



Youth as cultural mediators in ecological literacy: A moronene-based participatory campaign in a post-artisanal and small-scale gold mining community

Basri Basri^{1,*}, Masayuki Sakakibara², Hendra Prasetya³, La Sahara⁴, Chitra Dewi¹, Nanang Rahmadani⁵

¹ Department of Public Health, Sekolah Tinggi Ilmu Kesehatan Makassar, Makassar, South Sulawesi 90234, Indonesia;

² Research Institute for Humanity and Nature, 457-4 Motoyama, Kamigamo, Kita-ku, Kyoto, 603-8047 Japan;

³ Research Center for Mining Technology, Badan Riset dan Inovasi Nasional, Central Jakarta, Special Capital Region of Jakarta 10340, Indonesia;

⁴ Department of Physics Education, Universitas Halu Oleo, Kendari, South East Sulawesi 93561, Indonesia;

⁵ Department of Dental Health, Sekolah Tinggi Ilmu Kesehatan Amanah Makassar, Makassar, South Sulawesi 90231, Indonesia.

*Correspondence: basrikesmas@gmail.com

Received Date: April 6, 2026

Revised Date: July 13, 2026

Accepted Date: July 22, 2026

ABSTRACT

Background: Artisanal and small-scale gold mining (ASGM) has caused river pollution, deforestation, ecological disruption, and weakened the intergenerational transmission of Moronene ecological knowledge. This study examines how SEPAKAT, a local youth organization, designed, implemented, and experienced a Moronene-based ecological literacy campaign to improve ecological knowledge, strengthen youth-mediated intergenerational knowledge transfer, and identify enabling factors, constraints, and practical implications for post-ASGM recovery. **Methods:** The study used participatory action research and an embedded mixed-methods design. The proposed campaign model was validated through contextual/content validation with local stakeholders, process validation through triangulation of interviews, focus group discussions, observations, campaign documents, and participation records, and outcome validation using a one-group pretest–posttest design involving 50 participants. Quantitative data were analyzed using descriptive statistics and paired-sample t-tests, while qualitative data were analyzed thematically and integrated through triangulation. **Findings:** The campaign was implemented in four sequential phases, with Story Space and workshops receiving the largest time allocation (34%), underscoring the central role of intergenerational dialogue and collaborative learning. Overall ecological knowledge increased significantly from 2.67 ± 0.61 to 4.05 ± 0.49 (mean difference = 1.38; 51.7%; $t = 9.57$; $p < 0.001$). Youth mediation also improved significantly, particularly in translating Moronene ecological knowledge into educational media (mean difference = 1.58; 59.8%; $t = 10.08$; $p < 0.001$). The strongest enabling factors were the cultural legitimacy of Moronene values (4.42 ± 0.51 ; 88%) and SEPAKAT's leadership (4.28 ± 0.56 ; 84%), while limited resources and logistical challenges constrained implementation. **Conclusion:** Youth-led, culturally grounded ecological literacy can strengthen environmental learning, ecological recovery, and intergenerational continuity in post-ASGM communities, while positioning youth as active cultural and environmental mediators. **Novelty/Originality:** This study demonstrates how youth-led intergenerational co-production can operationalize Indigenous ecological knowledge within a structured ecological literacy model in a post-extractive setting.

KEYWORDS: ecological literacy; indigenous knowledge; Moronene tradition; post-ASGM community; youth-led campaign.

Cite This Article:

Basri, B., Sakakibara, M., Prasetya, H., Sahara, L., Dewi, C., & Rahmadani, N. (2026). Youth as cultural mediators in ecological literacy: A moronene-based participatory campaign in a post-artisanal and small-scale gold mining community. *Interaction, Community Engagement, and Social Environment*, 4(1), 124-146. <https://doi.org/10.61511/icese.v4i1.2026.3684>

Copyright: © 2026 by the authors. This article is distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).



1. Introduction

Artisanal and small-scale gold mining (ASGM) has been widely associated with environmental degradation, especially in regions where extraction activities occur with limited ecological safeguards (Dossou Etui et al., 2024; Meutia et al., 2023). In Bombana Regency, Southeast Sulawesi, post-ASGM conditions have left a substantial environmental burden, including river pollution, deforestation, ecological disruption, and threats to local livelihoods (Fikriansyah, 2022). These impacts extend beyond the biophysical environment, affecting local knowledge systems, social relationships, and the capacity of communities to sustain environmentally responsible practices across generations. In communities where ecological knowledge has traditionally been embedded in cultural values and customary practices, environmental degradation may also weaken the social channels through which ecological responsibility is learned and transmitted. These conditions highlight the need for ecological literacy approaches that not only improve environmental knowledge but also restore culturally embedded mechanisms for transmitting ecological values and strengthening community participation in environmental recovery (Bansah et al., 2024; Dewi et al., 2025; Meutia et al., 2023).

In the Moronene community, traditional ecological values such as *mondoke*, which reflects harmony with nature, and *popotara*, which emphasizes mutual cooperation, provide an important cultural foundation for environmental stewardship (Eminarti & Hak, 2019; Sinapoy, 2018). These values are not merely symbolic; They shape everyday understandings of land, water, forest, and collective responsibility (Jabalnur et al., 2019). However, modernization, extractive pressures, and socio-economic change have reduced the visibility and continuity of this knowledge among younger generations (Pickard, 2022). As a result, ecological literacy in post-ASGM communities cannot be addressed solely through technical environmental education (Firnadi, 2025; Morales, 2020; Tsai et al., 2025). It requires educational approaches that reconnect environmental understanding with local cultural meaning, intergenerational dialogue, and socially legitimate forms of learning. Within this study, these indigenous values serve as the foundation of ecological literacy by guiding how environmental knowledge is understood, communicated, and transmitted across generations through culturally grounded learning processes (Morales, 2020; Salazar et al., 2024).

Youth organizations can play an important role in this process because they are often positioned between customary knowledge and contemporary forms of communication (Sithole, 2024; Sithole et al., 2024). In Bombana, the local youth organization SEPAKAT has developed an ecological literacy campaign that integrates Moronene values into storytelling, workshops, school outreach, visual communication, and community learning activities. Rather than treating young people only as recipients of environmental information, the campaign positions them as facilitators, translators, and public communicators of Moronene ecological knowledge (Caviedes et al., 2024). This creates an opportunity to examine how youth-led and culturally grounded interventions can contribute to ecological recovery in post-extractive settings (Oraon et al., 2024).

Seniman Pemuda Kreatif (SEPAKAT) is a local youth organization in Bombana that integrates art, culture, and environmental education into community-based activities. The organization emerged in response to youth concerns about the negative impacts of artisanal and small-scale gold mining, particularly environmental pollution, ecological degradation, and the weakening of local cultural values. SEPAKAT involves youth from different villages and operates through several functional divisions, including arts and culture, environmental education, communication and media, and partnership and advocacy. Its activities include Moronene cultural arts training, environmental awareness campaigns, school-based education, creative media production, and community outreach. In this study, SEPAKAT is important because it functions not only as the campaign organizer but also as a cultural mediator, connecting Moronene ecological knowledge, youth creativity, and contemporary environmental education in the post-ASGM context of Bombana. SEPAKAT was selected as the case study because it is one of the few local youth organizations that

systematically integrates Moronene ecological values into structured environmental education through sustained community-based activities, making it an appropriate setting for examining youth-led ecological literacy in a post-ASGM context.

Existing studies have demonstrated the importance of environmental education (Hajj-Hassan et al., 2024; Zhao et al., 2024), indigenous knowledge (Caviedes et al., 2024; Sangha et al., 2025), and youth participation (Kirby & Zwickle, 2021; Maurer et al., 2020; Peiró-Signes et al., 2025) in promoting ecological literacy, environmental awareness, and pro-environmental engagement. However, previous studies have primarily examined environmental education, indigenous knowledge, and youth participation as separate topics, while providing limited evidence on how local youth organizations integrate these elements into a structured ecological literacy intervention that facilitates intergenerational knowledge transfer in post-mining communities. Many studies discuss indigenous knowledge (Maurer et al., 2020; Wendlandt Amézaga et al., 2022), youth engagement (Sithole, 2024; Sithole et al., 2024), or ecological literacy separately (Hastuti et al., 2021; Oraon et al., 2024). Fewer studies examine how these elements interact within an intervention model that responds simultaneously to environmental damage, weakened cultural transmission, and the need for participatory recovery. This gap is particularly important in post-ASGM contexts, where ecological restoration must be linked to local identity, community ownership, and long-term environmental sustainability (Rakuasa et al., 2024; Husamah et al., 2025; Ihwughwavwe & Aniebonam, 2024; Morales, 2020; Oraon et al., 2024; Tsai et al., 2025).

To address this gap, the present study investigates both the implementation process and the outcomes of a youth-led ecological literacy intervention grounded in Moronene indigenous knowledge in Bombana. Specifically, the study aims to, (1) describe the design and implementation of the Moronene-based ecological literacy campaign; (2) assess its influence on participants' ecological knowledge and environmental engagement; (3) analyze the role of youth in mediating the intergenerational transfer of Moronene ecological knowledge into contemporary educational media; and (4) identify the enabling factors, implementation constraints, and practical implications of this intervention in a post-ASGM context. Based on these aims, the study addresses the following research questions: How was the campaign designed and implemented? In what ways did it influence ecological knowledge and engagement? How did youth function as mediators of intergenerational knowledge transfer? What factors supported or constrained the campaign, and what implications does the intervention offer for ecological literacy in post-ASGM settings?

2. Methods

2.1 Research framework

This study is guided by a framework in which post-ASGM environmental degradation and the weakened transmission of Moronene ecological knowledge create the need for a culturally grounded ecological literacy intervention (Fig. 1). The intervention is implemented by SEPAKAT through a four-phase campaign and is rooted in the Moronene values of *mondoke* and *popotara*, which provide the cultural principles that guide environmental learning, intergenerational dialogue, and community participation throughout the intervention. Within this framework, youth act as cultural mediators by translating elders' ecological knowledge into contemporary educational media and public learning activities. Through this mediation process, the intervention is expected to enhance ecological knowledge, strengthen intergenerational knowledge transfer, increase environmental engagement, and encourage broader community participation. The effectiveness of these outcomes is influenced by enabling factors, such as cultural legitimacy and organizational leadership, as well as contextual constraints, including resource and logistical limitations.

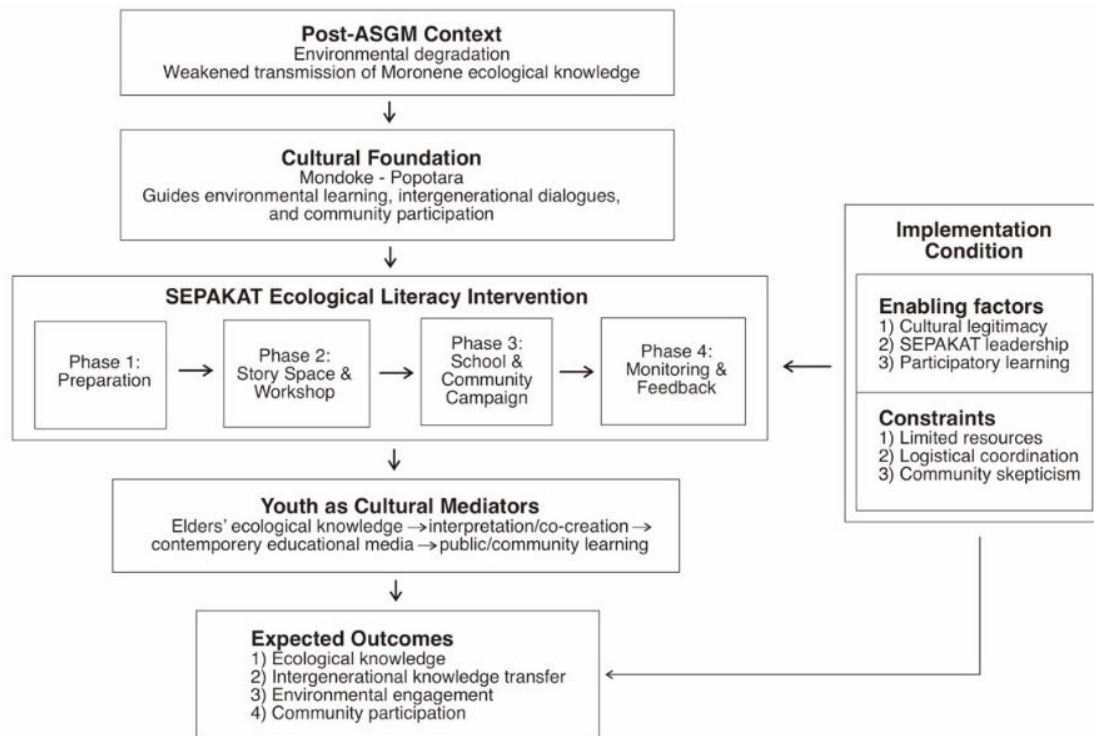


Fig. 1. Conceptual framework of the Moronene-based ecological literacy intervention

2.2 Research design

This study used an embedded mixed-methods design within a participatory action research framework to examine SEPAKAT's Moronene-based ecological literacy campaign in a post-ASGM community. An embedded design was selected because it enabled quantitative assessment of intervention outcomes while simultaneously providing qualitative insights into how the intervention was implemented and experienced by participants. The qualitative part explored how Moronene ecological knowledge was shared by elders, interpreted by youth, and transformed into campaign activities through interviews, focus group discussions, observations, Story Space sessions, and reviews of youth-produced media. The quantitative part employed a one-group pretest–posttest design and a stakeholder-rating survey to measure changes in ecological knowledge, youth mediation, enabling factors, constraints, and practical implications. Quantitative data were analyzed using descriptive statistics and paired-sample t-tests, while qualitative data were analyzed thematically. The findings from both components were integrated through triangulation to explain not only whether the campaign produced measurable changes, but also how and why the intervention worked within its local cultural context.

2.3 Study setting

The study was conducted in Bombana Regency, Southeast Sulawesi, Indonesia, an area that has experienced substantial environmental and social impacts associated with artisanal and small-scale gold mining (Fikriansyah, 2022). The research focused specifically on Tahi Ite and Wumpubangka villages where Moronene cultural practices remain active and where SEPAKAT implemented youth-led ecological literacy activities (Fig. 2). This setting was selected because it provides a relevant context for examining the interaction between indigenous ecological knowledge, youth-led intervention, and environmental recovery in a post-ASGM landscape. The continuing presence of Moronene cultural practices in these communities also made it possible to analyze how local ecological values were incorporated into contemporary educational and community-based communication activities (Jabalnur et al., 2019).

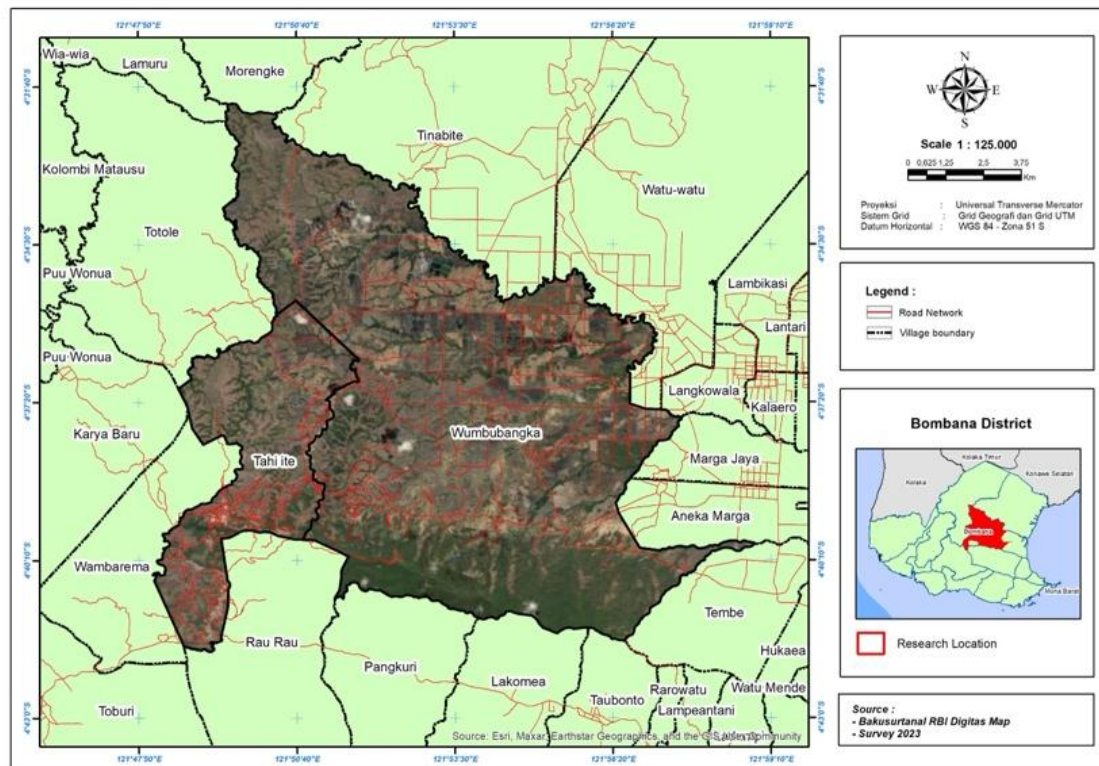


Fig. 2. Study location in Bombana Regency, Southeast Sulawesi, Indonesia—an area historically impacted by artisanal and small-scale gold mining (ASGM) activities

2.4 Participants and sampling

This study involved 70 participants, consisting of 20 qualitative informants and 50 quantitative respondents. The qualitative and quantitative participants were recruited separately to avoid overlap between the two data sources. For the qualitative component, 20 key informants were selected purposively from six stakeholder groups: Moronene elders ($n = 4$), SEPAKAT youth leaders and facilitators ($n = 5$), women artisans ($n = 3$), teachers ($n = 3$), former miners ($n = 3$), and student representatives ($n = 2$). Recruitment was conducted iteratively across these stakeholder categories and continued until data saturation was reached, defined as the point at which additional interviews and discussions no longer generated substantively new information relevant to Moronene ecological values, campaign implementation, youth mediation, and post-ASGM environmental conditions. Data saturation was reached with 20 informants while maintaining representation across the six stakeholder groups. Qualitative informants were included if they had direct involvement in or knowledge of the campaign, familiarity with Moronene ecological values or post-ASGM environmental issues, willingness to participate in interviews, focus group discussions, or observation activities, and the ability to provide relevant information based on their social or functional roles. Individuals were excluded if they were unfamiliar with the campaign or local environmental context, were unable to provide informed consent, were unavailable during data collection, or withdrew from the study.

For the quantitative component, a total-sampling approach was used among campaign participants who met the eligibility criteria for paired pre- and post-intervention assessment. All eligible participants who were available for both measurement points were invited to participate, and 50 respondents met the eligibility requirements and provided complete paired pre- and post-campaign questionnaire data. Therefore, the quantitative sample represented all eligible campaign participants with complete paired measurements rather than a statistically selected subset, and no additional sample-size calculation was applied. The quantitative respondents consisted of participants in school- and community-based campaign activities, including students, community youth, teachers, women artisans,

and former miners who were not included in the qualitative informant group. Respondents were included if they participated in the SEPAKAT ecological literacy campaign, were available during both pre-campaign and post-campaign data collection, were willing to complete the structured questionnaires, and provided informed consent. Respondents were excluded from the quantitative analysis if they did not complete either the pre-test or post-test questionnaire, provided incomplete survey responses, participated only in activities outside the measured intervention process, were already included as qualitative informants, or withdrew from the study. This separation allowed the qualitative component to provide in-depth contextual explanations of the intervention process while the quantitative component assessed within-participant changes associated with the campaign.

Table 1. Participant structure of the Moronene-based ecological literacy campaign by mixed-methods component

Participant category	n	Functional role in the study/campaign	Main data contribution
Qualitative informants (n=20)			
Moronene elders	4	Providers of traditional ecological knowledge, oral narratives, and cultural values related to land, rivers, forests, and biodiversity	Interviews, Story Space discussions, cultural validation
SEPAKAT youth leaders/facilitators	5	Organizers, facilitators, and translators of Moronene ecological knowledge into campaign activities and educational media	Interviews, participant observation, campaign documentation
Women artisans	3	Contributors to culture-based educational materials and community workshop activities	Interviews, focus group discussions, workshop observation
Teachers	3	Supporters of school-based environmental learning and classroom implementation	Interviews, focus group discussions, school activity observation
Former miners	3	Contributors of local perspectives on environmental risk, mining impacts, and post-ASGM transition	Interviews and focus group discussions
Student representatives	2	Representatives of youth learners involved in campaign reflection and feedback	Interviews and reflection notes
Quantitative respondents (n=50)			
Campaign participants from school and community activities	50	Participants who joined the ecological literacy campaign and completed pre- and post-campaign questionnaires and stakeholder-rating survey	Pre-test, post-test, and structured survey

2.5 Research and Intervention design

The intervention was designed as a six-month longitudinal and periodic campaign, not as a one-time activity (Fig. 3). It was implemented from May to October 2025 through four sequential phases that allowed participants to progress gradually from knowledge mapping to intergenerational dialogue, the co-creation of educational media, public dissemination, and reflective evaluation. This longitudinal structure was important because the campaign aimed not only to deliver environmental information, but also to facilitate repeated learning encounters, strengthen youth mediation, and observe changes in ecological knowledge and engagement before and after the intervention.

The intervention was developed and implemented by SEPAKAT using a Community of Practice framework. Phase 1 focused on preparation, including mapping Moronene ecological values, identifying post-ASGM environmental concerns, and preparing campaign materials. Phase 2 involved Story Space forums and cultural workshops, where Moronene elders, SEPAKAT youth, and community participants exchanged ecological narratives and

co-created campaign content. Phase 3 expanded the campaign into schools and community spaces through posters, videos, performances, and outreach activities. Phase 4 consisted of monitoring, feedback collection, and reflective evaluation of participation, learning outcomes, and practical implications. This staged design enabled the intervention to function as a cumulative learning process rather than a single awareness event.

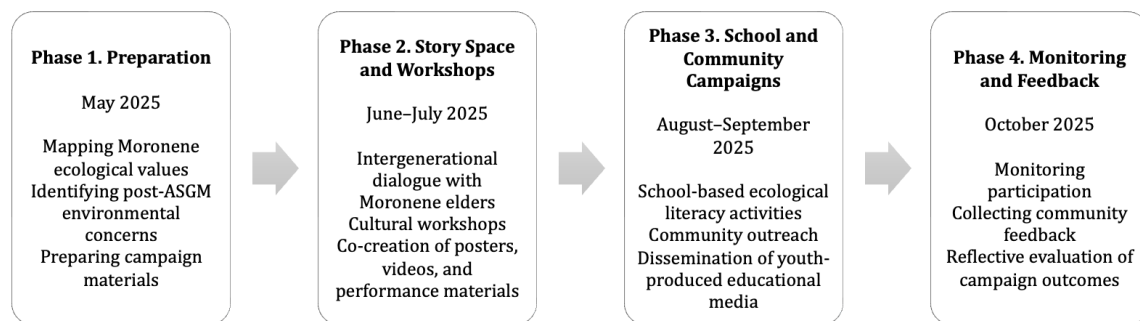


Fig. 3. Flowchart of the Moronene-based ecological literacy campaign, May–October 2025

2.6 Data collection and analysis

As presented in Table 2, each research objective was matched with specific data collection methods and analytical procedures. The first objective focused on campaign design and implementation using documentation, records, observations, and monitoring notes, which were analyzed through thematic analysis and descriptive review. The second objective examined ecological knowledge and environmental engagement through interviews, FGDs, observation, surveys, and participation records using thematic and descriptive analysis. Thematic analysis followed an iterative process involving data familiarization, initial coding, theme development, theme review, and interpretation. Emerging themes were continuously compared across interviews, focus group discussions, observations, and documentary evidence during the triangulation process. The third objective analyzed youth mediation through Story Space observations, youth-produced media, and interviews with youth and elders, supported by thematic analysis and cross-source comparison. The fourth objective identified enabling factors, implementation constraints, and practical implications using reflections, interviews, field notes, and adaptive-response documentation, analyzed through thematic analysis and triangulation. Because the quantitative component employed a one-group pretest–post test design, the statistical analysis was intended to estimate within-participant changes associated with the intervention rather than to establish definitive causal effects.

Table 2. Alignment of study objectives, data collection methods, and analytical procedures

Study objective	Data collection methods	Analytical procedures
Describe the design and implementation of the campaign	Program documentation, activity records, field observations, monitoring notes	Thematic analysis and descriptive review
Assess ecological knowledge and environmental engagement	Interviews, focus group discussions, participant observation, surveys, participation records	Thematic analysis and descriptive analysis
Analyze the role of youth in intergenerational knowledge transfer	Observation of Story Space sessions, review of youth-produced media, interviews with youth and elders	Thematic analysis and cross-source comparison
Identify enabling factors, constraints, and practical implications	Participant reflections, interviews, field notes, documentation of adaptive responses	Thematic analysis and triangulation

2.7 Research validity and ethical considerations

The Moronene-based ecological literacy model was validated through contextual, process, and outcome validation. Contextual validation was conducted through participatory engagement with Moronene elders, SEPAKAT youth facilitators, teachers, women artisans, former miners, and student representatives to ensure that the model reflected local ecological values, particularly *mondoke* and *popotara*, and remained relevant to the post-ASGM context of Bombana. Process validation was conducted through triangulation across semi-structured interviews, focus group discussions, participant observations, Story Space observations, campaign documents, youth-produced media, and participation records. Evidence from these sources was systematically compared to confirm the consistency of implementation processes and participants' experiences throughout the intervention. Outcome validation was conducted using a one-group pretest–posttest design involving 50 campaign participants.

Quantitative data were analyzed using descriptive statistics, including mean, standard deviation, mean difference, percentage increase, and high-agreement percentage, while paired-sample *t*-tests were used to examine the statistical significance of pre-post changes in ecological knowledge and youth mediation scores. Qualitative data were analyzed thematically and integrated with quantitative findings through triangulation to strengthen the interpretation of how and why the model worked within its local cultural and post-ASGM setting.

Ethical approval for this study was obtained from the Health Research Ethics Committee of Sekolah Tinggi Ilmu Kesehatan Makassar under protocol number 025/KEPK/STIK/MKS/V/2025 and was approved on 15 May 2025. Before data collection, all participants were informed about the objectives, procedures, voluntary nature, potential benefits, and possible risks of the study. Participants were also informed of their right to decline participation or withdraw from the study at any stage without penalty. Informed consent was obtained from all adult participants before interviews, focus group discussions, observations, and questionnaire administration. Where participants were under 18 years of age, parental or guardian consent and participant assent were obtained, as appropriate. Participants' identities were protected through anonymization, and all personal information was treated confidentially and used solely for research purposes.

3. Results and Discussion

3.1 Results

3.1.1 Campaign design and implementation

As presented in Table 3, the intervention was structured into four sequential phases over a six-month period. The extended duration of Phase 2 allowed repeated interactions between Moronene elders and youth participants, creating opportunities for collaborative knowledge exchange, iterative learning, and the co-production of culturally grounded educational materials. This intensive engagement likely established the foundation for the subsequent improvements in ecological knowledge and youth mediation observed during the intervention. By contrast, Together, the four phases formed an integrated intervention pathway in which Phase 1 established the cultural and educational foundation, Phase 2 facilitated collaborative learning and knowledge co-production, Phase 3 translated the learning outcomes into broader community engagement, and Phase 4 supported reflection and continuous improvement of the intervention.

Table 3. Quantitative structure of the Moronene-based ecological literacy campaign in 2025

Phase	Duration	Share of total intervention (%)	Main focus	Core activities
Phase 1. Preparation	1 months (May 2025)	16	Knowledge mapping and material preparation	Mapping Moronene ecological values, identifying local environmental concerns in Bombana regency, preparing campaign materials
Phase 2. Story Space and Workshops	2 months (June–July 2025)	34	Intergenerational dialogue and co-creation	Story Space forums, collaborative production of educational media
Phase 3. School and Community Campaigns	2 months (August–September 2025)	25	Public dissemination and outreach	Posters, videos, school-based activities, community outreach
Phase 4. Monitoring and Feedback	1 months (October 2025)	25	Reflection and evaluation	Monitoring participation, documenting community feedback, evaluating campaign outcomes

3.1.2 The influence on participants' ecological knowledge and environmental engagement

Table 4 shows a clear increase in ecological knowledge across all three environmental domains targeted by the Moronene-based ecological literacy campaign in Bombana. The mean score for river protection increased from 2.68 ± 0.59 before the intervention to 4.12 ± 0.47 after the intervention, with a mean difference of 1.44 and a percentage increase of 53.7%. Biodiversity conservation score increased from 2.74 ± 0.63 to 4.06 ± 0.51 , with a mean difference of 1.32 and a percentage increase of 48.2%. Sustainable forest management score rose from 2.58 ± 0.61 to 3.98 ± 0.49 , with a mean difference of 1.40 and the highest percentage increase at 54.3%. Overall ecological knowledge increased from 2.67 ± 0.61 in the pre-campaign stage to 4.05 ± 0.49 in the post-campaign stage, with a mean difference of 1.38 and an overall increase of 51.7%. These results indicate a consistent upward trend in participants' ecological knowledge following the campaign. These improvements are consistent with the intervention, in which repeated Story Space discussions, collaborative workshops, and community-based learning activities provided participants with multiple opportunities to acquire, discuss, and apply Moronene ecological knowledge throughout the six-month campaign.

Table 4. Pre-post comparison of ecological knowledge scores across the three environmental domains targeted by the Moronene-based ecological literacy campaign in 2025

	River protection	Biodiversity conservation	Sustainable forest management	Overall ecological knowledge
mean $\pm$ SD				
Pre-campaign	2.68 ± 0.59	2.74 ± 0.63	2.58 ± 0.61	2.67 ± 0.61
Post-campaign	4.12 ± 0.47	4.06 ± 0.51	3.98 ± 0.49	4.05 ± 0.49
Mean difference	1.44	1.32	1.40	1.38
95% CI of difference	1.14–1.74	1.04–1.60	1.09–1.71	1.09–1.67
% increase	53.7	48.2	54.3	51.7
<i>t</i> -value	9.70	9.33	9.17	9.57
<i>p</i> -value	<0.001	<0.001	<0.001	<0.001
Cohen's <i>d</i> _z	1.37	1.32	1.30	1.35

The pre-post differences were statistically significant across all ecological knowledge domains, with *t*-values ranging from 9.17 to 9.70 and *p*-values below 0.001. The 95% confidence intervals for all mean differences were entirely above zero, indicating that the direction of the observed changes was consistently positive. The mean difference ranged from 1.32 to 1.44 points, with the overall ecological knowledge score increasing by 1.38

points (95% CI: 1.09–1.67). The corresponding paired-samples Cohen's (d_z) values ranged from 1.30 to 1.37, indicating large within-participant effect sizes across all ecological knowledge domains. For overall ecological knowledge, the effect size was also large ($(d_z=1.35)$). These findings indicate that the observed changes were not only statistically significant but also substantial in magnitude, suggesting meaningful improvements in participants' understanding of river protection, biodiversity conservation, and sustainable forest management following the campaign. Nevertheless, given the one-group pretest–posttest design, these findings should be interpreted as substantial intervention-associated changes rather than definitive evidence of causality. The largest mean gain was recorded in river protection, while the highest percentage increase was observed in sustainable forest management. Overall, the results are significant because they suggest that the campaign strengthened participants' understanding of key environmental issues addressed in the intervention and produced measurable improvements across the main domains of ecological knowledge. As illustrated in Figure 3, post-campaign mean scores were consistently higher than pre-campaign scores across all ecological knowledge domains, supporting the statistically significant improvements presented in Table 4.

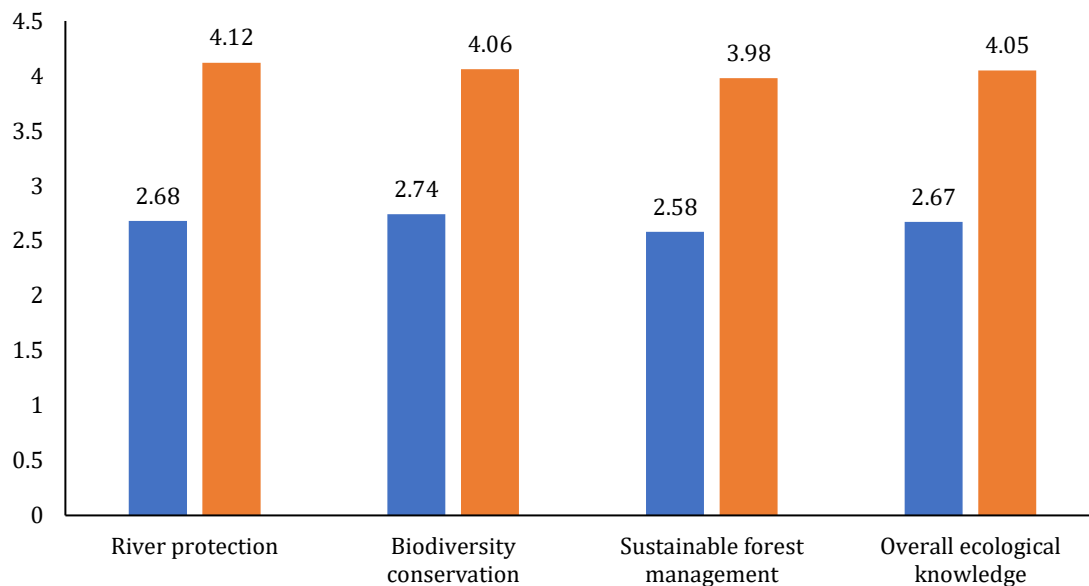


Fig. 3. Pre- and post-campaign ecological knowledge scores across the environmental domains targeted by the Moronene-based ecological literacy campaign in 2025

3.1.3 The role of youth in mediating the intergenerational transfer of Moronene ecological knowledge into contemporary educational media

As shown in Table 5, the pre–post differences across all dimensions of youth mediation were statistically significant, with t -values ranging from 9.11 to 10.08 and p -values below 0.001. The 95% confidence intervals for all mean differences were entirely above zero, indicating consistently positive within-participant changes across the four dimensions. Paired-samples Cohen's (d_z) values ranged from 1.29 to 1.43, indicating large effect sizes. Table 5 further shows that the largest improvement occurred in the translation of Moronene ecological knowledge into contemporary educational media (mean difference = 1.58, 95% CI [1.27, 1.89], ($t(49)=10.08$), ($p<0.001$), ($d_z=1.43$)), followed by the perceived effectiveness of youth as cultural mediators (mean difference = 1.51, 95% CI [1.20, 1.82], ($t(49)=9.87$), ($p<0.001$), ($d_z=1.40$)). These results indicate that the observed improvements were not only statistically significant but also substantial in magnitude, particularly in youths' capacity to translate indigenous ecological knowledge into contemporary educational forms. Overall, the findings presented in Table 5 support the interpretation that youth functioned as active cultural mediators who received ecological

knowledge from elders, transformed it into accessible educational media, and disseminated it across wider learning spaces. However, given the one-group pretest–posttest design, these findings should be interpreted as substantial intervention-associated changes rather than definitive evidence of causal effects.

Table 5. Pre-post comparison of scores on youth mediation in the intergenerational transfer of Moronene ecological knowledge into contemporary educational media

Youth mediation dimension	mean $\pm$ SD		Mean difference	95% CI of difference	<i>t-value</i>	<i>p-value</i>	Cohen's d_z
	Pre-campaign	Post-campaign					
Youth engagement with elders' ecological narratives	2.76 $\pm$ 0.61	4.18 $\pm$ 0.49	01.42	1.12–1.72	9.42	<0.001	1.33
Translation of Moronene ecological knowledge into educational media	2.64 $\pm$ 0.58	4.22 $\pm$ 0.46	01.58	1.27–1.89	10.08	<0.001	1.43
Dissemination of youth-produced media across learning spaces	2.71 $\pm$ 0.63	4.09 $\pm$ 0.51	01.38	1.08–1.68	9.11	<0.001	1.29
Perceived effectiveness of youth as cultural mediators	2.69 $\pm$ 0.60	4.20 $\pm$ 0.48	01.51	1.20–1.82	9.87	<0.001	1.40

3.1.4 Enabling factors, implementation constraints, and practical implications of the intervention in a post-ASGM context

Table 6 shows that stakeholder ratings identified both strong enabling conditions and important implementation challenges associated with the Moronene-based ecological literacy campaign. Among the enabling factors, the highest mean score was observed for the cultural legitimacy of Moronene values in environmental learning (4.42 $\pm$ 0.51), with 88% high agreement, indicating that local cultural values were the strongest foundation of the intervention. This was followed by the organizational leadership of SEPAKAT (4.28 $\pm$ 0.56; 84%) and participatory learning formats, such as Story Space, workshops, and outreach activities (4.20 $\pm$ 0.59; 82%). These findings suggest that the campaign was primarily supported by cultural relevance, local organizational capacity, and participatory implementation. However, several important constraints were also identified. Limited financial and material resources received the highest mean score among the constraints (4.18 $\pm$ 0.63), followed by logistical coordination across villages (4.04 $\pm$ 0.67) and initial community skepticism toward culture-based environmental education (3.76 $\pm$ 0.71). This pattern indicates that although the intervention was socially and culturally grounded, its implementation still faced operational and resource-related limitations.

The practical implications received consistently high ratings across community, educational, organizational, and policy dimensions. The strongest community-level implication was strengthening community ownership and intergenerational ecological continuity (4.40 $\pm$ 0.52; 88%), indicating strong community relevance and the potential for sustaining ecological practices across generations. At the policy level, the highest-rated

implication was the integration of the intervention into local government post-ASGM recovery programs (4.40 ± 0.52 ; 86%), highlighting its potential contribution to locally coordinated environmental recovery initiatives. Integration into school-based environmental learning was also highly rated (4.30 ± 0.57 ; 84%), demonstrating its relevance for strengthening environmental education, while the use of the intervention by NGOs and community organizations as a replicable outreach model received a strong rating (4.22 ± 0.60 ; 82%), reflecting its broader programmatic applicability. These findings suggest that the intervention extends beyond the immediate campaign setting and may support broader applications in local governance, education, and community-based environmental programs. Overall, the sustainability and wider applicability of the campaign appear to depend on strong cultural legitimacy, participatory local leadership, and adequate institutional and operational support.

Table 6. Stakeholder ratings of enabling factors, implementation constraints, and practical implications of the Moronene-based ecological literacy campaign (n = 50) in 2025

Category	Indicator	mean $\pm$ SD	High agreement (%)	Rank within category	Interpretation
Enabling factors	Cultural legitimacy of Moronene values in environmental learning	4.42 ± 0.51	88	1	Strongest enabling factor
	Organizational leadership of SEPAKAT	4.28 ± 0.56	84	2	Very strong enabling factor
	Participatory learning formats (Story Space, workshops, outreach)	4.20 ± 0.59	82	3	Strong enabling factor
Implementation constraints	Limited financial and material resources	4.18 ± 0.63	80	1	Most severe implementation constraint
	Logistical coordination across villages	4.04 ± 0.67	76	2	High operational constraint
	Initial community skepticism toward culture-based environmental education	3.76 ± 0.71	68	3	Moderate-to-high social constraint
Practical implications	Integration into local government post-ASGM recovery programs	4.40 ± 0.52	86	1	Highest policy relevance
	Integration into school-based environmental learning	4.30 ± 0.57	84	2	Strong educational relevance
	Use by NGOs and community organizations as a replicable outreach model	4.22 ± 0.60	82	3	Strong programmatic relevance
	Strengthening community ownership and intergenerational ecological continuity	4.40 ± 0.52	88	1*	Highest community relevance

3.1.5 Qualitative findings on model implementation and change mechanisms

The qualitative results show that the Moronene-based ecological literacy model operated through five interconnected mechanisms: cultural grounding, intergenerational dialogue, youth mediation, participatory learning, and adaptive implementation, as

summarized in Table 7. Cultural grounding ensured that environmental learning remained rooted in Moronene values, intergenerational dialogue facilitated knowledge exchange between elders and youth, youth mediation translated indigenous knowledge into contemporary educational media, participatory learning promoted collaborative engagement, and adaptive implementation enabled the campaign to respond to local needs and contextual challenges. These findings complement the quantitative results by explaining the social, cultural, and educational processes through which the observed improvements in ecological knowledge and youth mediation were achieved, thereby providing a more comprehensive understanding of the intervention's effectiveness. This component, therefore, strengthens the mixed-methods argument by showing not only that participant scores improved, but also how the campaign produced change through Moronene values, Story Space interaction, youth-led media translation, and community-based learning. This is consistent with the qualitative research design of this study, which used interviews, focus group discussions, participant observation, Story Space observations, campaign documents, and youth-produced media to examine cultural meanings, implementation processes, youth mediation roles, enabling factors, and constraints.

Table 7. Qualitative results on the moronene-based ecological literacy model

Main Theme	Qualitative Data Sources	Key Qualitative Finding	Interpretation for the Model
Cultural grounding of ecological literacy	Interviews with Moronene elders, Story Space observations, FGDs, campaign documents	Participants understood ecological issues more clearly when river protection, forest care, and biodiversity conservation were linked to Moronene values, especially <i>mondoke</i> and <i>popotara</i> . Elders described nature not only as a physical resource but also as part of collective moral responsibility.	The model gains cultural legitimacy because ecological literacy is framed through local values rather than delivered as external environmental instruction.
Story Space as intergenerational learning mechanism	Story Space observations, interviews with elders and youth facilitators, field notes	Story Space became the main setting where elders shared ecological narratives, former miners reflected on environmental damage, and youth interpreted these narratives into campaign messages.	The model works through intergenerational dialogue, allowing traditional ecological knowledge to be transferred, discussed, and adapted into contemporary learning formats.
Youth as cultural mediators	Interviews with SEPAKAT youth leaders, review of youth-produced posters, videos, and performance materials, participant observation	Youth did not function only as campaign participants. They translated elders' oral narratives into posters, videos, performances, and school outreach materials.	Youth mediation is the central mechanism of the model because young people connect customary knowledge with modern educational media and wider public audiences.
Participatory learning and community engagement	FGDs, workshop observations, school activity observations,	Workshops and outreach activities encouraged participants to discuss local environmental problems directly, including river	The model strengthens ecological literacy by combining cultural reflection,

	participation records	pollution, forest degradation, and ecological disruption after ASGM. Teachers and students viewed the campaign as relevant because it combined local culture with practical ecological issues.	participatory discussion, and practical environmental learning.
Implementation constraints and adaptive responses	Interviews with SEPAKAT facilitators, former miners, teachers, field notes, monitoring records	The campaign faced limited financial resources, logistical difficulty across villages, and early skepticism toward culture-based environmental education. SEPAKAT responded through low-cost media, flexible scheduling, local youth networks, and repeated community dialogue.	The model is contextually feasible but requires operational support, especially funding, coordination, and institutional collaboration for wider replication.
Perceived usefulness for post-ASGM recovery	FGDs, stakeholder reflections, campaign evaluation notes	Participants perceived the campaign as useful for strengthening environmental awareness, rebuilding community ownership, and reconnecting younger generations with Moronene ecological knowledge.	The model contributes not only to ecological knowledge improvement but also to cultural continuity and community-based recovery in post-ASGM settings.

3.2 Discussion

3.2.1 Intervention stage as a mechanism for deep ecological learning

The findings indicate that the campaign’s effectiveness was closely tied to its phased design. Implemented over 6 months, the intervention moved systematically from preparation to intergenerational dialogue and co-creation, then to public dissemination, and finally to monitoring and feedback. The larger share of time devoted to Story Space forums and workshops suggests that the campaign treated collaborative learning and cultural exchange as the core pedagogical mechanism rather than as a preliminary activity. This is analytically important because it shows that ecological literacy was built through a sequence of cultural grounding, reinterpretation, and circulation, not through one-directional environmental messaging (Firnadi, 2025). In post-ASGM contexts, where environmental degradation is linked to weakened social and cultural continuity, such a design is likely to be more effective than short awareness campaigns because it allows time for trust building, meaning making, and community ownership to emerge (Khan et al., 2023; Wilson, 2014).

This interpretation is consistent with the broader rationale of the study, which frames ecological recovery as both an environmental and socio-cultural challenge. The intervention responded to that dual challenge by first identifying Moronene ecological values, then translating them into educational forms, and only after that expanding them into schools and community spaces (Sinapoy, 2018). Accordingly, the campaign design itself serves as a learning model that integrates cultural continuity with environmental communication (Dewi et al., 2025; Ningrum et al., 2018; Suartama et al., 2024). Prior studies similarly suggest that environmental education becomes more meaningful when it is grounded in local narratives and participatory learning structures (Hajj-Hassan et al., 2024; Husamah et al., 2025; Morales, 2020). Unlike previous studies that primarily emphasize the importance of participatory environmental education or indigenous knowledge, the present study demonstrates how these elements can be systematically integrated into a structured four-

phase intervention that combines cultural grounding, youth mediation, collaborative learning, and community dissemination within a post-ASGM context. The implication is that ecological literacy programs in comparable settings should be designed as cumulative and participatory interventions rather than as isolated information events (Rai, 2007; Wingfield, 2013).

3.2.2 Ecological knowledge gains and the role of cultural relevance

The pre-post results show improvement across all three ecological knowledge domains targeted by the intervention: river protection, biodiversity conservation, and sustainable forest management. Because these domains correspond directly to the environmental pressures described in the post-ASGM context of Bombana, the improvement is meaningful beyond mere statistical significance. It suggests that the findings suggest that the campaign contributed to improvements in ecological understanding in areas that matter most for local environmental recovery (Islam et al., 2022). The fact that gains occurred across all three domains also indicates that the intervention did not merely increase issue-specific awareness, but fostered a broader and more integrated ecological perspective among participants (Rai, 2007; Uprety et al., 2012).

What appears to have made these gains possible was the cultural framing of environmental knowledge. The campaign did not present river systems, forests, and biodiversity as abstract scientific topics detached from community life. Instead, ecological themes were connected to Moronene values such as *mondoke* and *popotara*, thereby linking environmental understanding to moral responsibility and local identity. This matters because ecological literacy is more likely to become durable when participants can interpret environmental issues through shared values rather than external terminology alone (Maryati et al., 2022). Previous studies have emphasized the importance of integrating local wisdom into environmental learning, demonstrating that indigenous values can strengthen environmental awareness and community relationships with nature (Caviedes et al., 2024; Morales, 2020). Other studies have examined environmental education approaches as mechanisms for improving ecological understanding and pro-environmental behavior (Hajj-Hassan et al., 2024; Zhao et al., 2024), while research on youth participation has highlighted the potential of young people as agents of environmental communication and community engagement (Sithole, 2024; Sithole et al., 2024). However, these previous studies have largely examined local wisdom, environmental education, or youth participation as separate dimensions.. The present study supports that literature by providing evidence that a culture-based ecological literacy campaign was associated with measurable improvements in ecological knowledge within a post-ASGM community. The implication is that future environmental learning in similar contexts should incorporate local cultural frameworks as central pedagogical resources rather than treating them as supplementary elements.

3.2.3 Youth mediation as the bridge between tradition and contemporary communication

One of the most distinctive findings of the study concerns the role of youth. The results show that the strongest improvement within the mediation dimensions occurred in the translation of Moronene ecological knowledge into contemporary educational media, followed by the perceived effectiveness of youth as cultural mediators. This pattern indicates that youth were not simply involved as participants or campaign assistants (Shutaleva et al., 2021; Sithole et al., 2024; Wexler, 2009). They occupied a central interpretive role by receiving ecological narratives from elders, reformulating them into media such as posters, videos, and performance materials, and helping circulate them across learning spaces. In effect, the intervention positioned youth as the bridge between customary ecological knowledge and contemporary public communication (Reuter et al., 2020; Shutaleva et al., 2021; Sithole et al., 2024).

This matters because intergenerational transfer in present-day indigenous and post-extractive communities rarely occurs through oral transmission alone (Rakuasa et al., 2024; Rai, 2007). Environmental change (Datta et al., 2022), schooling (Lawson & Albright, 2016), and media transformation alter the ways in which knowledge is received and shared (Liu et al., 2020). In this study, Story Space forums and workshops created a formal setting for elders to share ecological values, but the continuation of that process depended on youth being able to reinterpret those values in forms that were visible and usable in schools, community events, and public forums. This finding resonates with prior literature emphasizing the role of youth in environmental stewardship and intergenerational learning (Elshaer et al., 2023; Sormin & Sihombing, 2023). However, the present study sharpens that discussion by showing that youth mediation can be analytically specified and measured through dimensions such as knowledge translation, dissemination, and mediating effectiveness (Upreti et al., 2012; Zeldin et al., 2008). In this study, youth mediation was operationalized as a measurable construct by assessing three interconnected dimensions: the capacity of youth to translate indigenous ecological knowledge into contemporary educational forms, disseminate these transformed messages across learning spaces, and effectively function as cultural mediators between elders, communities, and younger generations. The implication is that community-based environmental programs should intentionally position youth as co-creators and translators of indigenous knowledge, especially where the goal is to sustain both ecological literacy and cultural continuity.

3.2.4 Enabling factors and the limits of implementation

The results further show that the campaign's success was strongly supported by the cultural legitimacy of Moronene values, the organizational leadership of SEPAKAT, and participatory learning formats such as Story Space, workshops, and outreach activities. Taken together, these enabling factors suggest that the intervention gained traction because it was locally grounded, socially trusted, and enacted through forms of learning that encouraged participation rather than passive reception. This interpretation is supported by the qualitative findings, which showed that Moronene elders, SEPAKAT facilitators, and community participants collaboratively shaped campaign activities, thereby strengthening local ownership, trust, and sustained participation throughout the intervention. This is an important finding because it reinforces the idea that effective ecological literacy is not produced by content alone. It depends on whether the intervention is culturally acceptable, institutionally carried by credible actors, and socially organized in ways that invite contribution from the community.

At the same time, the study identifies meaningful implementation limits. Financial and material shortages, logistical coordination across villages, and early skepticism toward culture-based environmental education all appeared as important constraints (Ramli et al., 2025). These barriers are not marginal details (Awayehu Gugssa, 2024). They shape the scale, continuity, and replicability of the intervention. Addressing these challenges may require stronger collaboration between community organizations, local governments, educational institutions, and external funding partners to ensure that culturally grounded ecological literacy initiatives can be sustained and expanded beyond pilot-scale implementation. In that sense, the findings present a balanced picture: cultural legitimacy and local leadership can make an intervention meaningful and acceptable, but operational sustainability still depends on resources and coordination. Previous studies similarly indicate that participatory and indigenous knowledge-based interventions are strengthened by local grounding, yet they also require broader support to remain effective over time (Awayehu Gugssa, 2024; Rojas Casarrubias et al., 2025). The implication is that ecological literacy initiatives in post-ASGM settings should be understood as both social and organizational projects. Their long-term viability requires not only community engagement but also institutional investment and logistical support (Adranyi et al., 2024; Pouresmaieli et al., 2024).

3.2.5 Implications for recovery, education, and community resilience

The practical implications reported in this study extend the significance of the findings beyond the immediate campaign setting. High ratings for community ownership and intergenerational ecological continuity suggest that the intervention strengthened not only ecological knowledge outcomes but also local commitment to sustaining ecological values. At the same time, the strong ratings for integration into local government recovery programs, school-based environmental learning, and NGO outreach indicate that the campaign has relevance across policy, education, and community-based environmental programming. This is important because post-ASGM recovery cannot be addressed through technical restoration alone. It also requires rebuilding ecological understanding, strengthening social participation, and enhancing local capacity to carry environmental values forward (Kyaw & Sakakibara, 2022; Measham et al., 2024).

Viewed in this light, the main contribution of the study is not simply that indigenous values matter or that youth participation is helpful. Its contribution is more specific: it shows how youth-led intergenerational co-production can operationalize indigenous ecological knowledge within a structured literacy intervention in a post-extractive setting. This is where the study adds to the existing literature. Rather than treating ecological literacy, indigenous knowledge, and youth engagement as separate elements, it demonstrates how they interact within a coherent intervention model that links cultural continuity, environmental understanding, and participatory recovery. The broader implication is that ecological recovery in post-ASGM communities should be approached as a combined environmental, cultural, and educational process. Programs that integrate these dimensions are more likely to generate not only environmental awareness, but also resilience and continuity.

3.2.6 Limitations and future research

This study has several limitations. First, the research used a purposive sample of participants drawn from a specific post-ASGM community in Bombana, which limits the generalizability of the findings to other indigenous, post-mining, or environmental education contexts. Second, the quantitative component employed a one-group pretest-posttest design without a control group; therefore, the observed improvements in ecological knowledge and youth mediation should be interpreted as intervention-associated changes rather than as a definitive causal effect. Third, the study did not include long-term follow-up, which means that the durability of participants' ecological knowledge, youth mediation roles, and community engagement after the campaign could not be assessed. Fourth, several findings were based on self-reported questionnaires and stakeholder ratings, which may be influenced by social desirability or positive response bias. Fifth, the study did not provide detailed disaggregated analysis by age group, gender, participant category, or level of campaign involvement, thereby limiting a more precise understanding of which participant groups benefited most from the intervention. Future research should address these limitations by using larger and more diverse samples, comparative or quasi-experimental designs, longer follow-up periods, and disaggregated outcome analyses. Future studies are also encouraged to examine the applicability and adaptability of the Moronene-based ecological literacy model in different indigenous communities, post-extractive landscapes, and environmental education contexts to assess its broader transferability.

4. Conclusions

Future research should address these limitations by using larger and more diverse samples, comparative or quasi-experimental designs, longer follow-up periods, and disaggregated outcome analyses. Future studies are also encouraged to examine the applicability and adaptability of the Moronene-based ecological literacy model in different

indigenous communities, post-extractive landscapes, and environmental education contexts to assess its broader transferability. The Moronene-based ecological literacy campaign was successfully designed and implemented through a four-phase participatory model, improved participants' ecological knowledge and environmental engagement, strengthened the role of youth as mediators of intergenerational ecological knowledge, and identified the key enabling factors, implementation constraints, and practical implications of the intervention in a post-ASGM community. The findings suggest that ecological recovery in post-mining areas should not rely only on technical environmental restoration but should also incorporate local culture, youth participation, and community-based learning. From a practical perspective for communities, this model can be used to strengthen environmental awareness, preserve Moronene ecological values, and promote collective responsibility for protecting rivers, forests, land, and biodiversity. Therefore, local governments, schools, youth organizations, and community institutions are encouraged to integrate culture-based ecological literacy into school curricula, youth eco-mediator training, village-level intergenerational forums, and post-ASGM recovery programs.

Acknowledgement

The authors sincerely express their gratitude to the Government of Bombana Regency, Indonesia, for granting permission to conduct this research and for providing support during the sampling process.

Author Contribution

Conceptualization, B. and H.P.; Methodology, B.; Software, H.P.; Validation, B., M.S. and H.P.; Formal Analysis, H.P.; Investigation, B., L.S.; Resources, B.; Data Curation, H.P.; Writing – Original Draft Preparation, B.; Writing – Review & Editing, H.P.; Visualization, B.; Supervision, M.S.; Project Administration, B.; and Funding Acquisition, M.S.

Funding

This study was carried out as part of the Feasibility Study entitled Social Acceptance of Regional Innovation for Reducing High-Impact Environmental Pollution under the Research Institute for Humanity and Nature (RIHN). Financial support for this work was also provided by JSPS KAKENHI through Grant Number 16H02706 awarded to Masayuki Sakakibara.

Ethical Review Board Statement

Ethical approval for this study was obtained from the Health Research Ethics Committee of Sekolah Tinggi Ilmu Kesehatan Makassar under protocol number 025/KEPK/STIK/MKS/V/2025, approved on 15 May 2025. Before data collection, all participants received information about the study objectives, procedures, voluntary nature, potential benefits, and possible risks. Written informed consent was obtained from all adult participants. For participants under 18 years of age, parental or guardian consent and participant assent were obtained. Participants were informed that they could decline participation or withdraw from the study at any time without penalty. Their identities were anonymized, and all personal information was kept confidential and used solely for research purposes.

Informed Consent Statement

Informed consent was obtained from all participants involved in the study. For participants under 18 years of age, parental or guardian consent and participant assent were obtained, where applicable.

Conflicts of Interest

The authors declare no conflict of interest.

Declaration of Generative AI Use

During the preparation of this work, the authors used ChatGPT to assist in language editing and paraphrasing. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

Open Access

©2026. The authors. This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original authors and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third-party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit: <http://creativecommons.org/licenses/by/4.0/>

References

- Adranyi, E., Stringer, L. C., & Altink, H. (2024). Artisanal and small-scale gold mining governance and cross-sectoral policy coherence in Ghana. *Resources Policy*, 96, 105235. <https://doi.org/10.1016/j.resourpol.2024.105235>
- Awayehu Gugssa, M. (2024). Barriers to environmental education in Ethiopia: do they differ from a global analysis?. *International Research in Geographical and Environmental Education*, 34(2), 156-173. <https://doi.org/10.1080/10382046.2024.2352285>
- Bansah, K. J., Acquah, P. J., & Boafo, A. (2024). Land, water, and forest degradation in artisanal and small-scale mining: Implications for environmental sustainability and community wellbeing. *Resources Policy*, 90, 104795. <https://doi.org/10.1016/j.resourpol.2024.104795>
- Hastuti, H. B. P., Muis, E. W., Setiawati, I. R., Rezki, N. N., & Fajrin, R. H. (2021, April). Traditional Ecological Knowledge for the Deer Conservation in the Form of Folklore. In *2nd Annual Conference on Social Science and Humanities (ANCOSH 2020)* (pp. 220-224). Atlantis Press. <https://doi.org/10.2991/assehr.k.210413.051>
- Caviedes, J., Ibarra, J. T., Calvet-Mir, L., Álvarez-Fernández, S., & Junqueira, A. B. (2024). Indigenous and local knowledge on social-ecological changes is positively associated with livelihood resilience in a Globally Important Agricultural Heritage System. *Agricultural Systems*, 216, 103885. <https://doi.org/10.1016/j.agsy.2024.103885>
- Datta, R., Kayira, J., & Datta, P. (2022). Land-based environmental education as a climate change resilience: A learning experience from a cross-cultural community garden. In *Justice and equity in climate change education* (pp. 214-233). Routledge. <https://doi.org/10.4324/9780429326011-11>
- Dewi, C., Rahmadani, N., Syahrir, M., Rahayaan, J. J. D., & Nurjannah, F. (2025). EcoMoronene: A local wisdom-based conservation learning model to address environmental degradation. *EcoVision: Journal of Environmental Solutions*, 2(2), 100-116. <https://doi.org/10.61511/evojes.v2i2.2025.2233>
- Dossou Etui, I. M., Stylo, M., Davis, K., Evers, D. C., Slaveykova, V. I., Wood, C., & Burton, M. E. (2024). Artisanal and small-scale gold mining and biodiversity: a global literature review. *Ecotoxicology*, 33(4), 484-504. <https://doi.org/10.1007/s10646-024-02748-w>
- Elshaer, S., Martin, L. J., Baker, T. A., Roberts, E., Rios-Santiago, P., Kaufhold, R., & Butsch Kovacic, M. (2023). Environmental health knowledge does not necessarily translate to action in youth. *International journal of environmental research and public health*, 20(5), 3971. <https://doi.org/10.3390/ijerph20053971>

- Eminarti, & Hak, P. (2019). Etnopedagogi dalam masyarakat Moronene di Desa Lamoare Kecamatan Poleang Tenggara Kabupaten Bombana. *Jurnal Penelitian Pendidikan Sejarah UHO*, 4(2). <https://doi.org/10.36709/jpps.v4i2.9837>
- Fikriansyah, D. (2022). *Bombana Regency: From regional expansion to the dynamics of gold mining, 2003–2021*. Hasanuddin University.
- Firnadi, A. A. (2025). Integrating local wisdom into climate literacy: Cultural practices and climate resilience in Indonesia. *Journal of Geographical Sciences and Education*, 3(2), 141–154. <https://doi.org/10.69606/geography.v3i2.225>
- Hajj-Hassan, M., Chaker, R., & Cederqvist, A. M. (2024). Environmental education: A systematic review on the use of digital tools for fostering sustainability awareness. *Sustainability*, 16(9), Article 3733. <https://doi.org/10.3390/su16093733>
- Husamah, Rahardjanto, A., Indria Pemana, T., & Lestari, N. (2025). Learning media for environmental education, what can the Scopus database tell us? A review. *Al-Jahiz: Journal of Biology Education Research*, 6(1). <https://ejournal.metrouniv.ac.id/index.php/Al-Jahiz/index>
- Ihwughwawwe, S. I., & Aniebonam, S. O. (2024). Conceptual framework for enhancing environmental awareness through community-based education programs in Southeast Asia. *International Journal of Multidisciplinary Research and Growth Evaluation*, 5(5), 1173–1187. <https://doi.org/10.54660/ijmrge.2024.5.5.1173-1187>
- Islam, E., Wahab, H. B. A., & Benson, O. G. (2022). Community participation in disaster recovery programs: A study of a coastal area in Bangladesh. *European Journal of Development Research*, 34(5), 2438–2462. <https://doi.org/10.1057/s41287-021-00460-7>
- Jabalnur, Heryanti, Safiuddin, S., & Intan, N. (2019). The role of customary law community of Moronene Hukaea Laea in managing ulayat forests in the Rawa Aopa Watumohai Conservation Area. *Journal of Law, Policy and Globalization*, 90. <https://doi.org/10.7176/jlpg/90-06>
- Khan, S., Masoodi, T. H., Islam, M. A., Arjumand, T., Raja, A., Parrey, A. A., ... & Bhat, J. H. (2024). Ecosystem degradation to restoration: a challenge. In *Climate Crisis: Adaptive Approaches and Sustainability* (pp. 19-33). Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-44397-8_2
- Kirby, C. K., & Zwickle, A. (2021). Sustainability behaviors, attitudes, and knowledge: Comparing university students and the general public. *Journal of Environmental Studies and Sciences*, 11(4), 639–647. <https://doi.org/10.1007/s13412-021-00717-x>
- Kyaw, W. T., & Sakakibara, M. (2022). Transdisciplinary communities of practice to resolve health problems in Southeast Asian artisanal and small-scale gold mining communities. *International Journal of Environmental Research and Public Health*, 19(9), Article 5422. <https://doi.org/10.3390/ijerph19095422>
- Lawson, H. A., & Albright, J. (2016). Categories, boundaries, and bridges: The social geography of schooling and the need for new institutional designs. *Education Sciences*, 6(3), Article 32. <https://doi.org/10.3390/educsci6030032>
- Liu, P., Teng, M., & Han, C. (2020). How does environmental knowledge translate into pro-environmental behaviors? The mediating role of environmental attitudes and behavioral intentions. *Science of the Total Environment*, 728, Article 138126. <https://doi.org/10.1016/j.scitotenv.2020.138126>
- Maryati, S., Lihawa, F., Yusuf, D., Pratama, M. I. L., Kasim, M., Akase, N., & Hubaib, N. M. (2022). Improving community environmental literacy regarding the impact of mercury use in the artisanal small-scale gold mining sector (A study in Sumalata Timur District, North Gorontalo Regency, Gorontalo Province). *Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan (Journal of Natural Resources and Environmental Management)*, 12(4), 633–643. <https://doi.org/10.29244/jpsl.12.4.633-643>
- Maurer, M., Koulouris, P., & Bogner, F. X. (2020). Green awareness in action—How energy conservation action forces on environmental knowledge, values and behaviour in adolescents' school life. *Sustainability*, 12(3), Article 955. <https://doi.org/10.3390/su12030955>

- Measham, T., Walker, J., Haslam McKenzie, F., Kirby, J., Williams, C., D'Urso, J., ... Boggs, G. (2024). Beyond closure: A literature review and research agenda for post-mining transitions. *Resources Policy*, 90, Article 104859. <https://doi.org/10.1016/j.resourpol.2024.104859>
- Meutia, A. A., Bachriadi, D., & Gafur, N. A. (2023). Environment degradation, health threats, and legality at the artisanal small-scale gold mining sites in Indonesia. *International Journal of Environmental Research and Public Health*, 20(18), Article 6774. <https://doi.org/10.3390/ijerph20186774>
- Morales, R. A. (2020). Educational digital media tools to reformulate activity and object in indigenous science and environmental education. *Journal for Educators, Teachers and Trainers*, 8(3), 127–134. <https://doi.org/10.37467/gka-revedu.v8.2666>
- Ningrum, E., Nandi, N., & Sungkawa, D. (2018). The impact of local wisdom-based learning model on students' understanding on the land ethic. *IOP Conference Series: Earth and Environmental Science*, 145, Article 012086. <https://doi.org/10.1088/1755-1315/145/1/012086>
- Oraon, P. R., Sagar, V., & Beauty, K. (2024). Ecological restoration of degraded land through afforestation activities. In *Land and environmental management through forestry* (pp. 201–216). Wiley. <https://doi.org/10.1002/9781119910527.ch8>
- Peiró-Signes, Á., Biondo, A., Sakka, G., Borsellino, V., & Galati, A. (2025). Exposure to social media pro-environmental campaigns and its impact on Generation Z's commitment to environmental sustainability actions. *Sustainable futures*, 10, 101320. <https://doi.org/10.1016/j.sfr.2025.101320>
- Pickard, S. (2022). Young environmental activists and Do-It-Ourselves (DIO) politics: Collective engagement, generational agency, efficacy, belonging and hope. *Journal of Youth Studies*, 25(6), 730–750. <https://doi.org/10.1080/13676261.2022.2046258>
- Pouresmaeli, M., Ataei, M., Nouri Qarahasanlou, A., & Barabadi, A. (2024). Building ecological literacy in mining communities: A sustainable development perspective. *Case Studies in Chemical and Environmental Engineering*, 9, Article 100554. <https://doi.org/10.1016/j.csee.2023.100554>
- Rai, S. C. (2007). Traditional ecological knowledge and community-based natural resource management in northeast India. *Journal of Mountain Science*, 4(3), 248–258. <https://doi.org/10.1007/s11629-007-0248-4>
- Rakuasa, H., Hidayatullah, M., & Suwandi, M. A. (2024). Community-based education in the digital age: Challenges and opportunities. *Journal of Asian Primary Education (JoAPE)*, 1(1), 16–23. <https://doi.org/10.59966/joape.v1i1.851>
- Ramli, R., Razali, R., Gadeng, A. N., Diana, N., & Hariadi, J. (2025). Integrating local knowledge into higher education: A qualitative study of curriculum innovation in Aceh, Indonesia. *Education Sciences*, 15(9), Article 1214. <https://doi.org/10.3390/educsci15091214>
- Reuter, T., Marien, M., & Chair, D. H. (2020). Civil society and youth leadership for transformation. *Cadmus*, 4(2), 88–104. <https://www.cadmusjournal.org/node/768>
- Rojas Casarrubias, C., Aparicio López, J. L., Rodríguez Alviso, C., Castro Bello, M., & Villerías Salinas, S. (2025). Community environmental leadership and sustainability: Building knowledge from the local level. *Sustainability*, 17(8), Article 3626. <https://doi.org/10.3390/su17083626>
- Salazar, C., Jaime, M., Leiva, M., & González, N. (2024). Environmental education and children's pro-environmental behavior on plastic waste: Evidence from the green school certification program in Chile. *International Journal of Educational Development*, 109, Article 103106. <https://doi.org/10.1016/j.ijedudev.2024.103106>
- Sangha, K. K., Leyton-Flor, S. A., Conner, N., Bhardwaj, A., & Bhardwaj, A. K. (2025). Transforming conservation by understanding the role of Indigenous peoples and local communities and their economies. *Global Ecology and Conservation*, Article e03949. <https://doi.org/10.1016/j.gecco.2025.e03949>
- Shutaleva, A., Martyushev, N., Nikonova, Z., Savchenko, I., Abramova, S., Lubimova, V., & Novgorodtseva, A. (2021). Environmental behavior of youth and sustainable development. *Sustainability*, 14(1), Article 250. <https://doi.org/10.3390/su14010250>

- Sihombing, R. A., Anwar, S., Liu, S.-Y., Muslim, M., Winarno, N., & Sihombing, P. J. (2025). Integrating local wisdom into environmental education: A systematic review of ethnoscience research in Indonesia. *Journal of Natural Science and Integration*, 8(1), 57. <https://doi.org/10.24014/jnsi.v8i1.35762>
- Sinapoy, M. S. (2018). Kearifan lokal masyarakat adat Suku Moronene dalam perlindungan dan pengelolaan lingkungan hidup. *Halu Oleo Law Review*, 2(2), 513-542. <https://doi.org/10.33561/holrev.v2i2.4513>
- Sithole, S. S., Walters, G. M., Mbatha, P., & Matose, F. (2024). Youth engagement in global conservation governance. *Conservation Biology*, 38(6), Article e14387. <https://doi.org/10.1111/cobi.14387>
- Sithole, S. S. (2024). *Youth engagement with conservation: From global platforms to local landscapes*. University of Lausanne Serval. <https://iris.unil.ch/handle/iris/141639>
- Sormin, A., & Sihombing, H. (2023). Empowering youth for sustainable cultural tourism: A case study Tipang Village, Baktiraja District, Humbang Hasundutan Regency, Indonesia. *Jurnal Ilmu Pendidikan dan Humaniora*, 12(1), 56-68. <https://journals.ristek.or.id/index.php/jiph/index>
- Suartama, I. K., Yasa, I. N., & Triwahyuni, E. (2024). Instructional design models for pervasive learning environment: Bridging formal and informal learning in collaborative social learning. *Education Sciences*, 14(12), Article 1405. <https://doi.org/10.3390/educsci14121405>
- Tsai, S. K., Chuang, T. Y., & Lin, Z. J. (2025). Enhancing environmental literacy through digital game-based learning: A technology-integrated attitude change approach. *Sustainability*, 17(16), Article 7416. <https://doi.org/10.3390/su17167416>
- Upreti, Y., Asselin, H., Bergeron, Y., Doyon, F., & Boucher, J. F. (2012). Contribution of traditional knowledge to ecological restoration: Practices and applications. *Écoscience*, 19(3), 225-237. <https://doi.org/10.2980/19-3-3530>
- Wendlandt Amézaga, T. R., Camarena, J. L., Celaya Figueroa, R., & Garduño Realivazquez, K. A. (2022). Measuring sustainable development knowledge, attitudes, and behaviors: Evidence from university students in Mexico. *Environment, Development and Sustainability*, 24(1), 765-788. <https://doi.org/10.1007/s10668-021-01467-0>
- Wexler, L. (2009). The importance of identity, history, and culture in the wellbeing of indigenous youth. *The Journal of the History of Childhood and Youth*, 2(2), 267-276. <https://doi.org/10.1353/hcy.0.0055>
- Wilson, K. (2014). *Communities of practice as a framework for understanding the professional impact of collaborative cultural work*. Institute of Cultural Capital. <http://iccliverpool.ac.uk/about/cultural-leadership/>
- Wingfield, J. C. (2013). Ecological processes and the ecology of stress: The impacts of abiotic environmental factors. *Functional Ecology*, 27(1), 37-44. <https://doi.org/10.1111/1365-2435.12039>
- Zeldin, S., Petrokubi, J., & MacNeil, C. (2008). Youth-adult partnerships in decision making: Disseminating and implementing an innovative idea into established organizations and communities. *American Journal of Community Psychology*, 41(3-4), 262-277. <https://doi.org/10.1007/s10464-008-9158-z>
- Zhao, Y., Liu, X., & Han, X. (2024). Enhancing pro-environmental behavior through nature-contact environmental education: An empirical analysis based on randomized controlled experiment design. *Frontiers in Environmental Science*, 12, Article 1491780. <https://doi.org/10.3389/fenvs.2024.1491780>

Biographies of Authors

Basri Basri, Department of Public Health, Sekolah Tinggi Ilmu Kesehatan Makassar, Makassar, South Sulawesi 90234, Indonesia.

- Email: basrikesmas@gmail.com
- ORCID: 0000-0002-2398-524X
- Web of Science ResearcherID: N/A
- Scopus Author ID: 57194828994
- Homepage: <https://scholar.google.com/citations?user=k8CtvS0AAAAJ&hl=en>

Masayuki Sakakibara, Research Institute for Humanity and Nature, 457-4 Motoyama, Kamigamo, Kita-ku, Kyoto, 603-8047, Japan.

- Email: sakaki@chikyu.ac.jp
- ORCID: 0000-0002-8188-6979
- Web of Science ResearcherID: N/A
- Scopus Author ID: 7102236258
- Homepage: https://www.chikyu.ac.jp/rihn_e/activities/project/staff/09/

Hendra Prasetya, Research Center for Mining Technology, Badan Riset dan Inovasi Nasional, Central Jakarta, Special Capital Region of Jakarta 10340, Indonesia.

- Email: hend051@brin.go.id
- ORCID: 0000-0002-3230-7918
- Web of Science ResearcherID: N/A
- Scopus Author ID: 57194829399
- Homepage: <https://brin.go.id/ornm/pusat-riiset-teknologi-mineral/page/dr-hendra-prasetya-msc>

La Sahara, Department of Physics Education, Universitas Halu Oleo, Kendari, South East Sulawesi 93561, Indonesia.

- Email: lasahara1977@gmail.com
- ORCID: 0009-0004-5514-8245
- Web of Science ResearcherID: N/A
- Scopus Author ID: 57211436424
- Homepage: <https://scholar.google.com/citations?user=qX9TZ6sAAAAJ&hl=en>

Chitra Dewi, Department of Public Health, Sekolah Tinggi Ilmu Kesehatan Makassar, Makassar, South Sulawesi 90234, Indonesia.

- Email: epidemiologi165@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: 58773574100
- Homepage: https://scholar.google.com/citations?user=gr1Ml_wAAAAJ&hl=en

Nanang Rahmadani, Department of Dental Health, Sekolah Tinggi Ilmu Kesehatan Amanah Makassar, Makassar, South Sulawesi 90231, Indonesia.

- Email: nanank.adam@gmail.com
- ORCID: 0000-0002-8089-6091
- Web of Science ResearcherID: N/A
- Scopus Author ID: 57740658100
- Homepage: <https://scholar.google.com/citations?user=6mo-qKMAAAAJ&hl=id>