groups, such as PASAG - *Paguyuban Siaga Merapi* (Merapi Preparedness Community) and Jalin Merapi – *Jaringan Informasi Lintas Merapi*, connect the community in Merapi (Merapi Information Network). Since 1994, PASAG Merapi has worked in the first initiatives phase of community-based disaster risk management (CBDRM) in Merapi [183]. JALIN Merapi is a communication platform for presenting statistics and information about Merapi and the community dynamic via multiple media [184], ranging from community radio to social media (see **Fig. 4.12**).

In addition to these two programs, the network-based sister village program was developed. A Sister village is a scheme that connects two or more communities surrounding Merapi, a high-risk party, and the buffer village (see **Fig 4.13**) [72,132,185]. In this approach, social bonds and kinship ties become crucial factors.

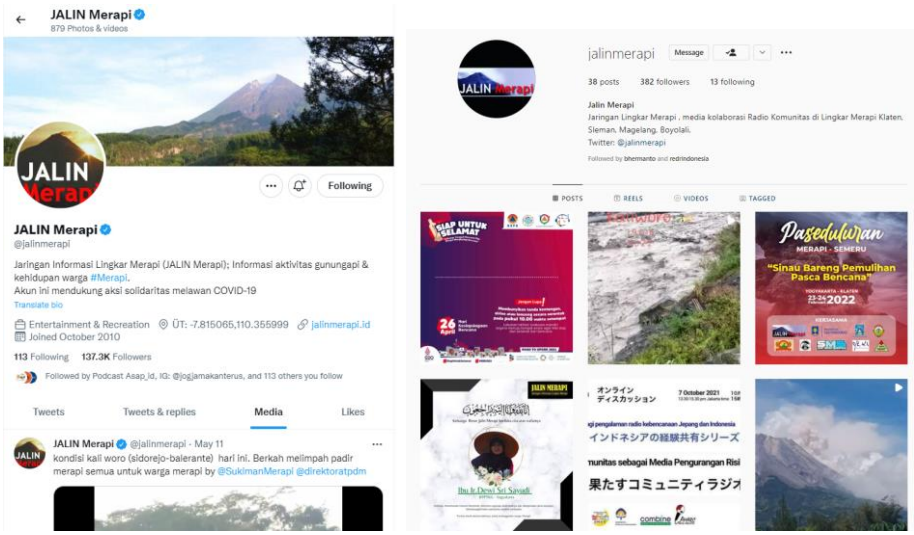


Figure 4.12 Jalin Merapi on social media
Source: Jalin Merapi [186,187], *accessed May 11th, 2022*

The preparation of this sister village system consists of assessing the village resources, founding a communication forum between the government, paired villages, and volunteers, preparing the guideline and supporting policy, preparing volunteer and field preparation, legalization, monitoring, and evaluation.

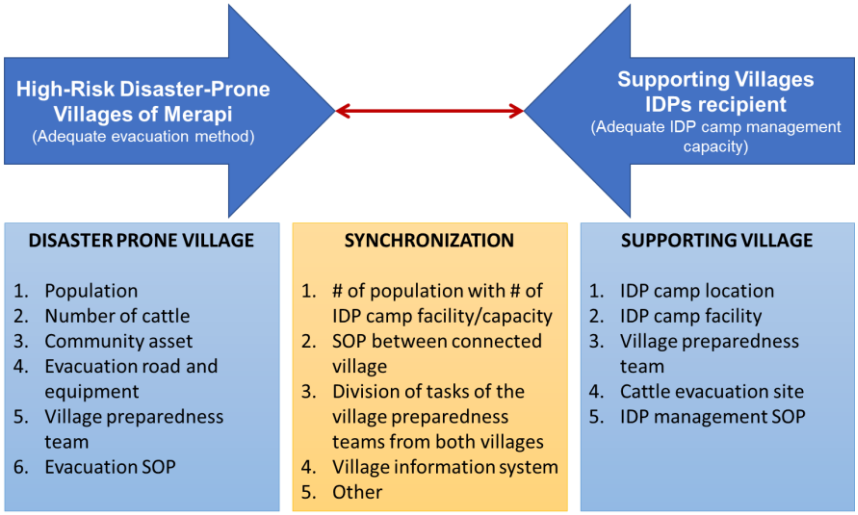


Figure 4.13 Sister villages schematic system
Source: adapted from Suprayoga Hadi [185]

This program has been motivated by the 2010 eruption, which showed chaos in managing the IDPs. In Merapi, the local government has developed this program since then. The village categorized as DPA level 3 (the highest risk) was connected to the supporting village (details in **Table 4.5** and the distribution in **Fig 4.14**).

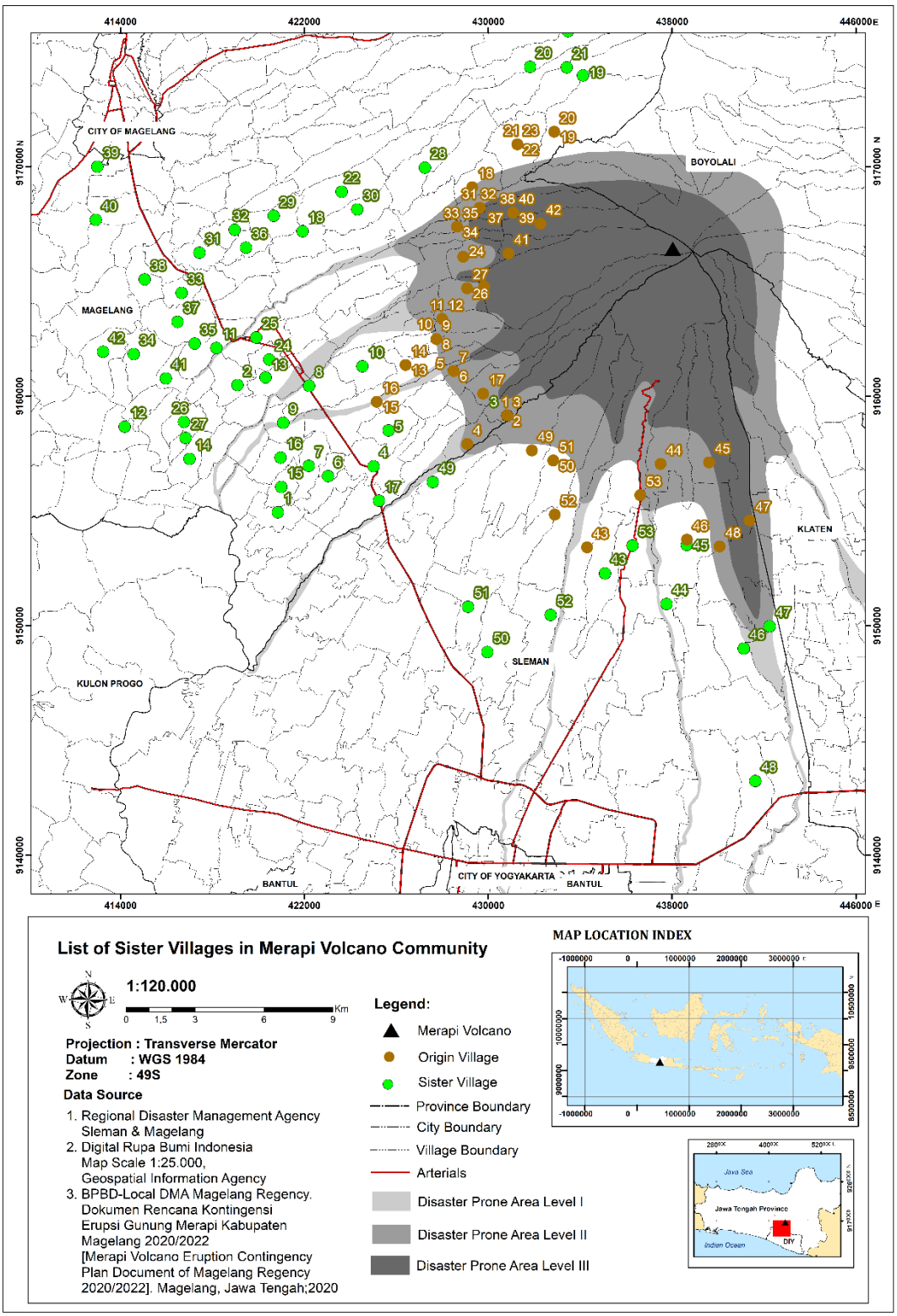


Figure 4.14 Distribution of sister villages in Merapi
Source: (1) Topographic map [36], (2) Contingency plan [188,189], (3) SIKK Magelang [67]

Table 4.5 List of Sister Village in Merapi

No	Disaster Prone Village	District	Regency	No	Supporting Village	District	Regency
1	Kaliurang	Srumbung	Magelang	1	Jamuskauman	Ngluwar	Magelang
2		Srumbung	Magelang	2	Pakunden	Ngluwar	Magelang
3		Srumbung	Magelang	3	Bligo	Ngluwar	Magelang
4	Nglumut	Srumbung	Magelang	4	Sucen	Salam	Magelang
5	Ngablak	Srumbung	Magelang	5	Kradenen	Srumbung	Magelang
6		Srumbung	Magelang	6	Somoketro	Salam	Magelang
7		Srumbung	Magelang	7	Tirto	Salam	Magelang
8	Ngargosoko	Srumbung	Magelang	8	Gulon	Salam	Magelang
9		Srumbung	Magelang	9	Seloboro	Salam	Magelang
10	Tegalrandu	Srumbung	Magelang	10	Bringin	Srumbung	Magelang
11		Srumbung	Magelang	11	Pabelan	Mungkid	Magelang
12		Srumbung	Magelang	12	Wanurejo	Borobudur	Magelang
13	Mranggen	Srumbung	Magelang	13	Gunungpring	Muntilan	Magelang
14		Srumbung	Magelang	14	Sokorini	Muntilan	Magelang
15	Srumbung	Srumbung	Magelang	15	Baturono	Salam	Magelang
16		Srumbung	Magelang	16	Tersan Gede	Salam	Magelang
17	Kemiren	Srumbung	Magelang	17	Salam	Salam	Magelang
18	Kapuhan	Sawangan	Magelang	18	Mangunsari	Sawangan	Magelang
19	Wonolelo	Sawangan	Magelang	19	Banyuroto	Sawangan	Magelang
20		Sawangan	Magelang	20	Pogalan	Pakis	Magelang
21	Ketep	Sawangan	Magelang	21	Wulunggunung	Sawangan	Magelang
22		Sawangan	Magelang	22	Podosoko	Sawangan	Magelang
23		Sawangan	Magelang	23	Ketundan	Pakis	Magelang
24	Sumber	Dukun	Magelang	24	Pucungrejo	Muntilan	Magelang
25	Ngargomulyo	Dukun	Magelang	25	Tamanagung	Muntilan	Magelang
26	Kalibening	Dukun	Magelang	26	Adikarto	Muntilan	Magelang
27		Dukun	Magelang	27	Tanjung	Muntilan	Magelang
28	Sengi	Dukun	Magelang	28	Jati	Sawangan	Magelang
29		Dukun	Magelang	29	Tirtosari	Sawangan	Magelang
30		Dukun	Magelang	30	Butuh	Sawangan	Magelang
31		Dukun	Magelang	31	Senden	Mungkid	Magelang
32		Dukun	Magelang	32	Treko	Mungkid	Magelang
33	Sewukan	Dukun	Magelang	33	Ambartawang	Mungkid	Magelang
34		Dukun	Magelang	34	Rambeanak	Mungkid	Magelang
35		Dukun	Magelang	35	Mungkid	Mungkid	Magelang
36	Paten	Dukun	Magelang	36	Gondang	Mungkid	Magelang
37		Dukun	Magelang	37	Paremono	Mungkid	Magelang
38		Dukun	Magelang	38	Bumirejo	Mungkid	Magelang
39		Dukun	Magelang	39	Banyurojo	Mertoyudan	Magelang
40		Dukun	Magelang	40	Mertoyudan	Mertoyudan	Magelang
41	Keningar	Dukun	Magelang	41	Ngrajek	Mungkid	Magelang
42	Krinjing	Dukun	Magelang	42	Deyangan	Mertoyudan	Magelang

No	Disaster Prone Village	District	Regency	No	Supporting Village	District	Regency
43	Candibinangun	Pakem	Sleman	43	Harjobinangun	Pakem	Sleman
44	Umbulharjo	Cangkringan	Sleman	44	Umbulmartani	Ngemplak	Sleman
45	Kepuharjo	Cangkringan	Sleman	45	Wukirsari	Cangkringan	Sleman
46	Wukirsari	Cangkringan	Sleman	46	Binomartani	Ngemplak	Sleman
47	Glagaharjo	Cangkringan	Sleman	47	Sindumartani	Ngemplak	Sleman
48	Argomulyo	Cangkringan	Sleman	48	Tirtomartani	Kalasan	Sleman
49	Wonokerto	Turi	Sleman	49	Merdikorejo	Tempel	Sleman
50	Girikerto	Turi	Sleman	50	Pandowoharjo	Sleman	Sleman
51	Girikerto	Turi	Sleman	51	Trimulyon	Sleman	Sleman
52	Purwobinangun	Pakem	Sleman	52	Donoharjo	Ngaglik	Sleman
53	Hargobinangun	Pakem	Sleman	53	Pakembinangun	Pakem	Sleman

Source: (1) Contingency plan [188,189]*, (3) SIKK Magelang [67]*

Utilizing Sister Village during emergency

In Magelang, the local DMA has utilized the concept of a sister village during an emergency. They construct a web-based real-time system to notify the hazards threat, evacuation route, disaster impact, and IDP (internally displaced people) data to communicate the disaster risk within their authority. In consideration of Merapi, the local DMA also utilized the sister village function, not only due to the evacuation shelters and other supporting infrastructure during a disaster but also volcanic threats that might take an exceedingly long time during an emergency. Sometimes, people must leave their homes for more than one or two days. Sometimes, permanently removed takes weeks or months, or the individual is given the option. The concept of a sister village could alleviate psychological or other problems, such as access to means of subsistence.

During an emergency, residents of Merapi's DPAs flee to evacuation shelters, schools, and other buildings. The local DMA has developed a web application that displays the evacuation route from origin to evacuation shelter for this Merapi sister community concept (see **Fig. 4.15,4.16, 4.17**).

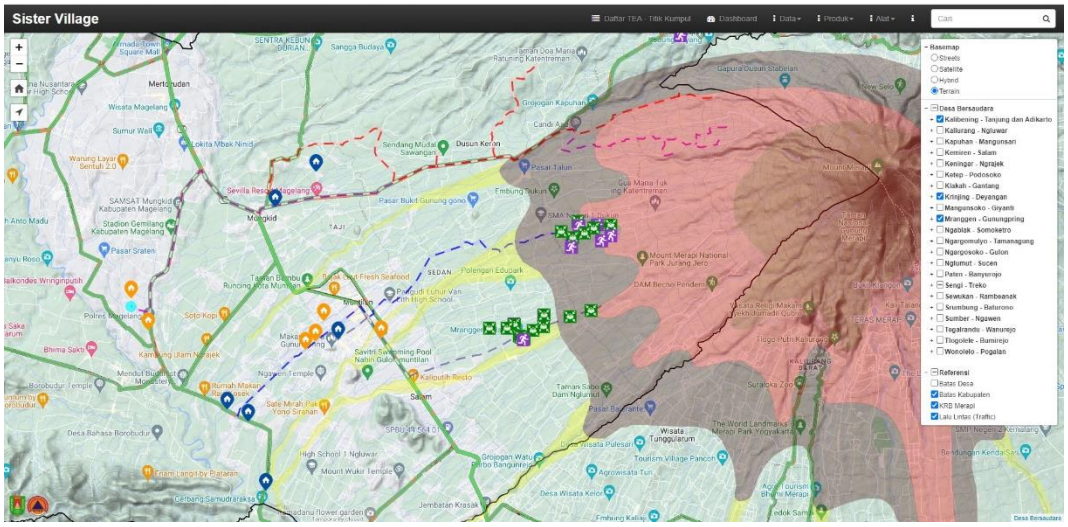


Figure 4.15 Web-based application shows sister village mode for evacuation during an emergency of Merapi

Source: SIKK Magelang, accessed 07 June 2022 at 10.44.

Numerous advantages, gaps, problems, and obstacles were identified during the program implementation. The program's benefits, including evacuation and shelter concerns, are reserved and will significantly assist during an emergency. In addition to enhancing the resettlement process in post-disaster recovery initiatives, this program also supports services for internally displaced persons through a livelihood strategy and kinship. This program is a community-based disaster risk management practice. Nonetheless, the administration of this program should be problematic, given the pre-disaster sociocultural context.

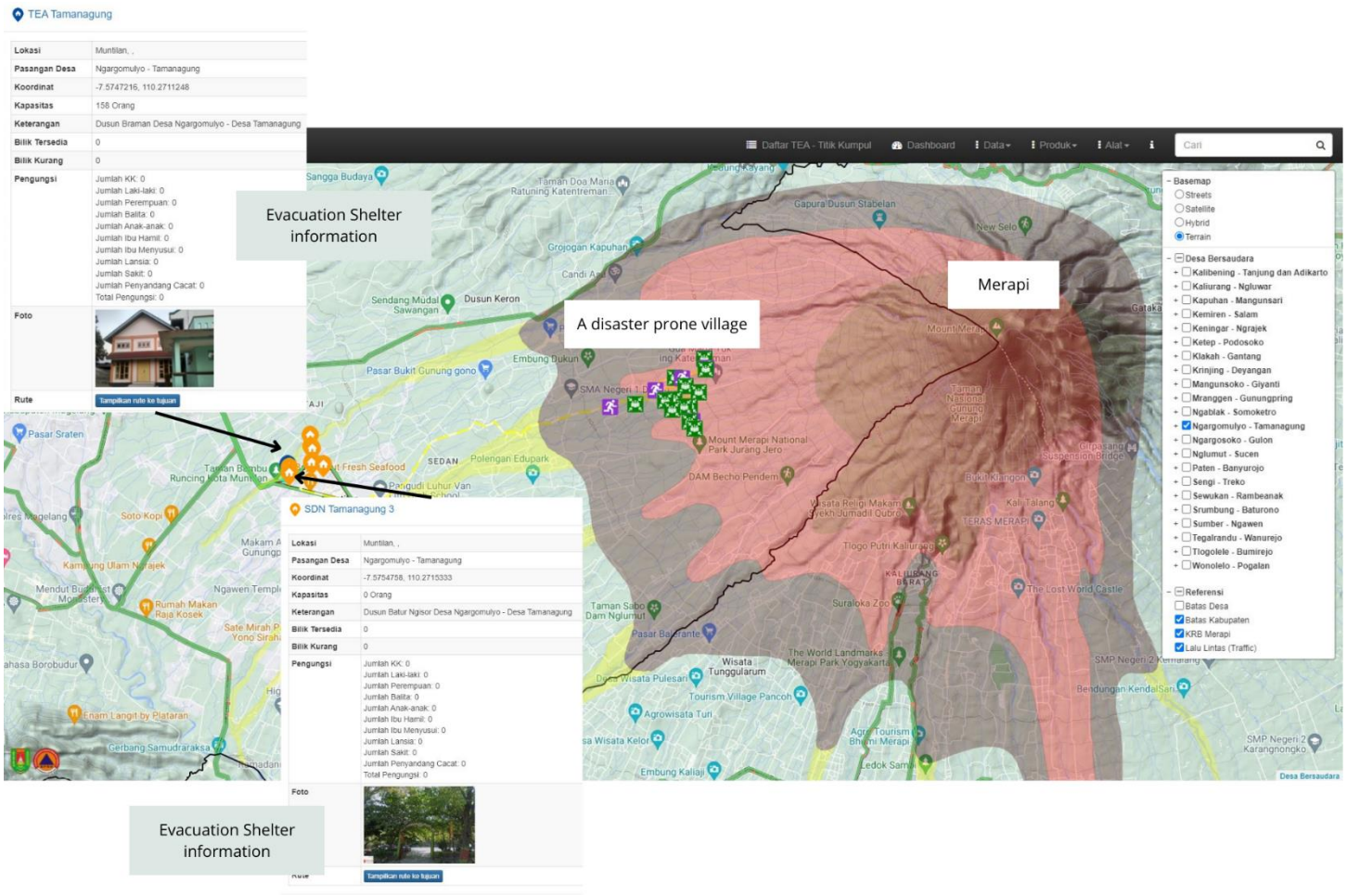


Figure 4.16 Sister village location and evacuation shelter information.
Source: SIKK Magelang [67]

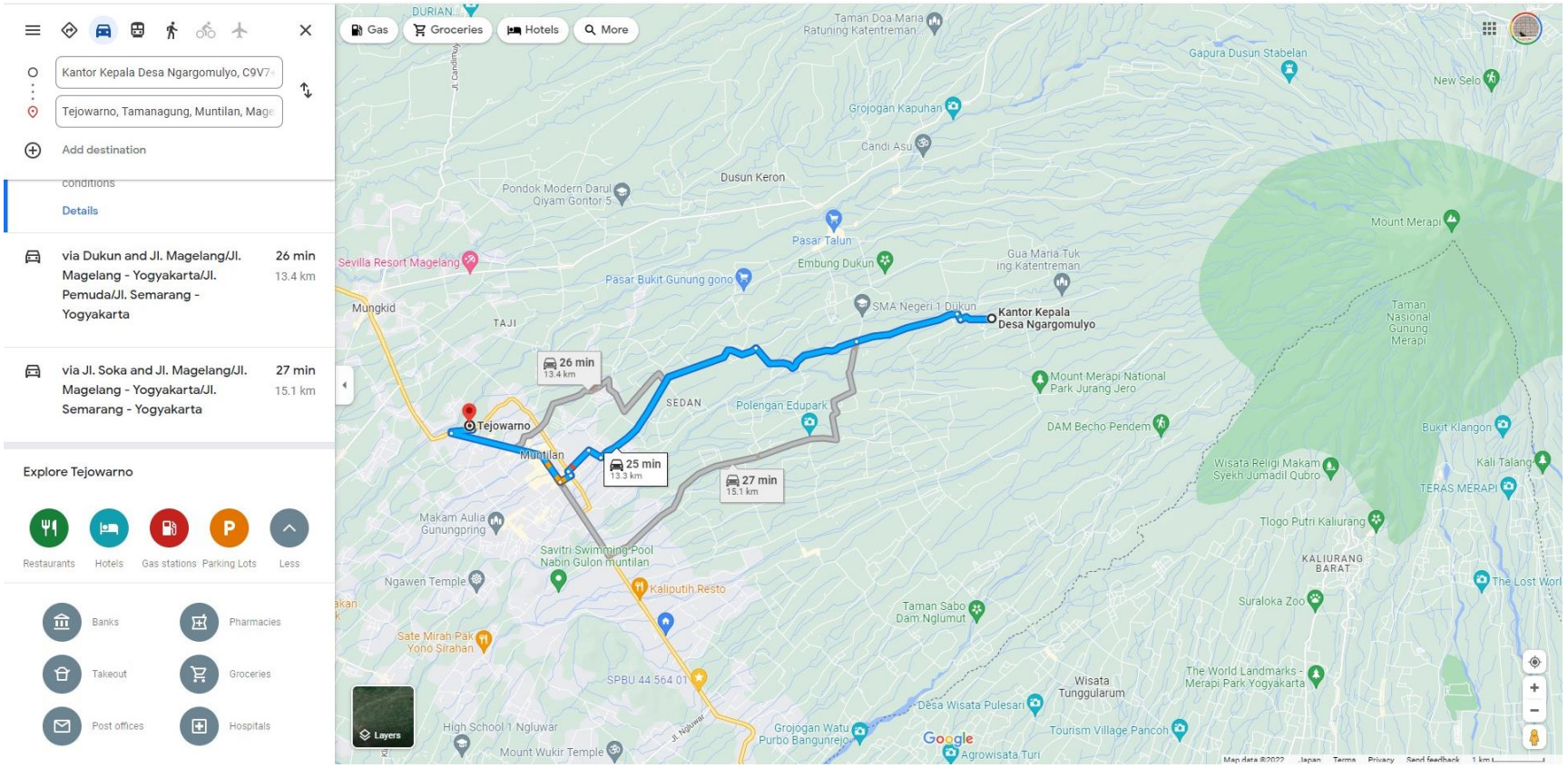


Figure 4.17 Mobility map simulation from the disaster-prone village and evacuation shelter using sister village concept
Source: SIKK Magelang [67] *and Google map* [39]

4.1.2.4. Disaster Resilient Village (DRV)

Two programs are established at the ministry level in Indonesia to assist the local community in becoming disaster-resilient (see **Table 4.6**). The first program is explicitly designed so the community can independently prepare for hazard risks regarding technical issues such as family evacuation, what items to prepare, where to meet, and other emergency concerns. The second programs prepare the community for hazards in a broader context based on its socioeconomic assets. Based on the Regulation of the Ministry of Social Affairs of the Republic of Indonesia No. 128 of 2011 regarding Disaster Preparedness Village [190], the Indonesian Ministry of Social Affairs developed the Disaster Preparedness Village concept. In the interim, the BNPB established disaster-resilient villages per Regulation of the Head of the BNPB No. 1 of 2012 on General Guidelines for Disaster-Resilient Villages [165].

Both were created because disaster occurrences in Indonesia have increased over time. The program is based on Indigenous knowledge, placing socio-cultural issues at the center of DRR. In addition, to decentralize development, it would be reasonable to place power at the village level for sustainability [165]. However, it should be noted that a community-based program does not entail a complete risk transfer to the community, and this idea should be a project of co-creation and collaboration to demonstrate that the local community can effect change.

Table 4.6 The difference between two DRV programs

Variables	**Disaster resilient village – *Desa tangguh bencana****	**Disaster preparedness village - Kampung *siaga bencana* ***
Context of village	Based on the administrative approach	'village' is a brand entity. More into community-based disaster management organization
Goals	Capacity building in community-based disaster management	Disaster awareness programs use the term resources access
Organization	Could be a new organization or embedded in an existing organization	New organization
Executor	It could be group participation or individual (volunteer) t	Individual-based
Community and organization partnership	Co-creation and collaboration with the various organization (polycentric governance)	Government as partner
Intervention	Co-creation and collaboration	Government-based intervention program
Target	Villages to sub-villages	Villages

*The program's name in Indonesian with the literal translation

Source: Habibullah [191], *Novian Andri A* [192]

As a capacity-building program, this DRV includes risk assessment, contingency plan planning, establishing a community-based DRR forum, continuous training, and capacity building, and regular monitoring and evaluation. This program receives funding from various sources, including the central and regional government budgets and the private and community sectors. In the Yogyakarta province community of Merapi's southern sectors, most villages have been designated as DRV. On the west side, however, the DRV village associated with Merapi hazards has not yet been spotted in a large area (see **Fig. 18**).

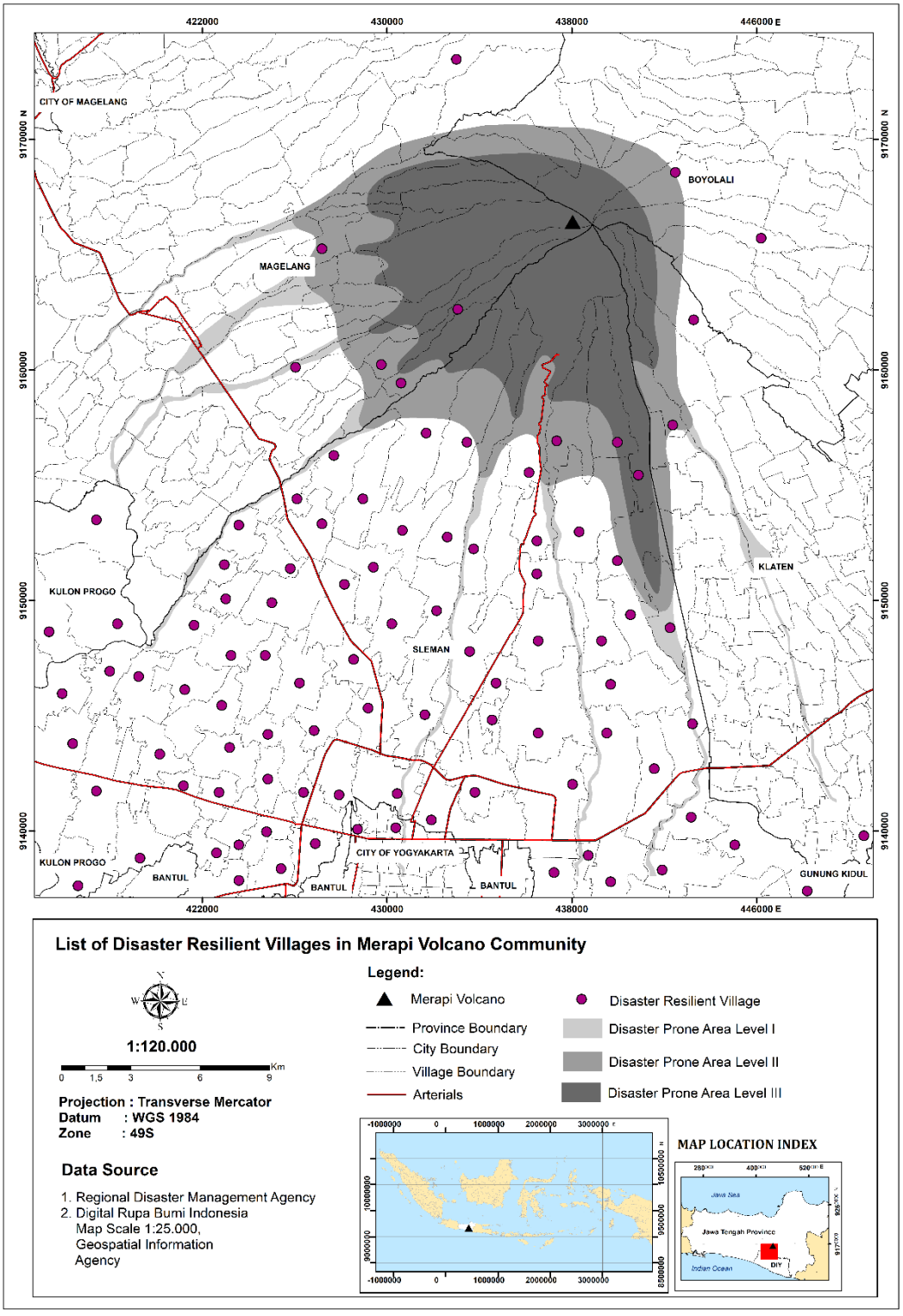


Figure 4.18 Distribution of DRV around Merapi
Source: BNPB – NDMA [193], *DI Yogyakarta Local DMA - BPBD DIY* [194], *Topographic map* [36]

4.1.3. Disaster Risk Reduction on Embedded Knowledge

4.1.3.1. Local Disaster Knowledge (LDK) as Local Ecological Knowledge (LEK) in Disaster Risk Reduction (DRR) practice

In complex and uncertain volcanic landscapes, Local disaster knowledge (LDK) is a knowledge system that focuses on the cause, consequence, and mitigation of volcanic eruptions in complex and uncertain volcanic landscapes [195]. It is depicted as a plural, embedded, relational, and embodied knowledge system that includes complementary types of knowledge obtained through daily livelihood practice, scientific information, and cultural and religious beliefs. Co-creation knowledge exemplifies the concept of inclusiveness between local community practice and the scientific perspective.

People in Merapi have been exposed to a high level of volcanic danger for a long time. People are highly dependent on resources, affecting their access to income sources. The interdependence of multiple system functions in the Merapi volcano community, including socio-cultural belief, knowledge system, spatial dispersion, and perceived disaster risk [24,50,196–199], influences their behavior during emergencies. People in Merapi believe that the land they currently reside in can be used to build homes and engage in economic activities **(Fig. 4.19)**. Even if they reside in a disaster-prone area that could be devastated by the Merapi volcano's eruption or lahars, the land must be preserved because it is their only source of income.

(a) (b)

Figure 4.19 Spring water in the upstream river of Merapi (Senowo River -upstream of Pabelan) (a); Women in Merapi: working for grass harvesting for livestock in Kepuharjo, Cangkringan (b)
Source: Mutiarni, 2013 [200]

In this community, resilience in practice has been practically developed based on long-standing experiences, as a multi-combination of knowledge and practice, between technical and ecological knowledge, and passed between generations by maintaining the social

relationship between community members and, for instance, by orienting houses toward the main street and planting trees.

4.1.3.2. Ecological Tourism Framework in Merapi

The UNWTO defines ecotourism as a form of tourism that includes educational and interpretive components and nature-based forms of tourism in which the primary purpose of the tourist is to observe and appreciate nature as well as the traditional cultures prevalent in natural areas [201]. In addition to ecotourism, the community-based tourism (CBT) framework for new destinations such as lava tours and tourism-based villages has been developed on Merapi. After the 2010 eruption, a lava tour destination emerged, indicating a recovery program for the post-eruption [57]

At Merapi, the tourism industry has become an integral part of the local community. This activity takes advantage of Merapi's distinctive landscape profile and cultural history. Merapi's tourism offerings include village-centered activities. According to Hadiwijoyo (2010) in [202], a tourism village is a rural area that offers reflections on the authenticity of the countryside. It provides concepts about the villages' economic, socio-culture customs, and daily life. The tourism concept utilizes a distinctive building architecture and spatial structure, or economic activities that are unique and exciting and have the potential to develop various components of tourism, including attractions, lodging, food, and other necessities. Approximately 37 tourist villages surrounding Merapi (see **Table 4.7**) are scattered randomly (see **Fig. 4.20**). This tourism village was designed with the input of the tourism administration and the local community. For instance, Pentingsari tourism village developed a tourism concept within environmental preservation and indigenous knowledge of Merapi. In other tourist villages, the idea of revitalizing the post-Merapi sand mining area resulted in a climate-sensitive activity and promotion of local goods (snake fruit).

Table 4.7 Tourism villages listed around Merapi Volcano

No	Tourism Village	Address
1	Pondok Wonolelo Tourism Village	Wonolelo, Widodomartani, Ngemplak, Sleman
2	BokesanTourism Village	Bokesan, Sindumartani, Ngemplak, Sleman
3	Palgading Tourism Village	Palgading, Sinduharjo, Ngaglik, Sleman
4	Jamur Tourism Village	Sendangrejo, Sleman, Sleman
5	Karangtanjung Tourism Village	Pandowoharjo, Sleman, Sleman
6	Temon Tourism Village	Temon, Pandowoharjo, Sleman
7	Tanjung Tourism Village	Ponason, Donoharjo, Ngaglik, Sleman
8	Pandowoharjo Tourism Village Display	Pandowoharjo, Sleman, Sleman

No	Tourism Village	Address
9	Ledok Nongko Tourism Village	Ledok Nongko, Bangun Kerto, Turi, Sleman
10	Garongan Tourism Village	Garongan, Wonokerto, Turi, Sleman
11	Sangurejo Tourism Village	Sangurejo, Wono Kerto, Turi, Sleman
12	Kinahrejo Tourism Village	Kinarejo, Umbulharjo, Sleman
13	Kembang Arum Tourism Village	Kembangarum, Donokerto, Sleman
14	Wonderful Kembang Tourism Village	Kembang, Wono Kerto, Turi, Sleman
15	Pulewulung Tourism Village	Wonosari, Bangun Kerto, Turi, Sleman
16	Kemirikebo Tourism Village	Kemirikebo, Girikerto, Turi, Sleman
17	Kelor Tourism Village	Turi, Kelor, Bangun Kerto, Sleman
18	Pentingsari Tourism Village	Pentingsari, Umbulharjo, Cangkringan, Sleman
19	Gadung Tourism Village	Gadung, Bangun Kerto, Turi, Sleman
20	Sempu Tourism Village	Sempu, Wono Kerto, Turi, Sleman
21	Kaliurang Timur Tourism Village	Kaliurang Timur, Hargobinangun, Pakem, Sleman
22	Daleman Tourism Village	Daleman, Girikerto, Turi, Sleman
23	Trumpon Tourism Village	Trumpon, Merdikorejo, Tempel, Sleman
24	Tanen | KAWITAN Tourism Village	Tanen, Hargobinangun, Pakem, Sleman,
25	Plosokuning Tourism Village	Wonosari, Bangun Kerto, Turi, Sleman
26	Petung Tourism Village	Petung, Kepuharjo, Cangkringan, Sleman
27	Pancoh Tourism Village	Pancoh, Girikerto, Turi, Sleman
28	Nganggring Tourism Village	Nganggring, Girikerto, Turi, Sleman
29	Bening Tourism Village	Bening Girikerto, Turi, Sleman
30	Tunggularum Tourism Village	Tunggularum, Wono Kerto, Turi, Sleman
31	Turgo Tourism Village	Turgo, Purwobinangun, Pakem, Sleman
32	Pulesari Tourism Village	Pulesari, Wono Kerto, Turi, Sleman
33	Sumber Tourism Village	Sumber, Dukun, Magelang
34	Gubug Kudus Tourism Village	Sucen, Salam, Magelang
35	Banyubiru Tourism Village Tourism Village	Wates, Banyubiru, Dukun, Magelang
36	Kaliurang Indah Tourism Village	Kaliurang Selatan, Kaliurang, Srumbung, Magelang
37	Somoketro Tourism Village	Somoketro, Salam, Somokerto III, Salam, Magelang

Source: Google map data scrapping [39] and [203]

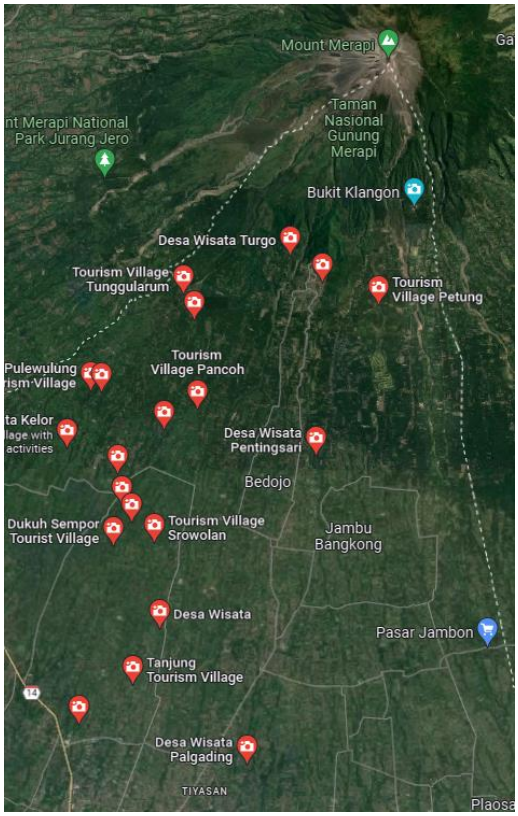


Figure 4.20 Tourism villages around Merapi Volcano
Source: Google map [39]

Some criticisms of tourism activities in disaster-prone areas emphasize the sustainability and high level of vulnerability resulting from the location [57]. In addition to the location, the "exploitation" of post-disaster conditions for recreational purposes produces a new terminology called dark tourism, which refers to unemphatic in making living activities [204].

4.2. Case Report 1: A Lesson Learned from Education for Disaster Risk Reduction in The Merapi Volcano Community in Yogyakarta, Indonesia for Bridging Community Resilience

4.2.1. Introduction

It has been a long effort of disaster relief promotion by the Hyogo Framework [205], Sendai Framework [74], and the Sustainable Developmental Goals (SDGs) [73]. Education is essential in strengthening people's capacity in disaster-prone areas [206]. Moreover, this process involves mitigating disaster risks and minimizing damage and loss during disasters [207]. However, in some cases, education on DRR needs to be improved to achieve adequate responses during such situations. Studies have attributed the failure of formal

education on DRR [208], inefficient early childhood education [209], and the importance of local knowledge on disaster education which has not been recognized yet [207], to inadequate disaster risk management. [206] stated that increasing knowledge and awareness, imparting education, and providing training on DRR are essential for all individuals, thereby promoting human security.

Indonesia is well known for its active volcanoes, of which Merapi Volcano is the most active. The local community of Merapi Volcano has experienced long exposure to this natural hazard. Since the eruption in 2010, DRR education in the Merapi Volcano community has become essential. To this end, programs related to education for DRR and the concept of sister schools and merged school activities [210] were launched. Various organizations, including non-government organizations (NGOs), are working toward providing DRR education to the local communities. This study aimed to understand and explore the local values of DRR education in Merapi Volcano communities to strengthen the DRR education process in other locations.

4.2.2. Research Method

In this study, we used the qualitative content analysis defined by Hsieh and Shannon [210] as a subjective interpretation of the text data content by identifying themes and patterns. Moreover, we also used comparative model studies to analyze the research results between the several types of DRR education. The data acquisition for this research will be secondary data in this document from research reports and journals, which discusses the form of education in DRR separately. We considered the following components in DRR education: knowledge development process, attitude, and behavior. Moreover, to complete the understanding, management or structure was added as the description of each education type.

This paper is structured as follows: Introduction and Research method; Safe School Learning in Indonesia, which in turn is categorized into three parts, implementing Safe School Learning (SSL) at the national and local level, SSL in Yogyakarta Province, and the Sister School Program as DRR Education in the Merapi Volcano community; Discussion; and Conclusion.

4.2.3. Safe School Learning as The Leading Framework for DRR Education in Indonesia

4.2.3.1. Implementing SSL at the National Level

In the local context of Indonesia, SSL is called *Satuan Pendidikan Aman Bencana – Disaster Safe Education Unit* (SPAB). SSL is the most recent concept of DRR education in Indonesia; it tries to integrate and protect children's rights, security, and survival, as well as the right to obtain quality and sustainable education. This program has been launched as part of the Worldwide Initiatives Safe School. Based on the guidelines published by the Ministry of Education and Culture data [177], more than 25,620 schools in Indonesia have implemented SSL, supported by government agencies and/or NGOs. Aside from that, it mentioned that SSL emphasized the collaborative action between the school and the neighborhood community. This program is expected to develop the school as the center of disaster risk management because of its best-quality physical structure, community center, and disaster emergency facilities. Implementing this concept has three main aspects: (1) Safe school facilities related to the location and physical structure. (2) Disaster management in schools that ensure the implementation of standard operating procedures in emergencies. (3) The integration of disaster prevention education and DRR education.

To ensure the regulations fully support SSL implementation at the education unit level [177], Indonesia provides open circumstances for various forms of disaster education. At present, the application of the SSL concept in Indonesia is focused on non-formally structured plans through extracurricular activities such as scouts, SSL summer camps managed by the local disaster management bureau, fostering teachers or extracurricular coaches, and related programs by NGOs. Meanwhile, the Ministry of Education and Culture of Indonesia [177], implementing DRR education through a structured curriculum, whether the integration of discussion themes of the 2013 curriculum or the development of local content-based subjects, is not well developed. Before 2013, the government of Indonesia provided a few course modules to help teachers integrate DRR issues, such as earthquakes, tsunamis, landslides, fires, and floods [211], into the learning process at the primary and secondary education levels. However, not all of Indonesia's natural hazards, including a volcano eruption, necessary considering Indonesia's geomorphology situation, are discussed in these course modules.

4.2.3.2. SSL in Yogyakarta Province

Following the national-level implementation of the SSL concept, disaster management has been introduced at the provincial and regional levels. Currently, there are 81 SSL at the Yogyakarta Province (DIY – Daerah Istimewa Yogyakarta *[Yogyakarta Special Region])* [212]. DRR education is provided at various levels of education, from elementary schools to junior, and senior high schools, with more importance given to the elementary school level **(Table 4.8)**. Further, these SSLs are distributed throughout all regions of DIY, not only in the Merapi Volcano community.

Table 4.8 Distribution of SSL in DIY, Indonesia, based on region and level of education

Region	ES	JHS	SHS	Total
Sleman	28	11	13	52
Kota Yogyakarta	3	0	0	3
Bantul	3	3	5	11
Kulon Progo	4	0	3	7
Gunungkidul	2	1	5	8
Yogyakarta Province	40	15	26	81

Source: Bappeda DIY [212]

Note

PS: Elementary School [SD – Sekolah Dasar]

JHS: Junior High School [SMP–Sekolah Menengah Pertama]

SHS: Senior High School [SMA–Sekolah Menengah Atas]

In the future, the Indonesian government must target all schools for applying SSL principles at each level by including it in the formal curriculum.

4.2.3.3. Sister Schools as Education for DRR in the Merapi Volcano Community

During the disaster following the volcano's eruption in 2010, there were instances in which the formal schools had to stop their activities for various reasons, such as entire destruction of school facilities, evacuation, and relocation of the students to different places, and location of the previous schools being within the prohibited area [213]. Because Merapi is an active volcano, the government has launched a program that reassures the sustenance of student education during disasters. The sister school program allows students to continue their education at a buffer school that supports them. Sister school engages schools that have implemented the concept of SSL and are located in the disaster-prone area surrounding the Merapi Volcano [179,180]. The sister school concept emphasizes the transfer of learning activities from a school located in a disaster-prone area to a safer school during the response, rehabilitation, and reconstruction phase. In 2015, in Sleman (DIY), 20 disaster preparedness schools were paired with ten sister schools [181].

4.2.4. DRR education in the Merapi Volcano Community: bridging between the formal, non-formal, and informal models

Based on the study by Shaw and Izumi [206], there are three types of DRR education: formal, non-formal, and informal. Formal forms are related to a structured design curriculum and assessments through the learning process. The non-formal form is the targeted learning process in extracurricular and/or after-class activities. Informal education is education that occurs outside the designed curriculum throughout daily life, such as knowledge sharing from parents or peers or between community members. Notably, the concept of DRR education is supposed to be an integration model for the whole community. However, the limited resources possessed by organizations or communities have not received the integrated process yet.

4.2.4.1. Formal Education

DRR education for this category works by integrating the disaster-related content into the formal curriculum, both in independent courses and by integrating thematic issues on related subjects, such as the school's curriculum capacity building for targeted people (students, trainees, volunteers) (see an example of class activity in **Fig. 4.21**). Integration related to the school curriculum means providing disaster education materials in different subjects, such as natural science, social studies, physical education, or thematic issues, such as environmental and neighborhood issues. Also, a few academic units have developed the subject with local content containing disaster education materials. In the process of knowledge development, there have been some findings from this model in the Merapi Volcano community:

1. Students, teachers, and staff know natural hazards like volcanoes, earthquakes, and floods. [209], their research explained that elementary school students learn about natural disasters and hazards from their pre-school days until they are in grades 5 and 6 of elementary school. Lesmana and Purborini [214] and Pambudi and Ashari [215] also added that students around Merapi Volcano understand the positioning of Merapi and have basic knowledge of the disaster. However, according to Mei et al. [216], the disaster knowledge level score is only 70/100 among the studied subjects. Unfortunately, students in their research area scored only 20%–23% on their understanding of DPA levels (Zone I to III).

Figure 4.21 Class activities for the education of DRR(M) [217]
Source: Gloria [217]

2. However, some of them, especially students, have not fully shared this knowledge with their parents, family, or friends in their neighborhood [209]; a total of 20% of the observed population belonged to this category (among elementary school students).
3. This knowledge development process also experiences many obstacles:
    a. Ineffective disaster prevention teaching practice relies primarily on textbooks and pictures as teaching media [209]. Sulistyaningrum [218] reinforced the ineffectiveness of this program, in which the use of educational teaching aids in the form of the animated video "Siaga Bencana Gunung Berapi–*[Ready for Volcano Disasters]*" changes the DRR educational process in primary schools in the Merapi area.
    b. Limited training for teachers related to DRR education has resulted in a lack of skill and knowledge of DRR issues [209]. Even worse, some teachers are not interested in including the disaster-related education material in their course process, although it is mandatory in the current curriculum.

4.2.4.2. Non-formal

Some schools and organizations include DRR education, not in the (specific) course but in an extracurricular curriculum or non-class activity for students or a target group. Often, the organization concerned with this DRR is the Local DMA (both at the provincial and regional levels; NGOs, universities, and other organizations have collaborated to promote this DRR education and awareness.

Extracurricular activities in formal schools with clear targets and objectives at each meeting or activity are examples of non-formal education in the context of DRR. For

example, through scout extracurricular activities, there is an exclusive club called “Disaster Mitigation Club” Typically, the school develops the extracurricular course collaboratively with guidance from the local government, the disaster-related bureau, and the education office. Teachers or trainers conduct this extracurricular learning activity for students through peer teaching/training [219]. The members of SSL conduct disaster preparedness school jamborees **(Fig. 4.22)** include internalizing disaster mitigation activities in their environment, such as what the student must do during the emergency and evacuation shelters; or what their family must prepare for facing the hazards.

Figure 4.22 Camp activities for students from SSL [220,221]

In addition to schools, education for DRR also involves local volunteers who are members of several disaster-related organizations, such as Tagana (Taruna Siaga Bencana - *Youth Disaster Safe Organization*) and DRR Forum, from the village (community) level to the national level. These organizations routinely conduct joint activities coordinated by the local and national disaster-related bureau and voluntary disaster management throughout the whole phases, such as helping to monitor the EWS (Early Warning System), evacuation process, logistic supply, and temporary or shelter building.

Moreover, the BPBD has conducted structured coaching activities for the public, including at schools, in communities, and with volunteers. Additionally, for introduction to disasters and disaster mitigation, BPBD has regularly conducted emergency simulations in disaster-prone areas, including volcano-prone disasters (see the illustration of a simulation drill [222] **(Fig.4.23).**

Figure 4.23 Merapi Volcano eruption disaster simulation drill

Sekolah Gunung Merapi is an independent community learning center serving vulnerable communities living in the Merapi Volcano area. This organization was founded in 2015 to help encourage the Merapi Volcano community and is concerned with the long-term recovery of the communities (see **Fig. 4.24**). In addition to the work on disaster recovery and mitigation, they work to provide the tools required for the local community to address and adapt to immediate global challenges, rapid environmental changes, and increasing social and economic instabilities.

Figure 4.24 Activities held in Sekolah Gunung Merapi (SGM) - School of Merapi Volcano. A non-formal school held by the volunteers [223]

Several program activities for DRR have received favorable responses from stakeholders, such as school residents, communities near the school, communities who work on DRR, youth organizations in the community, NGOs, BPBD, and universities. Nevertheless, sustainability is the measure of the success of a process of internalizing the educational process. Baskara [224] mentioned problems related to collaborative interaction between stakeholders. He gave the following example: Despite the remarkably elevated

level of knowledge of school residents (almost 100%), the participation level in promoting DRR activities to the community near the schools was still considerably low (<90%).

In addition to the sustainability of structured activities coordinated by the BPBD, the number of people who participated and experienced this type of education was one of the reliable indicators for non-formal education for DRR. For example, the community was enthusiastic about participating in disaster simulations, disaster preparedness camps, and volunteer jamborees. However, some existing studies have not provided definitive assessments of all targeted goals for each program.

4.2.4.3. Informal

Informal education has a more abstract form of activities than other education types. In this type, the education process has developed through daily activities, such as discussion in community gatherings and/or interaction with neighbors, the narration of stories, the performance of traditional and cultural activities, and their behavior toward hazards.

In the case of the Merapi Volcano Eruption of 2010, the community experienced relocating for a long time and making matters worse, and they separated from their previous communities. Some of the people entered their houses before the authority permitted it. The people's attitude toward their neighborhood after the disaster was reasonable because they evacuated without bringing their livestock with them [63]. Additionally, the Merapi community has strong ties regarding their origin, including ownership of assets. This statement was also expressed by Lavigne et al. [24], who added the closeness of socio-economic factors in the context of the people living around the volcano in Java, including Merapi Volcano. They went back soon after Merapi was in a stable state. The Merapi community believes that the land of Merapi is blessed. Although their neighborhood has not recommended settlement areas due to the highest level of disaster-prone areas, they continue their activities with the potential consequences such as damage and loss of their houses without getting any help from the government or donors.

Figure 4.25 Locals people tell the story about moving back and their hope after the Merapi Volcano eruption in 2010
Source: Lentera Indonesia (NET. Documentary) [225]

Pangukrejo resident has been open to sharing their experiences of the 2010 eruption and during low-magnitude eruptions in May and June 2018 (see **Fig. 4.25** and link to the documentary video). Experiences community members share, among others, the panic that struck them during the eruptions, what they did to minimize danger to themselves and members of their families, and how they have survived to this day [226].

The open attitude of affected people toward sharing their experiences is a form of how local knowledge functions to create behavior and attitude toward the disaster or natural hazard context. This attitude is in line with the study by Septiana et al. [207], in which they emphasized that stories or oral stories from the older generation to the younger generation have become part of the process of transferring knowledge. For example, when Merapi Volcano has a primary level of activity, community leaders will forbid residents from approaching the river. They tell stories through Javanese mythology that, at this time, there will be a secure connection between Merapi in the north and the sea in the south through the river.

Besides, Septiana et al. [207] added that the education process for DRR was carried out through scheduled cultural and spiritual activities and community meetings such as patrolling or monthly meetings to pray together called *mujahadah*. Some of the cultural events performed by the Merapi Volcano community are carefully related to their interactions with nature, including their gratitude for the blessings of life given by God. The traditional feast called tumpeng (cone rice) has shown how grateful the people are for their life –the cone form is like the top of a mountain. In Javanese mythology, this form represents respect for God [24,207]. Also, routine meeting activities, such as patrolling (night shift social security guard), are a form of DRR education in areas at risk of disaster.

In this activity, the community can share information about what is happening in their environment, including information on disaster matters.

DRR education in this model has never been conducted quantitatively. However, according to Septiana et al. [207], the informal education process, such as the behavior of the Merapi Volcano community and oral history, is the most effective form of building knowledge and shaping the behavior toward their environment. Lavigne et al. [24] added that the community has a firm bond with the Merapi Volcano, including how their experience of environmental exposure from it over a long time will influence the process of forming their attitudes toward Merapi Volcano and its risks.

4.2.5. Discussion

DRR education in Indonesia has become an essential issue in disaster mitigation and preparedness. People are increasingly aware of disaster-related issues, such as the risks they face, responses during an emergency, and preparedness before an emergency. Merapi Volcano is known for frequent small to moderate eruptions, pyroclastic flows produced by lava dome collapse, and the large population settled on and around the volcano's flanks [44]. Table 4.2 presents the results of the diverse types of DRR education conducted at Merapi Volcano.

According to **Table 4.9**, the process of DRR education has contributed to the formation of local people's attitudes toward natural hazards. Nevertheless, this process needs more comprehensive cross-type education for DRR in planning and implementation [227]. Amri et al. [227] add that collaborative action is essential to build a more comprehensive approach to knowledge development for the whole community, including a school part of the DRR forum. Here the local community can arrange the local curriculum for themselves based on the guidelines from authority and their life experiences. For example, community leaders can fill sessions in the DRR education process with their life stories and histories [207]. It is also necessary to hold collaborative disaster simulation and prevention drills, in which the jamboree is the forum that involves all related stakeholders.

Table 4.9 Summary of Education for DRR Process in Merapi Volcano community

Type of Education	Structure and Management	Knowledge Development, Attitude, and Behavior Toward Disaster Risk
Formal	Structured	Some of the targeted people did not share their knowledge with their community (family and neighbors)
Non-formal	Structured	Participation in education for DRR activities is a signal that targeted people are aware of and understand disaster risks
Informal	Unstructured	Their daily behavior toward the hazard and disaster risks is an indicator that they respect the human-nature connection

Source: Author, 2020

As the leading framework in DRR education, schools can act as leaders with help from other stakeholders, such as village leaders, local volunteers, and the local government. Schools can create the process of DRR education not only for the students but also for the communities near the school. It means a school can act to ensure the community members can continue their lives even if they must move or are relocated (see about sister schools in the previous section). School here means not only the school management but also the School Committee *[Komite Sekolah]*, which commonly consists of parents of the students, local leaders where the schools are located, alumni, activists, and NGOs that are concerned with the process of education, and individuals who observe the school management.

In addition to collaboration, as revealed by Faizatul et al. [228], experience-based and action-oriented learning provides a stronger possibility for understanding the disaster risk. With this learning, it is expected that the process of understanding risk and forming attitudes and community behavior will be more sustainable, more comprehensive, and create a more resilient society. It means the process of DRR education needs to be concerned with the activities and experiences of the classes and theory sessions.

4.2.6. Conclusion

Several types of DRR education in the Merapi Volcano community have illustrated that these processes must complement each other. The local community respects Merapi; hence, the interaction between humans and nature is robust. DRR education can use this value as the primary key for capacity building among the local people. There are some critical issues related to the possibility of scaling up the education for the DRR process: (1) collaborative action is essential; (2) the school can be a leader in the DRR education process, including when there is an emergency phase; and (3) the experience-based and

action-oriented learning provides a more successful possibility for understanding disaster risk.

4.3. Case Report 2: Social Learning for Disaster Risk Reduction through Local Initiatives in the Merapi Volcano Communities

4.3.1. Introduction

Disaster risk reduction (DRR) includes disaster education, preparedness activities, DRR capacity building, and raising community awareness [118]. The United Nations Office for Disaster Risk Reduction [74] stated that effective DRR combines non-structural soft and complex structural measures. This study focused on DRR emergency soft measures in local communities living in disaster-prone areas [229,230], such as participatory and community-based DRR programs, public involvement, and DRR risk perceptions [231,232].

Local communities, which have to deal with the complex impacts of disasters, have generally had unequal access to the knowledge and basic infrastructure needed to deal with daily life disaster contexts and have therefore tended to be ignored within national DRR policies and programs [233]. However, national DRR programs are expected to address disaster preparedness in local disaster-prone communities to protect their resources and livelihoods.

DRR activities have been recognized as being part of both epistemological and ontological learning paradigms [119–126] because of their primary aims of transforming behaviors, perceptions, and emotions through the four major learning perspectives of behaviorism, cognitivism, constructivism (cognitive and social), humanism, and connectivism [118]. Specifically, to ensure the establishment of focused DRR activities, the Sendai Framework for DRR 2015–2030 sees education as a cross-cutting issue [234].

When preparing local communities for DRR activities, social learning is needed. Although there have been several opinions on the origins of social learning [235,236], it is generally agreed that social learning requires collaborative public involvement. The initial social learning concepts came from environmental management and educational psychology, emphasizing collaboration [118]. Because of the ambiguity of the social learning definition, [236] developed a new social learning framework with the following learning objectives; (1) demonstrate that a change in understanding has taken place in the individuals involved; (2) demonstrate that this change goes beyond the individual and

becomes situated within more comprehensive social units or communities of practice; and (3) occurs through social interactions and processes between the actors in a social network

Nguyen, Imamura, and Iuchi [237] concluded that specific complex societal and socio-ecological problems require shared problem identification, which is only possible through a constructed awareness of each actor's mandates, goals, and perspectives. Therefore, to ensure an acceptable solution for all, social learning's most significant value comes from a practical framework that explores the critical problem elements with multiple perspectives and is characterized by complexity and uncertainty [238,239].

Kitagawa [118] extended Reed et al. [236] concept by claiming that DRR was a learning activity within the social constructivist paradigm, which sees knowledge as a social production arising from how people interact with others and their environments, that is, the social and cultural learning that takes place through exchanges and interactions. Therefore, this learning perspective is particularly pertinent for local communities living in disaster-prone areas as they have experienced recurrent hazards and have learned through their experiences.

Social constructivist approaches define learning as social, cultural, and communal, with the collective goal being more important than individual interests [118]. Therefore, collaboration is the essence of social DRR learning for local communities and external stakeholders. In addition, social learning regards the social and cultural contexts as essential elements of the learning process. Existing local community initiatives can be used for the DRR education case studies to develop collaborative and socio-cultural social learning. In this paper, local economic-based initiatives were established and managed by the local community rather than more external DRR activities, such as disaster prevention drills, simulations, seminars/conferences, or community training. Therefore, this study sought to provide an alternative view of DRR learning, in which the DRR activities had cognitive and behaviorist purposes that focused on the community's livelihood continuance strategies. Although the social learning concept has been part of the debate on effective DRR programs, using this concept to understand the needs of local communities can fully address their long-term requirements, that is, as the communities' live side by side with the risk, the actions they take in their daily lives need to be part of the DRR program.

To better elucidate this social learning DRR concept, the local initiatives in the Merapi local community, which was significantly affected by the Mount Merapi eruption in 2010, were examined. Even though some initiatives had been in place before the 2010 eruption, such as the cultural tourism villages, other initiatives emerged, such as lava tours.

This study was conducted under the social learning framework to understand how these initiatives work as part of the Merapi community DRR program. Based on local community-based economic initiatives: lava tours, tourism villages, and camping ground services, this research hoped to provide evidence that DRR activities should be included as part of community social learning processes.

The remainder of this paper is organized as follows. Section 2 outlines the research method, Section 3 examines the community-based economic driven (CBED) local initiatives in the Merapi volcano community, Section 4 discusses the findings, and Section 5 gives the conclusion.

4.3.2. Research Method

A qualitative study was conducted based on several data sources; literature studies (data text – content analysis), reports, journals, an online survey conducted in 2020, and field observations in 2018–2019. The literature review has been used to obtain the descriptive data supporting the two other data collections that explain the activities and how the community works within disaster risk reduction issues. Observation during fieldwork tried to understand what the locals do and interpreted the disaster risk reduction into their livelihood activities. While the online survey was conducted in 2020 to the local community who live in the Merapi Volcano area to understand the concept of disaster awareness, two questions within that online survey were used for this paper to describe that people in Merapi understand that the disaster risk information is not only for them as locals, but also to the visitors too.

The data were analyzed using a qualitative approach that juxtaposed the DRR learning findings within a social constructivist framework [118]: (1) What is knowledge; (2) How people learn; (3) Key theories; (4) Role of learner/instructor; (5) Learning and teaching methodologies. The concept of social learning of DRR used these five key issues to describe what people do in the Merapi Volcano area on the socio-constructivism approach.

4.3.3. Local Initiatives at Merapi Volcano: Community Based Economic Driven

The Merapi volcano is located on the border of Yogyakarta and Central Java, Java, Indonesia. In 2010, the volcano erupted with high intensity and caused significant damage and losses; 367 fatalities, 277 injuries, the displacement of 410,388 people [44], and

damage and losses totaling around USD 256.4 million [54]. However, this eruption provided significant disaster management lessons for DRR programs in Indonesia. After the 2010 eruption, local communities underwent rehabilitation and reconstruction.

The tourism sector in disaster-prone areas is at a high risk of pre-and post-disaster events, which is incredibly complicated for CBED tourist activities because the high risk of disasters can result in community-wide livelihood disruptions [57]. Like other post-disaster communities, the Merapi communities also face disruptions to their CBED activities. This study examined three main CBED tourism initiatives: the Pentingsari tourism village, lava tours, and campsite management (see **Fig. 4.26**).

The DRR concept was examined through the social learning paradigm. However, as these initiatives focus on economic fulfillment in the local communities, rather than only being associated with social learning, their development could also be aligned with social constructivism. This study provides an option to see from each case about the social learning process for understanding the DRR concept through the non-direct program of DRR, like a single learning paradigm (behaviorism) on disaster drill prevention. However, it is more on the social learning process, which aims more at social constructivism, where these initiatives are more about constructing the fulfillment of economic factors in local communities.

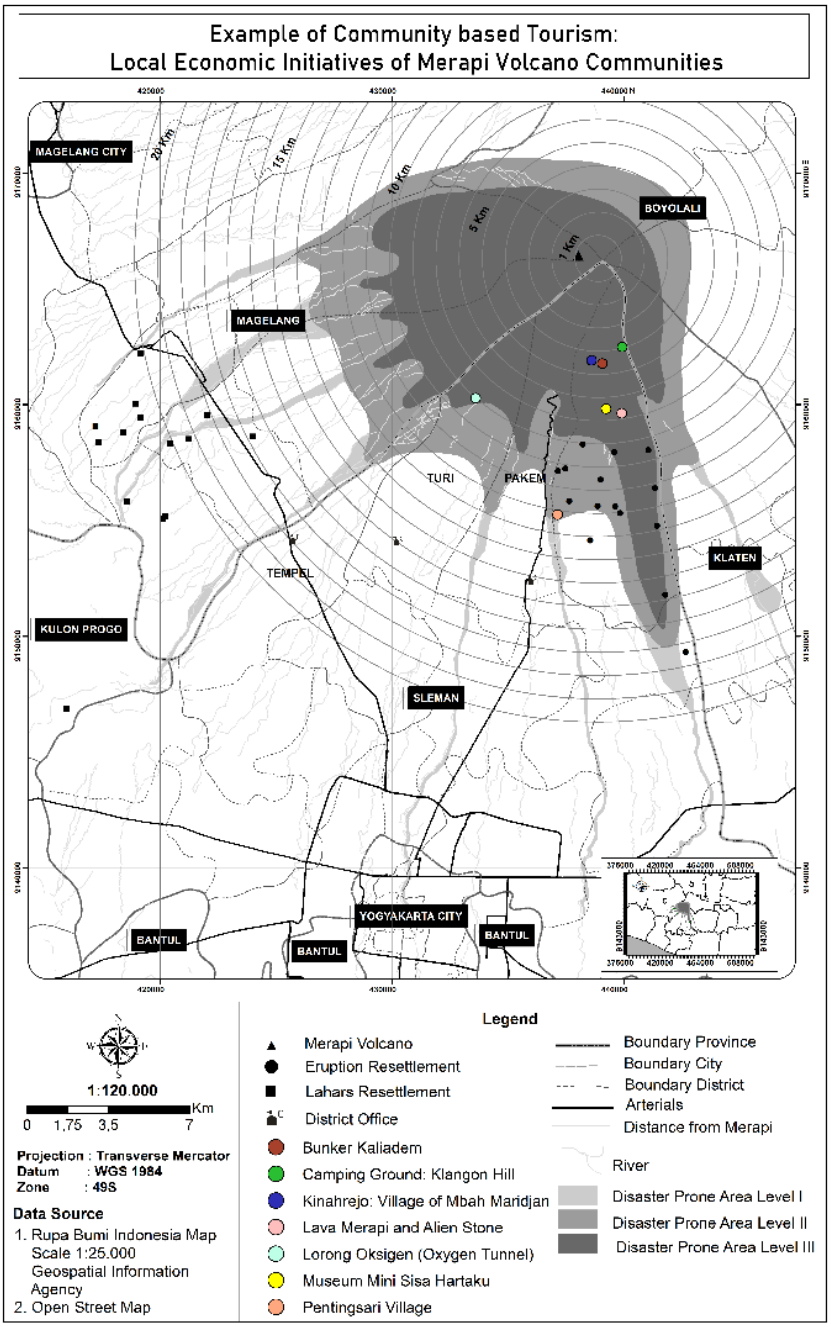


Figure 4.26 Location of CBED activities
Source: Authors, 2021
Data resources Map: 1. Topographical Map [36], 2. Hazard Map Merapi [38], 3. Google Map [39] scrapping data.

The Pentingsari tourism village was established before the 2010 eruption. Pentingsari is in Umbulharjo, Cangkringan, Sleman. Most people in this area work full-time in agriculture and part-time in tourist villages [57]. The village provides outbound activities, walking tours to several local producers, and cultural arts displays. The walking

tour visits local coffee production, demonstration *gamelan* lessons (traditional music), workshops on traditional toys and decorations, herb gardens, and the local spring to observe how the locals conserve their water resources (see **Fig. 4.27**). Therefore, Pentingsari Village is based around an ecotourism concept to highlight the relationships between the Merapi communities and their natural surroundings. During the walks, visitors are accompanied by local guides introducing them to traditional ecological knowledge about the Merapi volcano area.

Figure 4.27 Pentingsari Village
Source: Author, 2021; Photos resources: (1) Location; (2) Outbound Training on the campground area [240]; (3) Herb House [241]; (4) Traditional Music Instrument [242]; (5) Homestay accommodation [243]

This village limits the number of visitors due to its location and management capacity [244,245]. Besides the attractions, homestay and food services are also available. The management usually schedules the facilities and accommodation for the tourism activities, with many residents also involved in the tourism activities as homestay providers, food providers, or event managers. This village community works collaboratively with other attractions around Merapi, such as the lava tour providers in another village.

The lava tours are jeep tours that visit several points around Merapi (see **Fig. 4.28**). Several tour providers work collaboratively to manage this attraction, and there are several tour types, such as long, medium, and extended tours. The tour operators also provide a wet track, allowing the visitors to tour the upstream river area in Merapi. The first lava tour checkpoint is Kaliadem Bunker, initially built for emergency evacuation from Merapi volcano pyroclastic hazards. However, as this bunker was damaged in the 2006 eruption, and the area was closed after the 2010 eruption, visitors must join the lava tours visit as special vehicles, and an excellent spatial understanding of the area is needed. The second lava tour checkpoint is the Gendol River, upstream of Merapi. Here, tourists can visit Alien Rock, which emerged after the eruption, and view the Merapi caldera. The next lava tour checkpoint is the house of Mbah Maridjan, a local figure considered sacred by the local community. On October 26, 2010, Mbah Maridjan passed away from a pyroclastic flow in the first eruption. This lava tour also visits a mini-museum that displays the remaining resident treasures after the 2010 eruption, including motorcycles, bicycles, and other household items. The wet track lava tour along the river upstream of Merapi visits several other selected sites managed by the community and the private sector.

Around Merapi itself, there are several camping grounds **(Fig. 4.29)**, which are managed independently by the community, such as Klangon Hill, The Cengkerama, Kali Petung, Karang, Kaliurang Forest, Wonogondang, Sinolewah, and Bumi Lembah Merapi. The Klangon Hill campground is the campsite nearest to Merapi, at which there is a campsite and an outdoor sports area with a downhill cycling area.

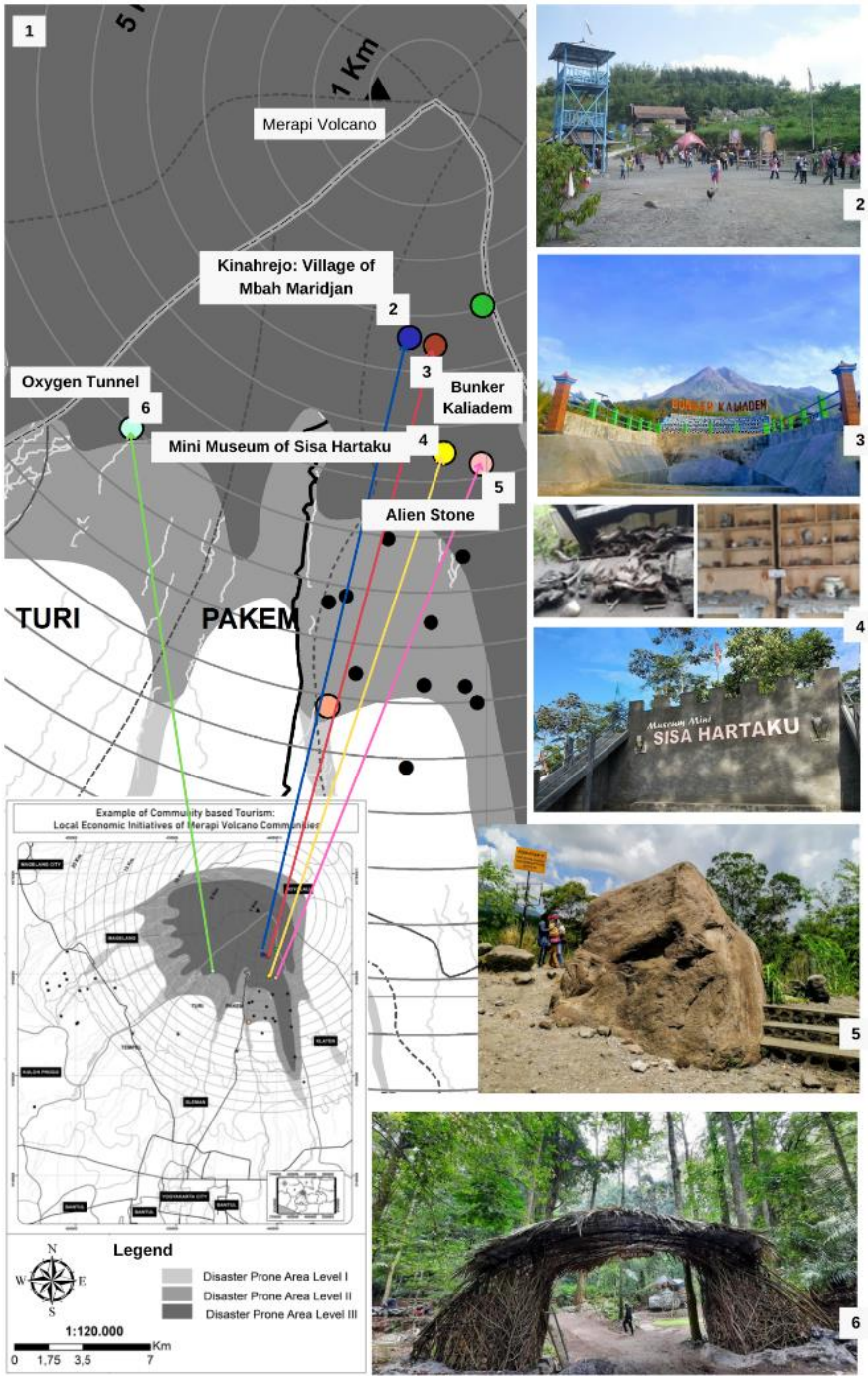


Figure 4.28 Location and lava tour checkpoints
Source: Author, 2021; Photos resources: (1) Location; (2) Kinahrejo Village: Mbah Maridjan House [246]; (3) Kaliadem Bunker [247]; (4) Mini Museum Sisa Hartaku [Treasure Mini Museum] up left right (fieldwork, 2019); bottom [248]; (5) Alien Rock [249]; (6) Oxygen Tunnel [250]

4.3.4. Discussion

The three cases of community-based economic driven (CBED) initiatives are examples of social DRR learning within the social constructivist framework. By getting involved in these activities, the local community (management and the residents) and visitors learn about the risks of volcanoes and their management. There are five main social constructivist elements (Kitagawa, 2021), each of which is described in the following:

1. What is knowledge?

Most of the CBED activities in Merapi are based on the community's knowledge of their surrounding environment [24,198]. In the Pentingsari, for example, local people are employed to inform visitors about the local village resources, such as the local coffee production. This village shows the daily lives of the people in the Merapi community.

Only officially managed and registered vehicles can be used on the lava tours, which limits the possibility of conflicts and public risk to visitors. Although there were always a maximum number of people allowed at Merapi because of the considerable risk, local knowledge of independent evacuations is essential. Therefore, the evacuation routes' knowledge, skills, and understanding depend on the local driver and lava tour management, and evacuation route signs have been placed everywhere to ensure rapid deployment if disaster strikes. The campsite areas also have several terms, conditions, and regulations that visitors must read and agree to before entering [251,252]

Based on an online survey of the local community in Merapi, the information about the Merapi emergency procedures, 91.4% of respondents agreed that everyone had to understand and adhere to these procedures, including the visitors (tourists) **(Table 4.10)**.

Table 4.10 Local community perceptions of the need to adhere to risk information around Merapi, including the business sector

Answer Choices	Response	
Needed	91.40%	202
Maybe	5.88%	13
No need	2.26%	5
Do not know	0.45%	1
TOTAL		221

Source: Author, 2021

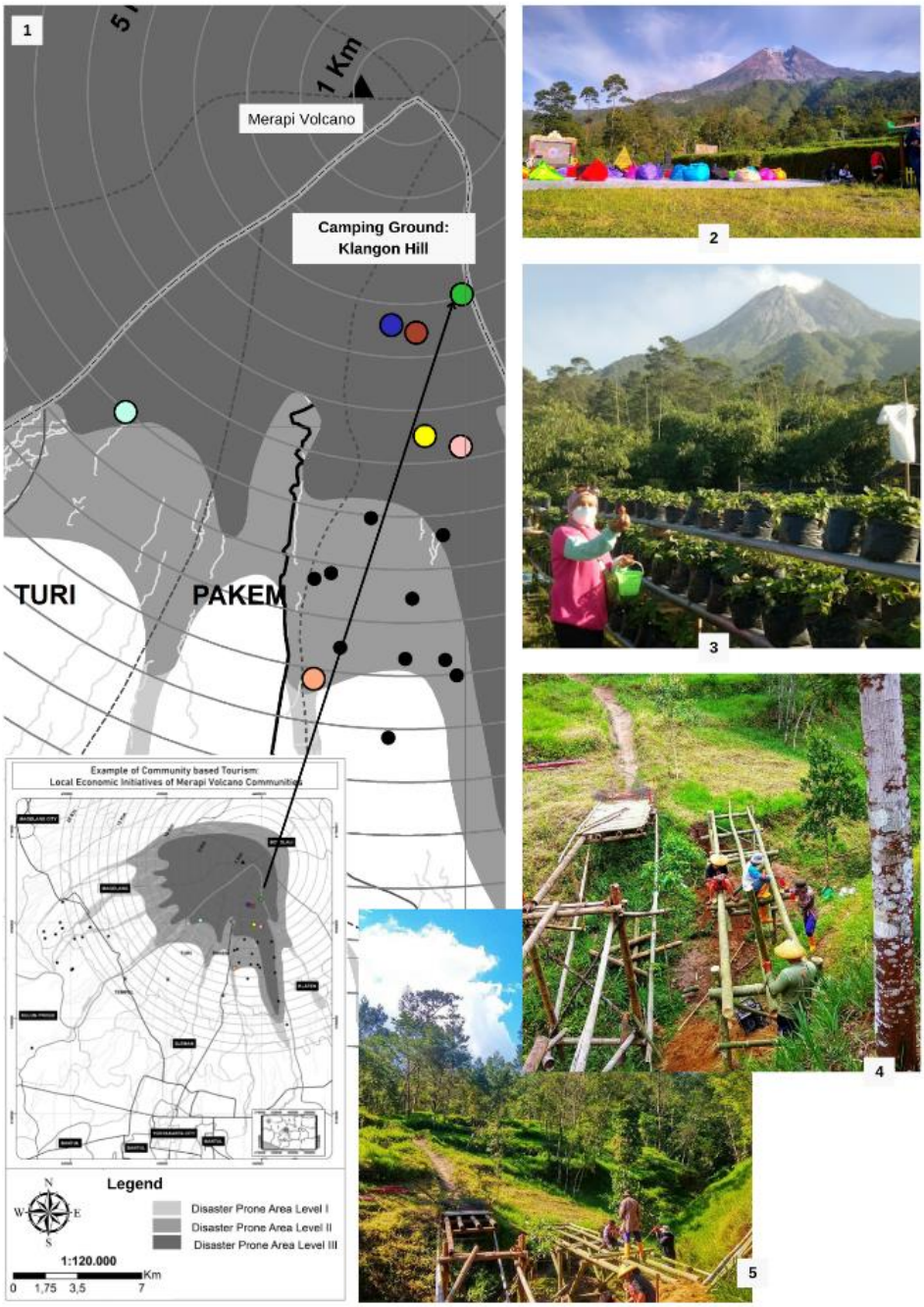


Figure 4.29 Klangon Hill
Source: Author, 2021; Photos resources: (1) Location; (2) Camping Site Klangon [253]; (3) Strawberry garden [254]; (4) & (5) The community works together to build the facilities in the camping ground area [255,256]

2. How do people learn?

CBED community members, management, and standard community members in Merapi understand the process. If conflicts arise, they resolve them by revising the standard operating procedures, encouraging capacity building and the development of specific skills,

and practicing agreement-based scheduling and equity. For example, conflicts often arose at the beginning of the lava tours, mainly because of the lack of lava tour operator accommodations, lack of neatness, crowding at specific points, drivers' skills, and visitor satisfaction and safety issues. When managing the tourist villages, the management fairly divides visitors among the homestay providers as not all participating residents have the same capacity to receive visitors; therefore, the village has a business model that can allocate visitors to homestay accommodation or the campground.

As this tourism village is in a disaster-prone area, the managers must provide information about disaster awareness as part of the visit rules and postpone, refuse, or cancel visits if the authority identifies any dangers. In the 2020 online survey, 85.97% of respondents agreed that they were willing to follow the government notices about activities in Merapi (see **Table 4.11**).

Table 4.11 Public perception of the acknowledgment of government instructions

Answer Choices	**Response**	
Yes	85.97%	190
Maybe	12.22%	27
No	1.81%	4
TOTAL		221

Source: Author, 2021

As the residents know they are living in a disaster-prone area, they are aware of the need to take precautions for themselves and their guests.

1. Key theories

   Situated learning states that people participating in a particular context learn how to do it better. Therefore, conflict resolution and providing better visitor services are part of the Merapi CBED learning process.

2. Role of the learner/instructor

   The social learning learner is active and collaborative; the community members learn from each other and share ideas to provide solutions. Therefore, the standard operating procedures are developed collaboratively by the community members and are designed to solve any problems that arise, such as the lava tour and tourism village management issues described previously. The Merapi community has also been collaborating with external stakeholders such as NGOs, universities/academia, and government, providing training to help resolve CBED management issues.

3. Learning/teaching methodologies

Social constructivism defines social learning as the opportunity to critically think, reflect, and be involved in group projects. In Merapi, social learning was evident in developing the collaborative CBED guidelines, as any revisions were thoroughly discussed with the members and external stakeholders.

4.3.5. Conclusions

The three CBED cases in Merapi found that DRR programs do not have to be disaster-specific programs such as disaster drills, seminars, training, or geoparks. By developing and participating in the Merapi community tourist attractions, locals, the management teams, and visitors have been made aware of the broader DRR context in Merapi (see summary in **Table 4.12**). The community's understanding of their disaster-prone areas allows them to manage and effectively guide their livelihood activities. Merapi local industry: sand mining, water, and forest exploitation; provides a living for much of the local community, and the broader sector contributes to the local economy by using the Merapi landscape as a tourism commodity.

Table 4.12 Summary of DRR Social Learning on CBED of Merapi Volcano Community

No	Key learning perspective	CBED Merapi
1	What is knowledge	The people understand Merapi's risk from volcanic activities but also understand that Merapi is their source of livelihood
2	How people learn	Managing the CBED cannot be separated from conflict management; therefore, solving the problem and making rules is part of social learning
3	Key theories	Situated learning: people learn about Merapi's hazards and resources, and the CBED conflicts are managed through community resolution
4	Role of the learner/instructor	Both visitors, local people, and external stakeholders work collaboratively to understand how to live in the Merapi area
5	Learning & teaching methodologies	Conflict resolution, problem-solving, and collaboration are the fundamental concepts in the social learning process

Source: Author, 2021

As illustrated in this study and the Sendai framework, DRR programs should not be separated from day-to-day economic activities because DRR is much broader than specially focused DRR programs, such as disaster drill prevention, disaster simulations, museum/diorama creations, or special seminars on policies.

4.4. The Transformative Capacity of Awareness Programs and Initiatives: Issues and Challenges

According to **Tables 4.13** and **4.14**, disaster awareness programs and initiatives in the Merapi Volcano community possess a transformative capacity. The program has dominated practice concerning the second elements (co-creation and collaborative elements) (TC2) and community participation (TC1). It indicates that the local community and other stakeholders have collaborated to address disaster-related issues in the study area. However, the remaining elements do not provide sufficient evidence to support this practice. The evaluation of the program's implementation remains absent.

Table 4.13 Identifying transformative capacity of disaster awareness programs and initiatives

No	Case Study	Theme	TC Elements	Evidence/Rationale	Implementation/ best practice on Merapi Narrations
e.g.,	*Safe School Learning (SSL)*	*education, community*	*2.1*	*It aims to increase the capacity of the school, students, teachers and staff, and the neighborhood around the school*	*a. Disaster knowledge and capabilities are informed regularly and well organized* *b. Safety of the school*
1.	Disaster Management Mandatory Training (DMMT) – *Wajib Latih Penanggulangan Bencana (WLPB)*	*community capacity building education*	1.1 2.2	1. Empowering **various stakeholders** to participate in the local community in disaster response	1. Mandatory disaster preparedness training in disaster-prone areas (DPA), including for paired villages (which get involved in sister village program) with all cycles of disaster risk management (prevention and mitigation, preparedness, response/emergency. and recovery) 2. It aims to increase the capacity building of the local community in reducing disaster risk and have better preparation for disaster **3. Focussed on the evacuation during emergency**
			1.2	2. Applying **inclusively** to all community members in the area.	4. Applying science and technology and incorporating elements of **local disaster knowledge**
			3.2	3. The community involved in designing disaster risk management, including the DRR, contingency plan, and **various scenarios** within these activities	5. This program has the main agenda: understanding the risk of Merapi and community-based early warning system (EWS) collaboratively, community mapping, and dissemination of disaster management policy from government to the community 6. The current program has been **conducted for local leaders**, especially on decision-making during emergencies. However, the drilling schedule and the event have involved all the community members (inclusively).
2.	Safe School Learning (SSL)	*education, community*	1.1 2.1	1. Capacity building of school residents by involving **various stakeholders**, from students, staff, teachers, local governments, community health office, a community near the school, NGO, and university/academia.	1. Safety, increasing knowledge, and attitude towards disaster preparedness are the goals of this program. It is designed to be implemented in 3 cross-learning activities: formal, informal, and non-formal 2. This program has been implemented through this mechanism: mainstreaming through school policies and regulations, allocating the budget, designing a contingency plan and EWS mechanism, forming a task force of school disaster preparedness, inserting disaster materials through extracurricular activities (scout and youth red cross)
			4.2	2. The SSL is to **disseminate information and education** through schools for disaster preparedness with the assistance of various stakeholders	3. This program also assures the **availability of supporting infrastructure** for emergencies (evacuation maps,

No	Case Study	Theme	TC Elements	Evidence/Rationale	Implementation/ best practice on Merapi Narrations
			2.2	3. It aims to **capacity building** of school as an institution and members such as students, teachers, school residents, and the community in the nearest neighborhood	evacuation procedures, evacuation gathering points, signs, medicines, evacuation equipment) 4. The activities are often limited to disaster simulations and dissemination. Not all designation programs have been implemented yet. 5. **Not all schools in the disaster-prone area (DPA)** have become part of the SSL program 6. The constraint of this program is that the portion of schools **budget allocation for DRR activities is limited**
3	Sister School	*education, network*	1.1 2.2	1. **Stakeholders work collaboratively** to design and implement the program	1. Prepare the school for preparedness in dealing with possible **emergency conditions**
			2.1	2. **Diverse and multi-level agencies** worked for this program, such as schools, local DMA, national DMA, the local community in DPA village, and paired schools, NGOs, and universities.	2. Ensure the **implementation of teaching and learning activities even though a disaster occurs**, especially for the school located in DPA. In the event of a Merapi eruption, the activities in the affected school will be moved to a paired school
			2.2	3. Schools in disaster-prone areas and paired schools are usually in a different area	3. To **mainstream the program**, there is signing the MOU between paired schools 4. This program involves the DMMT agenda, especially in the part of drill simulation.
4.	Sister Village	*network*	1.1 2.1	1. The **network-based** village communities that work **collaboratively** during disaster emergencies	1. This **program is utilized for emergency (evacuation**) in which pairing the village located in disaster-prone area zone 3 and the safer village, including pairing the community members (on a household scale). There is an MoU between the paired villages in implementing this program.
			4.1	2. Other the disaster emergencies time, these villages exchange **local product markets**	2. With this program, **preparedness during an emergency could be more measurable** such as logistic supply (food, toiletries, clothes, etc.), ensuring the governance of affected villages during emergency
			1.2	3. In the 2010 eruption, the IDPs experienced stress and psychological trauma because they lived in the evacuation shelter and had no activities for a long period. Therefore, **a sister village program was formed so that the IDPs would be** accepted into people's houses and do activities together during emergencies	3. There is a constraint of this program: the **possibility of horizontal conflicts** between IDP (internally displaced people) and the supporting village members.
			2.2	4. The paired villages in the sister villages program are in different areas	
5.	PASAG Merapi	*community*	1.1	1. **Empowering local communities** in DRR strategies and preparedness	1. **Improve disaster preparedness assistance** for the community. This community regularly participates in community-based disaster risk management (CBDRM) activities.
			1.2	2. Accommodating the **people's needs** in Merapi DPA, especially during **emergencies**	

No	Case Study	Theme	TC Elements	Evidence/Rationale	Implementation/ best practice on Merapi Narrations
			2.2 3.1	3. Increasing **community capacity** in disaster preparedness	2. The **vast area of Merapi**, across regencies/cities and provinces, hinders the coordination 3. There is **a limitation in tools and logistics inventory,** which means there is a dependency on external aids.
			4.1	4. Managing and participating in disaster management and emergency response training activities. Especially on the part of **ranchers and farmers in the logistic supply system** during emergencies.	4. PASAG members consist of people who live around the Merapi volcano and outside of this geographical area who has the same visions as PASAG
			2.1 2.2	5. Involving **multi-level government** and multi-sectors/agencies	5. This organization builds **a collaborative work** to distribute the information through community radio, Lintas Merapi 107.9 FM (a radio initiated by the JALIN Merapi)
6.	JALIN Merapi (Jaringan Informasi Lingkar Merapi)	*network*	1.1	1. **The community contributes** directly to reporting the Merapi condition based on visual and public perspectives or forwarding from authorized organizations in real-time through social media.	1. Using **various digital media platforms** to boost the targeted audience of information 2. The internal Jalin Merapi audience consists of Jalin Merapi volunteers, communication radio volunteers, and community radio networks 3. The internal audience is the primary source of updated Merapi information directly obtained from the field, such as visual and eruption of Merapi – based public capacity, area/location that need volunteers, the condition and logistic supply for the IDPs 4. Information from the internal audience is submitted to the Jalin Merapi digital media admin to be displayed on the website and then forwarded to all media platforms. 5. Through the Merapi website, accessors can find out the latest condition of Merapi, and donors can find out the needs that need to be distributed for the IDPs
			4.1 4.2	2. Dissemination of **information is faster** and more effective than conventional media, especially during an emergency.	
			2.1 2.2	3. Utilizing the society as the digital generation is in accessing the **digital platforms** for information distribution	
7.	Disaster Resilient Village (DRV)	*community capacity building*	1.1	1. **Communities are involved** in DRR strategies independently in design, formulation, and implementation.	1. Communities are involved in DRR strategies independently in design, formulation, and implementation. Independently here means that the community actively contributes and minimizes external support. As the community will be the one that they have to respond to the hazards of strike and external support not always being the fastest to reach, they must act right after the strike and do the preparedness before 2. This program used **a community organization approach**. The **disaster awareness has been**
			2.1 2.2	2. **Diverse and multi-level agencies** worked for this program	

No	Case Study	Theme	TC Elements	Evidence/Rationale	Implementation/ best practice on Merapi Narrations
			2.2 3.1 3.2	3. The community is given direct authority in disaster-related programs. However, it must be understood that a community-based program does not mean fully transferring the risk to the community; it is more about working collaboratively with the roles and capacity.	**internalized in the community** and **institutionalized in the village-level government** with policy and funding support 3. In this program, there are structural and non-structural mitigation, planning and preparing contingency plans, development of DRR action plan at the level of community, and capacity-building activities such as training and dissemination of disaster risk information
			4.1	4. This program is **an effort to establish a new system** to increase the effectiveness of the existing system in disaster governance	4. There are constraints on **the program's sustainability** since, in the current state, the involvement of youth is yet to strengthen
8.	Community–based Economic Driven (CBED)	*economic community*	1.1	1. **Communities** are involved in developing DRR strategies	1. Pentingsari and Kinahrejo tourism village, lava tour, and camping ground are an example of these programs and initiatives 2. Improving community economic **capital,** either in pre and/or post-disaster 3. These programs support the community disaster recovery **independently and collectively** 4. **Disaster literacy** practice 5. There is a constraint to this model: there is the **shifting process** to mass entertainment tourism instead of disaster education
			4.1	2. Helped with the development and improving **post-disaster economic** conditions	
			4.2	3. Added the **post-disaster recovery** strategy best practice	
			4.1	4. **Involving investors** to provide investment and loans as capital for the development of tourism activities	
			2.2	5. **Multi-agency**-based program implementation	
			3.1	6. This program has experienced **conflict resolution, problem-solving, and collaborative practice** through tourism management. For example, continuously monitoring and evaluating the guideline	

Source: [69,71,72,132,176,179,180,183,184,186–188,211,216,257–279]

Table 4.14 Mapping of transformative capacity in practice

No	Transformative Capacity Element Description	Keywords	P1	P2	P3	P4	P5	P6	P7	P8	
TC1	**Community participation (CP) and people-centered (PPC) programs design**										
TC1.1	Empowered community of practice	*Community involvement*	•	•	•	•	•	•	•	•	8
TC1.2	The people-centered oriented program designed	*People need inclusive planning, soft skill*	•			•	•				3
TC2	**Co-creation (CCR) and collaboration (CLB)**										
TC2.1	Diversity and transdisciplinary co-production of knowledge/ program/ initiatives	*Diverse stakeholders' involvement, creating knowledge/ program/ initiatives*		•	•	•	•	•	•		6
TC2.2	Diverse governance modes and network forms for implementing the programs/ initiatives	*Network Diverse stakeholders' involvement Program and initiatives implementation, capacity building*	•	•	•	•	•	•	•	•	8
TC3	**Reflective and learning – experienced-based approach (RE)**										
TC3.1	Enabling reflexivity and social learning	*Monitoring and evaluation; performance track*					•		•	•	3
TC3.2	Learning from tested solutions and practices	*Multiple alternatives practice and solution; path dependency. Experience-based*	•						•		2
TC4	**Innovation embedding (IE)**										
TC4.1	Resources Access	*Resources access; embedded innovation;*				•	•	•	•	•	5
TC4.2	Mainstreaming the transformative action	*Generalization; replication; policy framework;*		•				•		•	3

Notes:

1. P1 – program Disaster Management Mandatory Training (DMMT) – *Wajib Latih Penanggulangan Bencana (WLPB)*
2. P2 – program Safe School Learning (SSL)
3. P3 – program Sister School
4. P4 – program Sister Village
5. P5 – program PASAG Merapi
6. P6 – program JALIN Merapi (Jaringan Informasi Lingkar Merapi)
7. P7 – program Disaster Resilient Village (DRV)
8. P8 – program Community–based Economic Driven (CBED)

4.4.1. Understanding the issues: SWOT Analysis

From the finding of transformative capacity in practice, the SWOT analysis has been conducted to understand the issues and challenges in the study area within disaster governance and related issues. (see **Table 4.15).**

Table 4.15 SWOT analysis of transformative capacity in practice

STRENGTH	**WEAKNESS**
1. the local community commits to participate in disaster governance 2. have experience in co-creation and collaboration in practice 3. The community has been constructing their network-based interest towards Merapi, who live in the same geographical area or not.	1. A low level of youth group participation affects the program's sustainability 2. Lack of evidence in programs monitoring and evaluation 3. The community capacity profile causes a high dependency on external aids (for example, poverty) 4. Some programs have yet seen to be practically implemented as they were designed. For example, SSL is supposed to be a combination of formal – informal- and non-formal education. The formal curriculum design could not be answered this concept.
Key issues: community participation, networking in practice: co-creation, and collaboration	***Key issues: human capital, monitoring, and evaluation – reflective program implementation***
OPPORTUNITY	**THREAT**
1. A multi-agency approach in DRR strategies is an opportunity to share risk between the government, local community, and other stakeholders that work in the same area. 2. There are supporting policies and laws to support the programs and initiatives 3. Digital platform media could help the disaster governance 4. There is the flexibility to change and update contingency plan in supporting disaster governance based on the current necessity (COVID19 push the responsive plan, especially during an emergency – such as contingency plan, IDPs data, and shelter management) 5. Accommodate bottom-up panning for programs and initiatives that support disaster governance 6. In practice, the local community has extended the disaster awareness programs (DRR) to support their economic capital such as trade-offs, securing livelihood assets, and participating by occupation (supporting the emergency as their daily function such as farmer and ranchers)	1. The tourism sector experienced a shifting process to mass entertainment tourism instead of disaster literacy 2. The possibility of horizontal conflict in pairing programs (sister villages/schools) 3. The vast area of Merapi (2 provinces and four regencies/cities) hinders the coordination 4. The spatial diversity of the Merapi community has a different profile that could influence the disaster governance 5. The local disaster knowledge (LDK) has not been stored and passed to the next generation because of the lack of documentation and incomplete narrative story
Key issues: community planning in practice, co-creation, and collaboration, supporting disaster risk governance (policies, technology), economic capital in disaster risk governance	***Key issues: disaster risk governance (conflict management, coordination), disaster risk knowledge, economic capital***

4.4.2. The issue in shifting approach of disaster risk governance: transformative capacity in Community–based Economic Driven (CBED)

Disaster risk reduction (DRR) efforts have been questioned when pre-event disaster awareness programs do not meet expectations during the emergency [12]. Even though a community may have attended a DRR program and understand the disaster risks, they may not have been involved in appropriate emergency preparation. Therefore, there need to be alternatives to disaster awareness programs and initiatives.

Along with disaster education, preparedness activities, and capacity building, disaster awareness raising is a soft DRR measure [74,118]. Awareness programs are expected to increase the local community's capacity to deal with the complex consequences of disaster events. Initially, in the pre-event context, this awareness raising should increase the individual and community abilities to access knowledge and understand basic infrastructure. Even though many local community members have unequal access to these resources, this has tended to be ignored within national DRR policies and programs [233].

Current DRR awareness programs focus on specialized purposes only, such as disaster training drills and prevention, seminars/conferences, or community training. Accessing resources, including utilizing the assets needed to make a living, is essential for local communities living near hazard epicenters to sustain their lives during emergencies and over the long term. Therefore, using a combined DRR that raises disaster awareness and focuses on the people's livelihoods could fill the gaps between risk knowledge and preparedness and provide opportunities for developing multi-functional economic community initiatives near the hazard epicenter.

This research used transformative capacity (TC) to identify how local initiatives could be included in an alternative DRR program by combining livelihood and DRR activities to achieve higher disaster awareness-raising outcomes. TC enables structural changes to achieve sustainability goals [106]. If added to disaster governance, this capacity can develop resilience thinking and ensure system functions continue to work after a disaster [87]. Aside from these changes, the application of TC enables the creation, diffusion, and embedding of novelties, such as new ways of organizing, producing, consuming, and thinking through social, technological, and governance innovations, into community structures, cultures, and practices [22]. A TC focus allows for alternative solutions to be found when there are significant or prolonged disturbances and unsolved

challenges [7] and can activate risk knowledge and preparedness. TC inclusion could include programs and initiatives that improve infrastructure, support social protection mechanisms, provide essential social services, and develop institutional capacity [280].

This study used four TC elements based on their functions to identify the economic-driven local initiatives that could be associated with DRR: (1) community participation (CP) and people-centered (PPC) program designs; (2) co-creation (CCR) and collaboration (CLB); (3) reflective and learning-experienced-based approaches (RE); and (4) innovation embedding (IE). It also focused on disaster governance and the disturbance of freedom [281]. Therefore, this study was related to accessing resources at a community level, with the four TC elements being constructed based on the workings of a functional system: (a) agency and the interactions, and (b) process [22,106,117,128].

Community participation (CP) and people-centered (PPC) program designs require active community participation, inclusive planning, understanding of community needs, and soft skill capacity building. Co-creation (CCR) and collaboration (CLB) involve diverse stakeholders creating or implementing knowledge/ programs/initiatives. The reflective and learning-experienced-based approach (RE) accommodates monitoring and evaluation using a recorded performance track and requires experimentation and ideation based on experience and program testing to answer challenges. Innovation embedding (IE) embeds the innovation process required to access the resources and needs to be supported by a regulatory framework to widen the impact.

This study was an extension of a previous study that examined social learning DRR efforts and their combination with community-based economic activities [127]. The previous research found that the Merapi volcano community in Indonesia understood the DRR behaviors needed to reduce the disaster risks of community members and external stakeholders, such as visitors, government, or NGOs. This research used the same three Merapi community-based economic driven (CBED) initiatives; lava tours, tourism villages, and camping ground services; all of which had been significantly affected by the volcanic eruption in 2010. These cases were examined to determine an alternative DRR approach using satisfactory TC elements. Some initiatives had been in place before the 2010 eruption, such as the tourism villages, and other initiatives emerged after the disaster (i.e., lava tours). This study sought to identify which TC elements in the three cases had enabled environments that allowed changes to be made to resolve the remaining DRR challenges, such as determining a balance between the disaster awareness programs and proper preparedness

4.4.2.1. Research Method

This study used a qualitative approach to identify the evidence that met the TC elements. Both primary and secondary data were used to obtain information on the community's DRR issues and livelihood activities. The primary data was collected by observation in 2018–2019 and the secondary data consulted was previous literature, reports, and journals. To describe what the people do in the Merapi Volcano area from a socio-constructivist perspective, the data were analyzed using qualitative descriptions connected with the TC elements: (1) community participation (CP) and people-centered (PPC) programs design; (2) co-creation (CCR) and collaboration (CLB); (3) reflective and learning-experienced-based approach (RE); and (4) innovation embedding (IE).

The remainder of this paper is organized as follows. Section 2 outlines the research method, section 3 identifies the transformative capacity of the CBED local initiatives in the Merapi volcano community, section 4 discusses the findings, and section 5 concludes the paper.

4.4.2.2. Community-based economic driven: social learning for DRR

Merapi, a stratovolcano, is located 25 km north of urban Yogyakarta in Indonesia. More than four million people live within 30 km of the volcano, making it one of the world's ten most densely populated areas around volcanoes [42]. The 2010 eruption caused significant damage and losses with 367 fatalities, 277 injuries, the displacement of 410,388 people [44], and losses of around USD 256.4 million [54]. Before the 2010 eruption, the people in Merapi depended on the land and the rivers for their livelihoods, as well as the agricultural sector, mining, and community services. After the 2010 eruption, novel economic sectors emerged, such as trade, restaurants, lodging, and tourism services (Lavigne et al., 2008; Sikoki et al., 2013; Saragih et al., 2014; Lavigne, Morin, and Surono, 2015). Before the 2010 eruption, the Merapi community had developed a community-based eco-tourism concept. Other activities, such as lava tours, emerged after the 2010 eruption [57]. The spatial settings at Merapi, which accounted for the disaster risk, were designated for specific activities (education, tourism, and intensive agriculture).

The three main CBED activities are a tourism village in Pentingsari, a lava tour, and camping ground management. Located in Umbulharjo, Cangkringan, Sleman, Pentingsari was a tourism village before the 2010 eruption. As well as the activities associated with the tourism village management, agriculture has dominated most full- and part-time livelihood choices [57]. The tourism village concept involves learning with the local community and

using eco-tourism to highlight the relationships between the people, their environmental setting, and the Merapi volcano. Visitors can join various activities, such as outbound activities, walking tours, and cultural arts performances. The walking tour visits a local coffee plantation, where tourists can learn about post-harvest production, a gamelan (a traditional instrument) performance, workshops on making traditional toys and decorations, and visits to herb gardens and to the local spring to learn about local water conservation. The local guides tell tourists stories about the Merapi volcano area, outline the advantages and disadvantages of living there, and provide them with some disaster risk knowledge.

The lava tours began after the 2010 eruption. These jeep tours visit several tourist attractions related to Merapi, such as the post-disaster museums and villages, forests, and plantations. Tour providers collaboratively manage these activities with the people living in the tourist attraction areas. Several tour types, such as long, medium, and extended, are offered based on the number of visited attractions and the tour length. The tour also provides a wet track that allows visitors to explore a river in Merapi.

Table 4.16 Summary of DRR Social Learning on CBED of Merapi Volcano Community

No	Key learning perspective	CBED Merapi
1	What is knowledge	The people understand Merapi's risk from volcanic events but also understand that Merapi is their source of livelihood
2	How people learn	Managing the CBED cannot be separated from conflict management; therefore, solving the problems and making rules is part of social learning
3	Key theories	Situated learning: people learn about Merapi's hazards and resources, with any CBED conflicts being managed through community resolution
4	Role of the learner/instructor	Visitors, local people, and external stakeholders work collaboratively to understand how to live in the Merapi area
5	Learning & teaching methodologies	Conflict resolution, problem-solving, and collaboration are the fundamental social learning process

Source: Mutiarni and Nakamura [127]

The last CBED activity revolves around camping services at the community-managed camping grounds, such as Klangon Hill, The Cengkerama, Kali Petung, Karang, Kaliurang Forest, Wonogondang, Sinolewah, and Bumi Lembah Merapi. Some camping grounds are also managed together with the private sector. The Klangon Hill campground, which has a campsite, an outdoor sports area, and a downhill cycling area, is the nearest to Merapi,

DRR programs were embedded in the people's daily lives and included economic activities focused on livelihood assets. A DRR program does not have to comprise only

disaster-specific programs, such as disaster drills, seminars, or training. The observation of the Merapi CBED agenda revealed that there was a broader awareness-raising context in the DRR Merapi Volcano activities (see **Table 4.16**). The community's knowledge about the disaster-prone areas allows them to effectively design and guide their livelihoods. DRR programs should cover a much broader context and should not be separated from the local people's day-to-day economic activities in disaster-prone areas.

4.4.2.3. Discussion

The four TC elements were used to understand how the three community-based CBED activities supported DRR initiatives, which involved observing the existing practices and identifying the enablers for transformative DRR.

1. **Community participation (CP) and people-centered (PPC) programs were designed.**

   The three CBED activities were found to all involve TC because the activity management involved the local community. However, the TC analysis did not reveal the connections between DRR actions and livelihood strategies. It could only be concluded that the combined efforts helped enhance community resilience.

   It was found that the CBED management systems allowed community members to participate in tourism activities. Because most community members worked full-time in agriculture and part-time in tourism, it was apparent that tourism activity opportunities were available to all.

2. **Co-creation (CCR) and collaboration (CLB)**

   The management of the CBED activities involved community collaboration, such as the tourism village management and the lava tour providers. Management also received assistance from some external stakeholders, such as the local government, to enhance soft skills training, provide conflict resolution, and assist in providing professional management advice on tourism. This indicated that efforts were being made to understand what the locals needed, and the compromises needed between the DRR activities and livelihood strategies.

3. **Reflective and learning – experienced-based approach (RE)**

   Previous research used a social learning framework to analyze CBED and DRR activities. It was found that when these two were combined, it was possible to reach a wider group, which included the local community and external stakeholders. These activities involve learning about the Merapi Volcano disaster risks through experience-

based learning, monitoring and evaluation, conflict resolution, and collaboration. For example, the management guidelines for the redesign of the CBED programs/initiatives reflected the focus on a continuous learning process.

4. **Innovation embedding (IE)**

   When managing some activities, including the CBEDs in Merapi Volcano, there was a time when the guidelines could no longer meet the management needs, such as dealing with an increase in visitors with limited resources. Because of the substantial disaster risks in specialized tourism destinations such as Merapi Volcano, many adjustments are needed, such as dealing with the Merapi emergency warning system. This means that both the management and the visitors must focus on safety as the main issue, within which the people can develop their narrative norms for living in harmony with the hazards.

The CBED activities in Merapi were found to include TC elements in practice, which in turn supported transformative DRR through their disaster awareness-raising efforts. **Table 4.17** gives a summary of the TC elements and the context and evidence indicators, based on which, the following take-home lessons were developed:

1. experience and evidence-based learning are critical to increasing social learning engagement,
2. continuous learning helps the community and external stakeholders understand reflective concepts,
3. conflict resolution accommodates changes, which is the nature of innovation,
4. embedded learning engenders embedded innovation for the creation and design of the narrative norms for living in harmony with hazards, and
5. conflict resolution, problem-solving, and collaboration are the fundamental social learning concepts.

Implementing these three CBED initiatives exemplifies how existing programs can be transformed into alternative approaches to resolving local disaster governance challenges, such as the mismatch between DRR efforts and preparedness, prolonged resettlement processes, and accessing resources of equal value.

Table 4.17 Transformative Capacity (TC) elements on CBED of Merapi Volcano Community

No	Transformative Capacity Element	Keywords	Evidence/ Data
TC1	**Community participation (CP) and people-centered (PPC) programs design**		
TC 1.1	Empowered community of practice	*Community involvement*	Communities are involved in developing DRR strategies, and participate in designing the programs
TC 1.2	A people-centered oriented program designed	*People need inclusive planning, soft skill*	Programs are designed by the community for the community (including visitors)
TC2	**Co-creation (CCR) and collaboration (CLB)**		
TC 2.1	Diversity and transdisciplinary co-production of knowledge/ program/ initiatives	*Diverse stakeholders, involvement, creating knowledge/ program/ initiatives*	There is no clear evidence of this indicator in each case
TC 2.2	Diverse governance modes and network forms for implementing the programs/ initiatives	*Network* *Diverse stakeholders' involvement* *Program and initiatives implementation, capacity building*	The community receives assistance from external stakeholders for capacity building and conflict resolution
TC3	**Reflective and learning – experienced-based approach (RE)**		
TC 3.1	Enabling reflexivity and social learning	*Monitoring and evaluation; performance tracks*	The CBEDs experience conflict resolution, problem-solving, and collaborative practice through tourism management; for example, by continuously monitoring and evaluating the guidelines
TC 3.2	Learning from tested solutions and practices	*Multiple alternatives practices and solutions; path dependency. Experience-based*	
TC4	**Innovation embedding (IE)**		
TC 4.1	Resources access	*Resource access; embedded innovation;*	Improving the community's pre and/or post-disaster economic capital
TC 4.2	Mainstreaming the transformative action	Generalization; replication; policy framework;	Part of disaster literacy in practice

Source: Authors, 2022

Table 4.17 shows that three CBED cases analyzed in this research had TC enablers. However, it was difficult to quantitatively assess the results. For example, based on the percentage of the community working in tourism compared to the whole village population or the participation ladder, the CP in the tourism village management was possibly different from the CP in the lava tours [283,284]. The tourism village initiated through the community neighborhood systems may have developed because of perceived place attachment [24,26,27]. However, the lava tours were established after the 2010 eruption to highlight the cultural narrative value in the area. The lava tours cover a broader area than the tourism village and camping grounds to better access the local livelihood assets after the disaster. it is understandable because their attribute in accessing livelihood assets will determine the premise of response. It would lead to unfreedom the development was also driven by the pre-event conditions [285].

How the community has managed the CBEDs based on capacity has strongly influenced the programs and initiatives that could be TC enablers. For example, the conflict resolution between the lava tour providers and the jeep drivers differed from the closed

community management of the tourism village or the camping ground areas. There is a possibility that the conflicts resulting from unmet expectations were related to resource access and that the negotiation process and the stakeholders were different. An example of this conflict was when a driver, who directly connected with the visitors, did not follow the established lava tour activities, even though they knew that a specific track had to be followed (Tanaamah, Prabawa, and Rupidara, 2017; Aditya, 2021). In the tourism village, the conflicts were often associated with visitor distribution equality for the accommodation providers. This conflict was resolved by revising the previous guidelines and adding additional terms. To a certain extent, additional efforts such as capacity building on soft skills issues also become a solution for the types of management issues. To ensure a focus on disaster risk issues, the tourism activities around Merapi have strict management and condition-based guidelines on Merapi Volcano activities that visitors must obey. If the volcanic activity limits activities around the volcano, the tourism area must be closed, and visitors cannot enter.

Based on this brief description, the TC analysis indicated both the changes and the interdependencies between the TC elements and practices. As accessing resources determines how people respond to specific issues, these cases could be examples of how tourism activities related to livelihoods and disaster governance can be complementary. Similar to this finding, transformative capacity and the interdependencies between the TC elements require a multidimensional perspective [75,78,117,128].

4.4.2.4. Conclusions

Transformative capacity (TC) accommodates changes to certain system functions to overcome community disruptions following a disaster and the development of alternative approaches to include disaster governance in people’s daily lives to ensure sustainable functional systems. Using four TC elements, this study examined three CBED activities in the Merapi Volcano area to identify how current livelihood-related activities could also function as DRR activities and function as enablers to overcome the remaining disaster governance challenges.

Through the TC element lens, it was found that by developing and participating in the Merapi community-based tourism activities, locals, management teams, and visitors were made aware of the broader DRR contexts. The community's understanding of their disaster-prone areas allows them to manage and effectively guide their livelihood activities. Merapi local industry: sand mining, water, and forest exploitation; provides a living for the

local community and contributes to the broader local economic sector by utilizing the Merapi landscape as an asset. Overall, it was found that CP and people-centered programs, collaboration, reflective learning, and innovation had been put into practice as part of the CBED activities. The only TC element not clearly identified was co-creation, possibly because the local community had initiated these CBED activities. The results indicated that TC was more than the ability to instigate changes as it also involved the interdependencies between the TC elements that allowed for the modeling and assessment of the programs and initiatives. As the TC performance levels are yet to be determined, further research is strongly recommended to enhance preparations for transformative action.

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CHAPTER 5
EXPLORING THE OPPORTUNITY OF TRANSFORMATION: THE ROLE OF COMMUNITY IN DISASTER RISK REDUCTION (DRR) PROGRAM AND INITIATIVES FOR STRENGTHENING RESILIENCE

5.1. Background

Even though resilience theory is widely discussed in different disciplines, its use in the context of disasters, climate change, and development is still relatively new [9]. This paper uses the definition for resilience put forth by the United Nations International Strategy for Disaster Reduction (UNISDR) [83]: "The ability of a system, community, or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management." The concept of resilience is linked to community or social risk in a disaster-prone area. This focuses on ensuring the system's functioning after a shock [87] and understanding that resilience is a process, rather than an outcome, where the roles of community and society become an essential factor, and these can only be embedded in the society through a disaster risk reduction program. Furthermore, since preparedness is the key to reducing potential risk, it must be done beforehand and be well designed and tailored to the needs of people [9,10].

In recent years, disasters have proved to be enormous obstacles to sustained development and progress and a challenge to the well-being of communities worldwide [5]. In 2020 alone, aside from the COVID-19 pandemic, there were 389 recorded disasters, which resulted in 15,080 deaths, 98.4 million people affected, and an economic loss of at least 171.3 billion USD [6]. A disaster is a combination of technical faults and a failure of social systems made up of technical, social, organizational, and institutional factors [8], primarily induced by human activities [9–11].

There are three domains to understand risk analysis of disaster in society: the environmental changes and shocks, people's exposure, and prevention and response systems. Exploring how people cope with the environmental changes and shocks, depending on their capacity and their vulnerability profile, can aid us in understanding about the human side of disaster research [101]. Such exploration could consider a communities' perception, socio-economic enablement, information, communication, expectation, risk culture, age, gender, and other forms of social differentiation [101]. These social differentiations can lead to a variable range of vulnerability levels, both at individual and community levels. For example, different gender and age groups will face different difficulties and need different emergency aid during an emergency.

As people's decisions and behaviors at pre-event, during, and post-event situations can dramatically affect the impacts, vulnerability, recovery time, and resilience of individuals and communities [110,111], it is essential for local community living near the hazard to be aware about their risks [112,113]. This belief aligns with the evolution of DRR thinking and policy that has begun to foster public engagement, social capacity, community participation, and individual responsibility [110]. These people-centered approaches are based on the assumption that involving people in risk decisions empowers them, encourages ownership, responsibility, and participation [112,288]. However, convincing individuals to embark on activities that would reduce their vulnerability to natural hazards is difficult, especially in communities that have not recently experienced the impact of natural hazards [113]. In addition to this, there are community who do not want participate in the preparedness activities because they think that they cannot influence the natural process impact, such as a natural hazard [12]. At this point, it is necessary to help the community understand that they could intervene this condition: they can reduce the risk, as well as recover faster and better even after disaster strikes.

Although realizing that an assessment of people's exposure in the context of disaster risk is essential for local community, assessments are often conducted in the post-disaster

context. Considering that DRR is a continuous learning process [118,119,121–125], as well as the importance of reflective responses to deal with more complex and uncertain risks [102], it is essential to see the relationship between people's exposure and their social attributes in the pre-event context especially in communities which have experienced past disasters. This can facilitate the formulation of more people-centered DRR programs. For example, a program for families with children in primary and secondary school age, or for those with vulnerable family members (children, parents, vulnerable women, and people with disabilities). Consideration of such people-centered approaches to strengthen community disaster resilience can allow to understand how demographic factors can influence the necessary actions at every stage of disaster response at each of the respective levels of the individual, household, and community [87,103,289]. In this regard, several indicators are commonly used to measure the people's exposure to disaster in society, such as: (1) household structure (household headship, marital status, and type of family); (2) socio-economic status (income, wealth, political power, and education); (3) gender; (4) race and ethnicity; (5) age; (6) tenure; (7) urban or rural; (8) special needs population; (9) employment status; and (10) time spent living in the neighborhood [87,101,103].

The reports and studies on the experiences of the 2010 Merapi Volcano eruption a suggest that individuals' social profiles determine how they think about the Merapi Volcano [55]. This research tries to understand this point further and explores how the Merapi community understand risk, either through their own experiences with Merapi eruption in 2010, and/or due to the DRR programs held, and contribute towards providing a longitudinal and reflective study from the past. To recommend designing a more people-centered DRR program for the community, this study attempts to reflect the community's performance through individual attributes of the community (i.e., demographic profile) and pre-event DRR aspects (risk knowledge, information access, and network and stakeholders). This research hypothesizes that different individuals in the community, as indicated by their attributes, understand the disaster risk, access the risk information, and network and stakeholders, to prepare for the possibility of more complex and uncertain disaster risk in the future. This research attempted to investigate which community capability may be able to influence a shift in the approach to living with natural hazards.

5.2. Study Area

Merapi Volcano (**Fig. 5.1**) is home to around 1.6 million people, located 25 km north of urban Yogyakarta, Indonesia, [44–48]. Merapi, one of the many stratovolcanoes in

Indonesia, has an altitude of 2980 m and has erupted at least 80 times since 1768, the most significant of which (Volcanic Explosivity Index–VEI ≥ 3) were in 1768, 1822, 1849, 1872, 1930–1931, 2010, 2014, and 2018 [53,54]. The earlier eruptions had higher VEIs, but the 20th century eruptions were more frequent [53]. In 2010, there was a large-scale explosion of this volcano which caused 367 fatalities, 277 injuries, displaced 410,388 people, 2300 destroyed houses [44], and caused losses of 256.4 million USD [54]. Prior to the 2010 eruption, the people of Merapi depended on nature for their livelihoods: land and rivers, namely the agricultural sector, mining, and community services. After the 2010 eruption, however, different economic sectors emerged, such as trade, restaurants, lodging, and tourism services sectors [24,50,55,282]. The Merapi community was involved in the tourism sector before the 2010 eruption through concepts, such as the development of community-based tourism as an eco-tourism village, but other activities, such as a lava tour, have also emerged after the eruption 2010 [57].

The zoning system on volcanic risk in Indonesia is instrumental in influencing the level of vulnerability, especially in the case of evacuation during an emergency. There are two zoning on volcanic risk, (1) Spatial zoning which consists of three different levels on the disaster-prone area (DPA): (Disaster Prone Area Zone I (lowest risk), II, and III (highest risk)), as well as (2) time zoning which consist of 4 stages based on the volcano activities: normal active (base), attention (advisory), pre-alarm (watch), and alarm (warning) [50,55,174]. At the 2010 eruption, although this risk zoning system was implemented, the disaster-prone area zone had changed due to changes in the character of Merapi's activities suddenly. The public were not aware of the changes due to the limited information channels and lack of preparation for emergency conditions at the time, with the effect of which was compounded due to a larger scale of eruption compared to the past [55]. As a result, the pyroclastic flows of up to 13 km from the Merapi's crater on the 2010 eruption forced people living in a radius of 17–20 km to evacuate. Therefore, this study was conducted in an area within a 20 km radius of the Merapi Volcano **(Fig. 5.1).** The south area of the volcano has shown rapid urban growth [290], which has influenced the emergence of secondary urban areas, such as Pakem and Tempel, located less than 20 km from Merapi (see A and B in Figure 5.1).

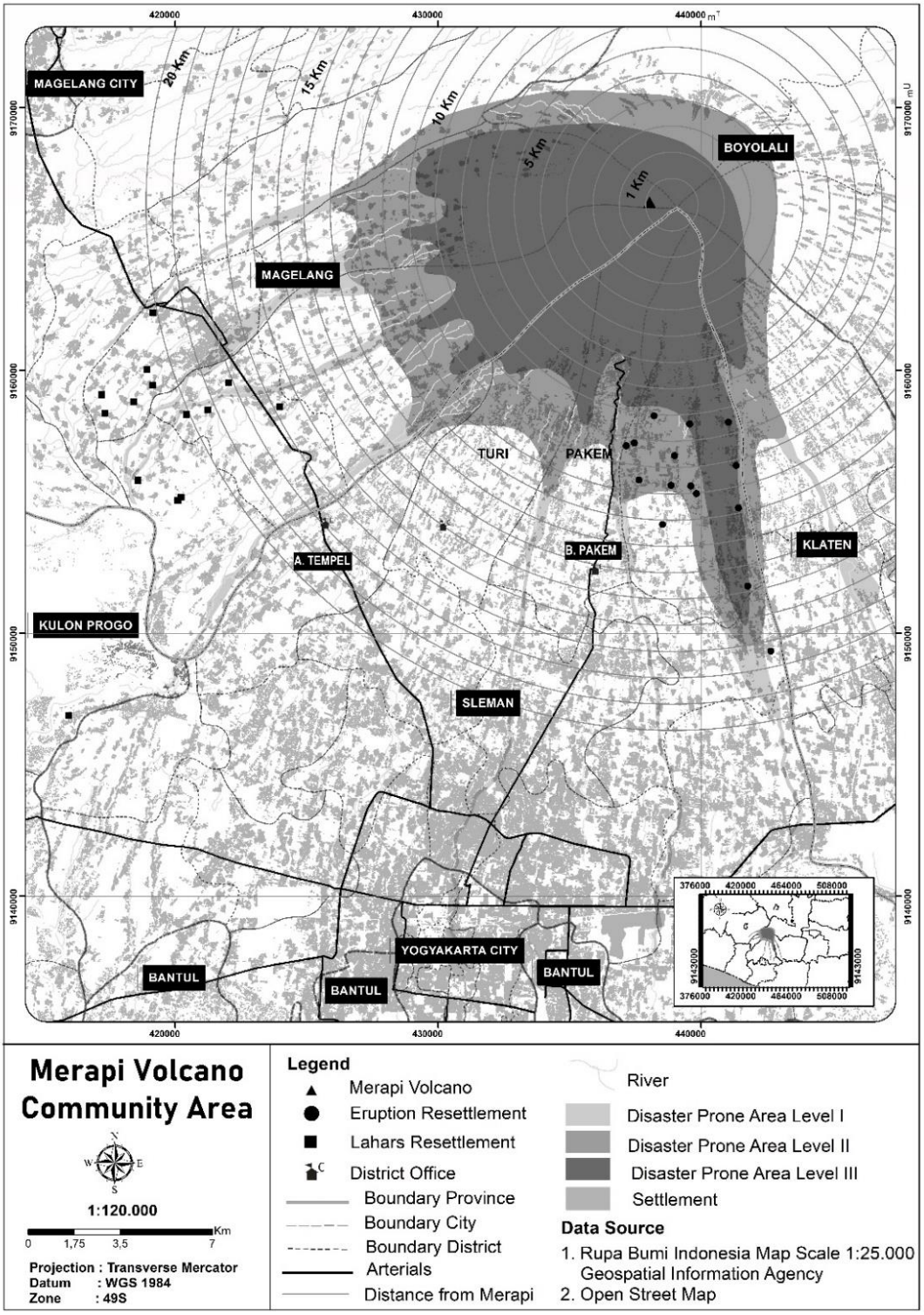

Figure 5.1 Merapi Volcano community area map.
Source: Author, 2021
Data resources map: 1. Topographical Map [36]; 2. Open street Map [37], 3. Hazard Map Merapi [38]

The DRR program at Merapi is undergoing development and consolidation. Each phase of the disaster management cycle has a corresponding program, as stated in the DRR strategy, such as risk assessment programs, spatial planning reviews, disaster preparedness schools (currently called School Safe Learning (SSL)–*Satuan Pendidikan Aman Bencana*), Disaster Preparedness Village (DPV), Disaster Resilient Villages (DRV), and River Schools, strengthening the infrastructure sector, strengthening the economic sector. These have been carried out at various levels from provinces to village, through Disaster Management Mandatory Training (DMMT) [174].

Aside from this, several networks and community-based activities have been implemented through Merapi communities, such as the implementation of a sister village, sister school, community-based risk reduction forum (PASAG Merapi), and community-based communication network (JALIN Merapi) [55]. These programs and networks were developed before the 2010 eruption since the communities experienced several recurrent disaster events. For example, the risk reduction forum (PASAG Merapi) was founded after the 1994 eruption.

A decade after a catastrophic volcanic eruption in 2010, the Merapi Volcano community in Java, Indonesia, has been living with a high possibility of recurrent volcanic hazards. On 5 November 2020, the level of volcanic activities of the volcano was raised [65][41], and, since then, there have been 16 eruptions [66,67], where 836 people from vulnerable group have had to be evacuated [66]. With the geodynamics of volcano being uncertain [68] and the added complexity of the reliance of local communities on the volcanoes, strengthening disaster resilience governance would remain a challenge. Some community members have experienced permanent displacement from their previous neighborhoods because of the 2010 eruption, and some new members from the community have also moved voluntarily after the 2010 eruption due to the urbanization in the south part of Merapi.

Yet, despite the uncertainties surrounding the spatial nature of the next volcanic eruption, due to limited resources, the government has been implementing DMMT as DRR programs only for people living in disaster-prone areas. After the disaster training, the local community who filled the post-training-survey mentioned that they were confused about translating the concept of hazard map into reality [55,64,69,70]. During the 2010 eruption, people were confused when the government evacuation warning was issued based on the proximity (20 km distance) from Merapi, rather than the disaster-prone area identified by the existing hazard map based on the magmatic activity and the volcano morphology. This

call had been made to be on the safer side and evacuate more people given that the scale of the 2010 eruption was higher than assumed by the hazard map. However, this resulted in confusion among people who were outside the disaster-prone area (DPA) and considered themselves safe from the risks. This implies that a wider area implementation of DRR programs is necessary to educate the wider community of the risks and prepare for an emergency.

Such awareness would also help the community utilize their networks and cooperate to evacuate themselves and their livestock to their sister villages (a sister village network is a network that connects the villages in Merapi disaster-prone area with buffer villages that are located in the Merapi safe zone [71,72]).

5.3. Data and Methods

This study used mixed method, using both quantitative research methods (non-parametric and parametric statistics), and the qualitative method

5.3.1. Survey and Sampling Design

Nonprobability purposive sampling was used in this research to understand Merapi communities' perspectives on several disaster issues (risk knowledge, information, and DRR program in pre-event). This sampling design helps to explore the phenomena that is happening in the area without generalizing the result for the community. Although this sampling method can lack clarity in the generalizing process and be biased to the population profile [291], it allowed the authors to reach the respondent population for data collection given the specific spatial distribution, time limitation, and several local community procedures for entering the community during the pandemic.

Assuming that Merapi community has a similar land tenure system [292–295], ethnicity, and race [296], and location in the rural area [50,55,297,298], only seven socio variables of people exposure [87,101,103] are used: gender, age, time spent living in the neighborhood, education, income, daily activity, and household profile **(Appendix A Table A1)**. This survey was conducted among people who either (1) live within 20 km of Merapi, or (2) have experienced the Merapi eruption of 2010, or (3) have been either temporarily or permanently displaced by the 2010 eruption. In addition, the definition of 'Merapi community' is taken to be the community living in 20 km proximity from Merapi Volcano. As this research aims to understand the public perception of people's exposure around Merapi Volcano, this study did not specifically target residents who participated in

DMMT who live in all levels of DPAs (see **Fig. 5.2**) since DMMT has been widely conducted in these areas since 2008 [64,69,131].

The survey was conducted using questionnaires through various streams, such as personal social media, public accounts, local influencers, and stakeholders' networks with whom the researcher previously worked. From a total population of 1.6 million near the Merapi Volcano, this online survey could obtain 215 usable responses through a reach of 476 people who completed an online survey between September and December 2020 on the online survey platform Survey Monkey **(Appendix A Table A1, Tables 1 and 2)**. Since the online survey cannot ensure the adequate spatial distribution of respondents, nor control who fills the questionnaire, it is acknowledged that the population profile can be biased. However, to reduce the unfit criteria of respondents, we required address information to be filled on the survey. Considering the data saving and the voluntary participation in this research, privacy consent obtained in the online survey provides an explanation on how the data is to be used and saved in the system. With this, the respondents have the choice to fill the survey or not.

Table 5.1 Individual attributes of respondent profiles

Description	Observed Frequencies	Percentage (%)
Sex		
Female	139	64.7
Male	74	34.4
Not stated	2	0.9
Age–A (years)		
$A \leq 24$	47	21.9
$25 < A \leq 54$	142	66.0
$54 < A$	21	9.8
No answer (N/A)	5	2.3
Duration staying in the neighborhood (years)		
$D \leq 10$	55	25.6
$10 < D \leq 30$	95	44.2
$30 < 30$	63	29.3
No answer (N/A)	2	0.9
Education		
Primary	27	12.6
Secondary	82	38.1
Tertiary	101	47.0
No answer (N/A)	5	2.3
Monthly income–I (USD) [1]		
Do not have fixed monthly income	65	30.2
$I \leq 210.42$	67	31.2
$210.43 < I \leq 350.70$	35	16.3
$350.71 < I$	22	10.2
No answer (N/A)	26	12.1
Daily life activity		
Work and homemakers	163	75.8

Description	Observed Frequencies	Percentage (%)
Unemployed and retirement	18	8.4
Students	32	14.9
No answer (N/A)	2	0.9
Household profile		
Single person HH	18	8.4
Couple without child	8	3.7
Parent with one child or more	146	67.9
No answer (N/A)	43	20.0

[1] 1 USD = 14,257.199 IDR (1 March 2021).

Table 5.2 Descriptive statistics on disaster risk reduction variables.

Description	Observed Frequencies	Percentage (%)
The accessibility of disaster information		
Yes	137	63.7
No	20	9.3
Maybe	51	23.7
Do not know	7	3.3
Awareness of Community based Disaster Risk Management (CBDRM) Organization existence in the community		
Yes	76	35.3
No	80	37.2
Maybe	59	27.4
Experience with DRR program(s)		
Yes	38	17.7
No	41	19.1
Maybe	8	3.7
No answer (N/A)	128	59.5
Advantages of DRR program for preparing the community for a possible threat		
Yes	40	18.6
No	0	0
Maybe	6	2.8
No answer (N/A)	169	78.6
Prioritizing the vulnerable group during and after the emergency		
Yes	143	66.5
No	13	6.0
Maybe	59	27.4
The importance of women group on the decision making and DRR		
Yes	102	47.4
No	26	12.1
Maybe	87	40.5
Perception for collaborating with external stakeholders would give advantages for community preparedness		
Yes	176	81.9
No	3	1.4
Maybe	36	16.7

5.3.2. Data Analysis

In this study, the data analysis is conducted in two stages: a non-parametric test and a parametric test (see **Fig. 5.2**). The non-parametric test was used to see whether the social attributes of the community have dependencies to the implementation and outcome of pre-event DRR context (risk knowledge, information access, and network and stakeholders) in their community. A parametric test was used to see if the individual sub-variables could become the predictor of implementation and outcome of DRR programs based on the significant result from the non-parametric test (the goodness-of-fit test)

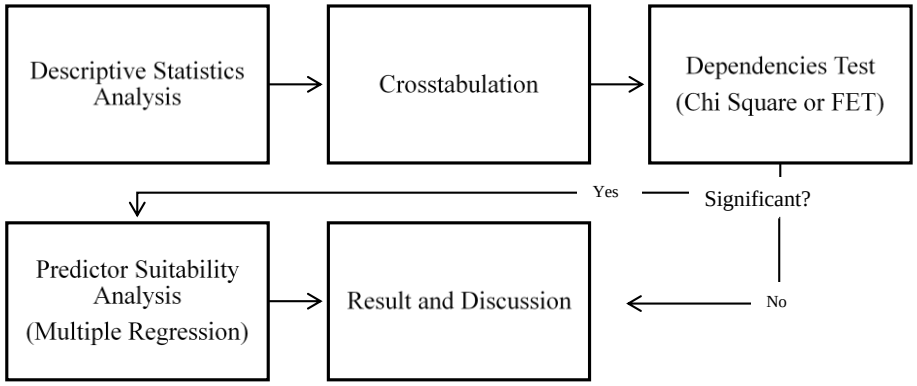

Figure 5.2 Data analysis flowchart.
Source: Author, 2021

5.3.2.1. Tools

IBM SPSS Statistics for Windows, version 27, was used in this study [299] to perform the descriptive analysis, calculate goodness-of-fit, and multiple regression. No answer (N/A) data has been omitted for the purpose of the statistical analysis.

5.3.2.2. Descriptive Analysis

The first analysis stage determined the respondents' attributes: gender, age group, activity, education, time living in their current neighborhood, and monthly income **(Table 5.2)**. This portion of the survey was voluntary, and not all respondents completed this section; however, the analysis excluded blanks in these fields.

Observed frequencies were also determined from the answers regarding the perceptions in the Merapi Volcano community to several questions related to the implementation of DRR: risk knowledge, information access, and network and stakeholders: (1) where did the community get their information; (2) what information did they receive; (3) how was the information accessed; (4) what experiences did they have of

DRR programs and of what type; (5) what advantages did the DRR program have for preparedness; (6) was there a CBDRM organization in their community; (7) did the DRR programs involve all community groups, including the vulnerable and women; (8) could they give an example of the role of women in the DRR programs in the community; (9) and what were their thoughts on collaborating with external stakeholders for disaster-related issues to provide advantages for preparedness? These variables were mainly processed in nominal data types and used to describe community perceptions for disaster-related issues.

Based on these variables, questions (excluding individual attributes) used for the next stage (goodness-of-fit test) require categorical data, such as yes, no, or maybe. These are question numbers 11,12, 14, 15, 16, 17, and 19, shown in **Appendix A Table A1**.

5.3.2.3. The Goodness-of-fit Test

The goodness of fit test assesses whether the observations or responses for one variable are associated with or independent of another [300–303]. This study used the Pearson chi-square test and the Fisher-Freeman-Halton exact test (FET) for analyzing goodness-of-fit. Chi-Square test is the first dependency test, for which some assumptions should be met [300,301,304]: (1) randomness of the sample, (2) independence between observations in each category; and (3) frequency of at least five for each category. If these assumptions cannot be fulfilled, another statistical model, such as FET, should be used for the goodness-of-fit [305]. Since, in this study, assumption (3) mentioned above could not be fulfilled, FET was conducted.

To conduct these tests, a null hypothesis (H_0) that there is no relationship between variables, and an alternative hypothesis (H_a) that there is a relationship between variables, was assumed. For example, in the case of representing the relationship between individual attributes (e.g., individual education level) of the community and information accessibility to Merapi Volcano disaster-related information: H_0 is that there is no relationship between the education level and access to the information, while H_a is that there is a relationship between education level and access to the information of Merapi Volcano.

The analysis involved a crosstabulation of the individual attribute and community responses to specific questions (DRR cases). IBM SPSS Statistics 27 crosstabulation and chi-square and FET were used to determine the degree of freedom between the community profile and the Merapi Volcano risk information on a 95% degree of confidence level.

To interpret the test results, *p*-values were calculated, and significant values asymptotically significant in chi-square or exactly significant in FET were compared with the set level of significance, here, 5%. The *p*-value can also be used to compare with the chi-square table as the standard [301,306].

5.3.2.4. Multiple Regression for Predictor-Suitability Analysis

Multiple regression is a statistical technique that can analyze the relationship between a dependent or criterion variable and a set of independent or predictor variables. It allows the prediction of one variable from information drawn from other variables [301,307]. In this study, multiple regression has been used to assess which sub-variables on the individual profile become significant predictors to the DRR program in the community, with a 95% degree of confidence level.

5.3.3. Survey Result

5.3.3.1. Individual Attributes Survey Result

The respondent attributes survey indicated that women dominated the group of respondents; most were under 54 years old, had been living in the current neighborhood for more than ten years, had high school or higher education, lived in families with one or more children, were either employed, homemakers, or students, and had income under 210.42 USD/month (see **Table 5.1**).

5.3.3.2. Descriptive Statistics Disaster Risk Reduction

Table 5.2 shows the descriptive summary results of the questions related to the pre-event activity (mitigation and preparedness) conditions related to risk knowledge, information access, and stakeholders and the network of Merapi Volcano communities. The community agrees that they can access the disaster information, prioritize the vulnerable group during and after the emergency, that women are an essential group in the decision making, and understand that collaboration with external stakeholders gives advantages to community preparedness. However, only a small number of the community (less than 20%) state that they have had the experience of the DRR program in recent times, with 59.5% not sure whether they have experienced it or not. Meanwhile, the community response on awareness of CBDRM organization's existence remains equally distributed among those who know, do not know, and are not sure (35.5%, 37.2%, and 27.4%, respectively).

5.4. Result and Analysis

5.4.1. Local Community: Risk Knowledge and Disaster Information Access

The Merapi Volcano community considers the volcano to be the most significant risk, followed by earthquakes, hydrometeorological hazards (climate change and floods), and pandemics, such as COVID-19 **(Appendix B Table A2)**, which is similar to the result from DMMT post-survey that the local community understand Merapi as source of threat [64].

In regard to risk information, most respondents stated that they felt well supplied with information about the Merapi Volcano (63.7%), with 23.7% feeling somewhat unsure **(Table 5.2)**. The primary sources of information were the mass media and online social media, chat apps, such as WhatsApp, and conservative media sources, such as TV, news portals (online and offline), and radio **(Appendix B Table A3)**. In addition, around 50% of respondents indicated that the Disaster Management Agency (DMA) was their source of information, with the least accessed disaster information coming from schools and insurance companies. The local community in Merapi tended to access the information from trusted sources, such as the local DMA, research center, or local government.

Table 5.3 Disaster topics of information accessed by the community

Group of Topics		Topics	Responses	
HI	Hazard information	Recent and updated information on Merapi Volcano	93.5%	275
HI	Hazard information	Knowledge about volcanic hazard	85.0%	250
E	Emergencies	Evacuation and emergencies procedure	73.8%	217
E	Emergencies	Evacuation shelter	72.1%	212
E	Emergencies	Evacuation route	71.4%	210
E	Emergencies	EWS—early warning system	69.7%	205
E	Emergencies	Time for evacuation	58.2%	171
M	Mitigation	CBDRM—community-based disaster risk management	51.7%	152
E	Emergencies	Contact and network communication during emergencies	48.0%	141
p	Preparedness	Disaster drill and simulation	44.6%	131
E	Emergencies	Live guidelines in the temporary shelters	42.9%	126
E	Emergencies	Organization of disaster emergency response	42.5%	125
HI	Hazard information	Folklore and traditional knowledge disaster-related	36.1%	106
		Total Respondent		294

The survey results show the types of information that respondents frequently accessed. The top two are focused on knowledge information regarding the Merapi Volcano status (see HI code on **Table 5.3**). The second most accessed type of information

dealt with procedures associated with evacuations, and the least accessed knowledge was of folklore and traditional knowledge related to Merapi. Similar to this, a DMMT post-survey also mentioned that the early warning mechanisms are known to more than 70% of the community, while knowledge of the hazard map and risk understanding is only known to 45% [46].

At Merapi, people have experienced recurrent volcanic disasters because of which they acknowledge the risk information provided by the authorities, especially in the context of zoning risk (DPA) to some extent. However, since the perceived risk of the Merapi community is said to be influenced by the three factors of risk knowledge and information, socio-economic, and cultural setting, as explained in Lavigne et al. [24] and Saragih et al. [55], people sometimes ignore the recommendations from the government. People of Merapi understand that eruption is part of a culture, and they perceive eruption as a 'normal' event and do not fear it [24,50,55] but, rather, embrace the volcano activity as their part of daily life. This belief resulted in the large casualties of 2010 eruption, as there were people who continued to stay in their neighborhood and rejected the evacuation, even after the evacuation command had been given by the government [55].

Table 5.4 Degree of freedom test between the individual attributes and information accessibility to Merapi Volcano disaster-related information

Variables	*n*	Value	*df*	Asymptotic Significance (2-Sided)	Exact Sig. (2-Sided)	Test
Sex	207	0.742	2	0.690	0.685	Chi-square
Age group	205	2.500	4	0.645	0.657	Chi-square
Duration of staying in the neighborhood	207	2.035	4	0.729	0.737	Chi-square
Education	204	12.673	6	0.049	0.047	Chi-square
Monthly income	183	6.578	6	0.362	0.366	Chi-square
Activity	207	7.762			0.084	Fisher's exact test
Household types	168	5.450			0.187	Fisher's exact test

The degree of freedom test **(Table 5.4)** revealed mixed results: H_0 asserted no relationship between individual attributes and access to disaster information, and *Ha* asserted a relationship between their attributes and access to disaster information. The only variable with a significant value was education; all others (sex, age group, duration of stay, monthly income, daily activity, and household type) showed no significant values. This means that there was no relationship between reliable access to disaster-related information and individuals' attributes in this community. Members of the community felt that they

could easily access Merapi disaster information and performed this action collectively. In addition, following the 2010 eruption, the communities kept tabs on the information related to the Merapi Volcano themselves [308].

The significance of the education variable, indicating an association between education in the population and information accessibility, should be further considered, since there is difference in the percentage profile between the respondents who fill this survey based on their education (primary 12.6%, secondary: 38.1%, and tertiary: 47%) compared to population (never going to school/not graduated from primary: 27.87%, primary: 18.63%, secondary: 42.73%, tertiary: 10.77%) [309–316]. There is a possibility that people with distinct levels of education would understand the disaster-related information differently due to differences in their comprehension capacity. Thus, there is a possibility that a population with a given education level would require a specific type of communication design to assist their understanding of risk and disaster information.

5.4.2. Community DRR Program Experience

Respondents were asked whether they had ever participated in a DRR program and the type of programs they felt were most suitable. The results show **(Table 5.5)** that disaster-related simulations and training were frequently conducted but participating in disaster social insurance had the least number of responses.

Table 5.5 Type of DRR programs in the Merapi Volcano community

	Categories of Topics	Programs	Responses	
AR	Awareness-raising	Disaster drill and simulation	67.90%	55
MP	Mitigation and preparedness	Disaster training and workshop	50.62%	41
MP	Mitigation and preparedness	Community meeting	40.74%	33
MP	Mitigation and preparedness	Disaster contingency plan-making	34.57%	28
MP	Mitigation and preparedness	Contributing to disaster evacuation route making and implementation	34.57%	28
MP	Mitigation and preparedness	Making community emergency SOP	33.33%	27
AR	Awareness-raising	Community disaster camp (school or volunteer)	32.10%	26
MP	Mitigation and preparedness	Building another structural mitigation	27.16%	22
AR	Awareness-raising	DRR campaign, fair, and feast	23.46%	19
LS	Livelihood securing	Livelihood based tourism on disaster-prone area training and capacity building	16.05%	13
LS	Livelihood securing	Livestock management during emergency	13.58%	11
LS	Livelihood securing	Participating in social insurance for disaster emergencies	11.11%	9
		Total Respondent		81

The crosstabulation of gender and involvement in DRR programs in their communities confirmed the existence of a strong gender bias in DRR participation. The survey results indicated that 75.6% of women had never participated in a DRR program, disaster drills, nor simulations in their community **(Appendix C Table A4)**. However, a post-survey of DMMT participants shows that 42% of women participated in the DMMT program [64]. To some extent, though, both studies show that some women had also taken part in the DRR program in the pre-event context.

Similar to the previous results of the gender variable, among the variables tested, only the duration of stay in the neighborhood showed significant relation to experience with and participation in a DRR program **(Table 5.6, Appendix D Table A6–A7)**. This relates to the differences in experience between those who had been in their neighborhood for more than 30 years and those who had lived there for less than ten years. These differences could relate to further differences in perception where people who experience recurring exposure may either be more prepared or normalize the threat completely, decreasing their preparedness level in exchange for easier access to livelihood sources [317]. Such a case is evident among the communities in Merapi, where people tend to live in their neighborhoods that ignore the risk zoning system for easier access to livelihood sources. No significant result was found among age, education, monthly income, household type, and DRR program experience, indicating that people from all backgrounds attended the programs **(Table 5.6, Appendix D Table A6–A7)**.

Table 5.6 Degree of freedom test between the individual attributes, the experiences of DRR programs[2], and advantages of DRR program for preparedness[3]

Variables	Case	*n*	Value	*df*	Asymptotic Significance (2-Sided)	Exact Sig. (2-Sided)	Test
Sex	2	79	7.884	1	0.005	0.006	Chi-square
	3	46	3.067	1	0.080	0.187	Chi-square *
Age group	2	77	5.009			0.079	Fisher's exact test
	3	44	1.747			0.538	Fisher's exact test
Duration of staying in the neighborhood	2	78	9.983	2	0.007	0.007	Chi-square
	3	45	0.851			0.853	Fisher's exact test
Education	2	78	2.850			0.419	Fisher's exact test
	3	45	1.853			0.621	Fisher's exact test
Monthly income	2	71	6.039	3	0.110	0.112	Chi-square
	3	44	1.231			0.867	Fisher's exact test
Activity	2	78	1.923			0.448	Fisher's exact test
	3	46	8.711			0.014	Fisher's exact test
Household types	2	69	1.993			0.474	Fisher's exact test
	3	41	1.589			0.616	Fisher's exact test

** Count in 2 × 2 table. [2] Case 2: the experiences of DRR programs. [3] Case 3: advantages of DRR program for preparedness.*

The survey results indicate that most respondents (84.1%) felt that the current DRR program helped them have better hazard preparedness **(Table 5.2)**. Only the people activity variable was significant **(Table 5.6, Appendix D Table A6–A7)**, indicating that the respondents' occupational status led to differing perceptions of the DRR programs. Since occupation can be related to the access to resources, such as financial and social networks, this could explain different perceived risk of the people as individuals or as a collective. However, no significant result to DRR program perceptions was found for gender, age, time living in the neighborhood, education, monthly income, nor household type.

5.4.3. Community-based Disaster Risk Management (CBDRM), Community Roles, Networks, and Collaboration

The local community's perceptions of the DRR program benefits were elicited with the use of several questions which considered their understanding of the current DRR programs, their impression of a community organization focused on disaster risk management, and the involvement of vulnerable groups and women in disaster-related issues **(Table 5.7, Appendix D Table A8–A11)**.

The responses regarding DRR specialist community organizations were as follows: 35.3% thought there was a particular DRR organization, 37.2% thought there was no such organization, and the remainder (27.4%) were unsure **(Table 5.2)**, which indicated that the CBDRM organization was little known in the community. The only variable that showed the relationship between the existence of the CBDRM organization and the community profile was occupation type **(Table 5.7, Appendix D Table A8–A11)**. This is related to individuals' networks during their day-to-day activities. For example, the same understanding might circulate among a circle of students who share activities.

Around two-thirds of respondents said that their community prioritized vulnerable groups, such as the elderly, children, disabled persons, and pregnant women **(Table 5.2)**, and there was a significant relationship found to education. Other variables, such as sex, age, duration of stay, monthly income, activity, and household type, were insignificant in prioritizing the vulnerable group during emergencies and post-disaster. This indicates that there was no relationship between the variables. However, the Merapi Volcano community prioritized this group after being exposed to the 2010 eruption [308]. When designing the contingency plan of Merapi Eruption, it is mandatory to assess the vulnerable group in the disaster-prone area and secure them during the emergency. In addition to this, the standard

operation procedure (SOP) recommends the vulnerable group to be evacuated on the scale of volcanic activity level III, earlier than the other community members [188,189].

Table 5.7 Degree of freedom test between the individual attributes, the existence of community-based disaster risk management (CBDRM) organization[4], prioritizing vulnerable groups during disaster emergencies[5], women's involvement in disaster and risk management[6], and the impact of collaboration on disaster preparedness and community resilience[7].

Variables	Case	*n*	Value	*df*	Asymptotic Significance (2-Sided)	Exact Sig. (2-Sided)	Test
Sex	4	155	1.034	1	0.309	0.323	Chi-square
	5	200	0.110	1	0.741	0.747	Chi-square
	6	187	0.996	1	0.318	0.361	Chi-square *
	7	210	1.826	1	0.177	0.186	Chi-square
Age group	4	152	1.936	2	0.380	0.393	Chi-square
	5	195	1.939	2	0.379	0.414	Chi-square
	6	182	4.771	2	0.092	0.091	Chi-square
	7	205	0.210	2	0.900	0.924	Chi-square
Duration of staying in the neighborhood	4	153	0.052	2	0.974	0.979	Chi-square
	5	198	2.580	2	0.275	0.276	Chi-square
	6	185	3.882	2	0.144	0.140	Chi-square
	7	208	0.692	2	0.708	0.691	Chi-square
Education	4	153	4.439	3	0.218	0.222	Chi-square
	5	196	8.051	3	**0.045**	**0.044**	Chi-square
	6	182	6.261	3	0.100	0.101	Chi-square
	7	205	1.209	2	0.546	0.545	Chi-square
Monthly income	4	140	2.911	3	0.406	0.411	Chi-square
	5	175	6.727	3	0.081	0.081	Chi-square
	6	162	2.733	3	0.435	0.442	Chi-square
	7	184	1.580	3	0.664	0.678	Chi-square
Activity	4	154	7.780	2	**0.020**	**0.018**	Chi-square
	5	198	0.639	2	0.727	0.739	Chi-square
	6	186	2.179	2	0.336	0.352	Chi-square
	7	208	0.769	2	0.681	0.687	Chi-square
Household types	4	129	2.935			0.258	Fisher's exact test
	5	162	4.050			0.120	Fisher's exact test
	6	152	3.252			0.208	Fisher's exact test
	7	169	.099			1.000	Fisher's exact test

* Count in 2 x 2 table. [4] Case 4: the existence of community-based disaster risk management (CBDRM) organization. [5] Case 5: prioritizing vulnerable groups during disaster emergencies. [6] Case 6: women's involvement in disaster and risk management. [7] Case 7: the impact of collaboration on disaster preparedness and community resilience.

There were no significant relationships between the various individual attributes with the questions of the involvement of women's in DRR programs. This means that the community see that the women took part in DRR activities in the community equally compared to men and see that their role is important **(Appendix C Table A4)**. Women at Merapi community have roles related family wellbeing, such as logistics supply management, children education, psychological, and community's wellbeing management **(Appendix C Table A5)**. In addition, the community has been practically involved in social insurance managed by the community which only can be used during disaster emergency. This insurance is used when the disaster aid has not yet been received by the

community. One women's group in Magelang, on the west side of Merapi (Nanggrung, Kamongan Village), conducted a Women Welfare Association activity to build awareness for emergencies called *nyapu dan nabung* (sweeping and saving). Every week, they hold a village clean-up movement, during which time they collect money from each member as social insurance for crisis conditions [318].

Then, to comprehensively understand risk communication and DRR program effects in the Merapi community, respondents were also asked about the local community's ability to collaborate with outsiders, such as NGOs/NPOs, universities, governments, and volunteers. The results **(Appendix D Table A11)** indicated that the community respondents agreed that collaboration could better prepare their communities to face risks.

5.4.4. Predictive Models of Sub-Variables of Individual Profile and DRR Programs

Multiple regression was carried out to investigate whether each sub-variables on the community's individual profile could predict certain dependent variables. This predictive uses the significant result from the goodness fit test (see sub-chapter 5.4.1, 5.4.2, and 5.4.3) and uses the sub-variables on the individual profile of the community to do the predictors test **(Table 5.8, Appendix E Table A12–A17)**. Using multiple regression analysis on SPSS from IBM, there are six models of this predictor test:

1. Model 1: education level: primary *(X1)*, secondary *(X2)*, and tertiary *(X3)* to predict the perception of disaster information accessibility scores.
2. Model 2: each gender (male *(X1)* and female *(X2)*) to predict the experience of DRR programs.
3. Model 3: duration of staying in the neighborhood (≤ 10 *(X1*), 10–≤ 30 (*X2*), > 30 (*X3*) years) to predict the experience of DRR programs.
4. Model 4: people's type of occupation (worker and homemaker–activity type 1 (*X1*), unemployed and retired–activity type 2 (*X2*), and students–activity type 3 (*X3*)) to predict their perception of the advantages of DRR programs for disaster preparedness.
5. Model 5: whether a type of occupation (worker and homemaker – activity type 1 (*X1*), unemployed and retired–activity type 2 (*X2*), and students–activity type 3 (*X3*)) to predict the value of their awareness of CBDRM existence in their neighborhood.
6. Model 6: education level (primary (*X1*), secondary (*X2*), and tertiary (*X3*)) to predict perceptions of the inclusive process during the disaster.

According to model (1), (2), and (3), the predictive test could not show which individual sub-variables is the predictor **(Table 5.8, Appendix E Table A12–A17)**. Model (1) shows that every level in education could access disaster risk information at the same level of easiness. In regard to the DRR program experiences, the results indicate that people at Merapi Volcano could experience the program regardless of their attributes, including gender and the length of time living in a place.

On the other hand, models (4), (5), and (6) could show which sub-variables could be the predictors **(Table 5.8, Appendix E Table A12–A17)**. Model (4) indicates that the group of workers and homemakers significantly contributed as the predictors to perception to advantages of the DRR program to disaster preparedness. However, in model (5), aside from the worker and homemaker group, the student's group could predict the CBDRM awareness in the Merapi Volcano community. The results from models (4) and (5) could indicate that these groups could contribute to the DRR in the pre-event context because of their access to resources, such as livelihood, which livelihood sustainability is one of the critical aspects of people-centered DRR planning [10]. For the students, who were significant predictors for CBDRM awareness, it may be that the youth organization and similar network systems could be beneficial for DRR programs due to their access to information and resources to prepare for possible disasters.

Based on model (6), two sub-variables significantly contribute to the inclusive process of the DRR program: those with primary education and those with secondary education. These predictors could predict the perception of inclusive planning on disaster risk reduction model, both in negative and positive contribution. Furthermore, the education level represents the community's accessibility to knowledge and information that might assist in recognizing risk and improve network reach.

5.5. Discussion

This study found that the Merapi Volcano community had varied responses to several indicators related to the relationship between individual attributes of community members related to risk knowledge and information, capacity building activities, and awareness of community-based DRR organization, roles, and network. Regarding risk knowledge and information, accessibility shows that people with different education levels could access the disaster risk information equally, and that the community understands that Merapi has volcano risk. This result contradicts the findings of another research that have

Table 5.8 Predictive model of sub–variables of individual profile and DRR programs.

Description		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
R		0.112	0.170	0.068	0.422	0.286	0.196
R^2		0.013	0.029	0.005	0.178	0.082	0.038
F		F (3, 209) = 0.891	F (2, 131) = 1.943	F (3, 130) =0.199	F (3, 85) = 6.139	F (3, 290) = 8.579	F (3, 289) = 3.835
p		0.447	0.147	0.897	0.001	0.001	0.010
Unstandardized B	*C*	1.800	1.745	1.695	1.930	1.988	1.780
	X_1	−0.133	0.005	−0.028	−0.744	−0.207	−0.521
	X_2	−0.276	−0.230	−0.195	1.070	0.346	−0.274
	X_3	−0.053	-	0.019	−0.310	0.140	−0.008
Coefficients SE	*C*	0.420	0.088	0.056	0.144	0.083	0.096
	X_1	0.457	0.121	0.358	0.203	0.101	0.193
	X_2	0.432	0.134	0.256	0.681	0.193	0.136
	X_3	0.430	-	0.238	0.317	0.052	0.130
Standardized Coefficients Beta *(β)*	*C*						
	X_1	−0.047	0.004	−0.007	−0.367	−0.134	−0.171
	X_2	−0.143	−0.168	−0.067	0.156	0.108	−0.140
	X_3	−0.028	-	0.007	−0.097	0.170	−0.004
t	*C*	4.290	19.878	30.108	13.448	24.023	18.490
	X1	−0.292	0.044	−0.079	−3.666	−2.051	−2.694
	X2	−0.638	−1.715	−0.762	1.571	1.791	−2.022
	X3	−0.122	-	0.081	−0.977	2.705	−0.063
p	*C*	0.000	0.000	0.000	0.000	0.000	0.000
	X1	0.771	0.965	0.937	0.000	0.041	0.007
	X2	0.524	0.089	0.448	0.120	0.074	0.044
	X3	0.903	-	0.935	0.331	0.007	0.950
Results		Predictors: (Constant), Tertiary, Primary, Secondary	Predictors: (Constant), Sex Female, Sex Male	Predictors: (Constant), duration of stay 3 (> 30 years), duration of stay 1 (≤ 10 years), duration of stay 2(10–≤ 30 years)	Predictors: (Constant), Activity 3 (students), Activity 2 (unemployed and retired), Activity 1 (workers and homemakers)	Predictors: (Constant), Activity 3 (students), Activity 2 (unemployed and retired), Activity 1 (workers and homemakers)	Predictors: (Constant), Tertiary, Primary, Secondary
Interpretation		weak, not significantly contributed to predicting model	weak, not significantly contributed to predicting model	weak, not significantly contributed to predicting model	the medium could predict to model with X1 has a significant contribution to the model	weak, could predict to model with X1 and X3 have a significant contribution to the model	weak, could predict to model with X1 and X2 have a significant contribution to the model
Significant predictors		-	-		-X1: workers and homemakers	X1: workers and homemakers. X3: students	X1: primary X2: secondary

found a higher level of formal education to contribute towards a higher level of risk knowledge [319]. However, on the other hand, another research study stated that education does not significantly contribute to the different perceived risks of the community [229,320]. These contradictive statements could be due to several factors: (1) the current respondent group has not represented the population at large (another sample is needed), or (2) there is adequate risk communication within this community (which could be due to

the variety in risk communication mediums and content design or due to the frequency of information accessed by the community).

This shows that there is a lack of clarity of the risk knowledge and a complex relationship between the individual attributes and the DRR indicators in this community. Even though, after the eruption of 2010, risk awareness of Merapi Volcano has increased significantly within the community [55,70,308], this study finds that further action is needed for designing people-centered DRR planning in order to strengthen community resilience. The findings indicate that the local community plays an essential role based on their attributes not as primary predictors, but as modifiers. Modifier here is defined as the variables that could change the size of the relationship of control variables, both as static and dynamic modifier [321]. In this research, the modifiers are the individual attributes, which could diversify how the local community perceives risk or could improve the extent of understanding of risk. For example, people who participate in different activities in Merapi have significant dependencies to the DRR activities. However, group based on sub-criteria of activities for their influence on DRR activities could not be measured, possibly because people in Merapi tend to act on collective action at the neighborhood scale, rather than on individual level. This result indicates that the individual attribute could influence the disaster risk reduction program on the community, both as a static and dynamic modifier. This finding supports a similar conclusion that individual attributes of the local community living in the disaster-prone area play a key role in comprehending the dynamic on disaster governance. [12,101,229,317,320].

The result that peoples in Merapi participated in the DRR program and had changes in their risk perception after the 2010 eruption, implies that 2010 eruption became a catalyst of transformation for the community and the disaster governance. Aligned with this result, Thomalla et al. mentioned that understanding risk knowledge could help design better intervention to achieve more transformative DRR that is more proactive and agile to the changes [14]. In addition to this, the equal access to disaster risk information, equal participation of women, and equal consideration of vulnerable groups in guideline, policy, and practice, indicate that the disaster governance in Merapi tries to be inclusive in their approach. This approach could be taken a step further [12,14] to accommodate people's choice to engage in this process [281] rather than restricting it to established disaster-prone areas.

Volcanic eruption which is already difficult to predict because of its geodynamics, has become worse and frequent due to the combined effect of climate change and

unplanned developments. This can cause multi-hazard situations and increase the complexity and uncertainty involved in disasters. This study indicates the need for tailor-made activities to support community resilience planning to ensure resiliency in such uncertain situations following a disaster [322]. For example, preparation of different content design and risk information for different age groups and revising the model of DMMT from a community-based disaster risk reduction organization to a more family or neighborhood level-oriented organization could allow the program to reach the wider community members and ensure a more multisectoral approach.

5.6. Conclusion

This study considers the needs of people-centered DRR program design and indicates that understanding people's exposure could help to strengthen community disaster resilience so that the community can prepare, respond, and recover after a disaster. It indicates that the level of formal education and gender is not an issue in accessing risk information or for joining DRR program in the community, as shown by the analysis. However, in the context of DRR program, social learning for disaster risk awareness is a crucial factor when designing inclusive DRR programs for the community, which was indicated by the lack of people's awareness of DMMT and the existence of CBDRM. This learning process could be institutionally embedded as part of the curriculum in formal education (structured curriculum in school) and non-formal education (structured curriculum outside of school), as well as in the informal learning process (unstructured everywhere) [323] in the community (such as through CBDRM), on a smaller scale, such as family or neighborhood scale. Similarly, the study also indicates that people's daily activities (e.g., occupation) additionally drive the differences present in the perspectives on the organization and networks, the importance of disaster preparedness, and CBDRM organization. Thus, it can be concluded that understanding how the community sees the disaster risk could help to transform their way of living with a recurrent natural hazard.

Further study is needed to see how individual roles and contribution of the local community work in each DRR management cycle to understand which individual attributes work as static modifiers or dynamic modifiers to be able to design a more people centered DRR program for strengthening the community resilience.

CHAPTER 6
DISCUSSION

6.1. Disaster Risk Governance in a Volcanic Hazard Community Shifting Approach: An Interdependent and Plural System

It was found that disaster awareness had been practically implemented in the Merapi Volcano community within the transformative capacity elements framework (see **chapter 4**). Disaster awareness as transformative capacity can be interpreted as plural, embedded, and interdependent within other programs, initiatives, and elements. These findings show that by using their capital, especially human and economic capital, transformative capacity can enable changes in how people react toward a particular situation, in this case, disaster occurrences or pre-event preparedness (see **chapter 5**)**.** As Holscher [22] and Wolfram [106] highlighted and as found in this study, transformative disaster awareness and preparedness capacity involves embedding value in current structures, cultures, and practices rather than introducing radical changes.

However, the issues and challenges associated with implementing DRR awareness programs and initiatives in the Merapi Volcano community need to be recognized (see **Table 6.1**). It was found that multi-agency participation was necessary to increase program development and implementation practice in the local communities. It was also found that DRR initiatives could be included as part of the post-disaster economic capital literacy framework in the affected local community, which indicated that this combination could

be upscaled for post-disaster communities and communities living in DPA that are vulnerable to recurrent hazards.

Table 6.1 Disaster governance issues and challenges in Indonesia

	Transformative capacity in practice	Categories
1	Implementing a new evacuation model (sister village/school)	disaster risk governance
2	New and diverse livelihood post-disaster recovery access	economic capital
3	Community commitment to participating in disaster governance	community planning in practice
4	Multi-level and diverse agency approaches to DRR strategies are an opportunity	community planning in practice
5	Learning and embedding knowledge in everyday values and building disaster literacy	human capital

Source: Authors, 2022

The local community respects Merapi, which means that the interactions between humans and nature are robust. Capacity building to support resilient communities can use the values that bond the local community with the Merapi Volcano as local disaster knowledge (LDK). However, the risk knowledge in the Merapi community has developed through their long exposure to the volcano and is a combination of LDK knowledge, scientific knowledge, and values. There are some critical issues related to the upscaling of DRR process education: (1) co-creation and collaborative actions are essential; (2) the school can be a leader in the DRR education process, including during emergencies; and (3) experience-based and action-oriented learning increase the probability of the increasing disaster risk value.

The local community benefits from its community-based economic-driven activities, such as the tourism villages and the lava tours (see **chapter 4**). Despite the current shift from disaster literacy to a mass tourism destination to gain economic capital, these practices involve LDK. Aside from that, digital media, social media, and community networks (Jalin Merapi) allow for the expansion of transformative capacities and practices, such as improving risk communication and practicing co-creation and collaboration within the various levels and diverse agencies in the Merapi area. The three CBED cases in Merapi found that the DRR programs did not have to be disaster-specific, such as disaster drills, seminars, training, or geoparks. By developing and participating in the CBED, disaster literacy spread across many agencies, including visitors. The community's awareness of living in DPAs provides the context that manages and guides their livelihood activities. Similar to this research, SFDRR indicates that disaster literacy should be integrated into everyday activities.

Nevertheless, disaster awareness practices still have several shortcomings that threaten the strengthening of the resilient community. The lack of in-depth, comprehensive cross-sectoral longitudinal performance assessments is a weakness and a threat. Maintaining the LDK and non-LDK knowledge is also needed. While the experiences gained by the local and non-local residents interested in Merapi do not need to involve a direct experience with eruption and lava flows, the narratives conveyed through the museums, disaster simulations, and information should assist in reducing the risks of the Merapi Volcano eruptions. Issues related to the conflicts and the horizontal disputes with the sister village/school practices also need to be resolved. Equality between the villages in Merapi's DPA and its sister villages should also be considered.

6.2. Disaster in Society and People-Centered Approach for TDRR

The disaster in society approach is focused on three areas: environmental changes and shocks, people's exposure, and prevention and response systems. As the community play a crucial role in disaster risk governance, it is essential to see how the primary demographics indicate pre-event vulnerability. This study, which was focused on a people-centered DRR program design, found that understanding the people's exposure could strengthen community resilience and better allow the community to prepare, respond, and recover after a disaster.

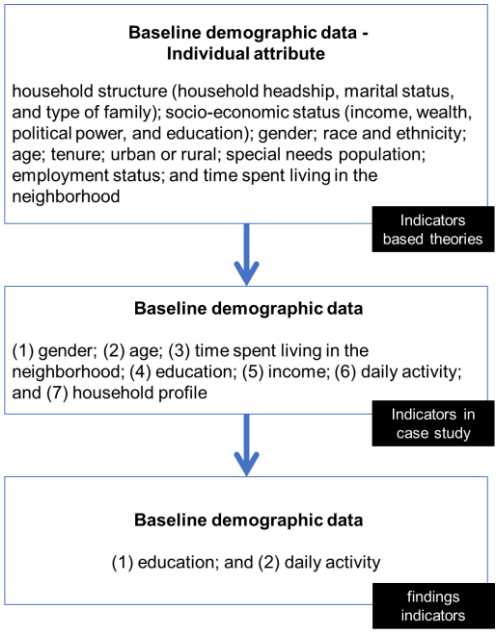

Figure 6.1 Individual attributes used in this research
Source: Author, 2022

It was found that these attributes were modifiers rather than primary predictors; that is, individual attributes could change the way the local community perceives risk or improve the understanding of risk. For example, people participating in different Merapi DRR and preparedness activities depend significantly on the DRR activities they have experienced. However, the influence of each sub-criteria for each attribute could not be measured by the DRR activities. People in Merapi may tend to take collective action at the neighborhood level.

In this research, two attributes were found to significantly contribute as modifiers: education level, which was related to inclusive DRR planning and had both negative and positive contributions; and daily activities, which were related to access to resources. Out of the ten individual attributes, this research only used seven (see **chapter 5**) to confirm the hypothesis for a pre-event relationship between individual attributes and DRR. Of these seven attributes, the only attribute that significantly contributed was education *(X1= primary, X2=secondary, X3= tertiary)* and daily activities *(X1= workers and homemakers, X2: unemployed and retired, X3= students)* (see **Fig. 6.1.**). These two attributes promote access to resources, such as economic resources (implied in the daily activities) and human capital resources (implied in the education level). The education level represents the community's access to knowledge and information that could assist in highlighting risk and improving network reach. Therefore, economic capital can provide a safety net during an emergency and ensure sustainable post-disaster livelihoods, as also mentioned by Naheed [324]. This result implies that these two essential factors could be utilized to build and strengthen a resilient community.

6.3. Transformative DRR for a Resilient Community: A People-Centered Approach

As commented on in the previous two sub-chapters, transformative capacity (TC) accommodates changes to the system functions caused by disaster disruptions and offers an alternative approach to the embedding of disaster governance into people's everyday lives to ensure functional community sustainability. In practice, TC embeds interdependencies between the elements in programs and initiatives. These two discussions show that economic and human factors are the keys to building and strengthening resilient communities (see **Fig 6.2**). DRR frameworks focus on capacity building and good governance. Paying attention to the way capital/assets are used and mobilized is essential [325]. Banica et.al. [326] and Thomalla, et.al. [14] stated that apart from destroying the

development process, disasters can also be an opportunity to revisit the chaotic development process through the application of focused, community-based transformation processes.

Community disaster awareness is essential to allow people and organizations to mitigate and adapt to disasters and hazards. For example, knowledge about the Merapi Volcano, threats, and access to resources in the disaster-prone areas is vital to anticipate possible future threats, both from the volcano itself and the more complex, such as hydrometeorology threats in the rapid growth areas around it. Disasters are usually spatially localized, that is, destruction is dependent on the profile of the surrounding territory [325,326]. For example, the risk is higher in cities than in low-density areas.

Economic resilience at the community level [327] can ensure the continuation of a post-disaster community. Blair and Mabee [327] added that local economic aspects could be used to accelerate post-disaster recovery. Usually, problems arise because of a disconnect between the local economy, supply chain access, human capital, governance models, and networking systems. Therefore, local economic development must be based on guaranteed raw materials, marketable products, and local capacity. Local communities can therefore be better prepared to face uncertainty from disaster threats if their economic capacity building is coupled with other elements, such as people-centered pre-event DRR program planning. For example, the sister village program mitigates the economic risks for people living in disaster-prone areas as it connects two or more villages around Merapi, one of which is in a high-risk area and the other of which acts as a buffer against disaster (see **chapter 4**). Presently, the sister village concept in Merapi is only operational in times of emergency. Because social cohesion is a critical factor, efforts are being made to develop social cohesion between the two communities during non-emergencies, such as buying and selling commodities, to strengthen their mutual symbiosis.

People-centered programs for TDRR harness the value of the local community and its resources, connect to external stakeholders using networking systems and allow the local people to continue to live with the disaster risk. However, recognizing the governance system's role in increasing community capacity is vital. As the performance of each TC element was not thoroughly investigated in this research, further research is needed to increase the preparations for transformative action.

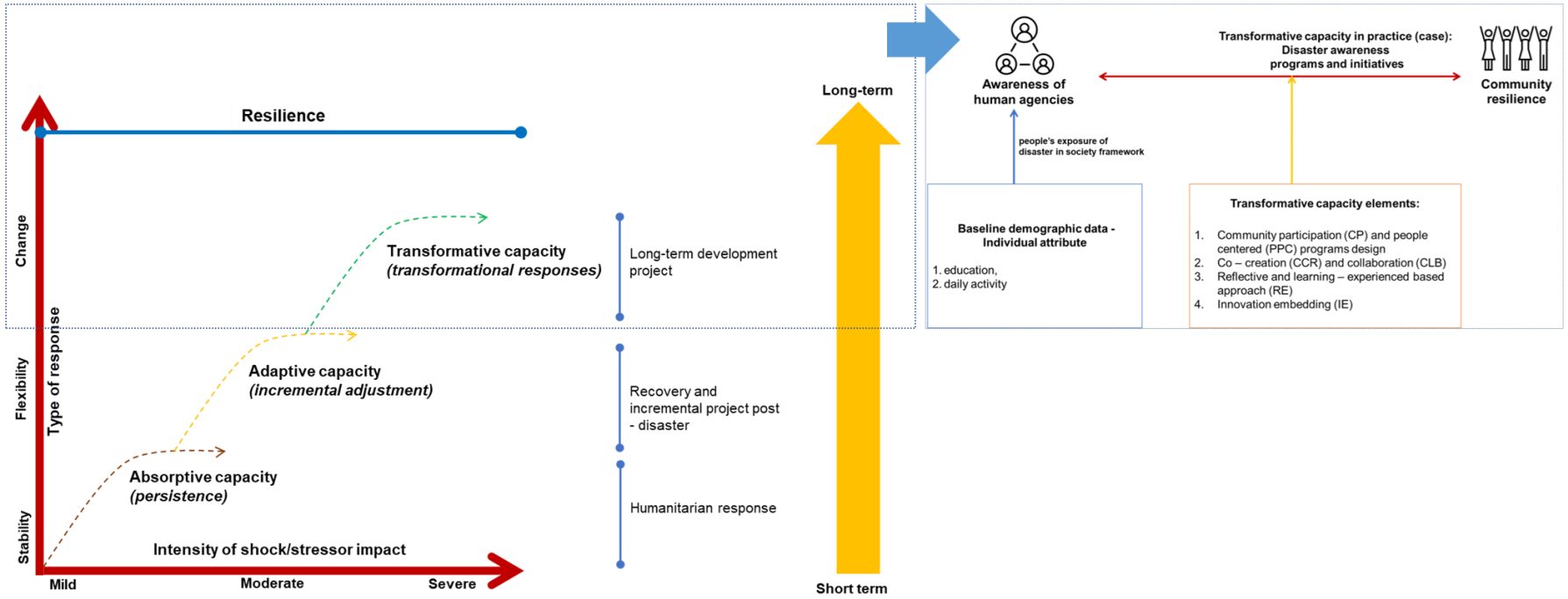

Figure 6.2 Findings result
Source: Authors, 2022

CHAPTER 7
CONCLUSION

7.1. Research Findings

This research provides insight into the transformative capacity of disaster awareness programs and initiatives for community disaster resilience. The Merapi Volcano community was chosen as the study area because it is an example of a post-disaster community that has had long-term experiences with recurrent volcanic hazards. A mixed-method case study was conducted, from which it was found that even though disaster governance awareness is fundamental, there was a mismatch between disaster awareness and preparedness. Therefore, the question arose as to what extent and how this disaster awareness could be used to encourage a transformation in resilient community governance.

1. **RQ1** How can disaster awareness programs be explained in terms of the DRR framework and its relationship between individual attributes in TDRR governance?
    a. ***RQ1a*** How can disaster awareness programs be explained in terms of the DRR framework and enable the identification of the challenges of DRR?
    b. ***RQ1b*** How is disaster awareness manifested in the relationship between individual attributes and DRR programs and initiatives to encounter recurrent hazard risk in TDRR governance?
2. **RQ2** How can disaster awareness be understood as a transformative capacity to achieve community resilience to recurrent natural hazards in spatially complex settings?

This study found that disaster awareness programs and initiatives focused on transformation aligned with the implementation of TDRR **(chapters 2 to 6)**. Raising pre-event disaster awareness could be a preventive DRR, a measure to prepare for a worst-case hazard threat. The TDRR focuses on possible future scenarios to ensure functional societal

development and enable comprehensive, innovative governance systems to deal with the remaining challenges. DRR programs that include development goals could use TC elements to enable a transformative capacity. Various programs and initiatives that involved a wide range of diverse stakeholders were found to be effective in Merapi. Therefore, TDRR involves pre-event and long-term prevention and mitigation that addresses both development and long-term planning. Innovative transformative disaster governance does not necessarily involve a new program approach as it can be embedded in current programs and initiatives to mainstream the innovations.

In conclusion, this study found that, in practice, building transformative capacity into disaster awareness programs was able to accommodate the changes needed to certain system functions, offered an alternative approach to understanding that disaster governance cannot be separated from everyday life, and was the foundation to sustainable economic and human community systems. Therefore, transformative capacity can be embedded within other programs, initiatives, and elements.

7.2. Research Implication

These research results showed how resilience support programs focused on economic and human capital (i.e., poverty and equality) can be embedded in current pre-event programs and initiatives, demonstrated the importance of disaster resilience governance, and highlighted the importance of considering disaster governance and development when addressing the remaining challenges (see **Fig. 7.1**).

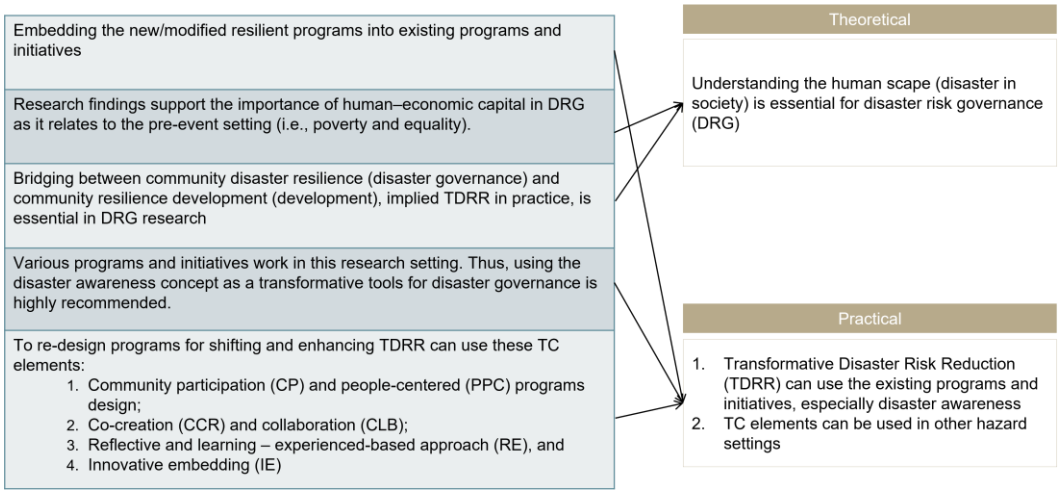

Figure 7.1 Contribution to theory and practical issues
Source: Author, 2022

Even with mitigation and preparedness programs, a major disaster could undo all the resilience development in local communities suffering from poverty and inequality. This research showed that daily activities and education, which are related to the resources available for employment and networking, could provide a community safety net in DPAs. Essentially, disaster risk governance and disaster risk knowledge [328] need to encompass the human toll of disasters, as commented on by Collins [101].

The conceptualization of the TC elements; (1) community participation (CP) and people-centered (PPC) program design, (2) co-creation (CCR) and collaboration (CLB), (3) reflective and learning–experienced-based approaches (RE), and (4) innovative embedding (IE); can be used in the other natural or man-made hazard settings to encourage long-term behavioral change and build enabled transformative systems.

7.3. Recommendation

The research results showed that the effective and efficient use of resources can assist in community transformations. Therefore, it is recommended that local resources be utilized to enable disaster governance transformation and support functional societal development goals. For example, the sister village concept designed for emergencies (evacuation) that was implemented in the Merapi Volcano community was found to minimize the inequalities in the local community's access to resources. Even though this community had an established commodity trade with the sister village, this practice could be included in DRR programs to increase the local community's safety net. IP (intellectual property) based business designs between the paired sister villages could be developed, with the local commodities in each sister village being highlighted, which could then be marketed within a tourism village framework to assist the community's economic development.

However, tourism may not be the most influential sector when considering effective disaster governance and spatial planning, as disaster governance must be the critical focus. Because various programs and initiatives with a diverse range of vertical and horizontal stakeholders were found to be effective in Merapi, transformative disaster governance awareness programs and initiatives are highly recommended. Moreover, innovative transformative disaster governance initiatives do not need to be developed as a new program as they can be embedded into current programs, which would be less challenging than in a formal policy setting.

This idea is in line with the World Bank's [329] local economic development (LED) concept, which emphasizes the development of local economic capacities to improve the future local community' quality of life. The LED concept is a multi-stakeholder program involving the public, business, and non-government partners working collectively to create conditions for economic growth and employment. Based on this research, a planning design framework entitled *"Interconnecting sister village resources to strengthening community disaster resilience: A LED (Local Economic Development) approach."* was developed, which regardless of the disaster situation, connects the resources of paired sister villages and encourages co-creation and collaboration (see **Fig. 7.2**).

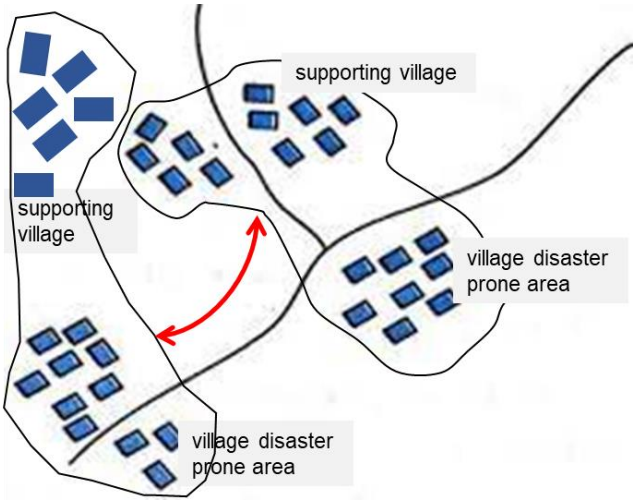

Figure 7.2 LED sister villages concept
Source: Author, 2022

7.3.1. Justification of Planning Concept

The justification for implementing this program is based on the following three reasons: (1) the gross regional domestic product (GRDP) in the Merapi Volcano area; (2) Merapi Volcano spatial community planning, and (3) the research results (see **Fig 7.3**).

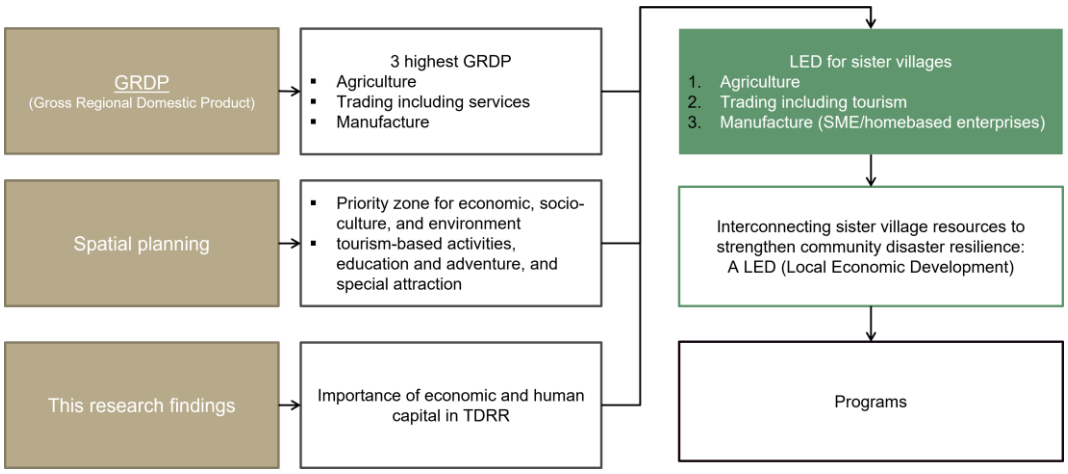

Figure 7.3 Justification for the sister villages concept as TDRR programs
Source: Authors, 2022

1. Gross regional domestic product (GRDP)

The gross regional domestic product (GRDP) from the district surrounding the Merapi Volcano was examined to understand the dominant sectors, especially in southern and western Merapi (see **Figs. 7.4** and **7.5**).

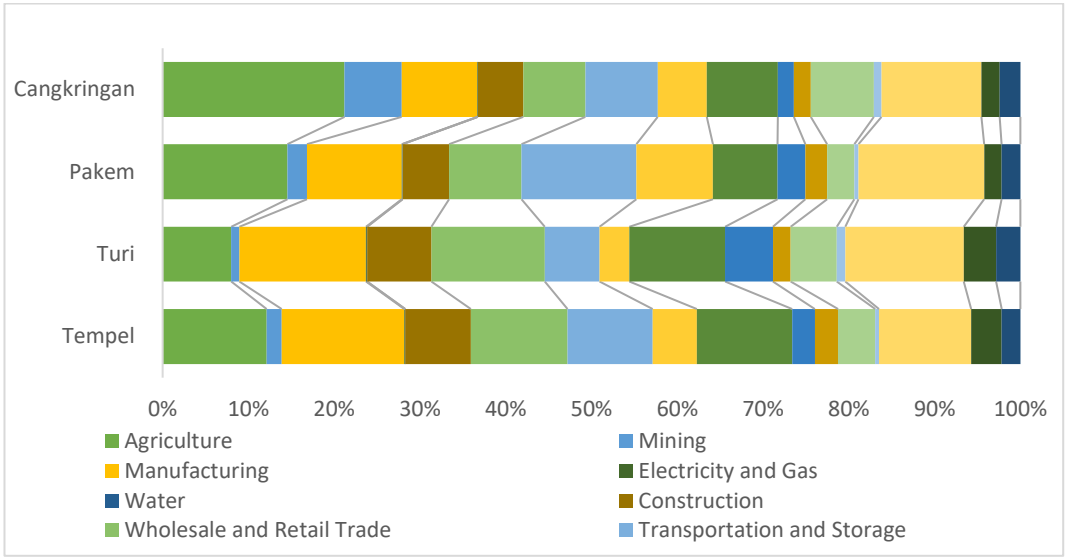

Figure 7.4 GRDP constant value in 2016 in Cangkringan, Pakem, Turi, and Tempel in Sleman Regency (southern Merapi Volcano area) in a million IDR
Source: BPS - Statistics of Sleman Regency [330]

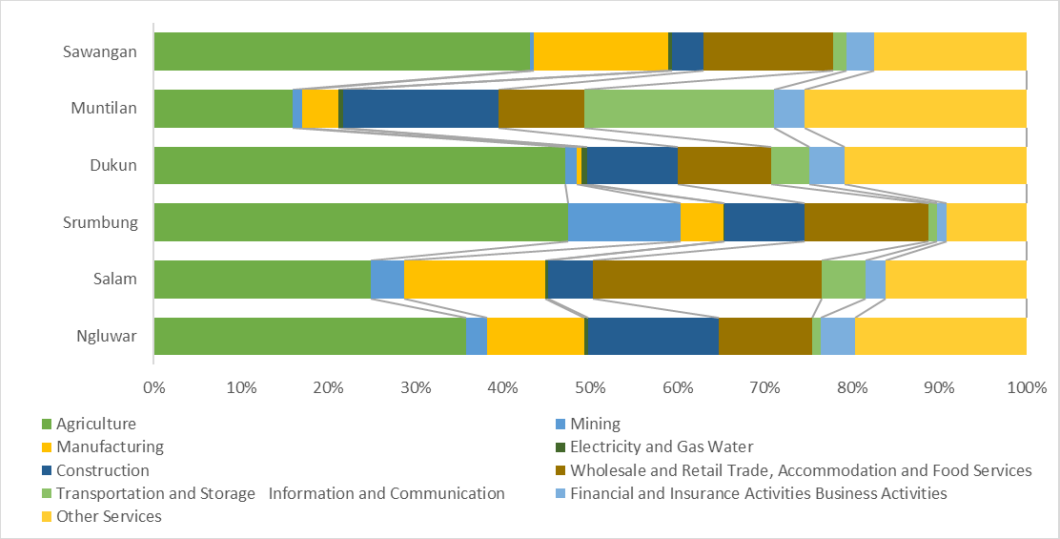

Figure 7. 5 GRDP constant value in 2012 in Sawangan, Muntilan, Dukun, Srumbung, Salam, Ngluwar in Magelang Regency (westside of Merapi Volcano area) in million IDR
Source: BPS - Statistics of Magelang Regency [331]

The GRDP analysis identified agriculture, trade and services, and manufacturing as the highest sectoral contributors to the regional Merapi economy. Therefore, these three sectors were considered in the concept planning.

2. Merapi Volcano Spatial Planning

Merapi is a part of the Indonesian National Strategic Area spatial planning. This area has been nominated as a priority zone because of its essential national security, economic, socio-cultural, and/or environmental roles. Primarily, aside from disaster governance, the Merapi Volcano's environmental roles are as a national park, for which economic, agriculture-based, socio-cultural, and environmental education and adventure tourism-based activities are prioritized [332–337]

3. Research result

This research highlighted the important bridging role of human and economic capital in TDRR and the connections between disaster governance and development planning (see **chapter 6**).

7.3.2. Planning Concept and Precedents

The Borobudur Tourism Development and Planning precedent is exemplified to understand the TDRR using the sister village planning concept. Borobudur is a Buddhist temple dating from the 8th and 9th centuries in central Java, which was restored in the 1970s and was then named a UNESCO World Heritage Site [338] (see **Fig. 7.6).**

Figure 7.6 Borobudur Temple Compounds (Indonesia)
Source: Giovanni Boccardi [339]

An interconnecting tourism system was developed in Borobudur to ensure that the tourism management was community-based and connected with the surrounding villages to increase the local communities' economic and human capital [341,342]. This interconnected system led to the development of a tourism center in each village, the "Balai Ekonomi Desa – Balkondes [Village Economic Center]."

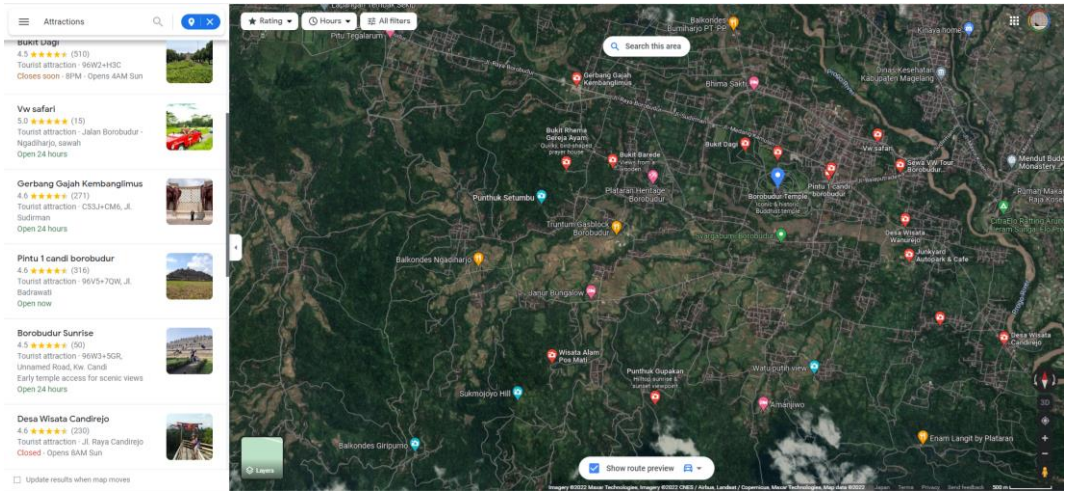

Figure 7.7 Distribution of Balkondes - [Village Economic Center] around Borobudur Temple
Source: Google Map [340]

The planning concept ensures that the tourist attractions in Borobudur are prioritized and managed by the local community. A polycentric collaborative approach to connect the local community was used to implement the program, for which the Borobudur management was

the mentorship partner, and Indonesian state corporate companies (BUMN), other private sector companies, and the government were sponsors.

Therefore, based on this planning concept, the Merapi sister village could be similarly developed, as outlined in the following (see **Fig. 7.8**):

1. High-value agriculture intensification

   Subowo [341] recommended that to further develop Merapi's economic capital to take advantage of the plantations/farms, food gardens, and SME raw material sources, an agriculture intensification program could be promoted for seeds, livestock, off-season horticulture, and functional food crops.

2. Eco-tourism: education and research, tourism village development

   The second part of the program could take advantage of the Merapi Volcano landscape and the community's tangible and intangible culture to develop the tourism sector. This could involve the development of tourist activities and supporting attractions such as a museum, tourist villages, and other tourism destinations (thematic parks and a camping ground) as well as support facilities (hotel, restaurant, tour/travel/transportation provider).

3. SMEs (Small Medium Enterprises) with local commodities as raw material

   The last part of the program involves a collaboration between the manufacturing and creative industries. Local materials (agriculture-based and narrative story inspirations) could be used to support this concept. The resources could include processed food, agriculture products, handicrafts, traditional textiles, and other local non-food creative products (clothing, merchandise, movies, books, art performance, and festivals).

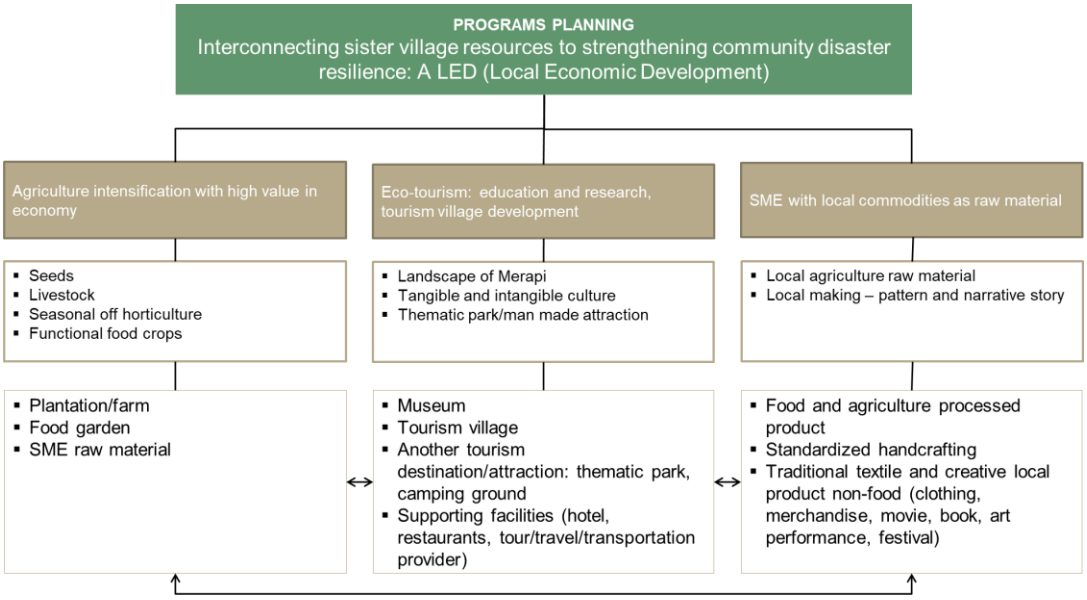

Figure 7.8 Sister village program planning using the LED concept

Source: Author, 2022

7.3.3. Example of utilizing sister villages using the LED approach: area profile and detailed programs s

This part shows how the sister village concept could be implemented with a village located in DPA (Ngargomulyo) and a supporting village in a safer area (Tamanagung), both of which have distinctive characteristics and similarities (see **Fig. 7.9**).

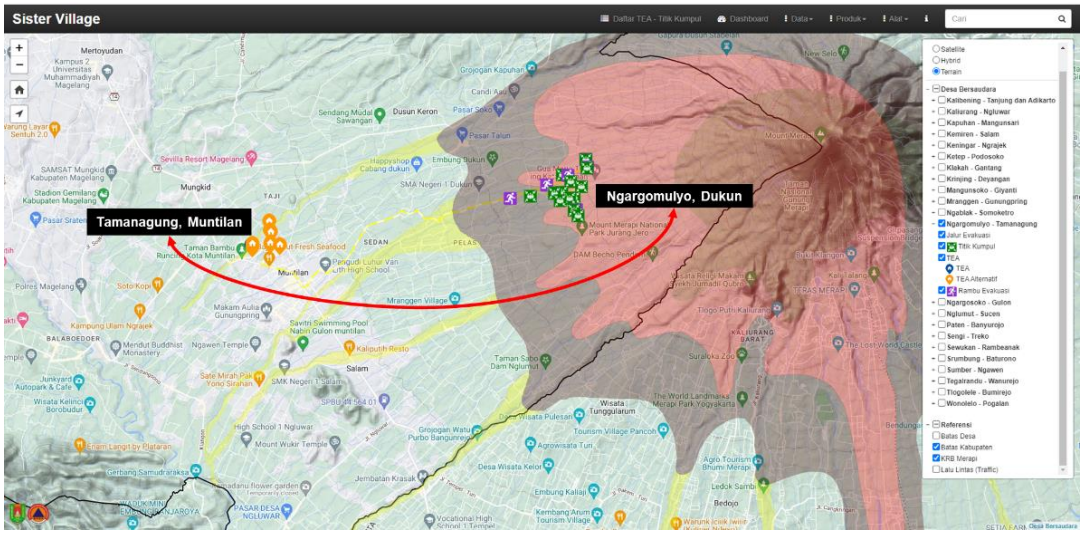

Figure 7.9 Illustration of the sister village connection in Merapi

Source: Modified from SIKK Magelang [67]

1. Ngargomulyo Village

Ngargomulyo is a rural village with a high elevation topography on the western side of the Merapi Volcano. The village economy is dominated by agricultural activities such as horticulture, livestock, and seed plantations (see **Figs. 7.10 and 7.11**) and has several tourist attractions, such as historical sites, cultural feasts, festivals, and food gardens.

Figure 7.10 Ngargomulyo Village View
Source: Google Street View [342]

Figure 7.11 Agricultural activities in Ngargomulyo; livestock (left) and greenhouse vegetable plantation (right)
Source: Ngargomulyo Village [343]

However, aside from the Merapi volcano hazards, this village is also vulnerable to drought if water resources are not properly managed, landslides, and climate change, all of which can disrupt agricultural activities and exacerbate poverty and inequality.

2. Tamanagung Village

Tamanagung is an urbanized area that has a central business district and a traditional regional market. The economy is dominated by SME manufacturing and home-based enterprises, such as handicrafts, food products, textiles, and stone. This area has several resources that could be potential tourist attractions, such as manufacturing products, trade areas, agriculture-based activities, cultural feasts, and festivals (see **Figs. 7.12 and 7.13**). However, the village is also vulnerable to lahars or debris flows from Merapi and has inequality issues that could hinder the upscaling of the sister village program

Figure 7.12 Tamanagung supporting sister village has urban scape activities
Source: Google Street View [344]

Figure 7.13 SME activities in Tamanagung which could support sister village activities
Source: Jawa Tengah Prov. PR department [345] *and Tamanagung Village* [346]

Three programs accommodate disaster governance, solve the inequality development issue, and advance the sister village concept.:

1. Building a village economic center

A village economic center could be built in the safer support village, which could be used as a multi-functional facility for economic and human capacity building. This economic center could be a restaurant, a homestay, and a showroom for local products (see **Figs. 7.14 and 7.15** as precedent concepts). This building would be the core facility for both sister village communities and could be run collaboratively by the two local community villages, the government, the private sector (as sponsors and mentors), and other tourism providers. The management would be responsible for promoting the sister villages. However, staff from both villages must be involved to increase the economic and human capital in both sister village communities.

Figure 7.14 Inside of the community-based economic center, a precedent from Borobudur Balkondes
Source: Balkondes Kembang Limus and Karangrejo [347–350]

Figure 7.15 Precedent concept in the economic center, the restaurant at Truntum Gasblock Borobudur
Source: Truntum Gasblock Borobudur [351–354]

2. Eco-tours and tailor-made events

This program would be developed based on the current tourism village attractions and concepts, such as bike tours, jeep tours, walking tours, rafting, and running/marathon events, but would involve both sister villages (see the precedent program in **Fig. 7.16**). There could also be tailor-made events for visitors, such as camping, meetings, and outward-bound training.

Figure 7.16 Precedent for activities managed by the local community through the village economic center
Source: Balkondes Borobudur [355]

3. Collaborative local product production and marketing

The last concept planning element could be collaborative local product production and marketing, focusing on local agriculture and non-agriculture products. This part of the program would be focused on the communities' regional IP (intellectual property) core values, such as *salacca* (snake fruit), coffee Merapi, Merapi itself (see **Figs. 7.17 and 7.18**), and other local products.

Figure 7.17 Salacca and an example of the processed product
Source: Wikipedia [356] *and Blibli* [357]

Figure 7.18 Batik textile with Merapi Volcano-inspired patterns
Source: Dewi, M. [358] *and Adhianti Rina* [359]

Various platforms could be used to market these end products, such as the village economic center, the local creative center, and e-commerce platforms (see **Fig. 7.19**).

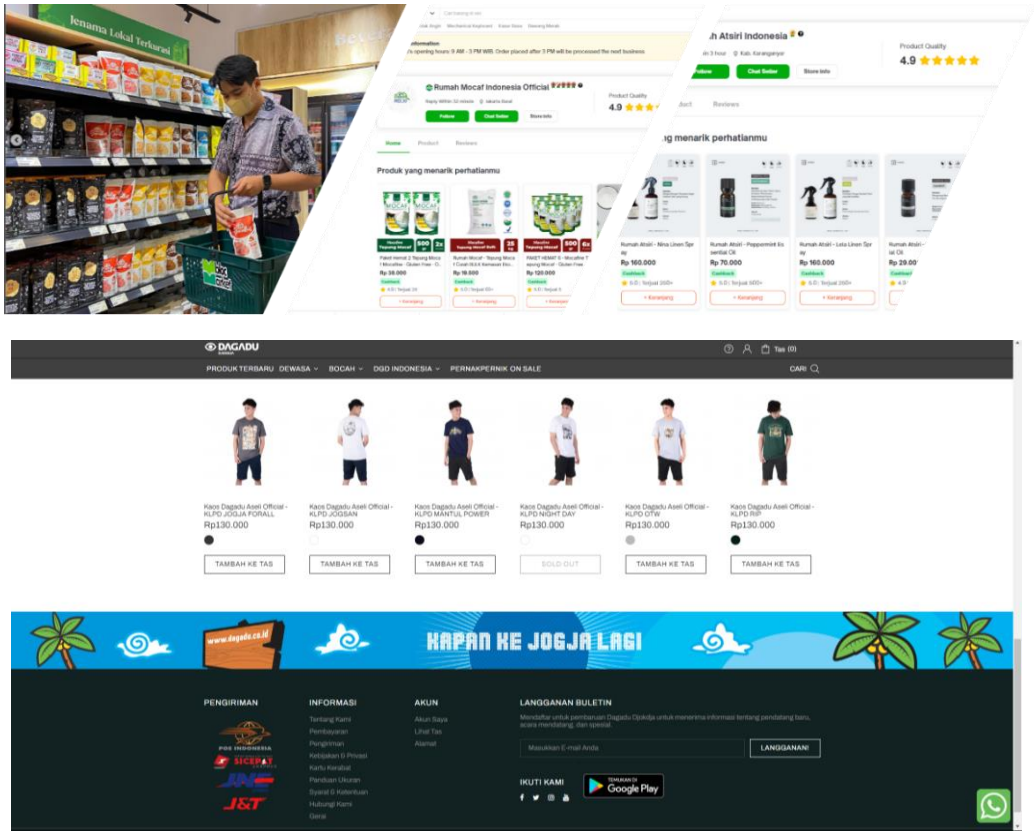

Figure 7.19 Various marketing platforms for local products: local creative showcase, brand website, and e-commerce platform
Source: Pos bloc Jakarta [360], *JNM Bloc* [361], *Dagadu Djokdja* [362], *Tokopedia* [363–365]

7.4. Research Limitation

This research had two main limitations related to the topic and technical issues.

7.4.1. Limitation of transformative capacity in resilience research

1. Transformative capacity studies have not yet been developed in practice. Therefore, finding and processing this thematic research and connecting the dots between the issues was complex and challenging.
2. Resilience has been widely discussed in several fields and time frames. Transformative capacity, which is part of resilience, has received less discussion than other capacities, such as absorptive coping mechanisms and adaptive capacity.
3. This research focused on a specific type of recurrent disaster occurrence with a rapid onset. Therefore, the community is exposed to disaster risks in a particular setting; however, the findings could be useful for other disaster governance situations.

7.4.2. Study Limitation

1. Details of the output and disaster awareness program and initiative evaluations in some specific locations were not obtained. As disaster risk awareness concerns the local community, a broader community should be considered in future research designs as people outside the area also need to be consulted. However, it was challenging to gain spatially well-distributed respondents because of the use of an

online survey and engagement limitations with the community and the respondents.

2. Time and resource limitations were an issue in getting more detailed data from the various respondent groups. This research was conducted online during the Covid 19 pandemic in 2020 – 2021, which further restricted the data collection.
3. The findings interpretations were related to the specific cultural setting at the selected study site. Therefore, a local understanding of the context, language, and culture was invaluable, which should also be considered in future research designs when collecting and analyzing local community data.

7.5. Future Research Direction

However, further studies are required to:

1. To explore transformative capacity in practice within different hazard settings, different assessment tools for different hazard types are needed, such as slow-onset disasters (i.e., coastal floods with multiple exposures from sea level rises and hydrometeorological hazards).
2. To understand the performance of disaster awareness programs and initiatives, further research is needed on the various stakeholder roles and functions in the affected/vulnerable areas and to identify the spatial and individual diversity.

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APPENDICES

Appendix A Online Survey Question List

Table A1. Online survey question list.

	Questions	Programs
	A. Individual attributes as community members	
1.	Sex (Gender)	(1) Female; (2) Male; (3) Not Stated
2.	Age (years)	(1) Less than 18; (2) 18–19; (3) 20–24; (4) 25–29; (5) 30–34; (6) 35–39; (7) 40–44; (8) 45–49; (9) 50–54, (10) 55–59; (11) 60–64; (12) 65–69; (13) More than 70
3.	Duration of stay in neighborhood (years)	(1) < 1; (2) 1–3; (3) 3–5; (4) 5–10; (5) 10–15; (6) 15–20; (7) 20–25; (8) 25–30; (9) 30–35; (10) > 35
4.	Education	(1) No education qualification; (2) Elementary School; (3) Junior HS; (4) Senior HS; (5) Professional Certificate/Diploma; (6) University Undergraduate; (7) University postgraduate (Master, Doctoral); (8) Others
5.	Monthly income (Million IDR)	(1) Do not have fixed monthly income; (2) < 3; (3) 3–5; (4) 5–8; (5) 8–10; (6) 10–15; (7) 15–25; (8) 25–35; (9) 35–45; (10) > 45
6.	Daily activity	(1) Employed; (2) Unemployed; (3) Retired; (4) Homemaker (including Housewife); (5) Student; (6) Entrepreneur
7.	Household profile	(1) Single person HH; (2) Couple without child; (3) Single parent with one child or more; (4) Parents with one child or more; (5) Others
B.	Risk knowledge and information	
8.	What is the possibility that the following hazards could affect life: (1) Hydrometeorological hazard; (2) Earthquake; (3) Volcanic Eruption; (4) Flood; (5) Landslide; (6) Drought; (7) Climate change; (8) Work accident; (9) Household accident; (10) Pandemic; (11) Traffic accident; (12) Crime; (13) Infrastructure failure; (14) Recreational hazard	(1) Never; (2) Rarely; (3) Neutral; (4) Possible; (5) Highly Possible
9.	Source of information	(1) TV; (2) social media; (3) Friends and family; (4) Internet (website); (5) News portal; (6) Local DMA; (7) National DMA; (8) Radio; (9) Community meeting; (10) Local government (aside local DMA); (11) DRR community (12) Workplace; (13) Printed information (billboard, brochure, etc.); (14) Emergency service; (15) School; (16) Insurance company; (17) Others
10.	Type of disaster accessed information	(1) Recent and updated information of Merapi Volcano; (2) Knowledge about volcanic hazard; (3) Evacuation and emergencies procedure; (4) Evacuation shelter; (5) Evacuation route; (6) EWS—early warning system; (7) Time for evacuation; (8) CBDRM—community-based disaster risk management; (9) Contact and network communication during emergencies; (10) Disaster drill and simulation; (11) Live guidelines in the temporary shelters; (12) Organization of disaster emergency response; (13) Others
11.	The accessibility of disaster information	(1) Yes; (2) Maybe; (3) No; (4) Do not know
C.	Capacity building and future perspective	
12.	Experience of DRR programs	(1) Yes; (2) No; (3) Do not know
13.	DRR programs participated in	(1) Disaster contingency plan making; (2) Disaster training and workshop (3) Disaster drill and simulation; (4) Community disaster camp (school or volunteer); (5) Making community emergency SOP—standard operational procedures; (6) Contributing into disaster evacuation route making and implementation; (7) Building another structural mitigation; (8) DRR campaign, fair, and feast; (9) Community meeting; (10) Livelihood based tourism on disaster-prone area training and capacity building; (11) Livestock management during an emergency; (12) Participating into social insurance for disaster emergency

14.	Advantages of DRR program for preparing the community for a possible threat	(1) Yes; (2) Maybe; (3) No; (4) Do not know
D.	Organization, roles, and network	
15.	Awareness of CBDRM organization in their neighborhood	(1) Yes; (2) No; (3) Do not know
16.	Prioritizing the vulnerable group during and after the emergency	(1) Yes; (2) No; (3) Do not know
17.	The importance of women group on the decision making and DRR	(1) Yes; (2) No; (3) Maybe
18.	Example of women roles in DRR program	(1) Evacuation shelter and routes planning; (2) Well-being management in the shelter (e.g., sanitation availability, cleanliness, health facilities, etc.); (3) The psychological condition of refugees; (4) Children education during the emergency; (5) Logistics and necessities (management) during emergencies; (6) Others
19.	Perception that collaborating with external stakeholders would give advantages for community preparedness	(1) Yes; (2) No; (3) Maybe

Appendix B Local Community: Risk Knowledge and Disaster Information Access

Table A2. Respondents' perceptions of hazard occurrence possibilities.

Hazards	Never	Rarely	Neutral	Possible	Highly Possible	Total	Weighted Average
Volcanic Eruption	0.81%	5.66%	4.04%	30.19%	59.30%	371	4.42
Earthquake	1.35%	12.13%	1.08%	43.94%	41.51%	371	4.12
Hydrometeorological Hazard	2.70%	14.29%	3.50%	46.36%	33.15%	371	3.93
Pandemic	4.31%	11.32%	5.12%	48.52%	30.73%	371	3.90
Climate Change	0.81%	12.67%	12.67%	48.79%	25.07%	371	3.85
Traffic Accident	1.89%	16.44%	8.89%	48.25%	24.53%	371	3.77
Infrastructure failure	3.50%	19.68%	10.51%	45.55%	20.75%	371	3.60
Recreational hazard	5.66%	15.63%	13.21%	47.17%	18.33%	371	3.57
Crime	6.47%	19.68%	10.24%	42.59%	21.02%	371	3.52
Work Accident	5.12%	25.88%	9.16%	39.08%	20.75%	371	3.44
Household Accident	4.04%	28.03%	11.32%	40.43%	16.17%	371	3.37
Flood	16.71%	19.95%	9.43%	28.03%	25.88%	371	3.26
Drought	11.32%	23.45%	10.24%	43.67%	11.32%	371	3.20
Landslide	25.34%	28.30%	8.63%	24.80%	12.94%	371	2.72

Table A3. Source of disaster risk information.

Source of Information	Responses	
TV	91.16%	268
Social Media	87.76%	258
Friends or Family	78.91%	232
Internet (website)	73.81%	217
News Portal	66.33%	195
Local DMA	57.82%	170
National DMA	56.46%	166
Radio	56.12%	165
Community Meeting	51.02%	150
Local Government (aside Local DMA)	42.52%	125
DRR Community	40.82%	120
Workplace	38.78%	114
Printed Information (Billboard, Brochure, etc.)	37.07%	109
Emergency Service	37.07%	109
School	33.67%	99
Insurance Company	5.10%	15
Others		13
Total Respondents		294

Appendix C Community-based Disaster Risk Management (CBDRM), Community Roles, Networks, and Collaboration

Table A4. Crosstabulation of gender and experience of participating in the Disaster Risk Reduction (DRR) program.

		Sex		Total
		Woman	Man	
Yes	Count	17_a	21_b	38
	Expected Count	23.1	14.9	38.0
	%	44.7%	55.3%	100.0%
No	Count	31_a	10_b	41
	Expected Count	24.9	16.1	41.0
	%	75.6%	24.4%	100.0%
Total	Count	48	31	79
	Expected Count	48.0	31.0	79.0
	%	60.8%	39.2%	100.0%

Each subscript letter denotes a subset of sex categories whose column proportions do not differ significantly from each other at the 0.05 level.

Table A5. Activities of women involvement in the Disaster Risk Reduction (DRR) Program.

Activities	Responses	
Logistics and necessities (management) during emergency situations	90.1%	136
Children education during the emergency	70.2%	106
The psychological condition of refugees	57.6%	87
Wellbeing management in shelter (e.g., sanitation availability, cleanliness, health facilities, etc.)	53.0%	80
Evacuation shelter and routes planning	27.8%	42
Others	11.9%	18
Total Respondents		151

Appendix D The Goodness of Fit Test

Table A6. Degree of freedom test between the individual attributes and the experiences of DRR programs.

Variables	*n*	Value	*df*	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Test
Sex	79	7.884	1	0.005	0.006	Chi-square
Age group	77	5.009			0.079	Fisher's exact test
Duration of staying in the neighborhood	78	9.983	2	0.007	0.007	Chi-square
Education	78	2.850			0.419	Fisher's exact test
Monthly income	71	6.039	3	0.110	0.112	Chi-square
Activity	78	1.923			0.448	Fisher's exact test
Household types	69	1.993			0.474	Fisher's exact test

Table A7. Degrees of freedom test between the individual attributes and advantages of the DRR program for preparedness.

Variables	*n*	Value	*df*	Asymptotic Significance (2-Sided)	Exact Sig. (2-Sided)	Test
Sex	46	3.067	1	0.080	0.187	Chi-square *
Age group	44	1.747			0.538	Fisher's exact test
Duration of staying in the neighborhood	45	0.851			0.853	Fisher's exact test
Education	45	1.853			0.621	Fisher's exact test
Monthly income	44	1.231			0.867	Fisher's exact test
Activity	46	8.711			0.014	Fisher's exact test
Household types	41	1.589			0.616	Fisher's exact test

* Count in 2 × 2 table.

Table A8. Degree of freedom test between the individual attributes and the existence of a community-based disaster risk management (CBDRM) organization

Variables	*n*	Value	*df*	Asymptotic Significance (2-Sided)	Exact Sig. (2-Sided)	Test
Sex	155	1.034	1	0.309	0.323	Chi-square
Age group	152	1.936	2	0.380	0.393	Chi-square
Duration of staying in the neighborhood	153	0.052	2	0.974	0.979	Chi-square
Education	153	4.439	3	0.218	0.222	Chi-square
Monthly income	140	2.911	3	0.406	0.411	Chi-square
Activity	154	7.780	2	0.020	0.018	Chi-square
Household types	129	2.935			0.258	Fisher's exact test

Table A9. Degree of freedom test between the individual attributes and prioritizing vulnerable groups during disaster emergencies.

Variables	*n*	Value	*df*	Asymptotic Significance (2-Sided)	Exact Sig. (2-Sided)	Test
Sex	200	0.110	1	0.741	0.747	Chi-square
Age group	195	1.939	2	0.379	0.414	Chi-square
Duration of staying in the neighborhood	198	2.580	2	0.275	0.276	Chi-square
Education	196	8.051	3	0.045	0.044	Chi-square
Monthly income	175	6.727	3	0.081	0.081	Chi-square
Activity	198	0.639	2	0.727	0.739	Chi-square
Household types	162	4.050			0.120	Fisher's exact test

Table A10. Degree of freedom test between the individual attributes and women's involvement in disaster and risk management.

Variables	*n*	Value	*df*	Asymptotic Significance (2-Sided)	Exact Sig. (2-Sided)	Test
Sex	187	0.996	1	0.318	0.361	Chi-square *
Age group	182	4.771	2	0.092	0.091	Chi-square
Duration of staying in the neighborhood	185	3.882	2	0.144	0.140	Chi-square
Education	182	6.261	3	0.100	0.101	Chi-square
Monthly income	162	2.733	3	0.435	0.442	Chi-square
Activity	186	2.179	2	0.336	0.352	Chi-square
Household types	152	3.252			0.208	Fisher's exact test

* Count in 2 × 2 table.

Table A11. Degree of freedom test between the individual attributes and the impact of collaboration on disaster preparedness and community resilience

Variables	*n*	Value	*df*	Asymptotic Significance (2-Sided)	Exact Sig. (2-Sided)	Test
Sex	210	1.826	1	0.177	0.186	Chi-square
Age group	205	0.210	2	0.900	0.924	Chi-square
Duration of staying in the neighborhood	208	0.692	2	0.708	0.691	Chi-square
Education	205	1.209	2	0.546	0.545	Chi-square
Monthly income	184	1.580	3	0.664	0.678	Chi-square
Activity	208	0.769	2	0.681	0.687	Chi-square
Household types	169	0.099			1.000	Fisher's exact test

Appendix E Multiple Regression Analysis

Table A12. Multiple regression result for predictive analysis: education level: primary, secondary, and tertiary significantly predicted perception of disaster information accessibility.

Variables	Unstandardized B	Coefficients SE	Standardized Coefficients Beta (β)	t	*p*
(Constant)	1.800	0.420		4.290	0.000
Primary	−0.133	0.457	−0.047	−0.292	0.771
Secondary	−0.276	0.432	−0.143	−0.638	0.524
Tertiary	−0.053	0.430	−0.028	−0.122	0.903

Constant = 1.800, F(3, 209) = 0.891, $p = 0.447$, R = 0.112, $R^2 = 0.013$.

The final predictive model was:

$$\textit{Disaster information accessibility} = 1.800 + (-0.133 \times \textit{primary education}) + (-0.276 \times \textit{secondary education}) + (-0.053 \times \textit{tertiary education}) \quad \text{(A1)}$$

Table A13. Multiple regression result for predictive analysis: each gender (male and female) could significantly predict the experience of DRR programs.

Variables	Unstandardized B	Coefficients SE	Standardized Coefficients Beta (β)	t	*p*
(Constant)	1.745	0.088		19.878	0.000
Sex Male	0.005	0.121	0.004	0.044	0.965
Sex Female	−0.230	0.134	−0.168	−1.715	0.089

Constant = 1.745, F (2, 131) = 1.943, $p = 0.147$, R = 0.170, R2 = 0.029.

The final predictive model was:

$$DRR\ program\ experience = 1.745 + (0.005 \times male) + (-0.230 \times female). \quad \text{(A2)}$$

Table A14. Multiple regression result for predictive analysis: duration of staying in the neighborhood (≤ 10, 10– ≤ 30, > 30 years) could significantly predict the experience of DRR programs.

Variables	Unstandardized B	Coefficients SE	Standardized Coefficients Beta (β)	t	*p*
(Constant)	1.695	0.056		30.108	0.000
Duration of stay 1 *(≤ 10 years)*	−0.028	0.358	−0.007	−0.079	0.937
Duration of stay 2 *(10–≤ 30 years)*	−0.195	0.256	−0.067	−0.762	0.448
Duration of stay 3 (> 30 years)	0.019	0.238	0.007	0.081	0.935

Constant = 1.695, F (3,130) = 0.199, $p = 0.897$, R = 0.068, R2 = 0.005.

The final predictive model was:

$$DRR\ program\ experience = 1.695 + (-0.028 \times \leq 10\ years) + (-0.195 \times 10 - \leq 30\ years) + (0.019 \times > 30\ years). \quad \text{(A3)}$$

Table A15. Multiple regression result for predictive analysis: people's type of occupation (worker, homemaker, unemployed, retired, and student) could significantly predict their perception of the advantages of DRR programs for disaster preparedness.

Variables	Unstandardized B	Coefficients SE	Standardized Coefficients Beta (β)	t	*p*
(Constant)	1.930	0.144		13.448	0.000
Activity 1 *(workers and homemakers)*	−0.744	0.203	−0.367	−3.666	0.000
Activity 2 *(unemployed and retired)*	1.070	0.681	0.156	1.571	0.120
Activity 3 *(students)*	−0.310	0.317	−0.097	−0.977	0.331

Constant = 1.930, F(3, 85) = 6.139, $p = 0.001$, R = 0.422, R2 = 0.178.

The final predictive model was:

$$Impact\ of\ DRR\ programs\ on\ disaster\ preparedness = 1.930 + (-0.744 \times workers\ and\ homemakers) + (1.070 \times unemployed\ and\ retired) + (-0.310 \times students). \quad \text{(A4)}$$

Table A16. Multiple regression result for predictive analysis: people's type of occupation (worker, homemaker, unemployed, retired, and student) could significantly predict the value of their awareness of CBDRM existence in their neighborhood.

Variables	Unstandardized B	Coefficients SE	Standardized Coefficients Beta (β)	t	*p*
(Constant)	1.988	0.083		24.023	0.000
Activity 1 *(workers and homemakers)*	−0.207	0.101	−0.134	−2.051	0.041
Activity 2 *(unemployed and retired)*	0.346	0.193	0.108	1.791	0.074
Activity 3 *(students)*	0.140	0.052	0.170	2.705	0.007

Constant = 1.978, F (3, 290) = 8.579, $p = 0.001$, R = 0.286, R2 = 0.082.

The final predictive model was:

$$\textit{Impact of CBDRM awareness} = 1.988 + (-0.207 \times \textit{workers and homemakers}) + (0.346 \times \textit{unemployed and retired}) + (0.140 \times \textit{students}). \quad \text{(A5)}$$

Table A17. Multiple regression result for predictive analysis: level of education (primary, secondary, and tertiary) could significantly predict the perceptions of the inclusive process during disaster.

Variables	Unstandardized B	Coefficients SE	Standardized Coefficients Beta (β)	t	*p*
(Constant)	1.780	0.096		18.490	0.000
Primary	−0.521	0.193	−0.171	−2.694	0.007
Secondary	−0.274	0.136	−0.140	−2.022	0.044
Tertiary	−0.008	0.130	−0.004	−0.063	0.950

Constant = 1.780, F (3, 289) = 3.835, $p = 0.010$, R = 0.196, R2 = 0.038.

The final predictive model was:

$$\textit{Inclusive process on disaster management} = 1.780 + (-0.521 \times \textit{primary education}) + (-0.274 \times \textit{secondary education}) + (-0.008 \times \textit{tertiary education}). \quad \text{(A6)}$$

Appendix F List of Publications from this research

A. International Journal (Peer Reviews)

1. Mutiarni YS, Nakamura H, Bhattacharya Y. Financing Disaster Risk Reduction: The Perspective of Budget Allocation for Awareness Programs in The Merapi Volcano Community. In IOP Conference Series: Earth and Environmental Science 2021 May 1 (Vol. 764, No. 1, p. 012037). IOP Publishing.
2. Mutiarni YS, Nakamura H, Bhattacharya Y. The Resilient Community: Strengthening People-Centered Disaster Risk Reduction in the Merapi Volcano Community, Java, Indonesia. Sustainability. 2022 Feb 15;14(4):2215.
3. Mutiarni YS, Nakamura H. Rethinking Disaster Risk Reduction: A Transformative Capacity Approach of Local Action in The Merapi Volcano Communities. SEATUC Journal of Science and Engineering (SJSE) 2022-1x. *(Accepted, on process)*.

B. Conference Proceedings (Peer Reviews)

1. Mutiarni YS, Nakamura H. Bridging The Community Resilience: A Lesson from Education for Disaster Risk Reduction on Merapi Volcano Community in Yogyakarta, Indonesia. In Proceedings of the 14th South East Asian Technical University Consortium Symposium (SEATUC 2020) 2020 Feb (pp. 105-110).
2. Mutiarni YS, Nakamura H. Social Learning for Disaster Risk Reduction Through Local Initiatives in the Merapi Volcano Communities. In Proceedings of the 16th South East Asian Technical University Consortium Symposium (SEATUC 2022) 2022 Feb.