Indonesian Journal of Applied Community Research
Vol. 1, No. 2, June 2026, pp. 52~65
ISSN: 3163-3285, DOI:

From beneficiaries to knowledge producers: citizen science and community-led climate adaptation in coastal Indonesia

Farhan
Universitas Nurul Jadid, Indonesia

Article Info

Article history:

Received Apr 22, 2026
Revised May 24, 2026
Accepted Jun 30, 2026

Keywords:

adaptive governance;
citizen science;
coastal adaptation;
community empowerment;
local knowledge.

ABSTRACT

Background: Coastal communities in Indonesia increasingly face tidal flooding, shoreline change, mangrove pressure, drainage disruption, and livelihood insecurity, yet residents' everyday knowledge of these risks often remains outside formal adaptation planning. **Objective:** This community engagement program aimed to transform coastal residents in Pesisir and Klaseman, Probolinggo, from passive beneficiaries of climate assistance into citizen knowledge producers capable of observing, documenting, validating, and communicating local climate evidence. **Method:** This program applied a participatory citizen science model through partner coordination, needs assessment, climate literacy orientation, observation training, participatory mapping, field monitoring, community validation, micro-adaptation action, and sustainability planning. **Results:** This program prepared a community-based monitoring architecture involving village actors, fishers, aquaculture workers, women's groups, youth, environmental cadres, and university facilitators. This program produced observation instruments, participatory risk maps, photo logs, livelihood narratives, validated risk themes, adaptation priorities, and a local monitoring schedule for continued community use. **Implication:** This program also strengthened residents' practical capacity to convert lived experience of coastal risk into locally discussable evidence for village-level adaptation. **Novelty:** The novelty of this program lies in integrating citizen science, local ecological knowledge, and community-led adaptation into an empirically grounded empowerment model that treats coastal residents as producers, validators, and users of climate knowledge.

Corresponding Author:

Farhan
Department of Islamic Communication and Broadcasting, Universitas Nurul Jadid
Jl. KH. Zaini Mun'im, Karanganyar, Paiton, Probolinggo, Jawa Timur, 67291, Indonesia
Email: farhan@unuja.ac.id

1. INTRODUCTION

Coastal Indonesia is increasingly governed through climate risk, yet many coastal residents remain positioned as beneficiaries of aid rather than producers of usable knowledge. This community engagement program is urgent because exposure is not abstract. Indonesia ranks among the countries with the largest populations in low-elevation coastal zones; about 60% of its people live along roughly 100,000 km of coastline, and more than 4.2 million people could face permanent flooding by 2070–2100 without adaptation (World Bank and ADB, 2021). Communities dependent on mangroves also experience a 1.27% higher poverty rate than non-coastal villages (World Bank, 2022). In coastal Gending, Probolinggo, vulnerability is already locally measurable. Pesisir and Klaseman are part of a coastal cluster where sea-level rise reached 5.59 mm per year, shoreline change was dominated by abrasion, and tidal flooding remains recurrent

(Fallahiyah, Sawiji, & Noverma, 2023). This makes community-based climate data a methodological necessity for local adaptation.

Existing community engagement and applied research have shown that participatory approaches can improve environmental literacy, disaster preparedness, and local institutional capacity. Coastal waste education has demonstrated the value of visual campaigns and local engagement [1], disaster preparedness work around Semeru has shown the importance of community-based evaluation [2], and participatory action research has been used to strengthen rural women's economic agency [3]. Internationally, citizen science has been recognised as a method for environmental monitoring, data quality improvement, and impact assessment [4], [5]. Studies also argue that citizen science can support a "right to research" and create synergies between scientific and local knowledge systems [6], [7]. Yet many initiatives still treat communities as testimony providers or field volunteers, not as co-designers of indicators, interpreters of coastal change, and users of data in village planning and adaptive governance outcomes.

This community engagement program aims to transform coastal residents in Pesisir and Klaseman from passive recipients of climate information into organised knowledge producers. It asks a practical question: how can residents document tidal flooding, shoreline change, mangrove conditions, drainage problems, and livelihood disruptions in ways that are simple enough for daily use but credible enough for local decision-making? To answer this question, this program trains 30–40 residents—fishers, aquaculture workers, women's groups, youth, and village actors—to collect, verify, map, and discuss climate-related observations. Its outputs include a citizen observation protocol, a participatory risk map, a community climate dataset, and a village-level adaptation brief. The emphasis is not on replacing expert science, but on creating an accountable interface between expert knowledge and lived coastal experience, where local observations become evidence for adaptation priorities. Through this design, this program treats method as empowerment and community participation as a source of valid evidence.

The expected contribution of this community engagement program is both practical and epistemic. Practically, residents gain skills in observation, documentation, mapping, and collective interpretation; village actors receive locally grounded evidence for adaptation planning; and community groups develop a repeatable monitoring routine after facilitation ends. Epistemically, this program challenges a common hierarchy in climate adaptation, where official expertise travels downward and local experience remains anecdotal. By making community observations visible, comparable, and discussable, this program creates conditions for more inclusive adaptive governance. Its success should therefore be assessed not only by attendance or training completion, but by whether residents continue producing data, whether this data enters village deliberation, and whether adaptation actions respond to the risks residents themselves identify. In this sense, citizen science becomes a democratic method for turning vulnerability into collective capacity, while community-led adaptation becomes an evidence practice rooted in local authority and shaped by everyday coastal experience.

2. METHOD

This community engagement program was designed as a participatory citizen science intervention in Desa Pesisir and Desa Klaseman, Kecamatan Gending, Kabupaten Probolinggo. Planning was grounded in partner relevance: village governments, coastal residents, fishers, aquaculture workers, women's groups, youth organisations, and environmental cadres were positioned not as beneficiaries but as knowledge actors. This design followed citizen science principles that stress co-creation, data usability, and community ownership of environmental knowledge [4], [5]. The planning stage translated coastal vulnerability into a structured intervention, as summarised below.

The planning design combined needs mapping, co-design, and strategic sequencing. First, this community engagement program identified community-defined problems: tidal flooding, drainage disruption, mangrove degradation, shoreline change, and livelihood vulnerability. Second, it mapped partner capacity, including available local organisations, communication channels, and prior environmental initiatives. Third, it formulated implementation strategies through small-group consultation, participatory mapping, and training needs assessment. This approach was informed by participatory action research in community-based adaptation, where locally situated knowledge must shape both problem definition and intervention design [8] (Neset et al., 2021). Therefore, planning did not merely prepare activities; it converted coastal experience into an operational framework for citizen-generated evidence.

Table 1. Overview of program design stages, activities, actors, and outputs

Stage	Activity	Main Actors	Output	Methodological Function
1	Initial partner consultation	University team, village government	Partner agreement	Establishing institutional entry
2	Community profiling	Facilitators, village officers	Social-ecological profile	Identifying risk context
3	Stakeholder mapping	Fishers, women, youth, cadres	Actor map	Ensuring inclusive participation
4	Risk problem inventory	Residents, facilitators	List of coastal problems	Defining locally perceived risks
5	Needs assessment	Participants, partners	Training needs matrix	Aligning program with capacity gaps
6	Instrument design	University team, community representatives	Observation sheets	Standardising citizen data
7	Participatory mapping design	Youth, fishers, women's groups	Base map format	Preparing spatial data collection
8	Training module preparation	Facilitators	Module and field guide	Structuring learning materials
9	Participant recruitment	Village government, local groups	30–40 participants	Building representative participation
10	Monitoring schedule design	Forum members	Fieldwork calendar	Ensuring continuity
11	Ethical briefing	Facilitators, participants	Consent and data protocol	Protecting community data
12	Reflection plan	Partners, facilitators	Evaluation framework	Linking action with learning

Information sources in this community engagement program consisted of four categories. Partner sources included village officials, community leaders, environmental cadres, and local group representatives who provided institutional context and access to participants. Participant sources included fishers, aquaculture workers, women's groups, youth, and households exposed to coastal hazards. Facilitator sources included university lecturers and field assistants responsible for training, mentoring, and data verification. Documentary sources included village profiles, local disaster records, coastal vulnerability references, training attendance sheets, observation forms, photographs, maps, and reflection notes. This triangulated information structure followed impact-assessment principles in citizen science, which require attention to participant diversity, data reliability, and learning outcomes [9], [10].

Implementation was conducted through sequential and iterative activities. This community engagement program began with climate literacy orientation, followed by technical training on observation forms, photo documentation, risk mapping, and simple digital reporting. Participants then conducted guided field observations of tidal flooding, drainage points, mangrove conditions, waste accumulation, shoreline change, and livelihood disruption. Mentoring was provided through field visits, group discussions, and mobile communication groups. Facilitators checked completeness, location consistency, and narrative clarity before community reflection meetings were held. This process drew on citizen science models that connect observation, collective interpretation, and stewardship action planning [11], [7]. Thus, implementation linked learning with practical adaptation.

Evaluation in this community engagement program used formative, process, and outcome-oriented assessment. Formative evaluation assessed participant baseline knowledge, training needs, and readiness to use observation tools. Process evaluation reviewed attendance, participation balance, mentoring intensity, data submission frequency, and quality of citizen observations. Outcome evaluation examined whether participants could produce usable data, interpret risk patterns, develop a participatory map, and formulate adaptation priorities. Reflection forums were used to validate findings and identify follow-up actions with village partners. This evaluation logic followed recent citizen science assessment frameworks that measure not only knowledge gain but also behavioural, institutional, and governance relevance [5], [6]. Evaluation therefore served as both accountability and collective learning.

3. RESULTS

3.1. Co-designed planning architecture for community-based coastal citizen science

Planning began by translating coastal vulnerability into a collaborative architecture for citizen-generated evidence. Rather than treating residents of Pesisir and Klaseman as passive recipients of climate education, this community engagement program planned a sequence through which residents could help define risk, prepare observation tools, map coastal problems, and establish rules for using community data. The planning logic followed citizen science scholarship that stresses co-design, participant diversity, data usability, and local ownership as conditions for meaningful environmental knowledge production [4], [5], [6]. Each activity was therefore designed to connect actors, instruments, and adaptation goals. Partner entry, needs assessment, stakeholder mapping, protocol design, monitoring preparation, and reflection planning formed a coherent pathway toward community-led adaptation.

Table 2 contains 15 planning components covering institutional, social, technical, ethical, communicative, and governance dimensions. This community engagement program targeted 2 coastal villages, identified 7 actor groups, prepared 5 coastal risk domains, and planned participation from 30–40 residents. Inclusion was designed through minimum participation targets of 40% women and 30% youth. Planning also prepared 4 observation themes, 1 citizen science protocol package, 1 data governance protocol, 3 core training sessions, 1 shared reporting channel, 3 reflection meetings, and an 8–12 week monitoring calendar. Participatory mapping was designed to identify at least 10 preliminary coastal risk points. Planned evidence included village profiles, stakeholder maps, needs matrices, observation sheets, photo-log guides, consent forms, base maps, monitoring schedules, validation checklists, and an adaptation brief template. These outputs show that planning produced both procedural infrastructure and knowledge infrastructure.

The planning architecture indicates that this community engagement program treated adaptation capacity as something built before field observation begins. A citizen science initiative can fail when communities are invited to collect data without prior agreement on participation, ethics, verification, and use. For that reason, this program prepared not only instruments but also social arrangements for inclusive knowledge production. This emphasis is consistent with Tengö et al. (2021) [7], who argue that local knowledge and citizen science require careful bridging, and with Vincent (2023) [12], who frames locally led adaptation as a question of authority, not merely participation. In practical terms, the planning stage created a route from lived coastal experience to village-level evidence. Rob, drainage disturbance, mangrove condition, shoreline change, and livelihood disruption were planned as observable, discussable, and actionable issues rather than informal complaints.

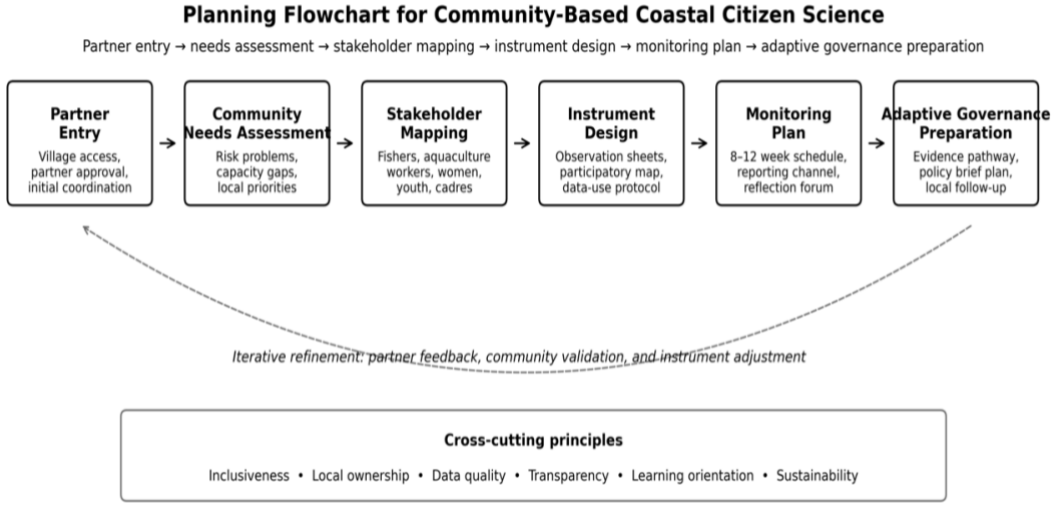

Figure 1. Flowchart of the planning logic for community-based coastal citizen science

Table 2. Planning matrix for preparing citizen-generated coastal climate evidence and community-led adaptation

Dimension / Component	Activity or Evaluation Focus	Actors Involved	Community Segment	Method / Facilitation Approach	Data or Output Produced	Quantitative Indicator	Quality or Verification Indicator	Use of Findings / Link to Adaptation	Evidence for Reporting
Institutional entry	Formal coordination with village authorities and local gatekeepers	Village heads, village officers, university team	Local government and village administration	Introductory meeting, partner consultation, administrative clearance	Partner approval, activity schedule, coordination notes	2 villages targeted	Approval confirmed by village representatives	Establishes legitimate access for community-based work	Meeting minutes, attendance list, partner letter
Social-ecological profiling	Identification of coastal vulnerability context and community exposure	Facilitators, village officers, local leaders	Coastal households and livelihood groups	Desk review and community dialogue	Initial village profile and coastal risk note	1 profile per village	Profile checked with village actors	Frames adaptation priorities around local exposure	Village profile, field notes, documentation
Stakeholder mapping	Mapping relevant actors and participation channels	Village government, fishers, aquaculture workers, women's groups, youth, cadres	Multi-actor community groups	Actor mapping matrix and group consultation	Stakeholder map	7 actor groups identified	Actor list validated by village partners	Prevents narrow participation and elite capture	Stakeholder matrix, validation notes
Community needs assessment	Identification of capacity gaps and practical learning needs	Candidate participants, facilitators, local partners	Adult residents and youth observers	Short survey, informal interview, focus discussion	Needs assessment matrix	4 skill domains targeted	Responses reviewed by facilitation team	Aligns training with community capacity	Needs forms, discussion notes
Risk problem inventory	Listing local problems linked to rob, drainage, mangroves, shoreline, and livelihoods	Residents, fishers, women, youth, environmental cadres	Households exposed to coastal hazards	Participatory problem listing and ranking	Priority risk list	5 risk domains prepared	Problems cross-checked across groups	Guides observation themes and mapping focus	Problem inventory sheet, photos
Participant recruitment	Selection of citizen observers and local representatives	Village partners, community leaders, facilitators	Fishers, aquaculture workers, women, youth, cadres	Purposive recruitment with inclusion criteria	Participant list	30–40 participants targeted	Minimum 40% women and 30% youth planned	Builds a socially distributed observation network	Registration form, demographic record

Citizen science protocol design	Preparation of observation procedure and reporting rules	University team, selected community representatives	Citizen observers	Co-design workshop and instrument simplification	Observation protocol	1 protocol package prepared	Readability checked with community representatives	Standardises citizen-generated climate data	Protocol draft, revision log
Observation instrument preparation	Designing tools for rob, drainage, mangrove, waste, and livelihood disruption	Facilitators, environmental cadres, youth	Local observers and household representatives	Template design, field simulation, tool review	Observation sheets, photo-log guide, impact note template	4 observation themes prepared	Trial use planned before full monitoring	Converts local experience into recordable evidence	Instrument package, simulation notes
Participatory mapping preparation	Designing spatial mapping of risk points and local place-based knowledge	Fishers, aquaculture workers, women, youth	Spatial knowledge holders	Printed base map, local naming, mapping symbols	Base map and mapping guide	≥10 preliminary risk points targeted	Points to be checked by more than one group	Prepares spatial evidence for adaptation discussion	Annotated base map, mapping guide
Data governance and ethics	Agreement on data ownership, consent, privacy, and data use	Participants, village government, facilitators	Community data contributors	Ethical briefing and collective agreement	Consent form and data-use protocol	1 data governance protocol prepared	Collective approval documented	Protects community control over sensitive information	Consent forms, approval notes
Training design	Structuring learning materials and facilitation sequence	Facilitators, village partners	All participants	Module preparation and participatory learning design	Training module and field guide	3 core sessions planned	Module reviewed by facilitation team	Prepares participants for observation and reporting	Training module, session plan
Monitoring calendar	Scheduling repeated observation and mentoring cycles	Citizen observers, facilitators, village partners	Hamlet-level observers	Calendar co-design and role distribution	Monitoring schedule	8–12 weeks planned	Schedule confirmed by participant availability	Ensures continuity of citizen observations	Monitoring calendar, role list
Communication system	Designing reporting channel and feedback mechanism	Youth, facilitators, village officers	Digital and assisted non-digital participants	WhatsApp group or simple digital form preparation	Shared reporting channel	1 reporting channel prepared	Admin role and reporting format agreed	Enables traceable data submission and feedback	Digital group record, reporting template
Reflection and validation planning	Preparing collective review of emerging evidence	Participants, village officers, facilitators	Cross-group community representatives	Deliberative forum design and validation checklist	Reflection forum plan	3 reflection meetings planned	Agenda reviewed with village partners	Links community data with adaptation priorities	Forum agenda, validation checklist
Adaptive governance preparation	Translating planned evidence into village-level recommendations	Village government, citizen observers, university team	Local decision actors and community representatives	Policy brief outline and follow-up planning	Adaptation brief template and action pathway	1 policy brief outline prepared	Content aligned with risk domains and data plan	Connects citizen science with village planning	Brief template, planning notes

3.2. Implementation of citizen-led coastal monitoring and adaptation practices

Implementation translated planning into a staged practice of learning, observation, validation, reflection, and action. This community engagement program conducted climate literacy orientation, citizen science briefing, tool practice, digital reporting, participatory mapping, repeated field observation, mentoring, validation, and micro-adaptation. The sequence was designed to prevent training from becoming a one-off educational event. Residents were supported to produce evidence about rob, drainage disruption, mangrove condition, waste accumulation, shoreline change, and livelihood disturbance. This approach is consistent with citizen science literature that places participants across several points of knowledge production rather than limiting them to data collection alone [4], [5]. It also reflects community-led adaptation thinking, where local observation, interpretation, and action are treated as connected practices.

The implementation matrix contains 15 components involving facilitators, village officers, fishers, aquaculture workers, women's groups, youth, environmental cadres, elders, and citizen observers. This community engagement program conducted 1 climate literacy session, 1 citizen science briefing, 3 observation practice exercises, 1 digital reporting clinic, and 1 shared reporting channel. Fieldwork was organised for 8–12 weeks with a target of at least 100 observation entries and ≥80% data completeness. Participatory mapping targeted at least 10 coastal risk points, while ecological documentation covered 2–3 observation points per village. Social evidence was prepared through 20–30 livelihood narratives, 4–6 mentoring meetings, 2 community reflection forums, 1 seasonal risk calendar, at least 2 micro-adaptation actions, 1 public communication product, and 1 implementation portfolio. These outputs show that this community engagement program produced technical, spatial, narrative, and action-oriented records.

The implementation pattern shows how citizen science can become a practical mechanism for redistributing authority over climate knowledge. Residents were not only asked to describe coastal problems; they were facilitated to observe, record, verify, interpret, and communicate them in forms that could enter local deliberation. This orientation resonates with Albagli and Iwama's argument that citizen science can support a right to research, and with Tengö et al.'s emphasis on productive links between scientific practice and local knowledge systems. In applied terms, this community engagement program created a pathway from lived vulnerability to discussable evidence. Rob, drainage problems, mangrove disturbance, and livelihood disruption became documented and collectively interpretable issues. Such an approach strengthens adaptive capacity because it links participation with data quality, local ownership, and the practical possibility of village-level response.

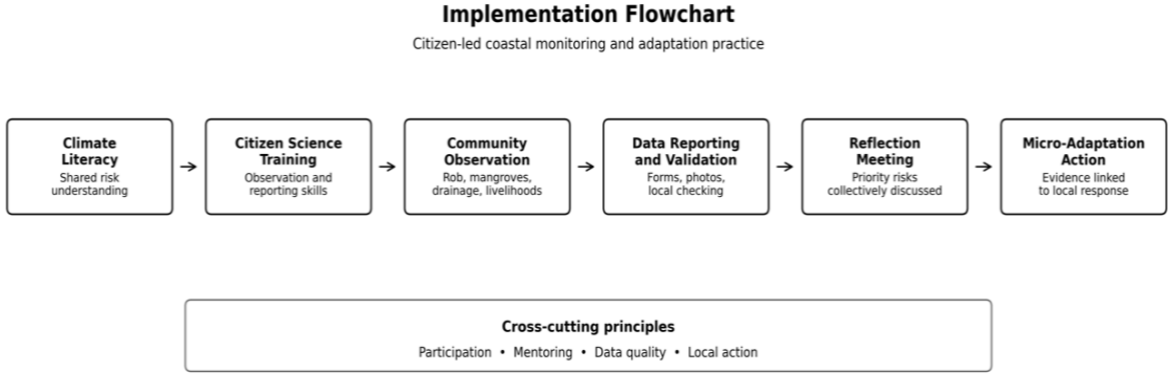

Figure 2. Flowchart of the implementation pathway for citizen-led coastal monitoring and adaptation practices

Table 3. Implementation matrix for citizen-led coastal monitoring, mentoring, data validation, and micro-adaptation practice

Dimension / Component	Activity or Evaluation Focus	Actors Involved	Community Segment	Method / Facilitation Approach	Data or Output Produced	Quantitative Indicator	Quality or Verification Indicator	Use of Findings / Link to Adaptation	Evidence for Reporting
Climate literacy orientation	Introduction to coastal climate risks, rob, drainage disruption, shoreline change, and mangrove functions	Facilitators, village officers, fishers, women's groups, youth	Coastal residents and local decision actors	Interactive briefing, local problem discussion, visual explanation	Attendance list, local risk notes, discussion record	1 orientation session; 30–40 participants	Participants identify at least 3 locally recognised coastal risks	Builds shared understanding before citizen observation begins	Attendance sheet, photos, discussion notes
Citizen science briefing	Reframing residents as community knowledge producers	Facilitators, citizen observers, village partners	Fishers, aquaculture workers, women, youth, cadres	Mini lecture, guided discussion, role clarification	Citizen observer role sheet	1 briefing module delivered	Participants understand reporting, observation, and validation roles	Shifts participation from training attendance to knowledge production	Briefing module, reflection notes
Observation tool practice	Practice using field forms, photo logs, and location notes	Citizen observers, youth, environmental cadres	Local observers and household representatives	Demonstration, simulation, peer practice	Completed trial forms and photo samples	3 practice exercises	≥70% of trial forms completed correctly	Improves reliability of citizen-generated evidence	Trial forms, facilitator checklist
Digital reporting clinic	Training in WhatsApp, Google Form, or KoboToolbox-based reporting	Youth, assisted adult participants, facilitators	Digital and low-digital-literacy participants	Hands-on clinic and peer assistance	Shared reporting channel and report template	1 active reporting channel	Reports include time, location, photo, and short narrative	Enables traceable and timely data submission	Digital log, screenshot archive, reporting template
Participatory risk mapping	Identification of priority points for rob, drainage, shoreline change, mangroves, and waste	Fishers, aquaculture workers, women, youth, village officers	Spatial knowledge holders	Printed map discussion, field marking, group verification	Draft participatory risk map	≥10 mapped risk points	Risk points confirmed by more than one participant group	Produces spatial evidence for village adaptation dialogue	Annotated map, field photos, map notes
Field observation cycle	Repeated monitoring of coastal hazards and everyday disruption	Citizen observers, environmental cadres, facilitators	Hamlet-level observers and exposed households	Guided and semi-independent field observation	Observation dataset, photo logs, field notes	8–12 weeks; ≥100 observation entries targeted	Data completeness expected to reach ≥80%	Creates repeated local evidence rather than isolated complaints	Observation forms, photo archive, data log
Mangrove and coastal condition documentation	Visual recording of mangrove condition, waste, damage, access barriers, and coastal	Environmental cadres, youth, fishers	Ecological observers and coastal users	Transect walk, visual checklist, photo documentation	Mangrove checklist and coastal condition notes	2–3 observation points per village	Photos and notes correspond to verified locations	Supports ecosystem-based adaptation awareness	Checklist, geotagged photos, field diary

	change								
Livelihood impact documentation	Recording disruption to fishing, aquaculture, mobility, household routines, and local work	Fishers, aquaculture workers, women's groups	Livelihood-dependent households	Short interview, story-based documentation, impact note	Livelihood narratives and impact records	20–30 narrative entries targeted	Clear link between hazard event and livelihood consequence	Connects climate risk with social vulnerability	Interview notes, narrative forms, field notes
Group mentoring	Review of submitted data and participant difficulties	Facilitators, participants, youth assistants	Citizen observers	Weekly or biweekly mentoring, troubleshooting, peer review	Corrected forms, mentoring log, feedback notes	4–6 mentoring meetings	Error reduction across submission cycles	Strengthens data literacy and participant confidence	Mentoring notes, corrected forms
Data validation	Checking completeness, location consistency, photo relevance, and narrative clarity	Facilitators, citizen observers, village representatives	Data contributors and validators	Validation checklist and group confirmation	Validated observation entries	≥80% data completeness targeted	Entries checked against required fields and local confirmation	Improves credibility of community-generated evidence	Validation checklist, data audit notes
Community reflection forum	Collective interpretation of emerging risk patterns	Participants, village officers, facilitators	Cross-group community representatives	Deliberative forum, visual discussion, group prioritisation	Validated risk themes and priority list	2 reflection meetings	Agreement on priority risks across participant groups	Converts raw observations into shared adaptation diagnosis	Meeting minutes, priority list
Seasonal risk calendar	Comparison between recent observations and local seasonal memory	Elders, fishers, women, youth	Residents with long-term local knowledge	Oral timeline discussion and calendar mapping	Seasonal risk calendar	1 community calendar	Consistency checked across participant accounts	Adds temporal depth to monitoring evidence	Calendar sheet, oral history notes
Micro-adaptation action	Small-scale response based on mapped and validated risks	Village actors, citizen observers, community groups	Residents affected by priority risk points	Collective action, local coordination, action documentation	Action record and before-after documentation	≥2 micro-adaptation actions	Each action linked to mapped risk evidence	Converts citizen evidence into practical adaptation	Action report, photos, local notes
Public communication	Sharing findings with wider residents and local stakeholders	Forum members, village partners, youth	Wider village community	Village forum, poster, brief, or information board	Public communication product	1 public brief or poster	Accessible language and visual clarity	Expands awareness beyond core participants	Poster, brief, meeting documentation
Implementation consolidation	Compilation of observation data, maps, narratives, validation notes, and action records	Facilitators, forum members, village government	Community forum and village decision actors	Data review workshop and documentation synthesis	Implementation portfolio	1 complete portfolio	Portfolio includes traceable data, maps, narratives, and action evidence	Prepares evaluation, policy brief, and follow-up planning	Portfolio, validation sheet, documentation archive

3.3. Monitoring, evaluation, and sustainability of community-generated climate evidence

Monitoring and evaluation focused on whether this community engagement program produced credible community evidence and a realistic pathway for continued local use. Evaluation did not stop at measuring attendance or satisfaction. It assessed participation, capacity development, data quality, community validation, use of findings, institutional follow-up, and sustainability planning. These elements are central to citizen science evaluation because community-generated data must be both socially legitimate and methodologically usable [5], [10]. The evaluation design therefore connected learning outcomes with adaptive governance. Residents' observations were reviewed not only as technical records but also as locally situated evidence that could support deliberation on rob, drainage disruption, mangrove condition, coastal waste, shoreline change, and livelihood disturbance.

Table 4 presents 7 evaluation components involving citizen observers, village officers, facilitators, youth assistants, women's groups, fishers, environmental cadres, and local partners. Participation review assessed the planned involvement of 30–40 participants across key community segments. Capacity assessment measured knowledge and reporting skills through baseline and endline indicators, while data quality audit reviewed observation forms, photos, location notes, and narrative entries using completeness, consistency, clarity, and relevance criteria. Community validation was targeted through at least 2 reflection forums. Use of findings was documented through a minimum of 1 adaptation brief or recommendation document. Institutional follow-up was reviewed through at least 1 role-sharing mechanism, while sustainability monitoring targeted a 3–6 month continuation plan. The evidence base included attendance records, checklists, audited datasets, annotated maps, meeting minutes, priority lists, role matrices, and monitoring calendars.

The evaluation pattern shows that this community engagement program treated citizen science as a cycle of accountability rather than a one-time data-gathering exercise. Data quality, community validation, and local follow-up were assessed together because climate adaptation requires evidence that is technically organised, socially recognised, and institutionally usable. This aligns with Wehn et al. (2021) [5], who argue that citizen science impact assessment must consider knowledge, behaviour, institutional relevance, and governance pathways. It also resonates with Albagli and Iwama's view of citizen science as a democratic claim to research capacity. In practical terms, monitoring and evaluation helped determine whether community observations could move beyond field documentation into village discussion, priority setting, and continued monitoring. The value of this stage lies in confirming whether residents' knowledge remained visible after facilitation and whether local actors accepted responsibility for sustaining the evidence cycle.

Figure 3. Flowchart of the monitoring and evaluation pathway for community-generated coastal climate evidence

Table 4. Monitoring and evaluation matrix for assessing participation, data quality, community validation, and adaptive follow-up

Activity Component	Participants / Actors	Method	Empirical Output	Indicator	Evidence
Participation review	Citizen observers, village officers, facilitators	Attendance review and participation recap	Participation record by actor group	30–40 participants reviewed; representation of fishers, aquaculture workers, women, youth, and cadres assessed	Attendance list, participant profile, meeting notes
Capacity assessment	Participants and facilitators	Pre-post checklist and practical demonstration review	Capacity score sheet and skill observation notes	Knowledge and reporting skills measured using baseline and endline indicators	Checklist, completed forms, facilitator notes
Data quality audit	Facilitators, youth assistants, citizen observers	Review of submitted forms, photos, location notes, and narratives	Audited observation dataset	Completeness, consistency, location clarity, and photo relevance reviewed; ≥80% completeness used as evaluation indicator	Observation forms, photo logs, validation sheet
Community validation	Citizen observers, women's groups, fishers, village representatives	Reflection forum and collective confirmation	Validated risk themes and corrected community map	At least 2 validation forums targeted to confirm priority risks	Meeting minutes, annotated map, validation notes
Use of findings	Village officers, community forum, facilitators	Review of risk themes against local adaptation needs	Draft adaptation brief and priority action list	Minimum 1 village-level brief or recommendation document prepared	Adaptation brief, priority list, documentation
Institutional follow-up	Village government, local groups, environmental cadres	Follow-up meeting and responsibility mapping	Local role-sharing agreement	At least 1 follow-up mechanism confirmed by local actors	Follow-up notes, role matrix, partner statement
Sustainability monitoring	Community forum, youth, cadres, village partners	Monthly monitoring plan and communication-channel review	Sustainability schedule and reporting routine	Monitoring continuation for 3–6 months targeted	Monitoring calendar, WhatsApp log, forum agreement

4. DISCUSSION

The planning achievements of this community engagement program carry practical and social implications beyond administrative preparation. By organising partner coordination, needs assessment, stakeholder mapping, instrument preparation, monitoring scheduling, and reflection forum design, this program repositioned coastal residents as legitimate contributors to climate knowledge. In a community where rob, drainage disruption, shoreline change, mangrove pressure, and livelihood disturbance are often experienced as everyday problems rather than formal evidence, planning created a structure through which local experience could become observable and discussable. Its practical function was to prepare a shared framework before field activities began, reducing the risk that citizen science would become merely symbolic participation. Socially, this planning process also opened space for fishers, aquaculture workers, women, youth, environmental cadres, and village actors to enter the same adaptation conversation. This matters because citizen science depends not only on tools but also on social legitimacy, trust, and shared ownership of evidence.

Several mechanisms explain why this planning stage became central to this program's logic. First, partner coordination secured institutional access, while needs assessment prevented training materials from being detached from residents' actual capacities and concerns. Second, stakeholder mapping made participation more deliberate by identifying groups whose coastal knowledge differs by livelihood, gender, age, and spatial exposure. Third, instrument preparation translated climate risk into practical categories that residents could observe: tidal flooding, drainage, mangrove condition, waste, shoreline change, and

livelihood disruption. This reflects Fraisl et al.'s (2022) emphasis on citizen science as a structured process of environmental data production, and Wehn et al.'s (2021) argument that impact depends on design quality, not participation alone. The planning mechanism therefore lay in connecting community inclusion with methodological order. Without this connection, local knowledge may remain anecdotal; with it, local knowledge becomes a basis for adaptation planning.

The implementation achievements of this community engagement program show the practical value of moving from awareness to evidence production. Climate literacy orientation and citizen science training introduced common concepts, but the more significant contribution emerged when residents conducted observations, submitted reports, joined validation activities, discussed findings, and linked evidence to micro-adaptation actions [13]. This sequence reduced the distance between climate education and everyday decision-making. In social terms, implementation made coastal risk more visible within the community. Problems such as rob, clogged drainage, mangrove disturbance, and livelihood disruption were no longer expressed only as complaints; they were documented through forms, photographs, narratives, maps, and reflection meetings. This practical shift is important because communities facing environmental risk often possess rich experiential knowledge but lack recognised formats for presenting it. This program therefore functioned as a bridge between lived vulnerability and locally usable evidence.

The pattern underlying implementation was iterative rather than linear in a narrow technical sense. Training, observation, reporting, validation, reflection, and action formed a cycle in which participants learned by producing and reviewing data. Youth supported digital reporting, adults contributed place-based and livelihood knowledge, women's groups documented household-level disruption, and village actors helped connect evidence to local decision spaces. This division of roles strengthened the implementation mechanism because each group supplied a different form of knowledge. Tengö et al. (2021) [7] argue that citizen science and local knowledge become productive when they are brought into dialogue rather than forced into a single hierarchy. Similarly, Spellman et al. (2021) [11] show that community science can support stewardship action when observation is connected to collective interpretation. This program followed that logic: observation generated records, validation strengthened credibility, reflection produced shared meaning, and micro-adaptation linked knowledge with practical response.

The monitoring and evaluation achievements of this community engagement program are socially important because they assessed whether community-generated data could remain credible, usable, and locally owned after training and field observation. Evaluation did not focus only on attendance or participant satisfaction; it reviewed participation, capacity development, data quality, community validation, use of findings, institutional follow-up, and sustainability planning [14]. This broader evaluation frame helped prevent a common weakness in community engagement: the production of temporary enthusiasm without a durable evidence cycle. By assessing observation forms, photo logs, location notes, narratives, reflection records, and follow-up mechanisms, this program treated residents' data as something requiring accountability and care. Socially, this also recognised community members as knowledge bearers whose observations deserve review, correction, and use. The practical implication is that adaptation becomes more defensible when it is supported by validated community evidence rather than isolated impressions or external prescriptions.

The mechanism behind this evaluation stage was the connection between measurement, validation, and institutionalisation. Baseline and endline review assessed changes in knowledge and reporting skills, while data quality audit examined completeness, consistency, location clarity, and photo relevance. Community validation then allowed residents to confirm whether mapped risks and interpreted patterns corresponded with local experience [15]. This sequence is aligned with Somerwill and Wehn's (2022) argument that citizen science evaluation should examine knowledge, attitudes, behaviour, and the usability of outcomes, and with Pateman et al.'s (2021) concern that participant diversity shapes the quality and legitimacy of environmental citizen science. The final mechanism was sustainability planning: role-sharing, communication channels, and monitoring schedules were used to keep the evidence process alive beyond facilitation. In this sense, this program's evaluation did not merely judge activities; it helped convert citizen science into a continuing practice of adaptive governance.

5. CONCLUSION

This community engagement program shows that coastal climate adaptation becomes more meaningful when residents are positioned as knowledge producers rather than passive beneficiaries. Its most important lesson is that local experience of tidal flooding, drainage disruption, mangrove change, and livelihood disturbance can be transformed into usable community evidence when supported by simple instruments, mentoring, validation, and reflection. The strength of this program lies in its integration of citizen science with community-led adaptation: residents were not only trained, but also guided to observe, document, discuss, and translate environmental information into local priorities. This contributes a practical empowerment model grounded in participation, evidence, and adaptive learning.

However, this community engagement program also faced limitations. Its monitoring period was relatively short, the number of citizen observers remained limited, and data quality depended on participants' digital confidence, available time, and consistency in field reporting. These limitations indicate the need for follow-up activities that extend monitoring across seasons, strengthen digital and spatial data skills, and involve more households, schools, and village institutions. Future programs should develop a community-managed coastal data forum, integrate findings into village planning mechanisms, and establish periodic mentoring with local government and universities. Sustainability will depend on whether citizen-generated evidence becomes part of routine adaptation governance.

ACKNOWLEDGMENTS

The author thanks the reviewers and editorial team, as well as the residents and officials of Desa Pesisir and Desa Klaseman, for their constructive feedback and participation in this program.

FUNDING INFORMATION

Author states no funding involved.

AUTHOR CONTRIBUTIONS STATEMENT

Farhan: conceptualization, methodology, formal analysis, investigation, data curation, writing – original draft, writing – review and editing.

CONFLICT OF INTEREST STATEMENT

Author states no conflict of interest.

AI USE DECLARATION

The author used artificial intelligence tools to assist with the generation of illustrative figures and with the formatting and layout of this manuscript. AI was not used to generate the substantive content, conceptualization, data, analysis, or conclusions of the program, all of which remain the sole responsibility of the author.

INFORMED CONSENT

Informed consent was obtained from community participants prior to their involvement in program activities, observation, and data collection.

ETHICAL APPROVAL

This community engagement program involved voluntary participation of community members in Desa Pesisir and Desa Klaseman, conducted in full compliance with relevant national regulations and institutional policies, in accordance with the tenets of the Declaration of Helsinki, and approved by the author's institutional review board or equivalent committee.

DATA AVAILABILITY

The data (observation instruments, participatory risk maps, photo logs, and coding materials) generated in this program are available from the corresponding author upon reasonable request.

REFERENCES

[1] R. A. U. Kulsum, "Waste management education in coastal communities: Evaluating the impact of visual campaigns and local engagement," *Indonesian Journal of Applied Community Research, 1(1), 10–18*, 2026.

[2] W. Jamilah, "Evaluating community-based disaster preparedness programs: A case study from Semeru area," *Indonesian Journal of Applied Community Research, 1(1), 44–51*, 2026.

[3] I. Darmawan, "Empowering women entrepreneurs through digital literacy: A participatory action research in rural East Java," *Indonesian Journal of Applied Community Research, 1(1), 1–9*, 2026.

[4] D. Fraisl, G. Hager, B. Bedessem, M. Gold, P.-Y. Hsing, F. Danielsen, et al., "Citizen science in environmental and ecological sciences," *Nature Reviews Methods Primers, 2, Article 64*, 2022, doi: 10.1038/s43586-022-00144-4.

[5] U. Wehn, M. Gharesifard, L. Ceccaroni, H. Joyce, R. Ajates, S. Woods, et al., "Impact assessment of citizen science: State of the art and guiding principles for a consolidated approach," *Sustainability Science, 16, 1683–1699*, 2021, doi: 10.1007/s11625-021-00959-2.

[6] S. Albagli and A. Iwama, "Citizen science and the right to research: Building local knowledge of climate change impacts," *Humanities and Social Sciences Communications, 9, Article 39*, 2022, doi: 10.1057/s41599-022-01040-8.

[7] M. Tengö, B. J. Austin, and F. Danielsen, "Creating synergies between citizen science and Indigenous and local knowledge," *BioScience, 71(5), 503–518*, 2021, doi: 10.1093/biosci/biab023.

[8] W. J. Barbon, C. Myae, R. Vidallo, P. S. Thant, E. Monville-Oro, and J. Gonsalves, "Applying participatory action research methods in community-based adaptation with smallholders in Myanmar," *Frontiers in Climate, 3, Article 734053*, 2021, doi: 10.3389/fclim.2021.734053.

[9] R. Pateman, A. Dyke, and S. West, "The diversity of participants in environmental citizen science," *Citizen Science: Theory and Practice, 6(1), Article 9*, 2021, doi: 10.5334/cstp.369.
[10] L. Somerwill and U. Wehn, "How to measure the impact of citizen science on environmental attitudes, behaviour and knowledge? A review of state-of-the-art approaches," *Environmental Sciences Europe, 34, Article 18*, 2022, doi: 10.1186/s12302-022-00596-1.
[11] K. V. Spellman, D. Cost, and C. P. Villano, "Connecting community and citizen science to stewardship action planning through scenarios storytelling," *Frontiers in Ecology and Evolution, 9, Article 695534*, 2021, doi: 10.3389/fevo.2021.695534.
[12] K. Vincent, "Development geography II: Community-based adaptation and locally led adaptation," *Progress in Human Geography, 47(4), 604–612*, 2023, doi: 10.1177/03091325231166076.
[13] R. Benameur, A. Dahane, B. Kechar, and A. Benyamina, "An Innovative Smart and Sustainable Low-Cost Irrigation System for Anomaly Detection Using Deep Learning," *Sensors (Basel, Switzerland),* vol. 24, Feb. 2024, doi: 10.3390/s24041162.
[14] [26] A. Biancardi, A. Colasante, I. D'Adamo, C. Daraio, M. Gastaldi, and A. Uricchio, "Strategies for developing sustainable communities in higher education institutions," *Scientific Reports,* vol. 13, Nov. 2023, doi: 10.1038/s41598-023-48021-8.
[15] [27] N. Szoko, E. Slade, A. Fields, K. Blankenship, E. Miller, and A. Culyba, "Implementation evaluation of a community-based youth participatory action research program.," *American journal of community psychology*, May 2025, doi: 10.1002/ajcp.12815.

BIOGRAPHY OF AUTHOR

Farhan focuses his primary area of expertise within Islamic Communication and Broadcasting (*Komunikasi dan Penyiaran Islam*). His academic research and community outreach heavily focus on the intersection of media, community communication patterns, and Islamic values. His core research interests include Journalism and Student Media; Digital Dakwah & Online Media; Interpersonal & Public Communication; and Nationalism and Pesantren Integration. He can be contacted at email: farhan@unuja.ac.id.