



## Perceptual Advantages of People Living in Semeru Volcanic Areas, Indonesia: An MRCV (Multiple Response Categorical Variable) Analysis

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### ABSTRACT

Why populations persist in active volcanic zones poses a fundamental challenge to risk perception models. We propose that perceptual advantages wherein tangible and intangible benefits filtered through local worldviews underpin this resilience. Through a thematic analysis of an open-ended question/answer study of communities in Mount Semeru, Indonesia, we identify six core frameworks of perceptual advantages. Analysis of Multiple Response Categorical Variable (MRCV) reveals that residents of high-risk zones cognitively amplify bio-cultural and livelihood benefits, showing significantly higher odds of emphasizing BIRTH/FAMILY (lineage/kin ties, birthright, and deep social networks that create an intergenerational connection to the land) and ECONOMIC (livelihood opportunities, including agriculture and volcano-driven tourism) advantages, while safe-zone residents prioritize ambient CLIMATE-related benefits (a preferred quality of life attributed to the region's cool, fresh air and superior air quality). Crucially, the influence of gender is context-dependent, as significant disparities in perception vanish within the high-risk zone. In this environment, the shared experience of chronic volcanic threat supersedes gender distinction to foster a "community of fate". Within this collective, a shared risk-benefit calculus and a unified identity override individual perspectives. These findings demonstrate that persistence in hazardous environments reflects an active cognitive recalibration of risk and benefit, necessitating disaster policies that integrate these perceptual realities.



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## 1. Introduction

Globally, over one billion people live within 100 km of an active volcano (Freire *et al.* 2019), creating a fundamental paradox in human-environment interactions where the landscapes are simultaneously sources of

catastrophic hazard and profound sustenance (Brown *et al.* 2017). This juxtaposition creates a critical disconnect between objective hazard (the quantifiable threat of pyroclastic flows, lahars, and tephra fall) and local risk perception, where the calculus of danger is mediated by cultural and economic factors. Traditional risk frameworks mostly emphasize vulnerability and exposure which often fail to explain why communities not only remain but thrive in objectively dangerous

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locations (Rymer 2000; Donovan *et al.* 2014; Cutter 2021).

Mount Semeru in East Java, Indonesia, exemplifies this paradox. As one of Indonesia's most active stratovolcanoes, it presents a continuous objective hazard through frequent eruptions (Solikhin *et al.* 2012), directly exposing 50,000-100,000 residents to high-magnitude threats (Thouret *et al.* 2022). Yet, foothills and valleys of the volcano sustains a population of nearly one million lives (BPS 2020a, 2020b), with communities not merely persisting but thriving for generations (Gaillard and Dibben 2008).

This paradox present challenges to simplistic explanations of poverty or entrapment (Lavigne *et al.* 2008). A growing scholarly perspective argues against viewing volcanic environments as inherently negative, instead recognizing their role as sources of livelihood and bio-cultural meaning (Dove 2008; Kelman and Mather 2008; Barclay *et al.* 2019; Choumert-Nkolo and Phélinas *et al.* 2020). While previous research has documented specific physical impacts, from volcanic air pollution (Nomura *et al.* 2004; Brown *et al.* 2017; Stewart *et al.* 2022; Wei 2025) to ash deposition in urban areas (Tomašek *et al.* 2021), analyses of perceived benefits remain scarce.

To address this knowledge gap, we employ the concept of perceptual advantage, encompassing both tangible and intangible benefits, filtered through the lenses of residential zonation and gendered perspectives, to uncover the cognitive basis of sustainable living in volcanic risk area. This framework enables a nuanced understanding of how communities culturally reconcile hazard with habitability (Kelman and Mather 2008). This study aims to identify the perceptual advantages held by communities on Mount Semeru, measure their association with residencies in high-risk zones, and analyze gender's moderating role, testing the hypothesis that these advantages offset objective risk in hazardous-area residency.

## 2. Materials and Methods

### 2.1. Study Sites and Times

The active stratovolcano Mount Semeru, in East Java, Indonesia (8°06'44"S, 112°55'27"E; summit elevation 3,676 m) frequently produces small to moderate explosive eruptions, generating pyroclastic flows and lahars that impact the proximal areas (Thouret *et al.* 2007; Perwita *et al.* 2023; Solikhin *et al.* 2012). The latest eruption initiated in December 2021 is one of the biggest eruptions in recent years, causing significant damage to

the surrounding communities (BNPB 2021; Kristianto *et al.* 2023; Utami *et al.* 2023). This persistent background risk makes it an ideal natural laboratory for studying disaster impacts on perceived living advantageousness.

We define a risky area as an objective geographical zone directly affected by pyroclastic flows and lahars. These zones were delineated using "Volcanic Hazard Map" from the Indonesian Center for Volcanology and Geological Hazard Mitigation (PVMBG) issued in 1996 and updated in 2021 (PVMBG 1996, 2021). According to the level of exposures in the maps, the area is categorized as risky depending on the colored zones: dark pink [Prone Zone III], light pink [Prone Zone II], and yellow [Prone Zone I], as these regions are directly affected by pyroclastic flows and lahars. In contrast to the risky area, unexposed zones located nearby but outside the hazard zones are safe (Figure 1). The sampling started in August 2018 and finished in September 2022.

### 2.2. Subject Criteria

Participants were recruited from both risky and safe areas in 38 different locations spanning 2 regencies, namely Malang and Lumajang. They were adult individuals, both male and female, who were at least 18 years old, capable of reading and writing, and able to work daily to fulfill their own needs. The entire session was verbally facilitated by trained local assistants to ensure comprehension. Instructions and on-screen text were read aloud and clarified as needed, allowing all participants to engage regardless of literacy.

We organized interview sessions asking about the advantages of living in volcanic risk areas. Each session had an average attendance of 10 participants. Among the total 753 participants, 258 (female 121, 46.9%) live in exposed areas, distributed across 16 locations, while 495 (female 247, 49.9%, test of equal proportions against female in exposed areas gives  $X^2 = 0.496$ ,  $p\text{-value} = 0.481$ ) reside in safe areas, spread across 22 locations. Participants were selected randomly in each location, with assistance from neighbourhood leaders and local team members.

### 2.3. Incentives and Procedure

The interview asking about the advantages of living in volcanic risk areas was part of a broader research project investigating local adaptation to living in volcanic risk areas. As a whole, in addition to written interviews on their experience and perceptions of living in such areas, we conducted a lab-in-the-field experiment

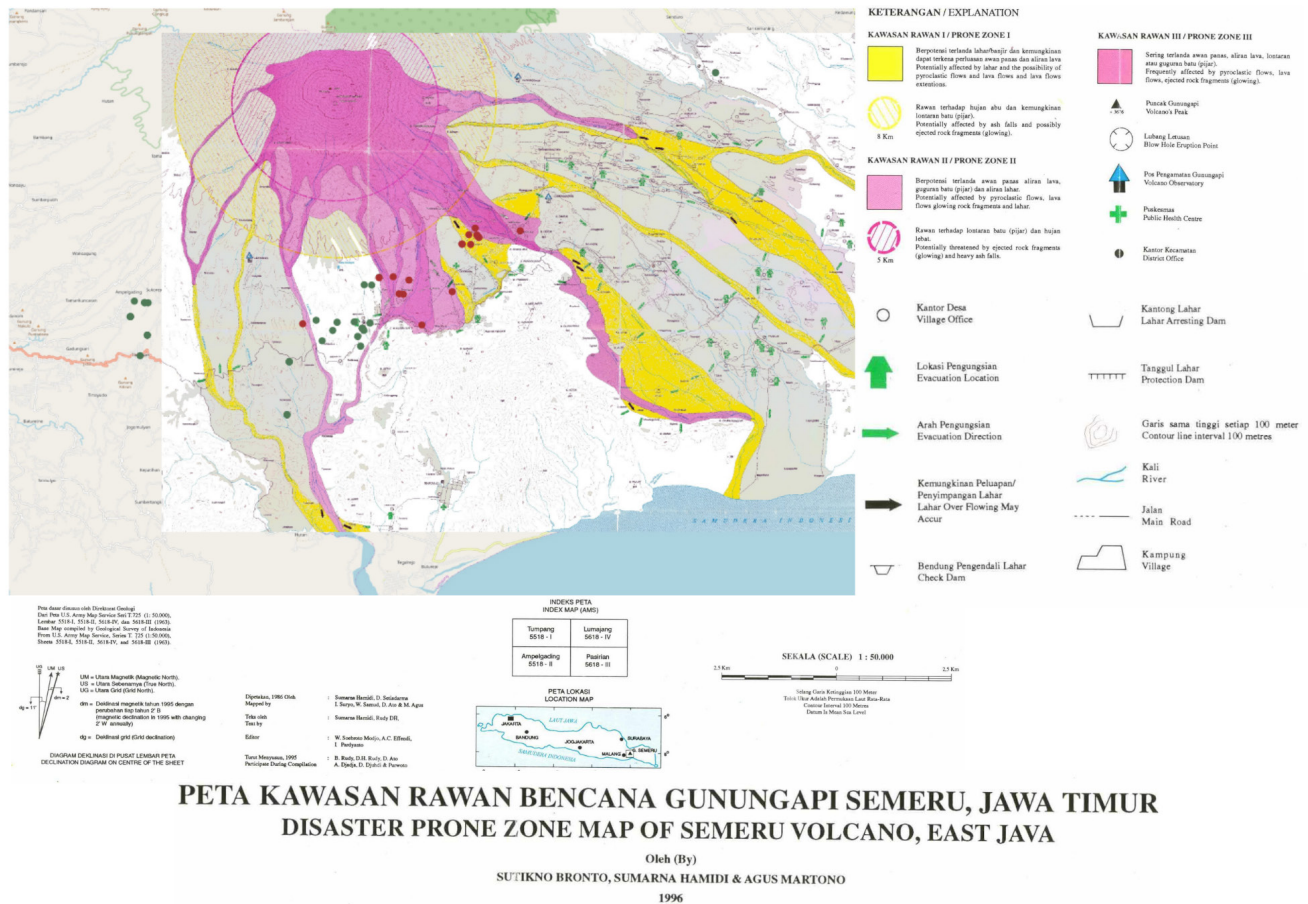


Figure 1. Sampling locations on Mount Semeru, East Java, Indonesia. Sampling sites are classified as Risky (red circles) or Safe (green circles) based on their position inside (pink/yellow) or outside the primary pyroclastic and lahar hazard zones

involving a series of incentivized economic tasks designed to elicit risk and social preferences, collection of basic socio-demographic features, and recording their genealogical histories. To incentivize participation and ensure meaningful decision-making, one of the tasks was randomly selected for real cash payment at the end of the experiment. Each session lasted approximately 40 minutes, during which participants completed various tasks on individual computer tablets connected via Wi-Fi. Typically, the interviews were conducted after the participants had finished their economic tasks. All instructions on the screen of the computers were provided in Bahasa Indonesia while the experimenter guided the sessions in Bahasa Indonesia, Javanese, or Madurese.

This research has been approved by The Ministry of Research Technology and Higher Education (Ref: 262/SIP/FPR/E5/Dit.KI/IX/2018). The protocol for this research has been approved by The Human Research Ethics Committee of the Bogor Agricultural University (Ref: 639/IT3.KEPMSM-IPB/SK/2022).

#### 2.4. Multiple Response Categorical Variable Analysis of Perceived Advantages

We asked an open-ended question: “*What are the advantages to live in a volcanic risk area?*” The open-ended nature of the question is designed to explore experienced feelings, perspectives and opinions, allowing for a deeper and nuanced understanding of their perceived advantages in living in a volcanic risk area. Their written answers were manually edited for typographic errors and partially English-tagged to facilitate later categorization. When a participant wrote an answer to the question, she/he often mentioned more than one response. For instance, one participant [AAA] wrote “*tanah subur, sumber mata air melimpah, dan sejuk*”; we infer these mentions as *subur*, *air*, and *sejuk* item responses of advantageousness. Another participant [BBB] wrote “*cuacanya dingin, subur*”; we infer this as *sejuk* and *subur*. Thus, the *subur* item response recurs in these two answers (as does *sejuk*). Out of the total 753 participants, we identified 36 recurrent items. These 36 item responses are elements of advantageous feelings,

perspectives and opinions experienced in living in volcanic risk area. These item responses are compiled into an English dictionary in Table 1.

This question/answer format is called an MRCV (Multiple Response Categorical Variable) (Coombs 1964) method because it allows participants to respond with multiple answers. Technically, therefore, it is as if a participant is presented with 36 items and is allowed to choose several of them, for instance, it is as if participant AAA took three answers out of 36 items. We generated an item-response table coded as 1 and 0, where 1 denotes an item chosen (positive response) and 0 denotes an item not chosen (negative response) (see Bilder and Loughin (2007)). From a  $753 \times 1$  table which was descriptive, the new item-response coding forms a  $753 \times 36$  binary matrix, which is the main variable of interest in this analysis. This approach transforms qualitative open-ended data into quantifiable categorical variables while preserving the richness of multiple responses per participant.

## 2.5. Core Framework of Perceptual Advantages

We recognize that the 36-item responses are elements of livelihood and bio-cultural meaning that reshape identity and resilience to reconcile hazard with habitability. From this empirical data, we identified six core conceptual frameworks that encapsulate the perceived advantages of living in volcanic risk areas. These frameworks are derived from the thematic analysis of the item responses and are summarized in Table 2. Each framework represents a distinct dimension of perceptual advantage, capturing both tangible and intangible benefits as articulated by the participants.

## 2.6. Log-linear Model for Perceptual Advantages

We would like to know how the core framework of perceptual advantages varies across risky and safe areas, as well as between males and females. We want to see if there is any association between the advantage frameworks and the area of residence and whether gender perceives these advantages differently

Table 1. The 36-item responses as elements of livelihood and bio-cultural meaning in living in a volcanic risk area

Item responses	English translation
<i>air</i>	abundant clean water
<i>asri</i>	scenic
<i>adem</i>	(cool) fresh and cool air quality
<i>batu</i>	rock
choice	no other choice
comfort	cozy
<i>cuaca</i>	(pleasant weather) fresh and cool air quality
<i>dingin</i>	(cool) fresh and cool air quality
<i>ekonomi</i>	(economy) robust economy
<i>gotong</i>	mutual cooperation
<i>kebun</i>	(farmer/livelihood) fertile crops provide significant economic benefits
<i>keluarga</i>	(family) close to family (strong familial ties)
<i>kerja</i>	(employment) ample employment opportunities
<i>lahan</i>	arable lands
<i>lahir</i>	(birth) have lived there since birth/ long-term residency
<i>makan</i>	(eat) easy to meet daily needs
<i>pangan</i>	(food) easy to meet daily needs
parent	(parent) close to family (strong familial ties)
<i>pasir</i>	sand
<i>pencaharian</i>	(livelihood) ample employment opportunities
<i>polusi</i>	minimal pollution
<i>rezeki</i>	(income) easy to meet daily needs
<i>rukun</i>	harmonious
safe	safe/secure
<i>sda</i>	natural resources
<i>segar</i>	(fresh air) fresh and cool air quality
<i>sejuk</i>	(cool) fresh and cool air quality
<i>subur</i>	lucrative minerals
<i>tambang</i>	mining source
<i>tanah</i>	fertile soil
<i>tanaman</i>	(regarding to fertile crops) fertile crops provide significant economic benefits
<i>tani</i>	(farmer/livelihood) fertile crops provide significant economic benefits
<i>tenang</i>	peaceful
<i>tenram</i>	peaceful
<i>udara</i>	(air) fresh and cool air quality
<i>wisata</i>	(tourism) close to tourist attractions

Table 2. Definitions of the six core frameworks for perceptual advantages

Item responses	Core framework	Perceived advantage
<i>sda, pasir, tambang, batu</i>	Direct economic and material benefits from extracting volcanic sand and stone	NATURAL RESOURCES
<i>subur, tanah, lahan, air</i>	Exceptional soil fertility that forms the foundation of the local agrarian economy	LAND
<i>ekonomi, kerja, pencaharian, makan, rezeki, wisata, tanaman, pangan, tani, kebun</i>	Broader livelihood opportunities, including agriculture and volcano-driven tourism	ECONOMIC
<i>lahir, parent, keluarga, choice, rukun, gotong</i>	lineage/kin ties, birthright, and deep social networks that create an intergenerational connection to the land	BIRTH/FAMILY
<i>aman, nyaman, tentram, asri, tenang</i>	A profound sense of safety, tranquility, and emotional well-being derived from the homeland	COMFORT
<i>udara, sejuk, segar, dingin, polusi, cuaca, adem</i>	A preferred quality of life attributed to the region's cool, fresh air and superior air quality	CLIMATE

or not. Statistically, this is a three-way contingency table analysis of the perceptual advantages by area of residence and gender. To analyze the MRCV data, we employed a log-linear model, which is suitable for examining the relationships between categorical variables. The log-linear model allows us to assess how the presence or absence of specific advantages is associated with the hazard zone area of residence (safe vs risky) and gender (male vs female), while controlling for their interactions. Following Bilder and Loughin (2007), the model includes  $W$  representing  $I$  ( $i = 2$ ) items of volcanic zone,  $Y$  representing  $J$  ( $j = 36$ ) items of perceptual advantage, and  $Z$  representing  $K$  ( $k = 2$ ) items of gender (see also Koziol and Bilder 2014). The log-linear model is specified as :

$$\log(\mu_{abc(ijk)}) = \gamma_{ijk} + \eta_{a(ijk)}^W + \eta_{b(ijk)}^Y + \eta_{c(ijk)}^Z + \lambda_{abc} + \lambda_{ij}^{WY} + \lambda_{ik}^{YZ} + \lambda_{jk}^{WZ} + \lambda_{ijk}^{YZ}$$

Where  $\mu_{abc(ijk)}$  represents the count of participants who selected a particular advantage item  $\eta_{b(ijk)}^Y$ ,  $\eta_{a(ijk)}^W$  denotes the area of residence (safe vs risky), and  $\eta_{c(ijk)}^Z$  represents gender (male vs female). The parameters  $\gamma$ ,  $\lambda$  capture the main effects and interactions among the variables. This model enables us to explore how various factors contribute to the perceived advantages of living in volcanic-risk areas.

### 2.7. Computational Implementation

The three-way contingency table above, however, is not standard because the  $Y$  variable is a multiple-response categorical variable. This multiple response nature means that the advantage items are not independent within each participant's response, e.g. in one instance subur, air, and sejuk items are correlated

because they come from the same participant AAA. Also, the marginal sum can be inaccurate due to multiplicity, which inflates the counts. Thus, traditional methods of Pearson chi-square statistics for analyzing the association between categorical variables are not appropriate due to the within-subject dependence among responses. As such, Bilder and Loughin (2007) developed alternative approaches by extending the test for marginal independence between two MRCVs. Later Koziol and Bilder (2014) further extended this approach to test for conditional independence between two MRCVs given a third categorical variable. They implement the methods proposed using R/S statistical language by creating the MRCV package to facilitate the analysis of multiple-response categorical variables in R software (R version 4.5.0 (2025-04-11), Copyright (C) 2025 The R Foundation for Statistical Computing). To fit the log-linear model to our data, we use the `genloglin()` function from the MRCV package. We hope to identify significant patterns and interactions among the core framework of advantages and hazard zone and gender, providing insights into the factors that influence residents' perceptions of living in volcanic risk areas. Using the fitted model, we calculated odds ratios with 95% confidence intervals to quantify the strength of such associations.

## 3. Results

### 3.1. Elements of Perceived Advantages

As noted in the Methods section, among the 753 participants, we identified 36 distinct responses that were recurrently mentioned. Participants—regardless of whether they lived in risky or safe areas, and whether they were female or male—felt that subur was the most frequently perceived advantage, followed by



Table 3. Prevalence of the core framework of perceptual advantage by gender and volcanic risk zone

	MALE in RISKY	MALE in SAFE	FEMALE in RISKY	FEMALE in SAFE
NATURAL RESOURCES	12	17	9	34
LAND	93	154	79	163
ECONOMIC	63	84	56	69
BIRTH/FAMILY	12	5	16	11
COMFORT	17	19	16	24
CLIMATE	51	121	58	145
Total	248	400	234	446

decreased compared to original item responses; for instance, female participants in safe areas now recorded a total of only 446 mentions, because the 801 raw responses were consolidated into the six core frameworks.

From Table 3, participants of both genders and from both areas most frequently mentioned words related to the core framework of LAND. In contrast, the NATURAL RESOURCES and BIRTH were the least frequently mentioned.

### 3.3. Association of Core Advantages with Zone and Gender

We used a log-linear model to determine which of those core perceptual advantages were most strongly associated with residential zone and gender. Specifically, we tested whether the odds of mentioning a specific core advantage  $Y_{ijk}$  differed between residents of safe and risky volcanic areas  $W_i$ , while controlling for gender ( $Z_k$ ).

The model demonstrated a good fit, with a null deviance 138445.754 and a much smaller residual deviance of 34.353 (for complete result see Appendix). The two-way interaction of residential area and core advantage was not statistically significant ( $p = 0.339$ ), while the interaction between core advantage and gender was marginally significant ( $p = 0.055$ ). This means that participants' responses were largely independent of whether they lived in safe or risky areas. However, gender may play a role, as females and males tended to differ slightly in how they described specific advantages, though their overall patterns were similar. The borderline significance of the gender-advantage interaction may also reflect modulation by residential area.

While the two-way interactions were not significant, the three-way interactions  $W:Y:Z$  were all highly significant ( $p < 2e-16$ ) (Result of the analysis are provided in the Appendix). This means that the effect of one variable depends on the combination of the other two: mentions of a core advantage may differ

based on the residential zone and gender. For instance, males in safe areas are expected to mention NATURAL RESOURCES advantage 113 times; this corresponds to the interaction term  $W_{SAFE}:Y_{NATURAL RESOURCES}:Z_{MALE}$  which has a log expected count of 4.728 ( $\exp(4.728) \approx 113$  counts). In comparison, the combination  $W_{RISKY}:Y_{ECONOMIC}:Z_{FEMALE}$  yields a log expected count of 5.131 ( $\approx 169$  counts).

With this model, we specifically wanted to know which core advantages are associated with safe areas and which with risky areas, and to examine whether gender modulates these associations. The `predict.gloglin()` function of package `MRCV` calculates odds ratios (OR) that describe the strength of these associations. We first looked at the associations between the core advantages and residential zones, while controlling for gender; and then we analysed the association between core advantages and gender, while controlling for residential zones.

#### 3.3.1. Association of Core Advantages with Residential Zone

Most of the associations concerning zones are not statistically significant, as shown by the confidence intervals of odds ratios crossing 1 (for complete result see Appendix). It means that the odds of mentioning a particular core advantage do not differ between residents of safe and risky areas, nor between genders within the same area. However, some associations are significant, as shown by the confidence intervals of odds ratios not crossing 1. These significant associations are of practical interest, and we summarize them in Table 4.

Our analysis reveals a systematic divergence in how residents of safe and risky volcanic zones perceive advantages, with gender acting as a significant moderator. Residents of high-risk zones showed significantly higher odds of emphasizing ECONOMIC (OR = 1.66 [Male], 2.22 [Female]) and BIRTH/FAMILY advantages (OR = 3.27 [Female], 4.67 [Male]) compared to their safe-zone counterparts. Conversely,

Table 4. Significant odds ratios for core frameworks of perceptual advantage by residential zone, controlled for gender

Formula	Control	Interaction	Odds ratio	Lower	Upper
z1=1,w1y6	Male	Safe:CLIMATE	1.61	1.05	2.46
z1=1,w2y3	Male	Risky:ECONOMIC	1.66	1.08	2.55
z1=1,w2y4	Male	Risky:BIRTH/FAMILY	4.67	1.61	13.54
z2=1,w1y6	Female	Safe:CLIMATE	1.54	1.00	2.39
z2=1,w2y3	Female	Risky:ECONOMIC	2.22	1.41	3.50
z2=1,w2y4	Female	Risky:BIRTH/FAMILY	3.27	1.47	7.29

Table 5. Significant odds ratios for core frameworks of perceptual advantage by gender, controlled for residential zone

Formula	Control	Interaction	Odds ratio	Lower	Upper
w1=1,y1z1	Safe	Male:NATURAL RESOURCES	0.46	0.25	0.85
w1=1,y1z2	Safe	Female: NATURAL RESOURCES	2.17	1.18	4.00
w1=1,y6z1	Safe	Male:CLIMATE	0.67	0.47	0.96
w1=1,y6z2	Safe	Female:CLIMATE	1.49	1.05	2.13

CLIMATE advantages were more strongly associated with safe-zone residence (OR = 1.54 [Female], 1.61[Male]).

The relationship was further refined by gender. Within the risky zone, the association with ECONOMIC advantages was stronger for females (OR = 2.22, see above) than for males (OR = 1.66). In contrast, the association with BIRTH/FAMILY advantages was stronger for males (OR = 4.67) than for females (OR = 3.27). These results demonstrate that the perceptual framing of volcanic landscapes is not only context-dependent but also shaped by gender-specific perspectives, with risky-zone residents cognitively amplifying socio-economic and lineage/kin tie benefits.

### 3.3.2. Association of Core Advantages with Gender

Next, we look at the association of core advantages with gender, controlling for residential zones.

We find that gender difference in advantage perceptions is strictly context-dependent, emerging only in safe zones (Table 5). In these areas, females showed significantly higher odds than males in citing advantages related to NATURAL RESOURCES (OR = 2.17) and CLIMATE (OR = 1.49), whereas males showed correspondingly lower odds for these categories (OR = 0.46 and 0.67, respectively). By contrast, no significant gender-based associations were detected within risky zones (not shown in Table 5), where perceptions of advantages were homogeneous across genders. This indicates that the shared experience of volcanic risk appears to override gender-specific perspectives, creating a unified perceptual framework among at-risk communities.

Our analysis reveals that the role of gender in shaping perceived advantage is fundamentally context-

dependent. A significant gender divergence emerged in safe zones, where males and females valued different advantage categories. Conversely, this gendered effect vanished in high-risk zones, where perceptions converged within the environment. This demonstrates that the lived experience of environmental hazard overrides gender-specific perspectives, creating a unified perceptual framework when facing shared existential threat.

## 4. Discussion

Our study demonstrates that human persistence in active volcanic zones is not a failure of risk perception (Lavigne *et al.* 2008), but a sophisticated cognitive adaptation that individuals in high-risk areas adapt to harsh environments by transforming daily tangible and intangible experiences into a shared perceptual framework that reinforces collective identity and resilience (Messer *et al.* 2015; Barclay *et al.* 2019). Similar ideas appear in prior work on human cooperation under environmental pressures (Henrich and Henrich 2007; Tomasello 2009). The emergent framework of six advantage categories reveals a systematic logic through which communities reconcile objective hazards with deeply rooted benefits. Crucially, we find that the valuation of these advantages is not static but dynamically shaped by both geographical context and gender, revealing fundamental insights into the construction of resilience.

The most compelling finding is the stark contrast in perceptual frameworks between risk zones. Residents of high-risk areas cognitively amplify bio-cultural and livelihood advantages, particularly BIRTH/FAMILY and ECONOMIC benefits. This suggests a cognitive recalibration where profound lineage/kin ties and

economic dependency actively reframe the volcanic landscape from a zone of threat to one of opportunity and identity (Kelman and Mather 2008; Bachri *et al.* 2015). Conversely, the stronger association of CLIMATE advantages with safe zones indicates that where the immediate threat is absent, more passive quality-of-life factors become perceptually salient.

Furthermore, we identify an important moderating role of gender that is area-dependent, despite the equal gender distribution in the sample. The significant gendered perceptions in safe zones where females showed stronger attachment to NATURAL RESOURCES and CLIMATE likely reflect differentiated social roles and environmental sensitivities. In contrast, significant disparities in perception vanish within the high-risk zone indicating that the shared, salient experience of volcanic threat can supersede gender distinction. Within this collective, a shared risk-benefit calculus and a unified identity override individual perspectives to foster a “community of fate” (Calegare *et al.* 2014; Messer *et al.* 2015; Barclay *et al.* 2019). However, a word of caution should be mentioned. With this paper we want to see specifically if there is any association between the advantage frameworks and the area of residence modulated by gender perspective. To focus, we do not consider other demographic factors of, for instance, age, marital status, number of children, or levels of educational attainment; these factors likely influence the feelings, perspectives and opinions experienced by the participants. In the absence of quantified demographic influences on perceived advantage, we believe that the shared, salient experience of volcanic threat can override gender distinction.

This convergence underscores that resilience in high-threat environments may be a collective, rather than individual, cognitive achievement. These findings challenge top-down risk management models that overlook local perceptual rationales. Effective disaster risk reduction must integrate this nuanced understanding of how communities construct value and meaning in hazardous landscapes. Policies that acknowledge these deep-seated perceptual advantages, particularly bio-cultural rootedness, will be better positioned to develop culturally resonant and sustainable resilience strategies.

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## Appendix

Data, statistical scripts, and results are available on <https://doi.org/10.5281/zenodo.18044639>