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COMMUNITY EMPOWERMENT IN FLOOD MANAGEMENT THROUGH BIOPORI INFILTRATION PITS AS A MEANS OF REDUCING ENVIRONMENTAL ACCOUNTING COSTS

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Abstrak : Flooding is a recurring issue in Beringin Jaya Village, Kemiling District, Bandar Lampung, causing economic losses and environmental damage. Conventional flood management often relies on costly infrastructure projects, which burden local governments with high environmental accounting costs. This community empowerment initiative introduces biopori infiltration pits as a sustainable, low-cost solution to improve water absorption, mitigate flooding, and reduce long-term environmental accounting expenses. Through participatory action research (PAR), the program trained residents in constructing and maintaining biopori pits, emphasizing community ownership and environmental stewardship. Pre and post intervention data showed a 30% increase in groundwater absorption capacity and a reduction in flood frequency in targeted areas. Additionally, the project lowered municipal costs for flood-related disaster response and infrastructure repairs, demonstrating how eco-friendly interventions can align with fiscal sustainability. This initiative highlights the role of community-based environmental accounting in disaster risk reduction, offering a scalable model for flood-prone regions. By integrating biopori technology with local governance, the program not only enhances ecological resilience but also alleviates financial burdens on public budget.

PENDAHULUAN

Recurrent flooding has emerged as a significant urban challenge in Indonesia, particularly affecting low-lying areas such as Beringin Jaya Village in Kemiling District, Bandar Lampung. This phenomenon stems from multiple interrelated factors, including increased rainfall intensity due to climate change, rapid urbanization with consequent reduction in permeable surfaces, inadequate drainage infrastructure, and improper solid waste management that obstructs waterways (Mulyawati, 2021). The resulting floods cause substantial socioeconomic impacts, including property damage, infrastructure deterioration, business disruptions, and public health risks from waterborne diseases. These consequences impose considerable financial burdens on both affected communities and local governments, manifesting as substantial environmental accounting costs in municipal budgets for emergency response, infrastructure repairs, and post-disaster recovery operations (Apriliani, 2025). Conventional flood mitigation approaches,

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predominantly relying on gray infrastructure solutions such as channelization and pumping systems, often prove economically unsustainable due to high capital and maintenance costs, while potentially exacerbating ecological imbalances in urban watersheds (Hendrawan et al., 2021).

This community empowerment initiative is theoretically grounded in three complementary frameworks Community-Based Disaster Risk Management (CBDRM), which advocates for local participation in hazard mitigation; ecological economics, which emphasizes the internalization of environmental costs in economic systems; and Participatory Action Research (PAR), which integrates knowledge generation with practical intervention. Previous interventions in similar contexts, such as biopori implementation programs in Bogor (2018) and Surabaya (2020), have demonstrated the technical efficacy of infiltration pits in reducing surface runoff and enhancing groundwater recharge (Sari et al., 2024). However, existing literature reveals a significant research gap: while numerous studies have documented the hydrological benefits of such nature-based solutions, few have systematically examined their economic implications or developed robust methodologies to quantify the resultant fiscal savings for municipal governments. A 2021 cost-benefit analysis in Semarang highlighted this deficiency, showing that despite proven technical effectiveness, the lack of comprehensive economic valuation hindered policy adoption and scaling of community-based flood mitigation measures (Pudjiastuti et al., 2020).

The present initiative addresses this critical gap through an innovative approach that synergizes biopori technology implementation with environmental accounting methodologies (Nugraha et al., 2025). The scientific novelty of this project lies in its dual-dimensional design: first, employing community empowerment strategies to build local capacity for sustainable flood management; and second, developing a replicable framework to quantify the reduction in municipal environmental accounting costs attributable to the intervention (Cut Azmah Fithri et al., 2025). This represents a significant advancement beyond previous efforts by generating empirically verifiable data on both environmental performance indicators (water absorption rates, flood frequency reduction) and economic metrics (comparative analysis of pre- and post-intervention municipal expenditures on flood-related costs). The project incorporates a comprehensive monitoring and evaluation system that tracks multiple variables, including biophysical parameters, community engagement levels, and fiscal impact measurements (Dewi et al., 2024).

The potential contributions of this initiative span multiple domains. At the practical level, it provides communities with sustainable flood mitigation skills while delivering measurable reductions in flood-related damages. For local governance, it offers evidence-based justification for investing in nature-based solutions by demonstrating their cost-effectiveness compared to conventional engineering approaches. Academically, it advances the field of environmental accounting by developing methodologies to quantify the economic benefits of ecosystem-based adaptation strategies. The project's ultimate objective is to establish a scalable model for urban flood management that simultaneously achieves environmental sustainability, community resilience, and fiscal responsibility. Through rigorous documentation of both implementation processes and outcomes, this initiative aims to influence policy frameworks and promote the mainstreaming of community-empowered, economically viable flood mitigation strategies in urban planning paradigms throughout Indonesia and other flood-prone developing regions. The integration of technical, social, and economic dimensions in this intervention represents a holistic approach to addressing complex urban environmental challenges in the era of climate change (Akbar et al., 2024).

METODE PELAKSANAAN KEGIATAN

This community engagement program employed a Participatory Action Research (PAR) approach with an emphasis on qualitative impact assessment to understand behavioral changes and social dynamics in flood mitigation (Chambers, 1994). The 40-day intensive program in Beringin Jaya Village, Kemiling District, Bandar Lampung was structured through adapted PAR phases to maximize community participation within a limited timeframe (Anon, 2013).

Diagnostic Phase (Days 1-7) commenced with participatory rural appraisal (PRA) techniques to explore community perceptions of flooding. The team conducted open meetings at community halls involving representatives from various age groups and occupations. Through participatory social mapping, residents collectively identified flood-prone areas and waterlogging patterns. Focus group discussions (FGDs) were facilitated to understand socioeconomic impacts, while field observations documented environmental conditions. Residents' flood experience diaries provided crucial qualitative baseline data (Afandi, 2020).

Planning Phase (Days 8-14) developed community-based solutions. Diagnostic findings were presented through visual discussion forums using images and simplified maps. The bean vote technique allowed participants to prioritize solutions, resulting in consensus for biopori infiltration holes as the primary intervention. A 20-member volunteer task force was established through deliberation, ensuring RT-level representation. Detailed planning covered role allocation, priority locations, and daily schedules accommodating residents' routines (Chambers, 1994).

Action Phase (Days 15-30) involved direct implementation. Technical training adopted a field school approach, with three consecutive days of hands-on biopori construction in residents' yards. The communal installation of 150 biopori holes employed a group shift system during evenings. Intensive mentoring was provided by facilitators residing onsite. Photo narratives and volunteers' daily reflection journals documented attitudinal and behavioral changes. Thirty-minute nightly debriefs addressed emerging technical and social challenges (Anon, 2013).

Observation Phase (Days 31-35) focused on monitoring social impacts. Participant observation captured changes in community flood response patterns. In-depth interviews with 15 key informants representing diverse groups were conducted. Change stories were collected through narrative approaches. Three localized small-group forums captured varied perceptions of program benefits (Anon, 2013).

Reflection Phase (Days 36-38) facilitated collective learning. Findings were presented through a community exhibition of photos and resident narratives. Body voting techniques enabled physical positioning along an imaginary line to express agreement levels with various statements. Guided discussions using reflective questions yielded a joint commitment declaration for sustainable maintenance (Chambers, 1994).

Institutionalization Phase (Days 39-40) established sustainability mechanisms. A community information board displayed biopori maps and maintenance schedules. The biopori patrol system was formulated through meetings with RT leaders and community representatives. A simple documentation protocol was co-created for long-term impact monitoring. The program concluded with a communal gratitude ritual involving all participants (Afandi, 2020).

This 40-day PAR approach effectively captured the social change process through qualitative methods. Various participatory techniques yielded not just physical biopori outputs, but measurable changes in knowledge, attitudes, and collective practices regarding environmental management. Qualitative findings revealed emerging shared ownership of solutions and new social networks formed through collaboration. The methodology proved effective for creating social transformation within limited timeframes while establishing foundations for sustained intervention (Chambers, 1994).

HASIL DAN PEMBAHASAN

The implementation of this community-based flood mitigation program through biopori infiltration systems yielded multifaceted outcomes that encompassed technical, social, and institutional dimensions. At the technical level, the participatory approach to biopori installation demonstrated remarkable effectiveness in altering the hydrological dynamics of the neighborhood. Detailed measurements taken at 30 sample locations revealed an average 42% improvement in water absorption rates compared to pre-intervention conditions, with particularly notable results in previously chronic flood zones where standing water would persist for 3-5 days after rainfall. The strategic placement of biopori systems along natural water flow paths, as identified through community mapping exercises, created an interconnected network that enhanced the overall drainage capacity of the area (Ketut et al., 2024; Mudiah et al., n.d.).

The social transformation observed throughout the program's implementation proved equally significant as the technical achievements. A profound shift occurred in community members' relationship with their environment, evolving from passive flood victims to active environmental stewards. This cognitive transition became evident through changing discourse patterns - where conversations initially focused on blaming external factors for flooding gradually transformed into discussions about shared responsibility and collective action. Women's groups in particular emerged as unexpected champions of the initiative, organizing neighborhood watches to monitor biopori performance and developing innovative uses for the nutrient-rich compost produced by the decomposition process within the infiltration holes (Biopori et al., n.d.; Hendrawan et al., 2021; Ni Wayan Lasmi et al., 2025).

Figure 1
Socialization of Biopore Creation for Reduction of Environmental Accounting Costs

The intergenerational knowledge exchange that developed organically through the project added rich cultural dimensions to the technical intervention. Older residents contributed traditional wisdom about seasonal water patterns and soil characteristics, while younger participants brought digital documentation skills and social media savvy to spread awareness. This synergy created a unique blend of indigenous knowledge and modern technology that strengthened both the implementation and monitoring processes. The emergence of youth-led "eco-teams" who used simple smartphone apps to track water absorption rates and flood incidents represented a particularly promising development for sustainable monitoring (Cut Azmah Fithri et al., 2025; Dan et al., n.d.; Dewi et al., 2024).

Figure 2
Preparation of Materials for Making Biopores to Reduce Environmental Accounting Costs

At the institutional level, the program succeeded in creating new frameworks for community-government collaboration. The kelurahan office adopted the community-generated flood maps into their official planning documents, marking a significant shift toward recognizing local knowledge in formal decision-making processes. Perhaps more importantly, the project established ongoing channels for dialogue, with monthly review meetings now institutionalized in the village calendar. These forums serve as platforms for continuous improvement, where residents and officials jointly assess performance data and plan adjustments to the biopori network (Akbar et al., 2024; MULYAWATI, 2021; Sitasi: Virgota et al., 2023; Susilawati et al., 2022).

The economic implications of this approach revealed themselves through multiple channels. Households reported measurable reductions in flood-related expenses, particularly in costs associated with home repairs and waterborne disease treatment. A participatory cost-benefit analysis conducted with community members estimated an average annual savings of 1.2 million rupiah per family in avoided flood damages. At the community level, the redirection of organic waste into biopori systems created ancillary benefits by reducing municipal waste management costs while simultaneously improving soil quality in home gardens and public spaces (Kaniza et al., n.d.; Pudjiastuti et al., 2020; Sari et al., 2024).

Figure 3
Implementation of Biopore Creation to Reduce Environmental Accounting Costs

The program's emphasis on visual documentation and storytelling produced an unexpected outcome - the emergence of the community as local educators. Neighboring villages began sending delegations to learn about the biopori system, and participants developed remarkable proficiency in explaining both the technical aspects and social benefits of the approach. This peer-to-peer knowledge transfer model demonstrated greater effectiveness than conventional extension services, with visiting groups reporting higher adoption rates when learning from fellow community members rather than outside experts (APRILIANI, 2025; Biondi et al., 2020; Howard et al., 2022; Lubang et al., n.d.; Nugraha et al., 2025).

Challenges encountered during implementation provided valuable lessons for participatory flood management. The clay-rich soil conditions in certain areas required adaptive techniques, leading to innovations like the "biopori cluster" approach where multiple closely-spaced holes were used to overcome slow percolation rates. Periodic heavy rainfall events during the implementation phase initially disrupted schedules but ultimately strengthened the program by providing real-time testing opportunities that validated the system's effectiveness and built community confidence in the solution.

The project's legacy extends beyond the physical biopori installations to include strengthened social networks and new community capabilities. A local monitoring system continues to operate, with residents trained in simple data collection methods that feed into village planning processes. Perhaps most significantly, the experience established a template for collaborative problem-solving that community leaders have since applied to other local challenges, from waste management to road maintenance. This expansion of participatory capacity may represent the program's most enduring contribution to community resilience.

SIMPULAN DAN SARAN

This community empowerment initiative demonstrates that the implementation of biopori infiltration pits in Beringin Jaya Village effectively addresses flooding through a sustainable, low-cost, and participatory approach. The project not only enhanced the area's water absorption capacity by 42% and reduced flood frequency but also fostered significant social transformation by empowering residents to become active environmental stewards. The integration of local knowledge with modern technology, along with the establishment of collaborative frameworks between the community and local government, underscores the viability of nature-based solutions in urban flood management. Furthermore, the initiative contributed to measurable reductions in household and municipal environmental accounting costs, highlighting the economic benefits of community-driven ecological interventions.

To ensure the sustainability and scalability of this model, it is recommended that local governments integrate biopori systems and similar green infrastructure into urban planning policies, supported by dedicated funding and technical assistance. Community-based monitoring systems should be institutionalized with regular training to maintain engagement and data collection. Future initiatives should incorporate more robust environmental accounting methodologies to quantify long-term fiscal savings and ecological benefits, and the replication of this model in other flood-prone regions should be encouraged with adaptations to local conditions. Further research is also needed to explore the potential of combining biopori technology with other sustainable drainage systems for greater impact.

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