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Community engagement in waste reduction: A critical component for Gunung Sewu Geopark conservation, Yogyakarta, Indonesia

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ABSTRACT

The key to achieving an effective and sustainable geopark waste management system is fostering community participation. This research about the Gunung Sewu Geopark, Yogyakarta, Indonesia, examines the phases and levels of community participation in waste reduction. The study involved surveying 1,757 respondents aged 18 and above using door-to-door questionnaires, which were analysed using the conditional probability method to determine participation stages and levels. The results indicate that community participation in waste reduction activities, such as composting and recycling is inadequate, with only 21.12% of respondents participating in the decision-making stage, 1.99% participating in the implementation stage, and 0.68% finding waste reduction activities valuable. Rural community participation level scores were 0.68 and categorised as very low. The incomplete stages of participation and low levels of participation are significant challenges for implementing sustainable waste management and maintaining conservation principles in Gunung Sewu Geopark. Further research could be conducted to determine the driving factors that most influence rural community participation so that geopark policymakers can develop strategies to increase participation more effectively and to targets.

KEY WORDS: conditional probability, geopark, participation stages, sustainable waste management, waste reduction

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1. Introduction

Reducing waste at its source has been on the Indonesian government's agenda to achieve Sustainable Development Goals, specifically goal 7: Affordable and Clean Energy, 11th goal: Sustainable Cities and Communities, goal 12: Responsible Consumption and Production, and goal 13: Climate Action. However, the success of waste reduction relies heavily on community participation, reflecting the principle of sustainable development through partnerships and government facilitation to empower the community's desire for involvement (Basu & Punjabi, 2020; Jomehpour & Behzad, 2020). The current waste management paradigm places the waste reduction stage of Reduce, Reuse, and Recycle (3R) at the top of the hierarchy (Iqbal et al., 2020). Integrating recycling and resource recovery activities into the waste management system is considered to be the ideal for achieving environmental sustainability (Iqbal et al., 2020; Saat et al., 2019) and more economically beneficial (Anwar et al., 2018; Hajar et al., 2020). However, waste reduction will not be successful without the participation of the community which is the source of the waste. Community participation in realising effective and sustainable waste management is a big challenge (Basu & Punjabi, 2020; Das et al., 2019; Jomehpour & Behzad, 2020; Pereira & Fernandino, 2019).

Participation of communities must examine unique components such as the stage of participation, the individuals participating, and the peculiarities of the process (Cohen & Uphoff, 1980). Community involvement in waste reduction can be measured depending on their involvement at various stages. According to Cohen & Uphoff's idea (1980), the community's involvement can be noticed at the different stages of decision-making, implementation, benefits obtained, and evaluation. Active participation can be seen when people are directly involved and contribute to group activities, in the processes, and enjoy the outcomes within a particular locality (Lachapelle & Austin, 2014). Community involvement is crucial for local activities and decision-making, allowing citizens to have influence and control (Devas & Grant, 2003; Lachapelle & Austin, 2014). Participation levels vary and are voluntary, giving individuals a choice to engage or withdraw (Goodson & Phillimore, 2012). Jomehpour & Behzad (2020) pointed out that achieving sustainable waste management relies on the active participation of the community in waste reduction. This suggests that involvement of the entire community concerned at the appropriate level will improve the handling of environmental issues.

A geopark is a single geographical area of potential geological landscape sites managed according to international standards, with an integrated, holistic approach, providing protection education and contributing to sustainable development, as outlined by UNESCO (2006). Given these functions, geoparks become highly vulnerable when waste management is not effectively carried out by the community. Unfortunately, numerous instances in daily life illustrate the high risk of damage to karst areas due to improper waste management practices. Keever & Zouros (2005) argue that geotourism and geoparks operate on principles of sustainability, which can enhance positive local economic impacts through increased tourist visitation. This demonstrates the significant role of geotourism and geoparks in local economic development. The geopark development framework includes three key points: preservation of the earth's heritage, economic empowerment, and community empowerment (Komoo, 2016). Geopark management requires the community's active role in applying geotourism conservation principles. As the host, the community should have knowledge and guidance in conserving the environment, which is primarily waste-related. As a continuous result of community life, waste will undoubtedly intersect with the environment where people live. The community's participation in waste management will be more optimal when the geopark manager gives waste issues more attention.

Geoparks, geoconservation, and geotourism are closely related concepts and have rapidly developed in recent decades (Wang et al., 2019). Nonetheless, the challenge lies in the community's ability to embrace the concepts and put into practice. While Geoparks, geoconservation, and geotourism share common approaches to involving communities in conservation efforts, the effective practical application of these principles remains elusive. The establishment and advancement of geoparks and their submission for UNESCO Global Geoparks status necessitate a management strategy. This strategy should consider each local community's socioeconomic well-being and the landscape's preservation. It should encompass aspects such as governance, development, communication, conservation, infrastructure, financial planning, and partnerships, as Nikolova & Sinnyovsky (2019) indicated. However, those responsible for planning and executing this, such as the Gunung Sewu Geopark management in Indonesia, have not yet offered specific guidance regarding waste management.

As rural areas experience economic and population growth, waste management becomes necessary, mainly because the tourism sector utilises a village's resources as tourist attractions (Masjhoer, 2018). The Southern Region of Gunung Sewu Geopark (SRGG) exemplifies a rural area with developed coastal tourist areas (Masjhoer et al., 2020). Waste management services generally do not match increased waste generation in rural areas. Boateng et al. (2016) state that waste problems in rural areas are generally still neglected. Previous research by Masjhoer et al. (2022) and Syafrudin et al. (2023) showed that SRGG rural communities have not implemented sustainable waste management. Waste management practices often found in rural areas include burning, backyard dumping, and illegally accumulating waste at various points around the village (Chen et al., 2019; Nxumalo et al., 2020). Waste management carried out conventionally by the community can trigger environmental problems and threaten human health (Lima et al., 2021; Yang et al., 2019). Decreased environmental quality and public health will reduce productivity and economic growth (Kubanza & Simatele, 2019).

The Government of Gunungkidul Regency, Yogyakarta, Indonesia, through Regent Regulation No. 51/2018 has placed waste reduction as the top

priority in the waste management hierarchy, reflecting the government's efforts in shifting waste management behaviour towards sustainable development. Waste reduction is the most crucial stage in waste management. The community holds full responsibility for executing this stage. By undergoing waste reduction activities, waste is transformed into segregated, minimum weight and volume, and residual waste, thus simplifying the waste handling process. Achieving sustainable waste management relies on the active participation of the community in waste reduction (JOMEHPOUR & BEHZAD, 2020). The participation phases and their levels need to be measured to determine how active the community is in reducing waste. The development of waste management plans in alignment with the concepts of geotourism and geoconservation necessitates information regarding the level of community engagement in waste management. This data is paramount in designing programs to preserve the geopark area. The active involvement of the Gunung Sewu community in safeguarding karst areas through waste management constitutes a critical criterion for maintaining UNESCO geopark status. Therefore, this study aims to assess the phases and levels of community participation in the southern region of Gunung Sewu Geopark.

2. Materials and methods

2.1. Location

The research was conducted in the Purwosari, Panggang, Saptosari, Tanjungsari, Tepus, and Girisubo districts, which are included administratively in the Gunungkidul Regency, Yogyakarta, Indonesia. This area was selected because it has been designated as a Tourism Strategic Area in the Regional Medium-Term Development Plan of Gunungkidul Regency for the period 2021–2026 and has experienced growth due to the opening of the Yogyakarta Southern Crossing and the development of commercial sectors. This has increased population and economic growth, further increasing the need for effective waste management. Although waste services are available in coastal tourism areas, residential areas manage their waste using unsustainable methods, resulting in waste problems such as illegal dumping in roadside areas and karst pits due to the additional waste load from tourism activities and the lack of waste services in settlements.

The study population comprises individuals who reside in the SRGG. The researchers used the Stratified Random Sampling method to select the regional sample to address the challenges of covering a vast research area within a limited time, energy, and costs. This involved grouping villages in each district based on the number of residents into high, medium, and low categories (DHOKHIKAH ET AL., 2015), resulting in 18 villages as area samples with a population of 96,892 (refer to Fig. 1). The research sample comprised respondents selected using random purposive sampling, with the criteria that residents in the sample area are willing to participate and are over 18 years of age (T'ING ET AL., 2020).

2.2. Data collection

Before data collection, the survey team received an explanation of the questionnaire they would ask respondents. This is so that the survey team can provide explanations to respondents regarding the variables being measured, as well as to avoid invalid data. The survey was conducted door to door in accordance with the sample size of respondents that has been determined for each neighbourhood in the SRGG. Respondents in each household were selected based on the criteria that they were willing to complete the questionnaire and were over 18 years old. Each sample of respondents in each village was divided by gender and age so that respondents who filled out the questionnaire had diverse identity attributes. This study did not test the questionnaire first because the local government limited the time given to the researchers to collect data in the field due to the COVID-19 pandemic. The survey team collected data from December 2021 to March 2022 without encountering significant obstacles. They collected field data while following the health procedures in place during the new-normal era. During the data collection process in the field, each enumerator equipped himself with personal protective equipment such as masks and gloves, carried a portable sanitiser, and carried proof of Polymerase Chain Reaction (PCR) test results.

Village	Population
Giri Asih	1,533
Giri Cahyo	4,239
Giri Purwo	9,047
Giriwungu	2,525
Girisekar	7,670
Girisuko	5,574
Kanigoro	6,868
Kepek	6,149
Ngloro	3,403
Kemadang	7,217
Kemiri	4,717
Ngestirejo	5,898
Sidoharjo	6,815
Tepus	9,531
Giripanggung	6,340
Karangawen	1,615
Tileng	4,368
Pucung	3,383

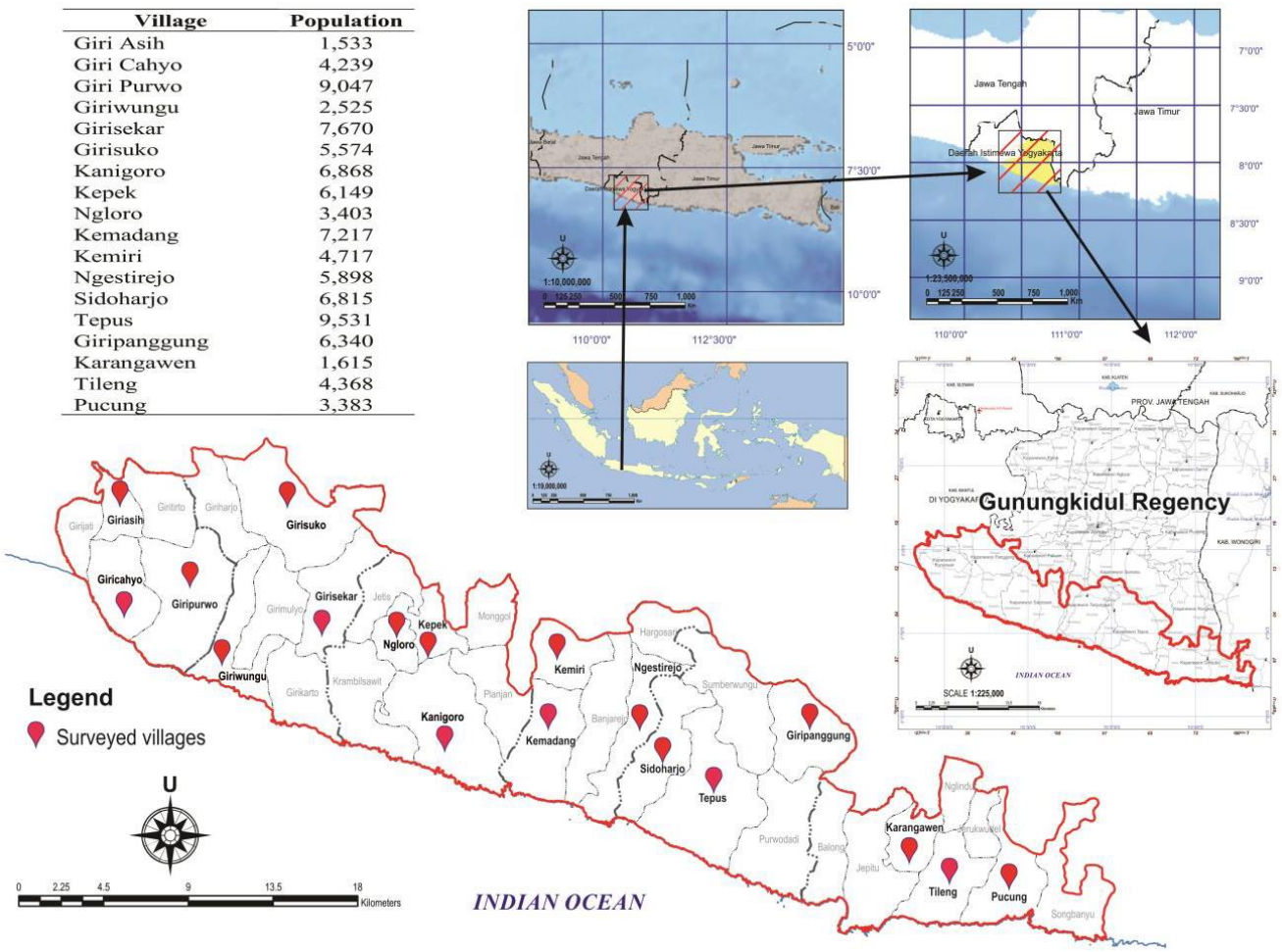

Fig. 1. Distribution of villages in the sample area

Community participation in this study was measured by looking at the extent of their involvement in the stages of decision-making, implementation, benefits, and evaluation. These participation stages follow the theory coined by COHEN & UPHOFF (1980). The questionnaire data was processed using statistical software and was then analysed descriptively. This research used the conditional probability of occurrence approach to determine the phases and level of participation. The probability that an event will occur if another event has occurred is known as conditional event probability (OTAYA, 2016). It expresses the ratio of the likelihood of the combined occurrence of the two events to the probability of the preceding event occurring as the relationship between two occurrences (KUTER, 2021). The formula for conditional probability is:

$$P(A|B) = \frac{P(A \cap B)}{P(B)} \text{ (a)}$$

Explanation: P(A|B) denotes the conditional probability of event A, given that event B has occurred. P (A and B) denotes the probability of events A and B occurring together. P(B) denotes the probability of event B occurring.

It is important to note that the previous event must have occurred for the conditional probability to be calculated. The scale is determined by dividing the class according to the preparation variable, which is four. In contrast, the length of the interval class adjusts to the number of questions, by as many as 11. Based on these calculations, the scale can be determined as shown in Table 1.

Table 1. Determination of the participation level scale

Scale	Score	Description
1	0 – 2	Very low
2	3 – 5	Low
3	6 – 8	High
4	9 – 11	Very high

3. Results

3.1. Socio-demographic characteristics of respondents

Most of the respondents were female (55.7%). More than 50% of the respondents were in the age range of 26-45 years old. More than 30% of respondents had a minimal income of IDR 500,000, most were in the IDR 500,001-2,000,000 range, and no more than 0.5% have a high income. Respondent's education is still relatively low, which can be seen from the high number of respondents who only received education up to elementary school level or did not attend school. Respondents with tertiary education were only a small portion, namely 4.1%. Most respondents did not work, and this was because women in the research location were housewives. Farmers, labourers, and traders were respondents' most common non-formal sector jobs. No more than 10% of respondents worked in the formal sector as civil servants or private sector employees. Table 2 gives details of the socio-demographic characteristics of respondents.

Table 2. Respondent characteristics

Component	Indicator	Sample Size	Percentage
Gender	Male	778	44.3
	Female	979	55.7
Age	18-25 Years	397	22.6
	26-45 Years	957	54.5
	46-65 Years	403	22.9
Occupation	Not Working	559	31.8
	Student	42	2.4
	Public/Private Employee	167	9.5
	Laborer	146	8.3
	Trader	350	19.9
	Farmer	410	23.3
	Others	83	4.7
Income	Up to IDR 500,00	601	34.2
	IDR 500,001 - IDR 2,000,000	860	48.9
	IDR 2,000,001 - IDR 3,500,000	288	16.4
	More than Rp. 3,500,000	8	0.5
Education	Elementary school	527	30.0
	Junior high school equivalent	479	27.3
	High school equivalent	289	16.4
	Higher education	72	4.1
	Not graduated from school / not in school	390	22.2

3.2. Reliability and validity tests

The results of the reliability and validity tests conducted on the questionnaire have been summarised in Table 3. The Guttman Split-Half Coefficient correlation value (Reliability test) and the Corrected Item to Total Correlation value (Validity test) were used to conclude the questionnaire's question points. Based on these tests, it can be concluded that the Implementation stage (I) questions are less reliable, which is a matter of concern for future research. It is recommended that additional questions be added to improve the reliability of the questionnaire. However, all question items are considered valid based on the validity test. Therefore, the questionnaire items related to each variable can be processed in the subsequent analysis stage.

3.3. Conditional probability of occurrence

Following COHEN & UPHOFF (1980) stages of participation theory, this study analysed four stages

of participation: decision-making, implementation, benefits, and evaluation. The data presented in Figure 2 are the Conditional Probability of Occurrence, which presents the yes answer as the basis for analysis. Figure 3 provides a clear picture of the stages of participation with the results calculated using the theory of COHEN & UPHOFF (1980).

Table 3. Reliability and validity test on the participation stages questionnaire

	Decision-making (D)	Implementation (I)	Benefits received (B)	Monitoring and evaluation (M)
Reliability test value and conclusion	0.840 ≥ 0.80	0.649 < 0.80	0.898 ≥ 0.80	0.953 ≥ 0.80
	The question items for the decision-making variable (D) as a whole (combined) are declared reliable	Question items for the Implementation variable (I) as a whole (combined) are declared less reliable	The items for the benefits variable (B) as a whole (combined) are declared reliable	Items for the monitoring variable (M) as a whole (combined) were declared reliable
Validity test value and conclusion	D1 = 0.603 > 0.062 D2 = 0.632 > 0.062 D3 = 0.773 > 0.062 D4 = 0.583 > 0.062	I1 = 0.544 > 0.062 I2 = 0.544 > 0.062	B1 = 0.624 > 0.062 B2 = 0.897 > 0.062 B3 = 0.912 > 0.062	M1 = 0.913 > 0.062 M2 = 0.913 > 0.062
	It can be concluded that all question items are valid	It can be concluded that all question items are valid	It can be concluded that all question items are valid	It can be concluded that all question items are declared valid

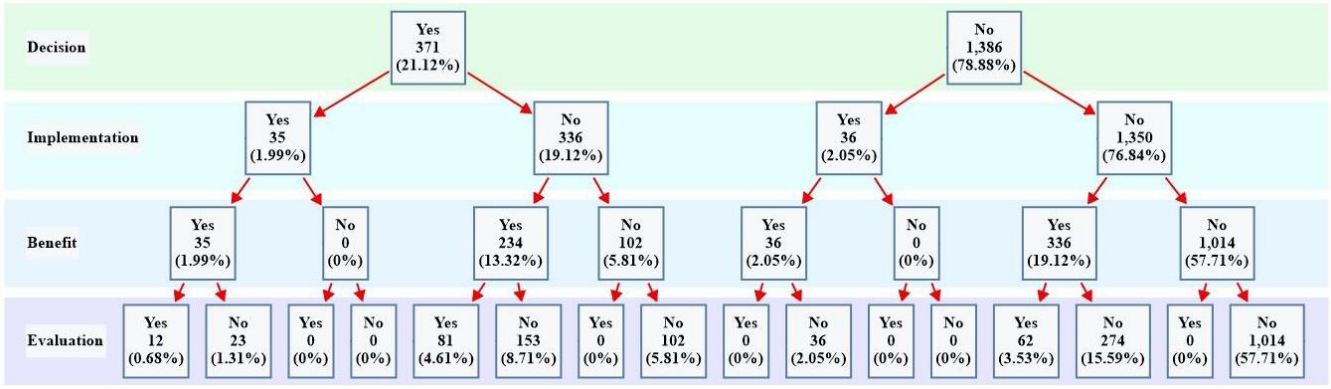

Fig. 2. Participation stages

3.4. Cross Tab Multivariance of participation stages

Respondents who attended socialization initiated by the government (decision-making stage) comprised 12.92% males and 8.2% females. The average age of those present was between 26-45 years old, with 15.42% of all respondents. In the decision-making stage, most attendees are farmers and traders, with a percentage of 5.24% and 5.01%, respectively. 10.81% of respondents who attended the decision-making stage had an income of IDR 500,001 – IDR 2,000,000 and 4.61% of ≤ IDR 500,000. When viewed from the level of education, only 1.94% of respondents who attended the decision-making stage had a college education. Most of the respondents involved had junior high school education level and below, with 16.67%. Details of the Cross Tab Multivariance can be seen in Table 4.

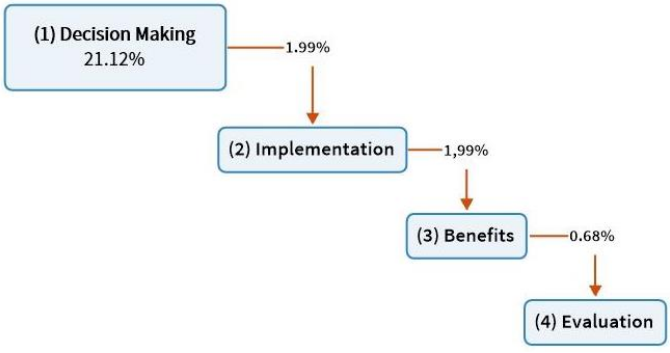

Fig. 3. Conditional probability in the participation stage

Table 4. Cross Tab Multivariance of participation stages

Participation stages		(1)		(1) | (2)		(1) | (2) | (3)		(1) | (2) | (3) | (4)	
		n_{YES}= 371 (21.1%)		n_{YES} = 35 (1.99%)		n_{YES} = 35 (1.99%)		n_{YES} = 12 (0.68%)	
Demographics		qty	%	qty	%	qty	%	qty	%
Gender	Male	227	12.9	12	0.68	12	0.68	0	0
	Female	144	8.20	23	1.31	23	1.31	12	0.68
Age	18 – 25 y.o	44	2.50	12	0.68	12	0.68	12	0.68
	26 – 45 y.o	271	15.42	23	1.31	23	1.31	0.00	0.00
	46 – >65 y.o	56	3.19	0	0.00	0.00	0.00	0.00	0.00
Employment	Not working	68	3.87	11	0.63	11	0.63	0	0.00
	Student	0	0.00	0	0.00	0	0.00	0	0.00
	Civil servant	46	2.62	12	0.68	12	0.68	12	0.68
	Laborer	55	3.13	0	0.00	0	0.00	0	0.00
	Trader	88	5.01	0	0.00	0	0.00	0	0.00
	Farmer	92	5.24	12	0.68	12	0.68	0	0.00
	Other	22	1.25	0	0.00	0	0.00	0	0.00
Income	Up to IDR 500,000	81	4.61	11	0.63	11	0.63	0	0.00
	IDR 500,001 – IDR 2,000,000	190	10.81	24	1.37	24	1.37	12	0.68
	IDR 2,000,001 – IDR 3,500,000	100	5.69	0	0.00	0	0.00	0	0.00
	> IDR 3,500,000	0	0.00	0	0.00	0	0.00	0	0.00
Education	Uneducated	80	4.55	0	0.00	0	0.00	0	0.00
	Elementary school	91	5.18	12	0.68	12	0.68	0	0.00
	Junior high school	122	6.94	11	0.63	11	0.63	0	0.00
	Senior High School	44	2.50	12	0.68	12	0.68	12	0.68
	College	34	1.94	0	0.00	0	0.00	0	0.00

4. Discussion

According to the Conditional Event Probability calculation, 21.12% of the survey participants had the chance to engage in the government-initiated socialization stage, a critical phase in decision-making. This government-provided socialization typically involves counselling or training related to waste management. It aims to encourage the community's active involvement in applying waste reduction through the Reduce Reuse Recycle (3R) concept. In this stage, the community that participates in the socialization will gain knowledge and make choices to implement the knowledge gained. Participation in decision-making involves attending discussion forums and contributing thoughts, responses, or opposition to a program (COHEN & UPHOFF, 1980). However, only 1.99% of respondents had carried out waste reduction activities in the implementation stage. Waste reduction activities carried out by these respondents were in the form of composting or recycling waste. COHEN & UPHOFF (1980) argue that the most common form of implementation participation is by running a given program. The next stage is the benefits received from waste reduction activities. All respondents who engaged in waste reduction activities experienced the benefits during this stage. They realized that waste reduction brings both environmental and economic benefits. The benefits resulting from the implementation of the waste reduction programme can be felt socially and personally. The benefits of the program's outcomes depend on the extent to which the community feels or enjoys development results. In the evaluation phase, a mere 0.68% of respondents were fully committed to waste reduction, mainly due to concerns that it might not significantly impact their daily lives. This condition is consistent with KELLY'S (2001) statement that local communities will go through a series of processes, engage, and play a role in issues that affect them.

The analysis of conditional event probability explains the stages of participation and the overall level of the respondents' participation. As shown in Figure 3, 21.12% of respondents claimed to have participated in the decision-making stage. Only 1.99% of them implemented waste reduction activities, and all felt the benefits. In the evaluation stage, only 0.68% of respondents answered positively. The participation level score for waste reduction is deficient, with a score of 0.68 on a participation level scale of 1. This low level of participation is attributed to the fact that waste reduction has not yet become a pressing need for the community in their waste management. As NDEKHA ET AL. (2003) argued, communities tend to take action when they perceive a common need and create mechanisms to address it. This low level of participation supports the findings of MASJHOER ET AL. (2022), who described the technical operations of waste management in the southern region of Gunungkidul Regency. The community provides trash bins at each home, but they do not sort the waste. The garbage is typically burned and dumped in karst pits, yards, and plantations. This situation regularly occurs in non-residential waste sources such as workplaces, shops, restaurants, markets, and public buildings (MASJHOER ET AL., 2022).

The number of respondents who continued active involvement in the implementation stage dropped dramatically. The attributes of respondents at this stage are the same as those at the benefit recognition stage. Male respondents only accounted for 0.68%, and females for 1.31% of the total respondents who had participated in the previous stage. Respondent's income ranged between ≤ IDR 500,000 and IDR 500,001-IDR 2,000,000, and their occupations were generally as farmers (0.68%), employees (0.68%), and not working (0.63%). The education levels of respondents at this stage were elementary, junior high, and high school, with percentages of 0.68%, 0.63%, and 0.68%, respectively. In the last stage, evaluation, respondents who felt that waste reduction was necessary were all female. The respondents are 18-25 years old, work as employees, have a high school education, and have an IDR 500,001-IDR 2,000,000 income.

The preliminary stages of participation illustrate how participation cannot be forced upon a community. Community participation is built voluntarily so people can choose how far to participate or even resign at any time (GOODSON & PHILLIMORE, 2012). Participating communities will contribute through their concerns, needs, interests, and values incorporated into their decisions and actions (NABATCHI & LEIGHNINGER, 2015). Therefore, it requires direct involvement from the community that contributes to the activities, processes, and outcomes of the group in a particular locality (LACHAPELLE & AUSTIN, 2014). Community presence in decision-making does not guarantee active participation in the later stages. The decision-making stage is crucial in determining community participation in the next stage. It requires continuous assistance efforts so that participation can last until the next stage. Full participation reflects the community's willingness to fulfil a common need. The participation rate calculation confirms the operational aspects and the subordinate role of the community. The low level of participation indicates that upstream waste management has not been running well and needs to be improved.

CHEN ET AL. (2020) highlighted factors that impede the implementation of waste reduction activities, including the lack of accurate information, the absence of economic incentives for the community, and unsupportive policies. People who receive socialization of waste reduction programs will have different levels of participation than those who do not (PICKERING ET AL., 2020). Insufficient awareness poses a significant challenge to effective waste management (KALA ET AL., 2020). Socialization provided by the government or interested parties will affect people's knowledge and increase awareness of protecting the environment to encourage a willingness to participate (CUDJOE ET AL., 2020; HAN ET AL., 2018; LAWRENCE ET AL., 2020; XIAO ET AL., 2017). Economic stimulus has also been shown to be one of the factors driving community participation, especially for low-income families (KNICKMEYER, 2020; YANG ET AL., 2022). Research by XU ET AL. (2021) and POSMANINGSIH (2017) explains the role of fame in a rural community that can influence community participation. On the other hand, the provision of ideal waste reduction facilities and systems needs to be considered by stakeholders if they want people to participate in a program (WANG ET AL., 2018; 2020). Socio-demographic conditions of the community, such as gender, income, education level, and age, also need to be considered in a program that requires community participation (HAN ET AL., 2019).

Public participation in waste reduction is still relatively low, especially in developing countries. The Reduce Reuse Recycle (3R) program the government has launched has not performed satisfactorily (MALIK ET AL., 2015). This can be seen from the fact that waste is still mixed, and not

considered a valuable raw material, and the low interest in joining as a Waste Bank customer (He & Lin, 2019; Nguyen et al., 2015; Raharjo et al., 2017). In contrast, developed countries have seen that waste reduction at the source is essential in order to reduce waste generation and help handle waste more effectively (Kuang & Lin, 2021). As the source of waste, the community has a crucial role in realizing a sustainable waste management system. The challenge of realizing effective and sustainable waste management now lies in efforts to increase its participation (Basu & Punjabi, 2020; Jomehpour & Behzad, 2020).

The ongoing spatial development also influences the increase in waste throughout the Gunung Sewu Geopark. Land use change occurs from land use with little activity to land use with complex activities. This increase in activity also increases the waste generated. Table 5 is a research result by Vitrianto (2023a) that provides an overview of changes in spaces within the geopark that affect changes in land use within it.

Table 5. The pattern of space change in Gunung Sewu Geopark Indonesia

Indicators	The pattern of space change
Sites	Function addition → tourism Function addition → geopark
Commerce & Industry	Function change → tourism commercial Land size change → land size addition Quality improvement → building repairs & improvement
Settlements	Function change → commercial settlements (lodging) Function addition → living house + lodging Land size change → land size addition Quality improvement → building repairs & improvement
Vacant land, rice paddies, fields	Function change → tourism facility Function change → commerce Function change → settlements Function change → road Function change → commercial settlements (lodging) Area reduction → no longer a vacant lot

Vitrianto's (2023a) explanation of the spatial transformations in Gunung Sewu geopark can be categorised into two primary groups: changes that introduce new activities and changes that generate additional activities. Spatial indicators within sites, industries, and settlements contribute to changes that introduce new activities. In contrast, open spaces are more likely to stimulate fresh activities. The introduction and emergence of these activities will inevitably lead to increased waste generation. For instance, developing tourism and geopark-related initiatives will create new activities involving more individuals. For example, the case of the Kali Ngalang geo site, which initially was just a river but has since been transformed into a geo site, which is likely attracting extensive research and educational visits. Similarly, converting a private settlement into a homestay will draw visitors, resulting in a higher waste output following these spatial changes. This situation may lead to future issues without a well-prepared waste management mechanism.

The conversion of privately owned land into commercial tourism areas will inevitably lead to increased human activities and movements, influencing waste generation. Nevertheless, certain areas, like Kampung Pitu and Nglanggeran, still uphold local wisdom. For instance, Kampung Pitu, guided by its local wisdom, sustains a population of seven families to preserve environmental equilibrium, as discussed in Vitrianto's (2023b) research. This wisdom becomes especially valuable when applied to waste management practices. The analysis of the participation stage indicates that the overall community in Gunung Sewu Geopark is not actively engaged in practices that contribute positively to waste management. This situation presents a clear challenge and calls for increased collaboration among diverse stakeholders within the geopark area.

The active involvement of the community in preserving the geopark area encompasses more than merely addressing issues related to resource destruction or exploitation. An essential consideration pertains to effective waste management. In karst regions, a prevalent issue is improper waste disposal, which involves using karst pits (luweng) as dumping sites. Waste is deposited frequently in locations like Luweng Golek, Gondang Cave, and numerous karst pits in residential areas. Additionally, residents utilise surface rivers along the southern perimeter of the Wonosari Plateau and subterranean caves with water flow for daily activities, including laundry involving detergent usage. The introduction of detergents poses a risk of contaminating the karst groundwater. Furthermore, household waste disposal systems, including septic tanks, commonly employ karst pits as their final disposal points, potentially resulting in groundwater contamination from various bacterial strains that can induce illnesses. Despite the area's utilisation as a tourist destination to bolster the local community's economic prospects, proper solid waste management practices are often lacking.

The general populace possesses a limited comprehension of the karst morphological system. The community perceives karst areas as akin to ordinary soils like clay and sand. The practice of accumulating waste is a cultural tradition in rural communities that persists. However, the community must recognise that the nature of accumulated waste has evolved. Historically, waste disposal primarily consisted of organic materials that could quickly decompose, whereas contemporary waste predominantly comprises non-biodegradable plastics. Accumulated plastics in locations such as caves, fractures, and karst pits, especially during the rainy season, get displaced and infiltrate karst cavities, resulting in disturbances and contamination of the subterranean aquifer. This knowledge should be disseminated and comprehended by all stakeholders in karst areas. It underscores the significance of preserving the physical aspects of the karst morphology and safeguarding the karst ecosystem against the introduction of solid or liquid waste. Geopark managers bear a responsibility in this regard, necessitating the immediate implementation of technical guidance, training, mentoring, and community support on waste management.

The role of geopark managers in disseminating knowledge to the local community and tourists is paramount (VITRIANTO ET AL., 2021). Specifically, the Gunung Sewu Geopark management leads the way in educating people about the conservation of karst areas, with a strong focus on waste management. The community lacks access to technical guidance and a comprehensive understanding of waste management principles in karst regions, which they have yet to receive. The negligence of environmentally detrimental waste management practices in Gunung Sewu Geopark could jeopardise its UNESCO Geopark status. Geopark managers need to establish technical waste management guidelines aligned with conservation principles. Socialisation and training programs promoting waste reduction through the 3Rs concept can be introduced to enhance public awareness. However, these programs must be carried out over the long term, incorporating mentoring and evaluation processes.

5. Conclusions

Community participation is one of the keys to achieving sustainable waste management. Waste management activities of geopark residents should be aligned with conservation principles to protect karst areas. Measuring the phase of community participation in waste reduction is essential to determine their commitment to environmentally friendly waste management. The degree of community involvement in waste reduction efforts in the southern region of Gunung Sewu Geopark is insufficient. The community's involvement is lacking in all phases of the initiative. Even those participating in the decision-making phase do not execute the agreed-upon program. Although communities that have initiated waste reduction efforts recognise the advantages of their actions, most choose not to participate entirely in the final evaluation stage. The incomplete stages of participation and low levels of participation are significant challenges in implementing conservation in Gunung Sewu Geopark. The biggest challenge in maintaining geopark conservation efforts is encouraging communities to manage waste sustainably.

Further research is needed to determine the driving factors of low community participation. There are various factors driving community participation in waste management. Therefore, it is necessary to know the main driving factors so stakeholders can develop appropriate programmes to improve the quality of community participation.

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