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Effectiveness of Biopore Policy Implementation in Urban Environmental Governance: A Case Study of Bandar Lampung City from the Perspective of Siyasah Tanfidziyah

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ABSTRACT

This study analyzes the effectiveness of implementing Bandar Lampung City Regional Regulation No. 4 of 2022 on drainage systems, particularly the application of Biopore Infiltration Holes (BIHs), and evaluates it through the normative framework of Siyasah Tanfidziyah. The research employs a socio-legal case study approach, integrating normative legal analysis with empirical findings at the local level. The findings suggest that the implementation of BIHs is suboptimal, not solely due to technical limitations, but primarily due to a discrepancy between the scale of intervention and the complexity of urban flooding problems, as well as weak institutional capacity and insufficient social sustainability. The efficacy of BIHs is found to be contingent upon low to moderate rainfall conditions, while budgetary constraints, inadequate monitoring mechanisms, and limited community participation further constrain its sustainability. These findings demonstrate that the effectiveness of nature-based solutions, particularly BIHs, is contingent upon the integration of policy design, implementation capacity, and the institutionalization of social practices. The absence of such integration has the effect of reducing policy effectiveness and undermining the constitutional right to a healthy and sustainable environment. The study posits that the constraints on environmental policy are not exclusively technical in nature; rather, they emanate from the inability to institutionalize implementation within a cohesive governance framework. From the perspective of Siyasah Tanfidziyah, this condition is indicative of the suboptimal realization of the principles of public benefit (maslahah), justice ('adl), trust (amanah), and responsibility.

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1. Introduction

Urban flooding has evolved into a persistent challenge in global environmental governance,[1] particularly in developing countries experiencing rapid urbanization, land-use transformation, and ecological system degradation.[2] In the context of the modern rule of law state, this issue not only reflects technical failures in water resource management but is also intrinsically linked to the fulfillment of the state's constitutional obligation to guarantee the right to a good and healthy environment, as enshrined in Article 28H(1) of the 1945 Constitution. Despite the continued development and implementation of infrastructure-based interventions, particularly conventional drainage systems, recent studies indicate that such technocratic approaches possess inherent limitations in addressing the systemic and multiscalar complexity of flood risks.[3] These limitations are not solely technical in nature but also reflect insufficient attention to governance dimensions, institutional capacity, and community-based adaptive mechanisms. Consequently, flood control policies often exhibit a disjunction between normative design and implementation outcomes, which in turn undermines the optimal realization of the state's constitutional mandate.

These limitations are empirically manifested across various urban contexts, including Bandar Lampung City.[4] Flooding continues to recur despite the existence of regulatory frameworks governing urban drainage systems.[5] This phenomenon indicates that the presence of normative instruments does not automatically translate into effective flood control. From an environmental law perspective, this condition reflects a gap between legal norms and their implementation (law in the books versus law in action),

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[1] J.-Y. Lee, "A Review of Urban Flooding: Causes, Impacts, and Mitigation Strategies," *Journal of Engineering Geology* 33, no. 3 (2023): 489–502, https://doi.org/10.9720/kseg.2023.3.489; A Azadgar et al., "Flood-sensitive land take (FSL) analysis: A new way to read how urban sealing shapes flood risk," *Journal of Environmental Management* 404 (2026), https://doi.org/10.1016/j.jenvman.2026.129513.

[2] P Ghosh, J S Sudarsan, dan S Nithiyanantham, "Nature-Based Disaster Risk Reduction of Floods in Urban Areas," *Water Resources Management* 38, no. 6 (2024): 1847–66, https://doi.org/10.1007/s11269-024-03757-4; K Liu et al., "Unraveling urban hydro-environmental response to climate change and MCDA-based area prioritization in a data-scarce developing city," *Science of the Total Environment* 948 (2024), https://doi.org/10.1016/j.scitotenv.2024.174389.

[3] J L Rainey et al., "Assessment of the growing threat of urban flooding: a case study of a national survey," *Urban Water Journal* 18, no. 5 (2021): 375–81, https://doi.org/10.1080/1573062X.2021.1893356; Y Liu dan Z Hui, "Coordinating Flood Control and Stormwater Harvesting Through Optimization of In-pipe Storage Capacity Use in Urban Stormwater Drainage System," *Water Resources Management* 40, no. 7 (2026), https://doi.org/10.1007/s11269-026-04610-6.

[4] "Banjir di 19 titik di Kota Bandar Lampung dan sejumlah Daerah Kabupaten tersebar di wilayah Provinsi Lampung," https://sda.pu.go.id, 2026, https://sda.pu.go.id/balai/bbwsmesujisekampung/pages/posts/banjir-di-19-titik-di-kota-bandar-lampung-dan-sejumlah-daerah-kabupaten-tersebar-di-wilayah-provinsi-lampung#:~:text=Curah hujan tertinggi terjadi pada 17 Januari,di 19 titik di Kota Bandar Lampung.

[5] Ramadhan Nurpambudi dan R Z Abdul Aziz, "Prediksi Kejadian Banjir Di Wilayah Kota Bandar Lampung Dengan Metode Artificial Neural Network," in *Seminar Nasional Hasil Penelitian dan Pengabdian Masyarakat 2022* (Institut Informatika dan Bisnis Darmajaya, 2022).

particularly in the execution of the state's obligation to manage natural resources sustainably, as mandated in Article 33(4) of the 1945 Constitution. In addition to rainfall intensity, flooding in Bandar Lampung City is closely associated with reduced soil infiltration capacity due to land-use conversion, high population density, and limited green open spaces.[6] This condition underscores that flooding cannot be reduced merely to a hydrological phenomenon but must be understood as a complex environmental governance issue involving the interaction between public policy, institutional capacity, and societal behavior.[7]

In response to the increasing risk of urban flooding, the Government of Bandar Lampung City enacted Regional Regulation No. 4 of 2022 on Drainage Systems, which promotes the implementation of Biopore Infiltration Holes (BIHs) as an environmentally based water management instrument. This policy reflects a shift toward a more integrative approach through the adoption of nature-based solutions (NbS),[8] while also embodying the responsibility of local government within the framework of decentralization. Normatively, the principle of environmental protection as stipulated in Article 3 of Law No. 32 of 2009 on Environmental Protection and Management emphasizes the importance of preventive and sustainable approaches in environmental risk control. Meanwhile, the authority of local governments in managing drainage systems and flood control constitutes part of concurrent governmental affairs as regulated under Law No. 23 of 2014 on Regional Government. [9] In the context of disaster management, flood risk governance is also aligned with the mitigation mandate established in Law No. 24 of 2007 on Disaster Management.[10] Accordingly, the implementation of BIHs not only possesses ecological legitimacy but is also supported by a legal framework that positions local governments as key actors in integrated flood risk management.

Conceptually, Biopore Infiltration Holes (BIHs) are designed to enhance water infiltration into the soil, reduce surface runoff, and support sustainable water resource conservation. [11] In urban contexts, this technology is regarded as a relatively simple, low-cost, and spatially adaptive solution. However, the effectiveness of BIHs is not determined solely by their technical advantages but is highly dependent on the quality of the policy

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[6] Suripin, *Sistem Drainase Perkotaan yang Berkelanjutan*, 2004.

[7] Budi Winarno, *Kebijakan Publik: Teori, Proses, dan Studi Kasus*, 2012; P P J Driessen et al., "Toward more resilient flood risk governance," *Ecology and Society* 21, no. 4 (2016), https://doi.org/10.5751/ES-08921-210453.

[8] Kamir R. Brata dan Anne Nelistya, *Lubang Resapan Biopori* (Penebar Swadaya, 2015).

[9] A Weningtyas dan E Widuri, "Pengelolaan Sumber Daya Air Berbasis Kearifan Lokal Sebagai Modal Untuk Pembangunan Berkelanjutan," *Volksgeist: Jurnal Ilmu Hukum dan Konstitusi* 5, no. 1 (2022): 129–44, https://doi.org/10.24090/volksgeist.v5i1.6074.

[10] A L Prianto dan A Abdillah, "Resilient Cities, Vulnerable Communities: Disaster Governance in the Coastal Cities in Indonesia," in *International Handbook of Disaster Research*, 2023, 311–22, https://doi.org/10.1007/978-981-19-8388-7_193.

[11] E Nurzal, "The Study of Area Infiltration Rate by Using Biopori Holes as an Effort to Reduce Water Level and Groundwater Conservation," in *IOP Conference Series: Materials Science and Engineering*, vol. 506, 2019, https://doi.org/10.1088/1757-899X/506/1/012030.

governance framework within which they are embedded.[12] In practice, environmental policies frequently encounter structural implementation constraints, including weak policy communication,[13] limited institutional capacity,[14] low levels of compliance,[15] and suboptimal public participation.[16] These conditions indicate that the primary challenge no longer lies in the selection of technical instruments, but rather in how such instruments are operationalized within complex governance contexts. This suggests the existence of an analytical gap in understanding the interaction between policy design and implementation capacity in determining the effectiveness of nature-based solutions at the local level.

A number of previous studies have examined the implementation of Biopore Infiltration Holes (BIHs) from various perspectives. A study by Fitri (2025) demonstrates that BIHs are technically effective in reducing inundation depth by up to 40%, although their implementation remains constrained in scale due to the substantial number of units required to manage runoff optimally.[17] Meanwhile, Romadona (2025), using a Geographic Information System (GIS)-based approach, identifies that biopore implementation has the potential to reduce surface runoff by up to 20.16%, particularly when integrated into spatial planning for residential areas.[18] On the other hand, Nabilah (2026) emphasizes the importance of participatory approaches in sustainable development, demonstrating that the effectiveness of environmental management is significantly influenced by the level of community engagement and governance transparency.[19]

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[12] I V Simanjuntak, A S Mulyani, dan L E Hutabarat, "The effectiveness of biopore technology on infiltration rate and organic waste processing," in *IOP Conference Series: Earth and Environmental Science*, vol. 878, 2021, https://doi.org/10.1088/1755-1315/878/1/012045; A Fitri et al., "Optimizing bio-pore infiltration systems for urban flood mitigation: A field study in Bandar Lampung, Indonesia," in *E3S Web of Conferences*, vol. 677, 2025, https://doi.org/10.1051/e3sconf/202567706007.

[13] A Anas dan T Baharuddin, "Implementation of environmental policies on the development of a new capital city in Indonesia," *Cogent Social Sciences* 10, no. 1 (2024), https://doi.org/10.1080/23311886.2023.2297764.

[14] M S Nasution et al., "Green governance and institutional resilience: strengthening environmental policies for a low-carbon economy in mangrove ecosystems," *Frontiers in Political Science* 7 (2025), https://doi.org/10.3389/fpos.2025.1631249.

[15] D Kassie, "Unravelling the legal labyrinth: Investigating barriers to effective adoption and enforcement of international environmental law in domestic jurisdictions," *Journal of Environmental Management* 352 (2024), https://doi.org/10.1016/j.jenvman.2023.119944.

[16] E E Yahans Amuah et al., "Reviewing the performance of environmental policies in addressing environmental and socio-economic issues and associated implementation challenges: Ghana's perspective," *Environmental Development* 56 (2025), https://doi.org/10.1016/j.envdev.2025.101288; Anas dan Baharuddin, "Implementation of environmental policies on the development of a new capital city in Indonesia."

[17] Fitri et al., "Optimizing bio-pore infiltration systems for urban flood mitigation: A field study in Bandar Lampung, Indonesia."

[18] K Romadona, Y Setiawan, dan S Indrasari, "Assessing Flood Mitigation in Bandar Lampung Using GIS-Based Analysis of Biopores Implemented in Residential Areas," in *IOP Conference Series: Earth and Environmental Science*, vol. 1557, 2025, https://doi.org/10.1088/1755-1315/1557/1/012025.

[19] R Nabilah et al., "Evaluation of sustainability development based on community perspective as a participatory approach in Pasaran Island, Bandar Lampung, Indonesia," in *BIO Web of Conferences*, vol. 171, 2025, https://doi.org/10.1051/bioconf/202517101001.

Despite their important contributions, these studies remain fragmented and have not fully explained the interconnections between technical, spatial, and socio-institutional dimensions in policy implementation. This gap aligns with the international literature indicating that the success of nature-based solutions (NbS) and sustainable urban drainage systems (SUDS) depends not only on ecological effectiveness,[20] but also on institutional capacity and the quality of policy governance.[21] However, most studies continue to focus predominantly on technical and managerial dimensions, with limited attention to the integration of normative frameworks in policy evaluation.

In this context, the development of an analytical approach capable of integrating technical, governance, and normative dimensions becomes essential, particularly in societies with strong religious value systems such as Indonesia.[22] The perspective of Siyasah Tanfidziyah offers a conceptual framework that emphasizes governmental responsibility in realizing public welfare, justice, and accountability.[23] Nevertheless, the application of this perspective in the analysis of urban environmental policy remains relatively limited.

Based on this gap, this study aims to analyze the effectiveness of the implementation of Bandar Lampung City Regional Regulation No. 4 of 2022 in the application of Biopore Infiltration Holes (BIHs), and to evaluate it through the perspective of Siyasah Tanfidziyah. This research not only assesses policy implementation outcomes but also examines how the values of public welfare (maslahah), justice, and governmental responsibility are reflected in practice.

This study introduces an analytical framework that integrates technical dimensions, policy governance, and normative evaluation within a comprehensive approach. This approach extends the study of public policy effectiveness by incorporating ethical and governance responsibility dimensions, while also providing a conceptual foundation for the formulation of more sustainable and equitable environmental policies.

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[20] C S S Ferreira et al., "Hydrological challenges in urban areas," in *Advances in Chemical Pollution, Environmental Management and Protection*, vol. 8, 2022, 47–67, https://doi.org/10.1016/bs.apmp.2022.09.001; G B Mosisa et al., "Nature-based solutions for urban climate resilience: implementation, contribution, and effectiveness," *Nature-Based Solutions* 8 (2025), https://doi.org/10.1016/j.nbsj.2025.100245; B Wickenberg, K McCormick, dan J A Olsson, "Advancing the implementation of nature-based solutions in cities: A review of frameworks," *Environmental Science and Policy* 125 (2021): 44–53, https://doi.org/10.1016/j.envsci.2021.08.016.

[21] O Mahlio dan E Lähde, "Nature-based solutions for coastal flood protection: potential for urban biodiversity and recreational ecosystem services in Helsinki," *Journal of Integrative Environmental Sciences* 23, no. 1 (2026), https://doi.org/10.1080/1943815X.2026.2624118; E Starkey et al., "Empowering Communities Through Urban Flood Resilience: A New Vision for Sustainable Drainage Delivery," *Journal of Flood Risk Management* 19, no. 1 (2026), https://doi.org/10.1111/jfr3.70202.

[22] S D Rismawati et al., "The Legal Politics of Religious Moderation in Indonesia: Responsive or Repressive?," *Journal of Legal, Ethical and Regulatory Issues* 24, no. 4 (2021): 1–8, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85108870899&partnerID=40&md5=0aab875b7559286a1c691d965d148687.

[23] Wulan Maulidia, Fathul Mu, dan Alan Yati, "State Apparatus Neutrality in Electoral Governance : The Siyasah Tanfidziyah Perspective on Oversight Frameworks in Indonesia," *Al adalah: Jurnal Hukum dan Politik Islam* 11, no. 1 (2026): 80–97.

2. Legal Material and Methods

This study adopts a socio-legal research approach with a case study design to analyze the effectiveness of the implementation of drainage policy based on Biopore Infiltration Holes (BIHs) within the context of urban environmental governance. This approach integrates normative analysis of the regulatory framework with empirical analysis of policy implementation practices in the field, thereby enabling a comprehensive evaluation of the gap between legal norms and their practical realization.[24] Epistemologically, the study is grounded in a qualitative-interpretative paradigm, emphasizing the interpretation of policy practices within their broader social and institutional contexts.[25]

The research was conducted in Bandar Lampung City, with a specific focus on Jagabaya I Subdistrict, Way Halim District, which was purposively selected based on its vulnerability to flooding and its designation as a site for BIHs policy implementation. Data were collected through both library research and fieldwork. The library research involved the analysis of primary legal materials, particularly Bandar Lampung City Regional Regulation No. 4 of 2022 on Drainage Systems, as well as other relevant regulations, complemented by secondary legal materials in the form of scholarly journal articles and academic literature. Fieldwork was conducted through semi-structured interviews with purposively selected informants, including representatives from the Public Works Office, local administrative officials, and affected community members, with the number of informants determined based on the principle of data saturation.

Data analysis was conducted qualitatively using a thematic analysis approach, encompassing processes of open coding, categorization, and theme development. Interview data were transcribed and systematically analyzed to identify key patterns related to policy implementation effectiveness, structural constraints, and the level of community participation. Data validity was ensured through source triangulation by comparing findings from interviews, policy documents, and relevant literature.

Subsequently, the analysis was conducted using an evaluative framework grounded in Siyasah Tanfidziyah, which was operationalized into four analytical indicators: (1) *maslahah* (policy benefit), (2) *'adl* (equitable distribution of benefits), (3) *amanah* (accountability and transparency), and (4) governmental responsibility. These indicators function as interpretative analytical tools to assess the extent to which the implementation of BIHs policy is not only technically effective but also aligned with governance principles oriented toward the realization of public welfare.

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[24] N Creutzfeldt, M Mason, dan K Mc Connachie, *Routledge handbook of socio-legal theory and methods*, *Routledge Handbook of Socio-Legal Theory and Methods*, 2019, https://doi.org/10.4324/9780429952814.

[25] L Webley, "The why and how to of conducting a socio-legal empirical research project," in *Routledge Handbook of Socio-Legal Theory and Methods*, 2019, 58–69, https://doi.org/10.4324/9780429952814-4.

3. Results and Discussion

3.1. The Gap Between Policy Design and Implementation Realities: A Siyasah Tanfidziyah Perspective

Normatively, the implementation of Bandar Lampung City Regional Regulation No. 4 of 2022 reflects a progressive policy orientation through the integration of environmentally based approaches, particularly the application of Biopore Infiltration Holes (BIHs), as part of an urban flood control strategy. Within the framework of Siyasah Tanfidziyah, this policy represents the state's responsibility to realize public welfare (maslahah) through sustainable ecological instruments,[26] wherein policy success is not merely measured by the existence of regulatory provisions, but by the effectiveness of their realization in governance practice.[27] In this context, the effectiveness of policy implementation must also be understood as part of the fulfillment of the state's constitutional obligation to guarantee the right to a good and healthy environment. Consequently, implementation failure does not only generate administrative implications but also signifies the non-fulfillment of fundamental constitutional rights.

However, empirical findings reveal a significant gap between the normative design of the policy and its implementation capacity in practice. Interviews with key stakeholders indicate that the effectiveness of BIHs is highly contingent upon the scale of their application. A Public Works official noted that "biopores are only effective when implemented at a large and evenly distributed scale; when applied in limited numbers, their impact remains negligible."[28] This finding underscores that the policy design has not fully accounted for the requirement of critical mass implementation, which is widely recognized in the literature on nature-based solutions as a prerequisite for the success of ecological interventions.[29] Accordingly, a misalignment emerges between the technical rationality of the policy and the realities of its implementation. This condition indicates that, despite its normative orientation toward flood control, the policy has not yet met the level of effectiveness required within the framework of environmental rights protection as a constitutional entitlement.

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[26] N F Mahadi, "Islamic world view towards a green economy," in *Islamic Finance and Climate Action: Ethics, Environmental Stewardship and Sustainability*, 2025, 19–29, https://doi.org/10.4324/9781003570936-4.

[27] Hamzah et al., "Sustainable Development of Mangrove Ecosystem Policy in South Sulawesi from the Perspectives of Siyāsah and Fiqh al-Bi'ah," *Juris: Jurnal Ilmiah Syariah* 22, no. 2 (2023): 367–80, https://doi.org/10.31958/juris.v22i2.10559.

[28] Dian Nugraha, Head of Water Resources Division, Public Works Department of Bandar Lampung City, interview by the author, Bandar Lampung, April 7, 2026.

[29] Christopher M Raymond et al., "A framework for assessing and implementing the co-bene fi ts of nature-based solutions in urban areas," *Environmental Science and Policy* 77, no. June (2017): 15–24, https://doi.org/10.1016/j.envsci.2017.07.008; Nadja Kabisch et al., "Nature-Based Solutions to Climate Change Adaptation in Urban Areas—Linkages Between Science, Policy and Practice BT - Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice," ed. oleh Nadja Kabisch et al. (Cham: Springer International Publishing, 2017), 1–11, https://doi.org/10.1007/978-3-319-56091-5_1.

This gap also reflects broader challenges in urban environmental governance, particularly in relation to institutional capacity and the quality of policy planning. In the field of urban environmental governance, implementation failure is often not attributable to deficiencies in technical design, but rather to institutional limitations in translating policy into effective and context-sensitive action.[30] This suggests that the effectiveness of BIHs is not solely determined by their technological characteristics, but by the capacity of government institutions to integrate policy design with empirically grounded implementation strategies.

In addition, fiscal constraints emerge as a significant structural barrier. The implementation of BIHs is not supported by sustainable funding mechanisms, resulting in sporadic and non-integrated program execution.[31] This phenomenon is consistent with findings in flood policy studies in developing countries, which demonstrate that resource limitations and weak institutional support constitute primary factors in the low effectiveness of mitigation policies.[32] From the perspective of Siyasah Tanfidziyah, this condition may be interpreted as a weak realization of the principle of amanah, whereby the state has not fully discharged its responsibility to ensure the sustainability of public policy.[33] At the same time, these findings reinforce that implementation challenges cannot be reduced to mere administrative failure, but are closely related to institutional design that has yet to ensure program sustainability in a systemic manner. From a constitutional law perspective, this condition also reflects the limited fulfillment of the state's positive obligations in guaranteeing the continuity of environmental policies as part of the protection of citizens' constitutional rights.

Furthermore, the flooding problem in the study area cannot be understood as an isolated technical issue, but is closely linked to failures in spatial governance, particularly the degradation of river functions due to settlement expansion along riverbanks.[34] This condition indicates that the BIH policy operates within a fragmented and non-integrated policy ecosystem. These findings are consistent with the green infrastructure literature, which emphasizes that nature-based solutions cannot achieve effectiveness unless integrated with spatial planning and comprehensive environmental management policies.[35]

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[30] H.-W. Chau et al., "Key Barriers and Challenges to Green Infrastructure Implementation: Policy Insights from the Melbourne Case," *Land* 14, no. 5 (2025), https://doi.org/10.3390/land14050961.

[31] Nugraha, interview

[32] Zbigniew W Kundzewicz et al., "Flood risk and climate change : global and regional perspectives Flood risk and climate change : global and regional perspectives," *Hydrological Sciences Journal – Journal des Sciences Hydrologiques* 59, no. 1 (2014): 1–28, https://doi.org/10.1080/02626667.2013.857411; Irfan Amir, Hamzah Hamzah, dan Sultan Hasanuddin, "The Legal Construction Of Mangrove Protection In Climate Change Mitigation : Legal Study On The South Sulawesi Scale," *Pena Justisia : Media Komunikasi dan Kajian Hukum* 23, no. 1 (2024): 1–17.

[33] I Rusydi, "Good Governance According To Islamic Perspective," *Munaddhomah* 4, no. 4 (2023): 1001–7, https://doi.org/10.31538/munaddhomah.v4i4.727.

[34] Nugraha, interview

[35] J Bush dan A Doyon, "Building urban resilience with nature-based solutions: How can urban planning contribute?," *Cities* 95 (2019), https://doi.org/10.1016/j.cities.2019.102483.

Within the analytical framework of Siyasah Tanfidziyah, this condition suggests that the policy has not fully realized the principle of maslahah 'ammah, as the benefits generated remain partial and have yet to address underlying structural problems. The principle of public welfare requires not only limited or short-term benefits, but also demands policies that produce broad, sustainable, and equitable impacts for society. [36] In this context, the gap between policy design and implementation reflects the state's failure to substantively realize public welfare, despite the formal legal legitimacy of the policy.[37]

Moreover, this condition indicates that policy implementation has not yet fully ensured the realization of the right to a good and healthy environment as a constitutional right of citizens. Thus, the gap between policy design and implementation does not merely reflect technical or administrative shortcomings, but reveals a deeper disconnect between the state's normative obligations and their empirical realization in governance practice.

Therefore, these findings reinforce the argument that the effectiveness of environmental policy cannot be achieved without the integration of regulatory design, implementation capacity, and governance principles oriented toward public welfare. In this regard, Siyasah Tanfidziyah provides a significant analytical contribution by positioning policy implementation as the central locus of evaluation, while simultaneously affirming that the success of public policy is determined not only by technical rationality, but also by the quality of governmental responsibility in substantively realizing societal welfare.[38]

3.2. Technical Effectiveness and Ecological Limitations of BIHs: Empirical Findings from an NbS/SUDS Perspective

From a technical standpoint, the findings indicate that the effectiveness of Biopore Infiltration Holes (BIHs) is conditional and hydrologically constrained. Field evidence shows that BIHs function optimally only under conditions of low to moderate water discharge. This is corroborated by statements from local administrative officials, who noted that *"under low discharge, biopores remain effective, but during heavy rainfall, they are unable to accommodate the volume of water*."[39] These findings suggest that the infiltration capacity of BIHs is subject to structural limitations associated with rainfall intensity and surface characteristics.

Community perceptions further corroborate these findings. Several respondents reported that BIHs provide limited benefits, such as reducing small-scale water pooling

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[36] Dinda Nurul, "Fiqh Siyasah as an Analytical Framework for Literacy Policy Implementation : Evidence from West Lampung , Indonesia," *Al adalah: Jurnal Hukum dan Politik Islam* 11, no. 1 (2026): 124–38.

[37] Faisal et al., "A Review of Maqâshid Sharîa on Handling the COVID-19 Pandemic in Lampung and West Java Province," *Al-'Adalah* 21, no. 1 (2024): 221–44, https://doi.org/DOI: http://dx.doi.org/10.24042/adalah.v21i1.21796. (2024)

[38] & Hervin Yoki Pradikta Rintan Tri Banowati Hapsar, Nurnazli, "Implementasi Pasal 20 Peraturan Kepala Kepolisian Negara Republik Indonesia Nomor 05 Tahun 2021 Tentang Penerbitan dan Penandaan Surat Izin Mengemudi Persfektif Fiqh Siyasah Tanfidziyah Studi di Polres Metro," *Jurnal Ilmu Hukum, Humaniora dan Politik* 5, no. 4 (2025): 3554–64, https://doi.org/https://doi.org/10.38035/jihhp.v5i4.. (2025)

[39] Elina, Head of Jagabaya I Subdistrict, interview by the author, Bandar Lampung, April 7, 2026.

and accelerating infiltration, yet remain ineffective in mitigating flooding during high-intensity rainfall events. At the same time, variations in user experience indicate that the effectiveness of BIHs is highly dependent on spatial conditions, particularly the degree of surface impermeability. In areas dominated by impermeable surfaces, such as paving blocks, the performance of BIHs declines significantly.[40] This suggests that BIH performance is inherently contextual and cannot be uniformly generalized across different urban settings.

Analytically, these findings confirm that BIHs constitute a localized, infiltration-based solution operating at a micro scale, and therefore cannot be positioned as a standalone solution to systemic urban flooding problems (IUCN 2020). Within the literature on nature-based solutions (NbS) and sustainable urban drainage systems (SUDS), infiltration-based interventions - such as biopores, rain gardens, and infiltration trenches - are designed to manage runoff at the local level, with effectiveness highly contingent upon systemic integration and implementation scale.[41] Accordingly, their effectiveness is optimized only when deployed as part of a broader infrastructure network (a network-based approach), rather than as isolated interventions. This condition indicates that the technical limitations of BIHs not only affect operational policy effectiveness but also have implications for the incomplete realization of the constitutional right to a good and healthy environment.

Furthermore, global literature emphasizes that NbS approaches are not intended to fully replace conventional drainage infrastructure, but rather to complement it within a hybrid infrastructure system that integrates natural solutions with engineered systems.[42] In this context, the limitations of BIHs in the study area should not be understood merely as technical failures, but as indicative of a misalignment between the scale of policy intervention and the complexity of urban flooding. Thus, reliance on a single policy instrument without systemic integration reflects not only technical design limitations but also shortcomings in policy formulation that fall short of the effectiveness standards required within the framework of environmental legal protection.

Accordingly, these findings demonstrate that the effectiveness of BIH-based policy is largely determined by the government's capacity to design integration between micro-level solutions and macro-scale drainage systems. In the absence of such integration, BIHs generate only localized and partial benefits, and are unable to produce a significant impact on overall flood risk reduction.

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[40] Alin, resident of Jagabaya I Subdistrict, interview by the author, Bandar Lampung, April 7, 2026.

[41] Raymond et al., "A framework for assessing and implementing the co-bene fi ts of nature-based solutions in urban areas"; S Sagala et al., "Sustainable Urban Drainage System (SUDS) as Nature Based Solutions Approach for Flood Risk Management in High-Density Urban Settlement," in *IOP Conference Series: Earth and Environmental Science*, vol. 986, 2022, https://doi.org/10.1088/1755-1315/986/1/012055.

[42] E Santos, "Nature-Based Solutions for Water Management in Europe: What Works, What Does Not, and What's Next?," *Water (Switzerland)* 17, no. 15 (2025), https://doi.org/10.3390/w17152193.

Within the analytical framework of Siyasah Tanfidziyah, this condition reflects not only the limited utility of the policy but also indicates that the state has not fully realized public welfare (*maslahah*) in a substantive sense.[43] Policies that remain partial and non-integrated ultimately risk producing limited benefits, thereby falling short of the demands of maslahah 'ammah, which requires public policies to generate broad, sustainable, and equitable impacts.

3.3. Fragmented Implementation Practices and Local Dynamics of BIHs Application in Jagabaya I, Way Halim District

In contrast to the preceding policy-level analysis, this section highlights how limitations in policy implementation manifest concretely at the local level. The primary focus shifts from policy design and structural capacity to the dynamics of everyday implementation, including actor behavior, variations in community experience, and the sustainability of practices in the field. This condition indicates that implementation challenges are not solely related to policy design or structural capacity, but also to how policies are internalized within everyday social practices, which often remain fragmented and insufficiently institutionalized.

Empirical findings indicate that the implementation of Biopore Infiltration Holes (BIHs) in Jagabaya I Subdistrict, Way Halim District, constitutes a strategic step in environmentally based flood control efforts. This implementation, including a community-based participatory program in 2025 involving various local actors such as residents, youth organizations, and women's groups (PKK), resulted in the installation of approximately 100 BIHs units distributed across 11 neighborhood units.[44] The program was carried out through relatively comprehensive stages, including site surveys, socialization, technical training, and installation at flood-prone locations. However, while these figures demonstrate measurable implementation outputs, they do not automatically reflect policy success, as effectiveness is highly dependent on the sustainability of practices and the degree of community internalization.

Nevertheless, despite a procedurally structured implementation design, field-level realization exhibits inconsistent and largely incidental patterns. Interventions undertaken by both government actors and community-based initiatives have not been accompanied by clear sustainability mechanisms, particularly in terms of maintenance and program replication. As a result, the presence of BIHs tends to reflect short-term, project-based activities rather than institutionalized environmental management practices. This finding underscores that implementation effectiveness is not determined solely by successful installation, but more critically by the long-term continuity of practice. In this regard,

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[43] Adi Tiya Tri Saputra, Frenki, dan Hendriyadi, "Analysis Implementation The Appointment Village Officials From Siyasah Tanfidziyah Perspective In Gedung Jaya Village," *Al-Manhaj:Jurnal Hukum dan Pranata Sosial Islam* 7, no. 2 (2025): 181–96, https://doi.org/10.37680/almanhaj.v7i2.8522. (2025)

[44] Ahmad et al. Edo, Zuhri, "PENERAPAN LUBANG RESAPAN BIOPORI GUNA MENANGGULANGI BANJIR DI KELURAHAN JAGABAYA 1 KECAMATAN WAY HALIM BANDAR LAMPUNG," *JICN: Jurnal Intelek dan Cendikiawan Nusantara* 2, no. 4 (2025): 6313–20. (2025)

policy implementation remains project-based rather than institutionalized practice, where program sustainability is heavily dependent on external interventions and has yet to be embedded within community routines.

At the implementation level, the effectiveness of BIHs demonstrates significant variation and is strongly influenced by local conditions and patterns of community use. Interview findings indicate that some residents perceive benefits at the micro scale, such as reduced water pooling around households and improved infiltration rates, particularly during low- to moderate-intensity rainfall. This suggests that BIHs provide tangible local benefits, albeit limited in scope. However, these experiences are not uniform. Other respondents consider BIHs to be relatively ineffective, especially in areas dominated by impermeable surfaces such as paving blocks, which hinder infiltration. As one respondent noted, *"biopores help, but are not very effective because the environment is dominated by paving blocks."*[45] This variation confirms that BIHs performance is not determined solely by technical design, but also by spatial characteristics and local environmental conditions. Accordingly, the effectiveness of BIHs in practice cannot be generalized uniformly, but must be understood as a contextual solution shaped by the interaction of technical, environmental, and behavioral factors.

In addition, maintenance emerges as a critical factor influencing the sustainability of BIH functionality. Field findings indicate that many biopore holes are not adequately maintained, and in some cases become clogged with soil or vegetation. This condition confirms that implementation success does not end at the installation stage, but is contingent upon the sustained practice of utilization. In this context, low levels of community engagement in maintenance reflect the absence of a strong sense of ownership over the environmental program. [46]

These dynamics further indicate that community participation remains situational rather than institutionalized. Public engagement tends to arise in response to external interventions but does not evolve into sustained, self-driven practices. This suggests a gap between formal participation and substantive participation, where communities have not yet fully assumed the role of primary actors in maintaining the functionality of BIHs.[47] This condition also implies that suboptimal implementation practices at the local level contribute to the limited realization of the right to a good and healthy environment, thereby reflecting a gap between constitutional mandates and social realities at the community level.

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[45] Alin, interview.

[46] Sari Utama Dewi et al., "Manfaat Biopori Terhadap Mitigasi Bencana Banjir Di Kota Bandar Lampung," *Jompa Abdi: Jurnal Pengabdian Masyarakat* 3, no. 2 (2024): 29–36, https://doi.org/https://doi.org/10.57218/jompaabdi.v3i2.1070.

[47] Fathul Mu'in et al., "Strengthening the National Waqf Ecosystem through LegalReform: An Analysis of Waqf Issues in the Provincesof Lampung and South Sumatra," *Al-Istinbath :Jurnal Hukum Islam* 9, no. 1 (2024): 81–100, https://doi.org/https://dx.doi.org/10.29240/jhi.v9i1.9320.

Analytically, these findings reinforce the view that the effectiveness of nature-based solutions is largely determined by implementation practices at the local level, particularly with regard to maintenance, environmental adaptation, and the sustainability of participation. In the absence of consistency in these practices, technical interventions such as BIHs are likely to produce limited and unstable impacts over time.

From the perspective of Siyasah Tanfidziyah, this condition reflects not only weaknesses in the operational dimension of policy, but also the incomplete realization of the principle of amanah in its implementation dimension, whereby the state has not fully ensured the sustainability of policy benefits for the community. Furthermore, the limited nature of substantive participation indicates that the policy has not fully realized the principle of *maslahah 'ammah*, as the benefits generated remain temporary and have not been broadly and sustainably distributed.

Accordingly, this practice-level analysis underscores that the primary challenges of BIHs implementation lie not only in policy design or technical aspects, but in how the policy is enacted, maintained, and internalized in everyday community life. Therefore, strengthening future implementation requires a shift from a project-based approach to a practice-based approach, in which communities are not merely beneficiaries but also primary actors in sustaining environmental solutions. In this regard, the fragmentation of implementation practices at the local level demonstrates that the success of environmental policy ultimately depends on the capacity to cultivate institutionalized, sustainable social practices aligned with the substantive objectives of environmental protection.

4. Conclusion

This study demonstrates that the implementation of drainage policy based on Biopore Infiltration Holes (BIHs) in Bandar Lampung City has not achieved optimal effectiveness due to the complex interaction of technical, institutional, and social constraints. From a technical perspective, BIHs are effective only under conditions of low to moderate water discharge and are unable to accommodate runoff during high-intensity rainfall, indicating a mismatch between the scale of intervention and the scale of the problem. From a governance perspective, budgetary limitations, weak monitoring and evaluation mechanisms, and low levels of community participation reveal a gap between policy design and implementation capacity. These findings confirm that the effectiveness of nature-based solutions is not determined solely by ecological performance, but also by the quality of governance, institutional capacity, and the degree to which practices are internalized within society. Furthermore, the study demonstrates that these implementation limitations do not merely affect administrative policy effectiveness, but also have implications for the suboptimal fulfillment of the right to a good and healthy environment as a constitutional right of citizens. From the perspective of Siyasah Tanfidziyah, this condition reflects that policy implementation has not fully realized the principles of public welfare (*maslahah 'ammah*), justice (*'adl*), trust (*amanah*), and governmental responsibility, resulting in policy benefits that remain partial, unevenly distributed, and unsustainable.

Theoretically, this study contributes by demonstrating that the relative failure of environmental policies based on nature-based solutions is not merely attributable to technical limitations, but to the inability to integrate policy design, implementation capacity, and institutionalized social practices within a coherent governance framework. Accordingly, the effectiveness of environmental policy requires not only technical and administrative approaches, but also the integration of ecological, institutional, and normative dimensions, including ethical governance values as articulated within the framework of Siyasah Tanfidziyah. Therefore, strengthening future policy requires a shift from partial approaches toward a systemic approach through the integration of BIHs with macro-scale drainage infrastructure, river spatial planning, enhanced institutional capacity, and the institutionalization of community participation as a sustainable social practice. This approach is essential not only for improving policy effectiveness, but also for ensuring the fulfillment of the state's responsibility to guarantee substantive environmental protection. Looking forward, further research employing quantitative and interdisciplinary approaches is needed to develop integrated drainage policy models that are adaptive, sustainable, and oriented toward the realization of public welfare.

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