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Management of Tomato (*Solanum lycopersicum*) Cultivation after the Mount Marapi Eruption in Nagari Tabek Panjang, Agam Regency

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Abstract

The 2023 eruption of Mount Marapi buried farmland in Nagari Tabek Panjang, Baso District, Agam Regency, under volcanic ash, reducing productivity and causing crop failure in tomato (*Solanum lycopersicum*), the main source of income for local farmers. This study aimed to identify the physical impacts of the eruption on land and tomato plants, analyze the socio-economic impacts on farmers, and formulate recommendations for post-eruption land and crop management. The study was conducted from January to March 2025 using field observation, visual documentation, structured interviews, and document review, with descriptive data analysis. Volcanic ash impaired photosynthesis and suppressed tomato growth; tomato harvests were reported to fall from 50–60 tons to 10–20 tons, and farmers' incomes declined. Ash removal from the fields, soil tillage, organic fertilizer, selection of more tolerant varieties, and support from extension agents and the government gradually restored plant growth, although yields had not returned to pre-eruption levels and fruit quality remained good. Because the data were presented descriptively without statistical testing, the findings indicate a tendency toward recovery rather than causal effects.

Keywords: tomato; Mount Marapi eruption; cultivation; recovery; farmer adaptation

1. Introduction

Indonesia lies within the Pacific Ring of Fire and therefore has many active volcanoes, one of which is Mount Marapi in West Sumatra. Volcanic eruptions often have major effects on communities, particularly in the agricultural sector. The 2023 eruption of Mount Marapi damaged farmland in Nagari Tabek Panjang, Baso District, Agam Regency. The volcanic ash that blanketed the land not only disrupted plant growth but also reduced productivity and the quality of harvested produce.

One of the main commodities affected was tomato (*Solanum lycopersicum*). Tomato is a high-value horticultural crop widely cultivated in Indonesia, valued for its nutritional content and its suitability for processing into various food products. Market demand tends to increase each year, making tomato the main source of income for many farmers in Nagari Tabek Panjang. Volcanic ash deposited on the soil surface can alter soil physical and chemical properties, for example by lowering pH, restricting water and nutrient uptake, and worsening conditions for plant growth. As a result, tomato productivity declined and many plants failed to yield a harvest.

The impacts of the eruption were not only agronomic but also socio-economic. Lower harvests reduced farmers' incomes, affecting household welfare and the sustainability of farming enterprises. Appropriate management is therefore needed so that the land can be restored and tomato cultivation can resume optimally. Post-eruption management includes removing volcanic ash from fields, tillage to improve soil structure and fertility, the use of organic and inorganic fertilizers, the selection of varieties more tolerant of environmental stress, and the adoption of environmentally friendly cultivation technologies, supported by the government and agricultural extension workers.

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Based on this background, this study aimed to (1) identify the physical impacts of the Mount Marapi eruption on land and tomato plants in Nagari Tabek Panjang, (2) analyze the socio-economic impacts on tomato farmers, and (3) provide recommendations for post-eruption land and crop management, including recovery strategies that have been and could be implemented, as well as the roles of the government and the community.

2. Literature Review

2.1. Tomato in Horticultural Farming Systems

Tomato (*Solanum lycopersicum*) is an economically and nutritionally important horticultural commodity in Indonesia. It is recognized as a source of vitamin C, vitamin A, lycopene, and other antioxidants that benefit human health [1]. Agronomically, tomato is an annual crop that grows best at temperatures of 20–27 °C and at elevations of 500–1,500 m above sea level [2]. Suitable soils are sandy loams rich in organic matter, with a neutral to slightly acidic pH (5.5–6.8).

Tomato requires adequate light, good drainage, and optimal nutrient management. Balanced application of nitrogen (N), phosphorus (P), and potassium (K) strongly influences vegetative and generative growth [3]. Organic fertilizers are also increasingly being developed to support sustainable agriculture, and biofertilizer application has been reported to improve fruit quality and fertilizer-use efficiency [4]. Pest and disease management is a crucial aspect because tomato is susceptible to Fusarium wilt, leaf blight, and fruit flies; biological control using agents such as *Trichoderma* sp. and *Bacillus subtilis* is increasingly being developed [5].

2.2. Impacts of Volcanic Eruptions on Agricultural Ecosystems

Volcanic eruptions affect agricultural systems extensively, both directly and indirectly. Volcanic ash can physically damage plants, cover leaf surfaces and thereby inhibit photosynthesis, and injure plant tissues [6]. Ash accumulation on the soil surface alters soil structure, reduces water infiltration capacity, and changes soil chemical properties, such as increased acidity and heavy-metal content [7].

Volcanic ash can also disturb soil microorganisms that are important for nutrient cycling; in some cases, populations of mycorrhizae and phosphate-solubilizing bacteria have declined sharply after eruptions [8]. In the long term, volcanic material containing silica, potassium, and calcium can improve soil fertility, but in the short term its presence more often inhibits plant growth [9]. Disruptions to irrigation, the distribution of seeds and fertilizers, and agricultural markets further aggravate these impacts.

Several major eruptions in Indonesia illustrate the diversity of outcomes. The 2010 eruption of Mount Merapi destroyed more than 6,000 hectares of farmland in Sleman, Klaten, and Magelang, with the loss of topsoil, the destruction of irrigation networks, and damage to food and horticultural crops [10]. The eruption of Mount Sinabung, which began in 2013, has had long-term effects on vegetable farmers in Karo Regency, North Sumatra, including the permanent relocation of farmland, while the 2017 eruption of Mount Agung in Bali disrupted planting calendars and the distribution of horticultural produce. These regional comparisons show that the resilience of local infrastructure and farming systems strongly influences the capacity to adapt to volcanic disasters.

2.3. Impacts of the Mount Marapi Eruption on Local Agriculture

Mount Marapi is an active volcano in West Sumatra that frequently shows volcanic activity. The 2023 eruption caused ashfall in several areas, including Nagari Tabek Panjang. According to a report by the West Sumatra Provincial Disaster Management Agency (BPBD) [11], horticultural land growing tomato, chili, and other vegetables sustained considerable damage after being covered by ash 1–5 cm thick. Farmers experienced reduced production, damage to plant tissues, and crop failure; because they depend on specific planting seasons, they had no short-term alternative for replacing damaged crops, resulting in economic losses and unstable horticultural supply [12].

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Data from the West Sumatra Provincial Agriculture Office [13], shown in Table 1, indicate the scale of the impact in Agam Regency. Besides crop damage, many farmers lost distribution channels because road access and transport vehicles were disrupted, and ash remaining on the land impeded rapid recovery. These conditions call for support from the government and related institutions to assess damage accurately and to provide technical and financial assistance.

Table 1. Impacts of the 2023 Mount Marapi eruption on horticulture in Agam Regency

Indicator	Value
Area of horticultural land affected	1,325 ha
Area of tomato land affected (light to severe damage)	± 735 ha
Farming households directly affected	1,180 households
Average decline in harvest	up to 60%
Farmers with losses > IDR 10 million per planting season	62%

Source: West Sumatra Agriculture Office [13].

3. Methodology

3.1. Research Location and Period

The study was conducted from January to March 2025 in Nagari Tabek Panjang, Baso District, Agam Regency, West Sumatra Province. The location was selected because of the substantial damage to farmland caused by the 2023 Mount Marapi eruption and the high level of tomato cultivation activity among the local community.

3.2. Materials and Equipment

The materials used included seeds of a local tomato variety, chosen for its adaptation to local conditions; organic fertilizer to improve soil structure and supply nutrients after the land was covered with ash; inorganic NPK fertilizer as the main nutrient source; botanical pesticides for pest and disease control; and clean water for irrigation. The equipment comprised hoes, buckets, hand sprayers, a plant-height measuring tool, and a digital scale for weighing the harvest.

3.3. Data Collection

The study used a descriptive approach combining qualitative and simple quantitative data. Data were collected using four techniques. First, periodic field observations were made of the condition of the ash-affected land, soil structure and moisture, tomato growth during the recovery period, and the cultivation techniques applied by farmers. Second, visual documentation in the form of photographs and videos recorded the processes of land clearing, planting, and maintenance, as well as plant development through to harvest. Third, structured interviews were conducted with local farmers and agricultural extension workers on post-eruption management strategies, constraints, the forms of assistance received and their effectiveness, and perceptions of the sustainability of tomato farming. Fourth, a document review covered reports from the Agriculture Office, production data from before and after the eruption, and relevant scientific literature.

3.4. Research Procedure

The research was carried out in several stages. A preliminary study consisted of direct observation at the site and initial engagement with farmer groups, extension workers, and nagari officials. Land preparation began with the manual and mechanical removal of volcanic ash and other eruption debris, after which the land was dried and loosened. Soil improvement was carried out with organic fertilizer, with liming applied when soil analysis indicated

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high acidity, and organic matter was mixed in evenly through minimum tillage. The local tomato variety was planted at a regulated spacing on raised beds. Maintenance included watering twice daily during the vegetative phase and once daily during the generative phase, follow-up fertilization, integrated pest and disease management, and daily monitoring. Plant height was measured weekly, and the number of fruits and harvest weight were recorded at harvest. All data were then evaluated quantitatively and qualitatively to draw conclusions and formulate recommendations.

3.5. Data Analysis

The data were analyzed descriptively. Quantitative data, such as plant height, number of fruits per plant, and harvest weight, were analyzed by calculating mean values and comparing them between pre-eruption and post-eruption conditions. Qualitative data from observations and interviews were interpreted narratively to understand farmers' adaptation behavior and the effectiveness of the management measures.

4. Results and Discussion

4.1. Impacts of the Eruption on Tomato Cultivation

The Mount Marapi eruption had a substantial impact on farmland in Nagari Tabek Panjang. Volcanic ash covered the land and the plants, reducing productivity and disrupting tomato growth. Field observations indicated that the plants experienced physiological stress due to reduced light intensity, impaired respiration and photosynthesis, and lowered soil temperature, consistent with Prasetya and Widiyanto [6].

Farmers and the government cleared ash from the land, re-tilled the soil, and applied organic fertilizer and compost. Setyaningrum et al. [9] showed that organic matter helps improve soil structure and increases soil microbial activity after eruptions. After these measures, tomato growth improved and replanted crops showed signs of adaptation, although yields had not fully recovered to pre-eruption levels. These conditions underscore the importance of a rapid response and emergency management; local governments need to establish early warning systems and provide technical guidelines for farmers so that negative impacts on cultivation can be minimized.

4.2. Quantitative Data on Growth and Production

The observed tomato plants were 60–180 cm tall, with 10–18 fruits per plant and a harvest weight of approximately 138–680 g per plant. A comparison of tomato harvests before and after the eruption is presented in Table 2.

Table 2. Tomato harvest before and after the eruption

Period	Tomato harvest (tons)
Before the eruption	50–60
After the eruption	10–20

Source: research data.

Based on the figures in Table 2, the harvest declined by approximately 60–83%. This is larger than the 30–60% decline reported by Ramadhani et al. [12] and the average decline of up to 60% reported by the West Sumatra Agriculture Office [13]. The difference should be interpreted with caution because the location coverage, period, and measurement method of each source are not uniform or are not specified.

4.3. Impacts on Growth and Harvest

Volcanic ash covering the leaf surface impairs photosynthesis [6]. Ash accumulation also increases soil acidity and disrupts the availability of essential nutrients, so that growth is inhibited and yields decline. After land clearing, fertilization, adequate irrigation, and the use of organic matter, tomato plants showed gradual recovery [9]. The quality of the fruit produced remained good, particularly in terms of size and color, although the quantity was limited.

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The use of improved varieties and agronomic measures such as biofertilization and water management has been reported to accelerate post-disaster plant recovery [14].

4.4. Socio-economic Impacts on Farmers

The eruption placed pressure on farmers' social and economic circumstances. Many farmers incurred losses because of crop failure and a drop in the selling price of tomato caused by oversupply from unaffected areas. Reduced income disrupted household needs, children's education, and routine expenses [15]. Government interventions in the form of seed and fertilizer assistance and labor-intensive (padat karya) programs, together with extension support, have begun to give farmers hope, and some farmers have formed farmer groups to strengthen cooperation in recovery [16]. Other social impacts include temporary migration, reduced working hours in farming, and increased dependence on social assistance, so recovery needs to include social empowerment and farmer capacity building [17].

4.5. Post-eruption Adaptation Strategies of Farmers

Farmers in Nagari Tabek Panjang developed several adaptation strategies to restore tomato cultivation, which are summarized in Table 3.

Table 3. Adaptation strategies of tomato farmers after the eruption

Adaptation strategy	Supporting reference
Routine removal of volcanic ash from land and plants	Setyaningrum et al. [9]
Use of organic fertilizer and soil microorganisms	Saragih et al. [8]
Selection of tomato varieties more tolerant of extreme environments	Fitria et al. [14]
Crop rotation with legumes	Nugroho et al. [3]
Participation in post-disaster cultivation training and extension	Supriyadi and Lestari [18]

Source: research data and the references listed.

These strategies have been reported to help raise productivity gradually and reduce the risk of crop failure. Farmers' initiative to learn and innovate demonstrates community resilience [17]. Collaboration among farmers, extension institutions, and academics can strengthen disaster-resilient farming systems, and it is important to build a database of local adaptation practices that can be widely shared.

4.6. Limitations

Several points should be considered when interpreting the results. First, the number and selection of respondents, the number of observation plots or fields, and the area underlying the production figures in Table 2 are not specified. Second, the growth and production data are presented as ranges without replication or statistical testing, so a causal relationship between the management measures and recovery cannot be established. Third, part of the discussion of socio-economic impacts relies on the literature, including studies from other regions, rather than on the interview data presented. Fourth, the study was conducted in a single nagari and during a single period, which limits generalizability.

5. Conclusion

The Mount Marapi eruption had a major impact on tomato cultivation in Nagari Tabek Panjang. Volcanic ash impaired photosynthesis and caused stress in the plants, and ash-covered soil experienced a decline in fertility. Harvests were reported to fall from 50–60 tons to 10–20 tons, and farmers' incomes and household economic conditions declined accordingly.

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Management measures consisting of land clearing, re-tillage, organic fertilizer application, selection of more tolerant varieties, the use of soil microorganisms, crop rotation, post-disaster training, and support from extension workers and the government were reported to restore growth and yields gradually. Yields had not fully recovered, but fruit quality remained good.

The government is advised to strengthen agricultural emergency response systems, including early information and technical guidelines, and to distribute seed, fertilizer, and equipment assistance quickly, accurately targeted, and accompanied by technical support. Farmers need post-disaster cultivation training, and the formation of farmer groups and collaboration with the government and academics can accelerate recovery. Future research should use designs with replication, clear sample sizes, and statistical analysis, together with periodic monitoring and evaluation so that recovery strategies can be continuously adjusted.

6. Declarations

5.1. Author Contributions

Conceptualization: F.A., and S.A.; Methodology: F.A.; Software: F.A.; Validation: F.A., S.A., and T.A.; Formal Analysis: F.A., and S.A.; Investigation: F.A.; Resources: F.A.; Writing Original Draft Preparation: F.A.; Writing Review and Editing: S.A., and F.A.,; All authors have read and agreed to the published version of the manuscript.

5.2 Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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The authors received no financial support for the research, authorship, and/or publication of this article.

5.4 Institutional Review Board Statement

Not applicable

5.5 Informed Consent Statement

Not applicable.

5.6 Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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