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Environmental *Fiqh* Analysis of Coal-Fired Power Plant (PLTU) Barru Operational Impacts on Ecosystem Sustainability

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Abstract

This study examines the environmental impacts of PLTU Barru's operations on ecosystem sustainability through the lens of environmental fiqh (jurisprudence), addressing the global ecological crisis with an Islamic perspective. The core problem lies in the lack of integration between Sharia principles and site-specific environmental analyses, particularly for coal-fired power plants such as PLTU Barru, which contribute to air pollution, water contamination, and biodiversity loss. Using a qualitative descriptive-analytical approach, data were collected through literature reviews, field observations, and in-depth interviews with stakeholders, and analyzed via triangulation to ensure validity. Findings reveal that PLTU Barru's emissions, effluents, and habitat destruction contravene Islamic principles of hifz al-bi'ah (environmental protection), maslahah (public welfare), and prevention of mafsadah (harm). The study proposes Sharia-compliant recommendations, including cleaner technologies, wastewater treatment, and reforestation, to mitigate impacts while meeting energy demands. These findings highlight the significance of integrating Islamic ethics into environmental management, offering a model for sustainable practices in energy infrastructure and contributing to global sustainability discourse.

Keywords: Environmental Fiqh; Islamic Sustainability; PLTU Barru; Hifz al-Bi'ah; Maslahah.

Introduction

The global ecological crisis presents one of the most pressing challenges of the modern era, necessitating multidimensional solutions that include ethical and spiritual frameworks (Milovanović et al., 2026). Environmental *fiqh* (jurisprudence), a branch of Islamic jurisprudence integrating Islamic principles with sustainability issues, has become increasingly relevant in this context (Amiruddin et al., 2024). From an

Islamic perspective, the concept of *khalifah fil ardh* (humans as stewards of the earth) underscores humanity's responsibility to maintain the balance of ecosystems as *amanah* (a divine trust) from Allah SWT (Wani & Azhar, 2024). While technological and regulatory approaches are common, addressing environmental degradation also requires a strong moral foundation to promote sustainable behavior (Zhanbayev et al., 2023).

A significant manifestation of this environmental challenge is the operational impact of Pembangkit Listrik Tenaga Uap (coal-fired power plants/ PLTU). While PLTUs serve as a crucial backbone of energy supply in many developing regions, their operations often have cause severe negative impacts on local ecosystems (Kabeyi & Olanrewaju, 2022). A specific case is the PLTU Barru in South Sulawesi, which generates electricity but simultaneously contributes to local ecosystem degradation (Muliati & Rosdiana, 2024). The core problems associated with such energy infrastructure include substantial air pollution, water contamination, and local biodiversity loss, directly threatening the sustainability of the surrounding environment (Kolawole & Iyiola, 2023).

Addressing the ecological consequences of PLTU Barru's operations is highly urgent given the immediate threats to local community health and ecosystem stability (Muliati & Rosdiana, 2024). The urgency of this research lies in the need for an Islamic values-based approach to address these environmental issues and bridge the gap between modern environmental challenges and religious ethics. Because the plant operates in a Muslim-majority region, utilizing environmental *fiqh* provides a culturally and spiritually resonant framework to foster collective awareness (e Nayab, 2025). This approach is not only locally critical for mitigating immediate harm but also contributes to the broader global discourse on sustainable development by offering a religiously grounded model for environmental stewardship.

Previous studies on the environmental impacts of PLTUs have primarily focused on technical and scientific metrics, such as measuring carbon emissions, assessing water quality, or evaluating public health impacts (Tham et al., 2020). For instance, research consistently shows that coal-based PLTUs produce significant carbon dioxide emissions and particulate matter, exacerbating climate change and health issues in surrounding communities (Widjanarko & Gultom, 2024). In the Islamic context, while some research has addressed environmental *fiqh*, it has largely focused on general concepts—such as water conservation or municipal waste management—without specifically examining the operational impacts of large-scale energy infrastructure (Hidayah, 2025). Consequently, existing literature often overlooks the intersection between specific industrial-ecological impacts and the spiritual dimensions that could drive ethical corporate and public policies (Astrachan et al., 2020).

A key limitation of prior studies is the lack of integration between normative Sharia principles and site-specific environmental impact analyses for facilities with unique ecological and social characteristics, such as PLTU Barru. This study seeks to address this gap by directly applying the framework of environmental *fiqh,* specifically, principles such as *hifz al-bi'ah* (environmental protection), *maslahah* (public welfare), and the prevention of *mafsadah* (harm) to evaluate the specific impacts of PLTU Barru. The novelty of this research lies in its specific linkage of Islamic environmental jurisprudence with empirical data from a coal-fired power plant, offering both theoretical enrichment to academic discourse and practical Sharia-compliant mitigation strategies for operators and policymakers. Therefore, the primary objective of this study is to analyze the operational impacts of PLTU Barru on ecosystem sustainability from the perspective of environmental *fiqh* and to formulate actionable, Sharia-based recommendations to minimize environmental harm while meeting energy demands.

Research Method

This research employs a qualitative, descriptive-analytical approach to examine the operational impacts of PLTU Barru on ecosystem sustainability. The primary focus of this research is the environmental degradation caused by the plant's operations, specifically air pollution, water contamination, and local biodiversity loss. To analyze these issues, the study employs the theoretical framework of Islamic environmental *fiqh*, grounded in the principles of *hifz al-bi'ah* (environmental protection), *maslahah* (public welfare), and the prevention of *mafsadah* (harm).

Data were collected through three primary methods: field observation, in-depth interviews, and literature/document review. Field observations were conducted systematically to document empirical ecosystem conditions. The observation procedures utilized instruments such as field notes, interview guides, and technical data extraction from the internal PLN Indonesia Power PDM Barru dashboard (specifically tracking Asset Wellness, thermal, and vibration metrics). These combined instruments were used to record data on operational asset status, river water quality, air pollution levels, and actual impacts on local vegetation (such as mangroves) and fauna around the PLTU Barru perimeter.

In-depth interviews were conducted using a purposive sampling technique to ensure participants possessed relevant knowledge and direct experience regarding the issue. The informants were selected based on specific criteria, with a strong focus on those directly affected by operations in the Lampoko Village area. The primary informants included local community representatives with diverse livelihoods—specifically a housewife, a local crop farmer, and a traditional fisherman—who provided

firsthand accounts of the socioeconomic, health, and ecological impacts over recent years. The document and literature review gathered secondary data from scientific journals, environmental reports, internal plant operational dashboards, and relevant *fiqh* literature, including contemporary scholars' fatwas on environmental conservation.

Data analysis was conducted using a triangulation approach to ensure the validity and reliability of the findings by cross-verifying interview transcripts, observational data, and literature. To systematically integrate the normative (*fiqh*-based) and empirical approaches, the analysis proceeded in two stages. First, the empirical data from observations and interviews were synthesized to establish the factual extent of the environmental impacts or *mafsadah* (harm). Second, these empirical findings were directly evaluated against the normative principles of *hifz al-bi'ah* (protection of the environment) and *maslahah* (public welfare). This integration enables the research not only to identify the environmental impacts of PLTU Barru accurately but also to propose practical, Islam-based mitigation solutions for operators and policymakers.

Result And Discussion

Empirical Findings on the Operational Impacts of PLTU Barru

Before evaluating the operations of PLTU Barru from an Islamic normative perspective, it is imperative to establish the factual conditions on the ground through rigorous empirical data. The primary critique of large-scale energy infrastructure often lies in the disparity between macro-economic benefits and micro-ecological degradation. Based on the triangulation of systematic field observations, in-depth interviews with affected local stakeholders, and the extraction of secondary operational data from the plant's internal systems, this study found that PLTU Barru's operations have triggered cascading ecological and socio-economic disruptions across three critical domains: air quality deterioration, water and soil contamination, and the degradation of coastal biodiversity.

Table 1. Informant Profiles and Empirical Evidence of Environmental & Socio-Economic Impact

Informant Profile	Livelihood / Sector	Empirical Evidence of Environmental & Socio-Economic Impact (*Mafsadah*)
A (45 years old)	Local Resident / Housewife	Air Quality & Health: Severe daily coal dust contamination in residential areas. High incidence of Upper Respiratory Tract Infections (ISPA), severe asthma exacerbations, and ocular irritation among family members and neighbors.
R (52 years old)	Agrarian / Crop Farmer	Soil Integrity & Economy: Rice yields drastically decreased from 5-6 tons to 3-4 tons per hectare. Soil

		acidification and crop diseases (black spots on leaves) caused a 100% increase in fertilizer/pesticide costs, leading to a 40% drop in overall income over the last 3 years.
HS (58 years old)	Coastal / Traditional Fisherman	Marine Biodiversity & Economy: Drastic drop in daily fish catch from 50-70 kg to 10-15 kg due to elevated sea surface temperatures near effluent discharges. Widespread mortality of mangrove seedlings. Increased operational costs due to further fishing routes (2-3 hours travel time).

(Source: Primary Data from Field Interviews)

As illustrated in Table 1, the triangulated interview data reveal a stark discrepancy between the plant's macro-level energy production and the micro-level ecological and economic degradation experienced by the local community. The empirical evidence demonstrates that air, water, and thermal pollution are not merely abstract environmental metrics; they translate directly into tangible public health crises and severe livelihood losses for the most vulnerable socio-economic sectors in Lampoko Village. The quantified losses—such as a 40% decline in agrarian income and a nearly 80% reduction in fishing yields—provide a concrete measure of the localized damage. This localized *mafsadah* (harm) establishes the vital empirical foundation required for the subsequent *fiqh* (Islamic jurisprudential) analysis.

First, the facility's coal combustion generates substantial atmospheric pollution, continuously releasing particulate matter (coal dust), carbon dioxide (CO2), sulphur dioxide (SO2), and nitrogen oxides (NOx) into the surrounding environment (B. Rahmat et al., 2021). The empirical reality of this pollution is acutely felt by the local community residing in the immediate vicinity, such as in Bawasalo Sub-Village, Lampoko Village. In-depth interviews revealed severe daily disruptions to the residents' quality of life. An informant representing the local households, a 45-year-old resident, reported that before the plant's establishment in the 2010s, the village environment was pristine. Currently, however, black coal dust rapidly contaminates domestic spaces, forcing residents to clean their properties multiple times a day. More critically, this continuous exposure has precipitated a local public health crisis. The informant noted a significant rise in *Infeksi Saluran Pernafasan Akut* (Upper Respiratory Tract Infections/ ISPA) and severe asthma exacerbations among the villagers, particularly children and the elderly, which strongly correlates with the wind direction that carries emissions directly from the plant's smokestacks. Furthermore, residents experience ocular irritation and sleep disruptions due to nocturnal emissions.

Interestingly, a critical paradox emerges when comparing these community grievances with the secondary data extracted from the PLTU's internal operational dashboard of PDM Barru. The internal monitoring system indicates that the plant's heavy equipment—such as the Primary Air Fan (PAF), Secondary Air Fan (SAF), and Induced Draft Fan (IDF A and B)—generally operates within optimal technical limits, categorized predominantly under "Good" or "Fine" Asset Wellness indicators regarding thermal and vibration metrics. However, this internal mechanical efficiency does not translate into external environmental safety. The plant may be operating optimally from an engineering standpoint, yet it simultaneously produces a severe ecological deficit for the surrounding community. This empirical finding strongly aligns with (Deng et al., 2020), who noted that the mechanical continuity of coal emissions, even when technologically regulated, inevitably exacerbates chronic respiratory diseases in adjacent populations due to cumulative exposure.

Second, the operational mechanics of PLTU Barru have led to profound water and soil contamination, primarily driven by the discharge of thermal effluents, potential heavy-metal leakage, and the dispersion of coal ash into the surrounding agrarian and coastal landscapes. Agricultural informants highlighted a devastating economic and ecological toll. A 52-year-old local farmer reported that agricultural productivity has plummeted sharply; rice harvests have dropped from an average of 5-6 tons per hectare to just 3-4 tons per hectare. The empirical observations indicate that coal dust settling on foliage disrupts photosynthesis, leading to plant decay, while rainwater mixed with coal particulates significantly increases soil acidity. Consequently, local farmers have seen their fertilizer and plant medicine costs double, while their overall income has decreased by approximately 40% over the last three years. Although the PLTU management has provided some financial compensation for specific crop failures, this transactional approach only addresses immediate economic symptoms. It entirely fails to resolve the underlying systemic soil degradation and water toxicity, leaving the agrarian ecosystem permanently compromised (Muliati & Rosdiana, 2024); (Paul & Bhatia, 2025).

Third, the confluence of habitat destruction and thermal pollution has severely fractured local biodiversity and devastated coastal livelihoods. The coastal ecosystem of Lampoko is particularly vulnerable to the thermal effluents discharged directly into the sea. Interviews with a 58-year-old traditional fisherman provided critical insights into the shifting marine dynamics. The informant reported that sea surface temperatures near the effluent discharge zone have noticeably increased, fundamentally altering the marine habitat. Consequently, local fish populations have migrated to deeper, cooler waters. This ecological shift has decimated traditional fishing

yields, plunging daily catches from an historical average of 50-70 kg per night to a mere 10-15 kg.

Furthermore, the fishermen face increased operational burdens, having to travel up to three hours further into the ocean, consuming more fuel while dealing with fishing nets blackened by coal particulate runoff. Compounding this issue is the failure of local ecological mitigation efforts. Reforestation initiatives, including the planting of thousands of mangrove seedlings provided by Dinas Lingkungan Hidup (Environmental Agency), resulted in widespread plant mortality, which was empirically attributed to elevated water temperatures and effluent toxicity in the vicinity of the plant.

Environmental *Fiqh* Analysis of the Operational Impacts

Having established the empirical extent of environmental degradation, this section critically analyzes the operational impacts of PLTU Barru, using the normative and philosophical parameters of Islamic environmental *fiqh* (jurisprudence). Moving beyond mere descriptive application, this analysis bridges the epistemological gap between empirical ecological metrics and Sharia-based environmental ethics (Apriliani & Nuryadin, 2024). By doing so, it offers a profound critical evaluation of the trade-offs between modern energy production and long-term environmental sustainability, judging the empirical facts against the ultimate *Maqasid al-Shariah* (objectives of Islamic law) (Srivastava et al., 2025).

Evaluated against the fundamental principle of *hifz al-bi'ah* (environmental protection), the documented atmospheric pollution, soil acidification, and marine thermal contamination represent a severe and multi-layered violation of the Islamic mandate to preserve natural resources (Ridho & Khasanah, 2025). In Islamic theology, the environment is not a mere commodity for industrial exploitation but *amanah* (divine trust) (Hutagalung, 2024). Derived from explicit Qur'anic injunctions such as Ar-Rum: 41, which explicitly warns against *fasad* (corruption) appearing on land and sea as a result of human actions, *hifz al-bi'ah* classifies the destruction of the local atmosphere and the mass mortality of marine ecosystems (such as the widespread death of mangrove seedlings) as a profound ethical failure (Sutrisno & Azmi, 2025). Humans, positioned as *khalifah fil ardh* (stewards of the earth), are entrusted with maintaining *mizan* (cosmic balance) (M. B. Rahmat, 2025). Previous technical studies often limit their scope of analysis to whether a corporation complies with secular state-mandated *Analisis Mengenai Dampak Lingkungan* (Environmental Impact Assessments/AMDAL) (Aljughaiman et al., 2024). However, an Islamic analytical lens shifts the paradigm significantly: it views these empirical ecological disruptions not merely as regulatory infractions, but as breaches

of theological accountability to the Creator (Hafidh, 2025); (Bin Salman & Asmanto, 2024). The pervasive black dust coating the homes in Bawasalo Sub-Village and the blackened nets of the fishermen are tangible manifestations of this *fasad*.

Furthermore, a highly critical tension exists when evaluating the plant's operations through the juxtaposed principles of *maslahah* (public welfare) and the prevention of *mafsadah* (harm) (Arham et al., 2022). The operation of PLTU Barru undeniably provides a macro-level *maslahah aammah* (general public benefit) by supplying vital electrical energy to support the economic, infrastructural, and social needs of the broader South Sulawesi province. Electricity is a modern necessity that fulfills the Sharia objective of preserving wealth and life (Ahyani & Figueiredo, 2024). However, Islamic jurisprudence possesses highly sophisticated mechanisms for conflict resolution when benefits and harms collide, encapsulated in the foundational legal maxims of *Ushul Fiqh* (Faizi & Ali, 2024). The foremost among these is the maxim *"Dar'u al-mafasid muqaddam ala jalb al-masalih"* (preventing harm takes precedence over acquiring benefits), coupled with the overarching principle of *"La darar wa la dirar"* (no harm shall be inflicted or reciprocated) (Esen, 2017).

When analyzing the empirical evidence through these maxims, the ethical conclusion becomes clear. The profound economic losses suffered by the marginalized sectors—farmers losing 40% of their income and fishermen losing up to 80% of their daily catch—coupled with the acute community health crises (ISPA and asthma), demonstrate that the *mafsadah* inflicted upon the local micro-community currently outweighs the localized *maslahah*. Islamic ethics dictate that a broader public benefit (electricity for the province) cannot be ethically sustained if it is predicated on the localized *zulm* (oppression) of a vulnerable community's health and livelihood (Rizaldy & Sopalo, 2026). Unlike previous technical environmental studies (Rathod et al., 2024), this specific *fiqh* analysis underscores a crucial ethical point: financial compensation provided by plant operators for failed crops is fundamentally inadequate. From a Sharia perspective, transactional compensation does not legally or ethically offset long-term, systemic harm to public health and the ecosystem's intrinsic value (Permata, 2025). The ethical implications are profound, demanding a paradigm shift where the immediate infrastructural benefits of energy provision are not achieved at the permanent expense of communal well-being and ecological equilibrium (Saiman & Mahadzir, 2024); (Chin et al., 2025).

Sharia-Based Recommendations for Mitigation

Based on the synthesis of empirical findings and the rigorous *fiqh* (jurisprudence) analysis, it is evident that the current operational model of PLTU Barru is ethically unsustainable under Islamic law. Therefore, this

study proposes practical, Sharia-compliant recommendations tailored for PLTU Barru operators, local governments, and community stakeholders. Grounded firmly in *hifz al-bi'ah* (protection of environment), *maslahah* (benefit), and the prioritization of preventing *mafsadah* (harm), these mitigation strategies integrate high-level Islamic ethical guidelines with necessary industrial and operational reforms (Khuluq, 2024).

a. **Mitigation of Air Pollution through Corporate *Ta'awun* (Cooperation)**

To address the severe atmospheric pollution that causes respiratory illnesses and degrades living conditions in Lampoko Village, plant operators must prioritize the Islamic theological mandate to prevent harm (Qur'an, Al-A'raf: 56) (Latifah & Marhayuni, 2023). This necessitates immediate capital investment to upgrade to cleaner technologies, such as advanced electrostatic precipitators, highly efficient water-spray systems for coal stockpiles, and comprehensive flue-gas desulfurization systems (Gingerich et al., 2018). Furthermore, internal corporate governance must reflect the Prophetic tradition: "the relationship between one believer and another is like that of a building, each part strengthening the other" (Muslim No. 4684) (Kastel, 2011); (Ali et al., 2024). In practice, this requires PLTU Barru to synchronize its internal mechanical metrics (such as the "Asset Wellness" monitored on its internal PDM dashboard) with external community health metrics. Moving beyond mere mechanical and economic efficiency, the corporation must embrace a genuine, Sharia-compliant ecological responsibility that views the surrounding community not as an externality, but as an integral part of its operational ecosystem (Sovacool & Dworkin, 2015); (El-Sherbini et al., 2023).

b. Mitigation of Water Contamination and Resource Sanctity

The contamination of agricultural irrigation and coastal waters severely violates the sanctity of water in Islam, a resource explicitly protected by the Prophet Muhammad, who strictly prohibited defiling stagnant or flowing water bodies (Narrated by Muslim) (Alvi et al., 2024). To eliminate the *mafsadah* (harm) of soil acidification and thermal marine pollution, operators must transition toward implementing advanced closed-loop wastewater treatment systems (Al-Khatib & AlHanaktah, 2025). Thermal effluents must be strictly recycled and cooled to ambient natural temperatures before any environmental discharge to prevent the further destruction of marine habitats and the subsequent collapse of the local fishing economy (Parul et al., 2025). At the policy level, local governments must impose stricter regulatory oversight of industrial discharges (Jadeja & Jain, 2022). This secular regulation should be morally reinforced by leveraging fatwas from local religious authorities (such as the MUI), elevating water

conservation from a mere legal requirement to a sacred religious obligation (e Nayab, 2025).

c. **Mitigation of Biodiversity Loss and Multi-Stakeholder Governance**

To counteract the alarming decline in fish populations and the failure of past mangrove reforestation efforts, operators must initiate scientifically guided, Sharia-compliant habitat restoration projects (Halimanjaya et al., 2022). These initiatives must reflect the deep Qur'anic view (Al-An'am: 38) that all non-human creatures exist as interconnected communities deserving protection and respect (Semida, 2024); (Citaningati & Alfianto, 2024). Future reforestation must first address underlying water toxicity to ensure the survival of planted mangroves (Uddin et al., 2024). Finally, to ensure long-term operational accountability, PLTU Barru and the regional government must establish a continuous, multi-stakeholder governance framework that involves corporate engineers, environmental NGOs, local community representatives (farmers and fishermen), and Islamic religious scholars (Iskandar & Sofuoğlu, 2025). This institutional collaboration, deeply rooted in the Islamic socio-ethical value of *ta'awun* (cooperation in goodness), will ensure that future environmental audits are regularly evaluated not solely against flexible state regulations, but against the unyielding ethical benchmarks of *hifz al-bi'ah* (protection of environment) and *maslahah* (public welfare) (Mallongi et al., 2025)

Conclusion

This study demonstrates that the operation of PLTU Barru has generated significant environmental degradation that is inconsistent with the principles of Islamic environmental fiqh, particularly *hifz al-bi'ah* (environmental protection), *maslahah* (public welfare), and the prevention of *mafsadah* (harm). By integrating empirical environmental evidence with Islamic legal principles, this research contributes to the growing discourse on Sharia-based environmental governance, showing that ecological accountability is not only a regulatory obligation but also a religious and ethical responsibility rooted in the concept of *khalifah fil ardh*. The findings highlight the need to embed Islamic values into environmental management through practical measures, including cleaner emission technologies, advanced wastewater treatment systems, habitat restoration, regular environmental audits, and collaborative governance based on the principle of *ta'awun*. These recommendations provide a practical framework for policymakers and PLTU operators to balance national energy demands with ecological sustainability while strengthening public accountability in Muslim-majority contexts. Although this study is limited to the environmental impacts of PLTU Barru, it offers a conceptual foundation for applying Islamic environmental jurisprudence to industrial

governance. Future research is encouraged to examine similar models across different industrial sectors and regions to further develop Sharia-informed approaches to sustainable development and environmental justice.

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