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The Impact of Implementing Sustainability Accounting Principles on the Effectiveness of Zakat Funds Utilization in Poverty Alleviation: A Modeling Approach Using Hidden Markov Models

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Abstract
This study examines whether sustainability accounting practices enhance the efficiency of Zakat in reducing poverty and advancing Sustainable Development Goal 1: "End poverty in all its forms everywhere." A semi-empirical Hidden Markov Model (HMM) is proposed to analyze the dynamic interactions among the integration of sustainability accounting practices (ISAP), institutional efficiency, and welfare outcomes. Panel data from nine Indonesian Zakat institutions (LAZs), collected between 2021 and 2023, are utilized to identify latent efficiency states (low, medium, high) and to examine whether variations in ISAP levels influence efficiency transitions over time. The findings indicate that most LAZs operate in low- to medium-efficiency states. Higher ISAP levels are associated with a greater likelihood of transitioning to higher-efficiency states, underscoring the significant role of sustainability accounting in organizational development. Nevertheless, sustaining high efficiency is challenging due to external shocks and changes in governance. The results suggest that ISAP functions not only as a reporting mechanism but also as a structural driver of organizational change and transformation. This perspective aligns with distortion theory, which links poverty reduction to substantive political reform. The study strengthens the relationship between sustainable accounting and Islamic social finance, adding to the accounting and development literature by showing how religious organizations employ data-driven governance to boost their social and economic impact through Zakat disbursement. These insights are directly relevant to policymakers, regulators, and practitioners seeking to strengthen institutional resilience and develop effective poverty-reduction strategies.
Keywords: Zakat, sustainability accounting, poverty alleviation, Hidden Markov Models, Sustainable Development Goal 1 (SDG 1), Islamic philanthropy.
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1.Introduction

Zakat, the third pillar of Islam, accelerates poverty reduction and promotes socio-economic equality by mandating the transfer of wealth from individuals with surplus resources (muzakki) to those in need (mustahiq) within society (Mawardi et al., 2023; Hunjra et al., 2024). Rooted in Islamic finance principles, Zakat plays a critical role in fostering community welfare, economic stability, and support for the underprivileged (Handayani, 2024). Recent studies indicate that, when effectively managed, Zakat can address urgent social challenges such as poverty, hunger, and inequality, while also contributing to sustainable development (Tok et al., 2022; Pericoli, 2023; Alhashmi, 2024; Handayani, 2024; Murcitaningrum & Machsun, 2024; Daud & Wahid, 725). To achieve substantial impact, Zakat fund management should integrate both traditional and contemporary management practices and incorporate sustainability principles (Hamid, 2023; Erni et al., 2024). Efficient Zakat administration requires comprehensive planning, transparency, and oversight to ensure funds are allocated in accordance with Islamic principles and societal requirements (Sadallah & Abdul-Jabbar, 2022). The effectiveness of Zakat distribution is enhanced when the public is well-informed about their obligations and the underlying rationale for compliance (Ashfahany & Nur Ishlahudin, 2023). The presence of credible and skilled amil (Zakat administrators) is vital for reinforcing public trust in Zakat institutions (Nasution et al., 2023; Owoyemi, 2020). Collectively, these components constitute a robust Zakat management framework that advances overall socio-economic well-being (Muhammad, 2024; Judijanto, 2024).

In Indonesia, organizations authorized to collect, manage, and distribute Zakat funds are known as Lembaga Amil Zakat (LAZ). These institutions fulfill the obligations of muzakki and address social justice for mustahiq (Bahri et al., 2021; Tulab et al., 2024). Despite their mandate, inefficiencies persist. Wasteful investments, resource misallocation, and inadequate planning lead to suboptimal fund distribution. Zakat management should prioritize efficiency by reducing implementation and operational costs and improving resource use. Combined

with effective outcome measurement tools, these strategies can optimize resource allocation and restore public trust (Ashfahany & Nur Ishlahudin, 2023). Failing to address these priorities results in higher overhead costs and unmet distribution targets, which diminishes Zakat's impact and erodes confidence in its effectiveness (Rizki, 2019; Ashfahany & Nur Ishlahudin, 2023; Mohamad & Sori, 2023).

Sustainability accounting provides a systematic approach to efficiency challenges. As a specialized branch of financial accounting (Alsarayrah et al., 2024), it prioritizes transparency in financial and non-financial disclosures, especially regarding environmental, social, and governance (ESG) performance (Jankalová & Jankal, 2024; Uglava, 2024). Integrating sustainability indicators into financial reports enhances transparency and accountability (Ozili, 2021) and enables stakeholders to understand a firm's environmental and social outcomes. This approach is anchored in sustainable accounting principles, such as the Triple Bottom Line (TBL), which assesses social, environmental, and economic performance and aligns with Zakat institutions' objectives in advancing sustainable development (Jankalová & Jankal, 2024). Stakeholder engagement and adopting standardized sustainability reporting frameworks, such as the Global Reporting Initiative (GRI), further support consistency and comparability, allowing organizations to benchmark their practices against international standards (Uglava, 2024; Dimitropoulos, 2024).

This study investigates how integrating sustainability accounting practices (ISAP) within Zakat management institutions affects organizational efficiency and social welfare in Indonesian communities. ISAP integration is expected to help Zakat institutions implement a system that emphasizes accountability, transparency, and responsible financial management through structured operational reporting at a cost-effective rate (Adewale et al., 2021; Fakdawer, 2024). Implementing ISAP addresses challenges such as high operational costs and inefficient fund allocation, enabling more effective use of Zakat in line with Shari'a principles (Ermawati & Suhardianto, 2024). To analyze the dynamic relationship between ISAP and Zakat efficiency, Hidden Markov Models (HMMs) are used to examine transitions in Zakat efficiency over time and provide insights into how sustainability accounting practices influence the flow and use of Zakat contributions. This approach accommodates operational uncertainties and advances understanding of how ISAP can enhance Zakat's role in poverty alleviation, marking a significant development in strategic Zakat management.

Indonesia is selected as the research context because of its distinctive socio-economic environment, cultural approach to Zakat, and its position as the country with the largest Muslim population (Erni et al., 2024). The country has been recognized as the most altruistic globally, leading the World Giving Index for six consecutive years with a score of 68% (Charities Aid Foundation, 2023). The Indonesian government has institutionalized Zakat as an instrument for poverty eradication through Law Number 23 of 2011, thereby emphasizing its role in social welfare. Socio-economic inequality and the predominance of consumptive Zakat distribution are critical factors in evaluating the effectiveness of Zakat for poverty alleviation and community welfare (Jauhari & Wijaya, 2023; Judijanto et al., 2024; Wasalmi, 2024). Furthermore, the requirement for sustainable development reporting, as stipulated in the Indonesian Financial Services Authority Regulation 51/2017 (Mutiha, 2023), underscores the importance of corporate governance and organizational transparency—factors that make Indonesia an appropriate setting for examining Zakat management practices.

This study is driven by a need to improve governance, transparency, and accountability in Zakat institutions, with the aim of enhancing their effectiveness in poverty alleviation (Qutaiba et al., 2024; Rasyid, 2025). These improvements are fundamental to Islamic social finance and directly support a UN SDG pillar (Tok et al., 2022). Limited adoption of sustainability accounting impedes governance, erodes trust, and reduces resource efficiency (Al-Faruq et al., 2025; Baehaqi et al., 2025). Using the ISAP-conditioned HMM framework, we assess dynamic performance by identifying changes over time and examining how adopting sustainability practices influences institutional dynamics and poverty reduction. This study responds to calls for empirical, dynamic, theory-driven research to evaluate whether sustainability accounting can enhance the performance of Zakat institutions and amplify Zakat's economic and social impact (Schaltegger et al., 2022; Garcia-Torea et al., 2023; Khan, 2024). This research is timely and essential, providing policymakers, practitioners, and scholars with insights on incorporating sustainability-driven governance reforms to make Zakat a more effective and resilient tool against poverty.

This work contributes to the literature on Islamic social finance, sustainability accounting, and poverty alleviation in several ways. First, it develops a new methodological approach using semi-empirical HMMs to investigate how Zakat institutions' efficiency levels vary over time across ISAP levels. This goes beyond traditional static efficiency measures, such as DEA or Tobit regression, by modeling unobserved transitions that describe how Zakat institutions evolve in response to changes in sustainability reporting. The research also shows that sustainability-focused accounting and reporting can increase corporate efficiency, build trust in society, and ensure wealth is distributed. Third, it closes the operational and conceptual gap between Islamic philanthropy and sustainable development by incorporating sustainability accounting into the Zakat management model. It also shows how more effective governance mechanisms enhance Zakat's capacity for long-term poverty mitigation and social justice.

The innovation of this study is in integrating sustainability accounting with dynamic modeling of institutional performance in Islamic social finance. This research is the first to apply HMMs to quantify both the probabilistic and temporal effects of ISAP on the performance of Zakat institutions. By viewing Zakat management effectiveness as a dynamic process shaped by sustainability accounting, the study moves beyond traditional cross-sectional analyses. The findings provide empirical evidence that effective governance and accountability improve welfare outcomes, advancing sustainability and development economics. The study also introduces a replicable framework for evaluating the sustainability of spiritually oriented institutions in emerging markets.

The study is organized as follows: Section 2 presents a literature review on Zakat as a socio-economic instrument for poverty alleviation and sustainable development. Section 3 explains the methodology, analyzing the dynamic relationships among Zakat Potential, ISAP, and poverty alleviation using HMMs to detect changes in efficiency over time. Section 4 outlines the primary findings, Section 5 examines their implications, and Section 6 discusses the significance of these findings for research. Section 7 concludes with a summary and acknowledgment of limitations.

2. Literature Review

Poverty is defined as a condition of extreme deprivation in which individuals are unable to meet basic human needs, including food, safe drinking water, sanitation, health, shelter, education, and access to information (Amir-ud-Din et al., 2018; Abdullah, 2022; Vegirawati et al., 2023). In addition to material deprivation, poverty is associated with adverse outcomes such as poor physical health, increased violence, and higher crime rates (Ridley et al., 2020). Islamic doctrine highlights the societal and economic consequences of poverty, noting that it may drive individuals to engage in theft, fraud, prostitution, drug abuse, murder, or even suicide to fulfill their needs (Manshor et al., 2020). Addressing poverty requires a comprehensive approach that incorporates both individual behavioral change and systemic reform (Salamova et al., 2023). Multiple theoretical frameworks have been proposed to explain the causes of poverty and inform potential interventions. The Theory of Individual Deficiencies attributes poverty to a lack of personal motivation, emphasizing self-reliance and economic discipline as pathways out of poverty (Bradshaw, 2007). The Theory of Cultural Belief Systems posits that cultural structures perpetuate poverty and advocates educational interventions to enhance financial literacy and savings (Bradshaw, 2007). In contrast, the theory of systemic inequality, also known as the Theory of Economic, Political, and Social Distortions, attributes poverty primarily to structural factors. This perspective emphasizes the importance of policy reform, robust welfare institutions, community development, and the implementation of minimum wages and social protections (Bradshaw, 2007). The Theory of Geographical Differences underscores disparities in economic opportunities and advocates for supporting local industries and infrastructure to promote self-reliant communities (Addae-Korankye, 2019a). Furthermore, the Cyclical Theory of Poverty associates poverty with external shocks, such as natural disasters and economic crises, and recommends policies that provide education and job training to enable individuals to adapt to these cycles (Addae-Korankye, 2019; Vegiarwati et al., 2023).

Zakat is one of the five pillars of Islam, serving as a crucial socio-economic tool for wealth redistribution and community welfare improvement (Shah & Sadiq, 2014). Zakat provides a means to address poverty and

promote equity between the rich and the poor, obligating individuals to allocate a portion of their wealth to eligible community members (Asnaf), and it should be given sincerely and with blessings. The literature review highlights several studies demonstrating zakat's significant long-term value in enhancing economic development and empowerment in these communities (Rizvi, K., 2008). For example, Almousa et al. (2021) investigated the influence of zakat on sustainable development among 440 recipients in Malaysia, using structural equation modeling. The study found that zakat has a significant effect on sustainable development, specifically in its economic, social, and environmental aspects. The authors proposed strengthening zakat's alignment with SDG practices, especially in Malaysia. This approach should move toward a paradigm where capital can be granted, donated, loaned, or used in vocational models, enabling zakat recipients to generate independent income (Sarif et al., 2024). In Bangladesh, various zakat funds have supported entrepreneurship scholarships and provided rickshaws, sewing machines, farm implements, and cattle, thereby boosting wages and economic entry, particularly for women entrepreneurs (Hoque et al., 2015; Anis & Kassim, 2016). As a result, zakat-supported programs in Bangladesh have played a major role in promoting sustainable livelihoods and breaking the poverty trap among women (Hoque et al., 2015).

Efficient Zakat management is an effective mechanism for wealth redistribution and poverty alleviation (Judijanto et al., 2025). Optimizing Zakat administration is essential to maximize its socio-economic impact (BAZNAS, 2024). Effective financial management enables timely collection and distribution, ensuring funds reach beneficiaries promptly and contribute to poverty reduction. Strong governance enhances transparency, builds public trust, and encourages greater contributions from muzakki (Khotijah & Setiadi, 2023; Owoyemi, 2020). Furthermore, Zakat-supported empowerment initiatives, such as providing business capital to mustahik, facilitate sustainable economic activity and improve living standards (Hamid & Damirah, 2023; Herianingrum et al., 2024). In addition, Zakat also contributes to human capital development by enabling disadvantaged individuals to acquire skills and increase productivity, supporting long-term poverty reduction (Alhashmi, 2024). However, challenges such as limited public awareness and insufficient financial education must be addressed to fully realize Zakat's potential for poverty alleviation. For example, Vegirawati et al. (2023) examined the disbursement of alms by 14 national Zakat institutions in Indonesia, categorizing programs into basic needs, education, and economic empowerment based on annual reports and institutional websites. The results indicate that while Zakat addresses immediate needs and education, its influence on long-term sectors such as regional development remains constrained by financial limitations. The study recommends enhancing Zakat management and increasing state support to strengthen poverty reduction initiatives.

These limitations highlight that institutional governance and operational efficiency are critical determinants of Zakat effectiveness. Transparent operations and robust governance frameworks build trust among muzakki and ensure equitable fund distribution. Expanding on these findings, Sawmar and Mohammed (2021) introduced a governance model linking board characteristics, procedural justice, stakeholder management, and transparency to Zakat compliance. Trust was identified as a significant moderating factor, especially in the regulated environments of Saudi Arabia and Malaysia, where state oversight strengthens institutional accountability. Building on governance and efficiency themes, Ismail and Masturah (2014) utilized a two-stage DEA model to assess the efficiency of Zakat institutions in Selangor, Malaysia, revealing that while collection efficiency improved over time, distribution efficiency remained inconsistent, indicating ongoing challenges in resource allocation. Similarly, Ashfahany and Nur Ishlahudin (2023) extended this analysis to Indonesia, evaluating Zakat efficiency in Banyumas Regency during 2018 and 2020. Full efficiency was achieved by 2020, although previous years faced operational deficits due to high service costs and limited funding. Lastly, Riani et al. (2024) compared Zakat institutions in Malaysia and Indonesia, identifying significant differences in enforcement arising from varying governance practices and resource management. The study concluded that high-performing organizations demonstrated excellence in transparency, fund efficiency, and stakeholder engagement, offering valuable insights for underperforming institutions.

Zakat's alignment with global development objectives, particularly the UN SDGs, has garnered considerable attention. Hoque et al. (2023) explored integrating Zakat and corporate social responsibility (CSR) as a strategic

approach to address socio-economic challenges while aligning with the SDGs, particularly No Poverty (1) and Zero Hunger (2). They revealed how combining Zakat with CSR enables entrepreneurs to fulfill both religious and social responsibilities. This shariah-compliant framework promotes sustainability and social equity, offering a practical model for Muslim-majority countries. Ma sum Billah (2016) examined Zakat's role in fostering eco-sustainable communities, presenting it as an alternative to modern social security systems to address poverty and inequality. Through analysis of Islamic texts and the socio-economic applications of Zakat, the study highlights its potential to provide financial aid while promoting wealth redistribution, reducing inequality, and encouraging sustainability. Integrating Zakat into broader socio-economic frameworks is emphasized as key to eradicating poverty, promoting sustainable development, and advancing community welfare. Sulistyowati (2023) demonstrated how Zakat principles align with SDG targets, including eradicating poverty (SDG 1), reducing hunger (SDG 2), promoting quality education (SDG 4), and fostering economic justice (SDG 10). In Indonesia, Said et al. (2023) used qualitative interviews and quantitative analyses to assess Zakat s contributions to the SDGs, revealing modest statistical correlations with poverty reduction, hunger alleviation, and educational quality. However, the study emphasized qualitative benefits, including enhanced intellectual development, psychological well-being, and self-reliance, underscoring Zakat s multidimensional impact on human development. Nurhasanah et al. (2023) proposed a sustainable Zakat empowerment model for productive businesses in West Java, Indonesia, aimed at improving the welfare of mustahiq through innovative utilization. Using a qualitative, analytical descriptive method, the study gathered data through focus group discussions, interviews, and document reviews. Findings highlighted that productive Zakat includes financial and material assistance, skill development, and mentoring. Effective implementation integrates Zakat with Infaq, Waqf, professional management, and holistic development, fostering economic independence and contributing to poverty alleviation and sustainable community development. Building on this, Erni et al. (2024) investigated the relationship between Zakat management practices and sustainable development in Indonesia. Their work focused specifically on institutional capacity, transparency, collection efficiency, and distribution effectiveness. To analyze these factors, the study used structural equation modelling with partial least squares (SEM-PLS) on data from 170 participants to examine key interactions. The findings revealed significant links between these factors and sustainable development outcomes. Based on these results, the research provided practical recommendations for Zakat organizations and policymakers, emphasizing transparency and efficient distribution to enhance socio-economic benefits.

Integrating new financial technologies and online platforms into Zakat practices has become essential to enhance their effectiveness and align them with global development objectives. The adoption of digital systems in Zakat management streamlines operational processes, facilitates donor participation, and improves fund management, thereby increasing the overall impact on poverty reduction (Santoso, 2019; Rafiki et al., 2024). Alfiani & Akbar, (2020) argued that fintech solutions, such as digital payment systems and data-driven fund management, significantly enhance transparency, accountability, and operational efficiency in Zakat systems. They emphasized the importance of aligning Zakat distribution mechanisms with SDGs by linking programs to specific targets, ensuring efficient management, and leveraging fintech to improve transparency. This integrated approach not only promotes social and economic justice but also upholds sustainability accounting principles, ensuring that Zakat systems contribute effectively to sustainable development. Alshehadeh et al., (2024) highlighted the role of digital Zakat platforms in promoting corporate sustainability by streamlining operations and aligning Zakat practices with global sustainability goals. Similarly, Riani et al., (2024) assessed the efficiency and stability of Zakat institutions in Malaysia and Indonesia using DEA Window Analysis for the period 2016 to 2020. The analysis included 14 institutions and found an average efficiency rate of 78%. The identified inefficiencies were primarily due to suboptimal allocation of funds and elevated management costs. Top-performing institutions exhibited both high efficiency and stability, whereas others required improvements in resource management and transparency. The study recommended enhancing Zakat operations through technological adoption and more effective distribution of funds.

Taken together, these studies underscore Zakat's transformative potential for poverty alleviation and sustainable development. By addressing immediate needs and fostering long-term empowerment through skill development,

microfinance, and entrepreneurial support, Zakat has shown its capacity to promote economic independence and social equity. Its alignment with global development objectives, especially the UN SDGs, underscores its relevance for tackling critical socio-economic challenges, such as poverty eradication (SDG 1), hunger reduction (SDG 2), and economic justice (SDG 10).

Despite these contributions, significant gaps remain in understanding the dynamic and multidimensional impact of Zakat. Most studies use static models that do not capture how Zakat effectiveness changes over time or across contexts, and current evaluations often focus on immediate outcomes, such as income generation and education support, without examining transitions between efficiency states or the factors driving these changes. This narrow view leaves questions about the long-term sustainability of Zakat-driven programs, optimal governance approaches, and integration into broader sustainability frameworks. While trust and transparency are recognized as critical for donor participation and institutional credibility (Owoyemi, 2020), little research has explored how these factors evolve and affect Zakat systems. To address these gaps, this study aims to: (1) examine the dynamics of Zakat management efficiency over time; (2) assess the impact of ISAP on Zakat management institutions in Indonesia; and (3) analyze the effect of these dynamics on the social welfare of local communities. Using HMMs, the research provides insight into how sustainability-oriented reporting influences institutional transitions among efficiency states, integrating sustainability accounting principles into Zakat management. This approach offers a multidimensional perspective encompassing economic, social, and environmental metrics, enhancing transparency and accountability, and aligning Zakat systems with global sustainability goals.

3.Methods

3.1 Sampling and Data Sources

This study covers all zakat institutions operating in Indonesia. It employs a purposive sampling approach, selecting only LAZs that publish detailed annual reports. These LAZs provided the Index of Zakat Management (IZN) and Impact of Zakat scores for 2021-2023. This period was chosen as it encompasses the period during which the sustainability reporting requirements of Indonesian OJK Regulation No. 51/2017 were in effect (Mutiha, 2023). Out of all registered LAZs, only nine satisfied these criteria, yielding 27 LAZ-year observations. Although the IZN framework applies to all Zakat institutions, including BAZNAS at the national, provincial, and regency/city levels, as well as LAZs (BAZNAS: Nasional, 2024), this study concentrates on LAZs for two primary reasons. Firstly, most Provincial and Regency/City BAZNAS do not publish sufficiently detailed and consistent annual reports, which creates a significant data constraint. Secondly, the IZN score for BAZNAS assesses broader regional Zakat management performance, whereas the LAZs' IZN scores focus on institutional performance, emphasizing internal governance and Zakat's role in reducing poverty (BAZNAS: Nasional, 2024). This focus aligns with our study's aim to evaluate institutional accountability and sustainability practices. We collected secondary data from the official annual reports of the LAZs, the "National Zakat Index," and the "Study on the Impact of Zakat by Amil Zakat Institutions" documents, published by Puskas BAZNAS, the Center of Strategic Studies affiliated with BAZNAS.

3.2 Model Specification

A semi-empirical HMM is employed to analyze the dynamics of Zakat management efficiency (ZME) and its relationship with ISAP and welfare improvement (WI). HMMs are well-suited for time-series data with latent structures, enabling the modeling of unobserved efficiency states alongside observed performance indicators (Ryou et al., 2020; Wu, 2021). By leveraging Markov chain properties, where each state depends solely on its immediate predecessor, the HMM uncovers hidden patterns in zakat efficiency and its association with ISAP. HMMs are widely used in economics and finance to capture regime-switching and temporal patterns (Yang & Jiang, 2014). In this context, the HMM framework facilitates examination of how LAZs transition between efficiency states and how ISAP influences these transitions, thereby affecting poverty alleviation.

The semi-empirical HMM is chosen because it offers the most reliable structure for the data characteristics and the study's purpose. First, the dataset is small, making full parametric estimation prone to overfitting and unstable likelihood optimization; the semi-empirical approach avoids these issues by requiring fewer

distributional assumptions while still capturing meaningful state dynamics (Kim et al., 2022; Song & Zhao, 2024) . Second, modeling state transitions as a direct function of ISAP intensity allows the analysis to test the study's core theoretical mechanism specifically, that accountability governance influences efficiency paths. This conditional structure cannot be reliably identified using a purely parametric HMM with limited observations. Third, employing a standard, non-parametric emission matrix maintains transparency and aligns with theoretical expectations by ensuring observed efficiency indicators map clearly and consistently onto the latent efficiency states, as supported in institutional performance modeling (Van Den Bosch, 2017). Collectively, these considerations make the semi-empirical HMM the most methodologically sound and theoretically justified choice for the research design.

Hidden states (S): Selecting the optimal number of latent states is essential when defining an HMM (Ossai & Madukaife, 2022; Rotous et al., 2024). This study classifies hidden states as efficiency levels for LAZs using a three-state model: Low, Medium, and High, grounded in theoretical, interpretive, and empirical rationale. Theoretically, efficiency in zakat institutions exists on a spectrum rather than as a binary division, consistent with studies in Islamic social finance that recognize three main performance clusters: underperforming, transitional, and efficient institutions (Abdullah & Suhaimi, 2020; Ascarya, 2021). Regulatory standards and benchmarking also classify zakat institutions as below standards, meeting standards, or exemplary performers (Elmaghrabi et al., 2020), further substantiating the three-state model as an informed link between theory and institutional practice. From an interpretive perspective, a two-state model oversimplifies by omitting transitional institutions, whereas models with four or more states often yield latent classes that lack practical meaning (Pohle et al., 2017), thereby reducing their utility for practitioners and policymakers. The three-state model, therefore, balances simplicity and policy relevance, offering clear, actionable categories. Empirically, this specification is validated through model comparisons across two to five states using the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). While these criteria are most reliable with larger samples (Cavanaugh & Neath, 2019), they provide indicative evidence in this context. Both criteria indicate that the three-state specification offers the best balance between model fit and simplicity, as summarized in Table 1.

Table 1. Model Selection Based on AIC and BIC

Number of States	Log-Likelihood	AIC	BIC
2	-32.45	72.90	75.30
3	-25.34	64.68	68.55
4	-23.11	66.22	71.56
5	-22.45	68.90	75.71

Source: *Output from R statistical software compiled by the author (2025)*

AIC and BIC values are lowest at three states (AIC = 64.68; BIC = 68.55), suggesting that this model best combines goodness-of-fit and parsimony. While additional states improve the log-likelihood, they do not significantly enhance the fit and instead introduce unnecessary complexity. Therefore, the three-state model is the most suitable representation of the data.

Observations (O):): The observable process Ot is a combined indicator of ZME and WI, discretized into low, medium, and high levels. The HMM models their joint effect instead of treating them separately. This approach reflects both theoretical and practical considerations: ISAP influences ZME, which in turn mediates effects on WI, but limited data make a multivariate model unstable. Additionally, Indonesian indices such as the National Zakat Index and BAZNAS welfare indices are composites of operational efficiency and welfare outcomes, making a joint signal more closely aligned with practice (Alwateer et al., 2023). Thus, the HMM captures the combined dynamics of efficiency and welfare.

Model parameters: The model includes three key components: {π, P(c), B}, offering a comprehensive framework for analysis.

Initial state distribution: It specifies the starting probability of being in each hidden state before any observations are made (Yusoff et al., 2014). It provides the baseline conditions from which the model begins to

trace state evolution, ensuring that the dynamics are not biased by arbitrary assumptions (Montanez et al., 2015). In this study, the initial state distribution indicates the probability that a LAZ starts the observation period in a low-, medium-, or high-efficiency state. This is important because LAZs may not all commence at the same level of performance: some are already well-established and efficient, whereas others face structural or operational constraints. By explicitly modeling these starting conditions, the HMM accounts for heterogeneity from the outset and avoids over-attributing early performance variations solely to ISAP effects. In practical terms, the initial distribution establishes the foundational efficiency paths of LAZs, providing a realistic baseline for assessing how ISAP-conditioned transitions subsequently lead to welfare gains or losses. The initial state probabilities are specified as follows:

$$\pi = (\pi_{Low}, \pi_{Medium}, \pi_{High}), \pi_j = P(S_1 = j) \quad (1)$$

Where:
S1 = the initial hidden state.
j = the hidden state for which the initial probability is calculated (j = 1 for Low Efficiency State; j = 2 for Medium Efficiency State; j = 3 for High Efficiency State).
πj = the initial probability that the system starts in state j.

Transition Probability Matrices: Unlike basic HMMs, this study conditions state transitions on concurrent ISAP categories. Consequently, the latent efficiency states of LAZs are dependent on both the preceding state and the ISAP condition, which is categorized as Low, Medium, or High. Three separate transition matrices are estimated for each ISAP condition. This method reflects the hypothesized impact of sustainability accounting practices on efficiency dynamics and assesses whether stronger ISAP increases the likelihood of remaining in or transitioning to higher efficiency states. The model structure reflects both the latent nature of institutional efficiency and ISAP's role in shaping state transitions. Conditioning the dynamics explicitly on ISAP enables the HMM to provide a probabilistic assessment of the impact of sustainability accounting practices on welfare outcomes. The kernel transition for ISAP is defined as follows:

$$P(\mu) = (P_{ij}^{(\mu)}), (P_{ij}^{(\mu)}) = P(S_{t+1} = j \mid S_t = i, ISAP_t = \mu) \quad (2)$$

Where:
St = the hidden state of LAZ efficiency at time t.
St+1 = the hidden state of LAZ efficiency at time (t+1).
ij = possible hidden states of LAZ efficiency, specifically low, medium, and high.
μ = the transition conditioned on the ISAP level at time. The ISAP level can be low, medium, or high.
Pij(μ) = the conditional probability that a LAZ in state i at period t transitions to state j at period (t+1), given its ISAP level μ.

Emission Probabilities: The emission matrix specifies the probability of observing each LAZ efficiency level (low, medium, high) given a particular hidden efficiency state. The combination of emission and transition matrices allows the model to distinguish between two key aspects: the manifestation of latent efficiency in observed efficiency signals and the evolution of efficiency trajectories conditional on ISAP power. This dual structure supports both the explanation of historical outcomes and the prediction of future trends. The observation mechanism is defined by the emission matrix as follows:

$$B = (b_j(o)), b_j(o) = P(O_t = o \mid S_t = j) \quad (3)$$

Where:
B = the emission matrix, where rows represent hidden states (Low, Medium, High); columns represent observation categories (low, medium, high).
O_t = the observed variable, representing the joint ZME and WI category.
S_t = the latent efficiency state of a LAZ.
j = the possible hidden states (Low, Medium, High), each associated with a different level of LAZ efficiency.
$b_j(o)$ = the emission probability, which is the likelihood of observing a specific performance category $O_t=o$ (for instance, low, medium, or high observed efficiency) given that the institution is in the hidden efficiency state $S_t=j$ (Low, Medium, or High) at time t.

Forward algorithm: The Forward algorithm computes scaled forward probabilities $\alpha_{j,t}$ (Titsias et al., 2016) for any LAZ-year sequence, indicating the likelihood of LAZ being in state j (Low, Medium, or High) at time t,

based on observations up to that point. Each $\alpha_{j,t}$ is divided by ct, a scaling constant at time t, to prevent the values from declining excessively and to maintain numerical accuracy (Li & Yu, 2015). After completing all steps up to T, the overall log-likelihood of observing the sequence, given the model, is computed as follows:

$$\log P(O \mid \lambda) = \sum_{t=1}^{T} \log c_t \qquad (4)$$

Where:
P(O|λ) = the overall likelihood of encountering the sequence Ogiven the model λ = (π, P,B).
O = the sequence of observed outcomes.
λ = the HMM parameters, including initial state probabilities (π), transition matrix (P), and emission matrix (B).
ct = the constant of scaling at time t.

This log-likelihood value shows the model's ability to explain the observed data. A higher log-likelihood indicates a better fit of the model to the data (Chiu & Rush, 2020; Bansal & Zhou, 2024). In practice, forward probabilities help identify periods when institutions are likely to be in transitional performance states, times when they are most open to change. These periods are important opportunities for interventions, such as ISAP strengthening, to support institutions in moving toward sustained high performance.

Viterbi algorithm: The Viterbi algorithm was employed to determine the most probable sequence of hidden performance states (Low, Medium, or High) that best characterizes each LAZ-year efficiency sequence. Unlike the Forward algorithm, which evaluates all possible paths to determine the total probability of the observed data, the Viterbi algorithm identifies only the single most probable sequence of hidden states (Grinberg & Perkins, 2015; Titsias et al., 2016). The fundamental recursive step of the Viterbi algorithm is as follows:

$$\partial_t(j) = \max_i \left[\partial_{t-1}(i)\, a_{ij}^{(ISAP_t)} \right] b_j(o_t) \qquad (5)$$

Where:
$\partial_t(j)$ = the probability associated with the most likely path ending in state $j$at time t,
$a_{ij}^{(ISAP_t)}$ = the ISAP-conditioned transition probability from state i to j
$b_j(o_t)$ = the likelihood of observing outcome $o_t$given state j.
At each step, the algorithm selects the transition with the highest probability, and these choices are aggregated to reconstruct the most likely sequence of states after all observations are processed (Caliebe, 2006). This results in a timeline of the most probable LZA performance states over the study period. In conjunction with the Forward algorithm results, the Viterbi path highlights periods when LAZs were likely in transitional states, providing strategic insights into the optimal timing for ISAP interventions to sustain high performance.

3.3 Measurement of Variables
3.3.1.Dependent Variable: Poverty alleviation
Poverty alleviation in this study is assessed using the BAZNAS Welfare Index (BWI). The BWI is an empirically validated, multidimensional framework that integrates Islamic welfare economics principles with contemporary development indicators, offering a broader perspective than traditional income-based poverty metrics (Beik & Arsyianti, 2016; Puskas BAZNAS, 2024). It defines welfare as both material prosperity and spiritual fulfillment (Beik & Arsyianti, 2016; Choiriyah et al., 2020). This approach addresses gaps in secular measures, which often overlook holistic well-being in Islamic contexts (Beik & Arsyianti, 2016; Hilmiyah et al., 2018). The index includes three interconnected components to comprehensively evaluate Zakat's impact. The first is the CIBEST Index, which assesses both spiritual and material well-being. CIBEST uses a quadrant system to classify households by their ability to meet material and spiritual needs (Beik & Arsyianti, 2016; Fathoni et al., 2021; Jaenudin & Hamdan, 2022; Herlita & Khaliq, 2021; Hilmiyah et al., 2018). The second component is the modified Human Development Index (HDI). It covers longevity and health, knowledge and education, and decent living standards, capturing Zakat's effect on human capital and long-term welfare beyond immediate relief (Nurzaman, 2010; Nuraini, 2022; Puskas BAZNAS, 2024). The third, the Independence Index, examines recipients' progress toward economic self-sufficiency. It assesses three thresholds: the Poverty Line, including basic food and non-food needs; Had Kifayah, a locally set standard reflecting regional conditions and family size for Zakat eligibility; and Nisab zakat, the minimum wealth criterion distinguishing zakat payers

from recipients, highlighting Zakat's role in transforming mustahik into muzakki (Puskas BAZNAS, 2022; Puskas BAZNAS, 2024). The BWI's integration into the National Zakat Index framework, as mandated by BAZNAS' 2020-2025 Strategic Plan, ensures institutional alignment and policy relevance, making it not merely an academic measurement tool but a practical instrument for Zakat performance evaluation and strategic planning (Puskas BAZNAS, 2024). This index's theoretical foundation in Islamic welfare economics, supported by numerous studies on Indonesian Zakat institutions, makes it a suitable and comprehensive tool for assessing poverty-alleviation outcomes in Zakat-based programs. This is especially important given its unique ability to measure both immediate material relief and long-term spiritual and human development impacts, which conventional poverty measurement methods often neglect (Beik & Arsyianti, 2016; Fathoni et al., 2021; Herlita & Khaliq, 2021; Jaenudin & Hamdan, 2022; Pratama, 2023; Elvira, 2024; Puskas BAZNAS, 2024).

3.3.2.Zakat Management Efficiency (ZME)

ZME refers to the ability of zakat institutions to maximize outputs, such as effective zakat distribution and poverty alleviation, relative to inputs, including Zakat collection, administrative capacity, and operational costs. In the extensive literature, efficiency is frequently assessed using the DEA methodology (Banker et al., 1984; El Ashfahany & Ishlahudin, 2023; Riani et al., 2024). However, the DEA predominantly emphasizes quantitative relationships between inputs and outputs, often neglecting qualitative factors such as governance quality, institutional impact, and stakeholder engagement (Lu et al., 2022). To mitigate these limitations, this study utilizes the National Zakat Index (NZI), developed by the PUSKAS Center (Nurzaman et al., 2017), as a more comprehensive measure of zakat management performance. The NZI integrates macro and micro dimensions. The macro dimension assesses government and societal support for Zakat institutions through indicators like regulation, budget, database, network, and literacy. The micro dimension evaluates institutional performance, including collection, management, distribution, and reporting, as well as the socio-economic impacts on mustahik across five areas: economic, educational, health, spiritual, and independence (Hilmiyah et al., 2018). Scores range from 0 to 1, with higher scores indicating more efficient Zakat management, reflecting operational effectiveness and social impact (Zulyanto et al., 2025). Since this study focuses on LAZ efficiency, the IZN value is derived only from micro dimensions, as macro dimensions relate to government participation relevant to BAZNAS performance (Puskas BAZNAS, 2022). IZN data are secondary and are obtained from the PUSKAS BAZNAS website to ensure reliability and comparability.

3.3.3.Implementing Sustainability Accounting Principles (ISAP)

Sustainability accounting integrates environmental and social metrics with financial reporting to reflect the broader impacts of business activities (Taufiq et al., 2025). In Indonesia, the OJK oversees these principles. Indonesian Regulation No. 51/2017 mandates ESG disclosures, aligning local practices with international standards such as the GRI Standards. Both frameworks emphasize transparency regarding environmental, social, and governance issues, including emissions, labor practices, and corporate ethics (Sinulingga et al., 2025). While POJK 51/2017 provides a legal basis for sustainability reporting, the GRI Standards offer a voluntary mechanism that enhances disclosure quality and comparability. Addini et al. (2019) indicate that environmental indicators in the GRI Standards align with Indonesia's PROPER evaluation system, reflecting a convergence of global and local CSR standards. However, POJK 51/2017 applies only to financial institutions and publicly listed companies, making it less relevant for non-profit organizations. Consequently, GRI Standards are better suited to organizations like LAZs for sustainability reporting. According to OJK (2017) and GRI (2022), the GRI Standards foster transparency in governance, financial management, and social impact, which are essential for LAZs. Moreover, voluntary adoption of the GRI Standards enhances accountability in Zakat fund distribution, upholds ethical standards, and demonstrates a commitment to sustainability.

A content analysis of LAZS annual reports from 2021 to 2023 was conducted to evaluate sustainability disclosures. The study used 23 GRI disclosure items (Table 2) focusing on governance, accountability, environmental stewardship, and social responsibility, aligning with sustainability accounting principles (Taufiq et al., 2025). These items (GRI 2, 3, 200-, 300-, and 400-series) suit non-profit and Zakat organizations, emphasizing transparency, ethical fund management, and community involvement (Ningsih et al., 2023). They reflect stakeholder expectations on resource use, ethics, and sustainability, covering governance, financial distribution, community participation, policy commitments, and environmental impacts. Using these items ensures objective measurement, comparability, and alignment with international standards, reinforcing ISAP's validity and boosting empirical credibility for policy and academic purposes analysis.

Table 2. Selected GRI Disclosure Scoring Items and Assessment Criteria

GRI Code	Description	More Details for Evaluation
GRI 2-1	Organizational details	Name, legal structure, location, scale of operations
GRI 2-6	Activities and value chain	Services, programs, suppliers, and the delivery chain
GRI 2-9	Governance structure	Board composition, oversight committees
GRI 2-12	Role of the governance body in sustainability	Oversight roles related to ESG issues
GRI 2-13	Delegation of sustainability responsibilities	Assignment to staff or departments
GRI 2-22	Statement on sustainability strategy	Strategic statement from leadership (e.g., Executive Director)
GRI 2-23	Policy commitments	Human rights, anti-corruption, ethics codes
GRI 2-24	Embedding policy commitments	Integration into operations and processes
GRI 2-26	Mechanisms for reporting concerns	Whistleblowing systems, grievance mechanisms
GRI 2-29	Stakeholder engagement	Methods and frequency of engagement, feedback systems
GRI 3-1	Material topic determination process	Risk assessments, consultations, and frameworks used
GRI 3-2	List of material topics	List of ESG issues prioritized by stakeholders
GRI 3-3	Management approach	Policies, resources, and KPIs for each material topic
GRI 201-1	Economic value generated/distributed	Breakdown of income and expenditures, program spending
GRI 201-4	Financial assistance from the government	Grants, subsidies, or tax benefits
GRI 302-1	Energy consumption	Electricity/fuel use data, renewable sources
GRI 305-1	Direct GHG emissions (Scope 1)	CO_2 emissions from facilities and transport
GRI 306-2	Waste by type and disposal	Recycled vs. landfill, hazardous waste data
GRI 401-1	Employee hires and turnover	Headcount by gender, region, and age group
GRI 403-1	Health & safety management system	Presence of OHS policies and structures
GRI 404-1	Average training hours	Total hours of training per FTE employee
GRI 413-1	Local community engagement	Community dialogue, feedback, participation
GRI 414-1	Supplier social screening	% of suppliers screened for human rights or labor risks

***Source**: Compiled by the author (2025)*

Consistent with Mutiha (2023), a binary scoring system was employed to assess disclosure quality, as it allows for precise and consistent identification of the presence or absence of specific disclosure items, thereby enhancing simplicity and replicability. Each item is scored as 1 or 0. A score of 1 means the LAZ provides sufficient relevant information that aligns with the GRI item. A score of 0 means there is no mention or not enough detail to meet the GRI's intent. The ISAP score is computed by aggregating the binary scores across the 23 GRI items for each LAZ during each reporting period. A score nearing 23 signifies good ISAP performance, reflecting a strong commitment to transparency, sustainability, and regulatory compliance. To enable standardized comparisons, the ISAP score is normalized into an ISAP Index on a 0 to 100 scale using the formula:

$$ISAP\ Index = \left(\frac{ISAP\ Score}{23}\right) \times 100 \qquad (6)$$

Table 3 below delineates the metrics employed in the research.

Table 3: Summary of Study Variables

Variable	Type	Measurement	Data Source	References
Poverty Alleviation Index (BWI)	Dependent	Assessed using the BAZNAS Welfare Index (BWI), a comprehensive framework that combines the CIBEST Index, Modified Human Development Index (HDI), and Independence Index to evaluate material, spiritual, and overall human development outcomes.	Secondary data from Puskas BAZNAS	Beik & Arsyianti (2016); Puskas BAZNAS (2024)
Zakat Management Efficiency (NZI)	Independent	Assessed using the micro dimension of the National Zakat Index (NZI), which measures five areas: economic, educational, health, spiritual, and independent outcomes. NZI scores range from 0 to 1.	Secondary data from Puskas BAZNAS	Nurzaman et al. (2017); Puskas BAZNAS (2024)
Implementing Sustainability Accounting Principles (ISAP)	Independent	Assessed through content analysis of LAZs' annual reports from 2021 to 2023 using a binary scoring system, where each of the 23 GRI disclosure items was marked as either disclosed (1) or not disclosed (0). The resulting ISAP score was then converted into a standardized ISAP Index ranging from 0 to 1.	Annual reports (2021–2023), obtained from the LAZ websites	Mutiha (2023); GRI (2022)

***Source**: Compiled by the author (2025)*

4.Results

Annual LAZs' observations from 2021 to 2023 were analyzed after discretization and removal of missing data, resulting in 23 observations across 9 LAZ sequences. The next sections will present the results of the semi-empirical HMM analysis conducted in R.

4.1. Initial Distribution

The initial state output is as follows:

$$\pi - [P(S_1 - Low), P(S_1 - Medium), P(S_1 - High)] - [0.00, 0.78, 0.22]$$

It shows that at the beginning of the observation period, most LAZs were in the Medium latent performance state (77.8%), while 22.2% were in the High state. None were initially in the Low latent performance state. This result reflects the sample's characteristics, where initial-year data typically involve LAZs with at least medium performance. Although the Low state remains theoretically possible, the findings indicate that most LAZs had already achieved a basic level of administrative and operational capability at the beginning of the study period.

4.2. Emission Matrix Latent State Mapping

The estimated emission matrix B is:

$$B = \begin{bmatrix} P(low \mid Low) & P(med \mid Low) & P(high \mid Low) \\ P(low \mid Medium) & P(med \mid Medium) & P(high \mid Medium) \\ P(low \mid High) & P(med \mid High) & P(high \mid High) \end{bmatrix} = \begin{bmatrix} 0.80 & 0.15 & 0.05 \\ 0.20 & 0.60 & 0.20 \\ 0.05 & 0.25 & 0.70 \end{bmatrix}$$

These results indicate strong diagonal dominance, as each latent state is most likely to generate its corresponding observation type. The likelihoods of accurate emission were 0.70 for the High state, 0.60 for the Medium state, and 0.80 for the Low state. This pattern suggests that the joint indicator (ZME-WI) provides meaningful information about the underlying latent effectiveness. Consequently, the Viterbi-decoded sequences can be interpreted as representing distinct efficiency states rather than arbitrary statistical combinations, thereby enhancing the interpretability and internal validity of the HMM.

4.3. ISAP-conditioned transition matrices

The estimated transition matrix outputs at the three ISAP levels are as follows:

$$P^{(ISAP\ Low)} = \begin{bmatrix} 0.333 & 0.333 & 0,333 \\ 0.444 & 0.222 & 0.333 \\ 0.200 & 0.400 & 0.400 \end{bmatrix}, \quad P^{(ISAP\ Medium)} = \begin{bmatrix} 0.25 & 0.50 & 0,25 \\ 0.60 & 0.20 & 0.20 \\ 0.333 & 0.333 & 0.333 \end{bmatrix}, \quad P^{(ISAP\ High)} = \begin{bmatrix} 0.333 & 0.333 & 0,333 \\ 0.25 & 0.25 & 0.50 \\ 0.60 & 0.20 & 0.20 \end{bmatrix}$$

These outputs demonstrate distinct dynamics under varying ISAP settings. At low ISAP levels, transition patterns are dispersed, with notable persistence observed in both the Medium and Low states. For instance, the probability of transitioning from the medium state to the Low state is 0.444. Upward mobility is clearer under Medium ISAP levels, with a 0.50 probability of moving from Low to Medium. However, moving from Medium to High remains limited. The highest upward mobility occurs at high ISAP levels, where the probability of moving from Medium to High is 0.50, compared to 0.20 at medium ISAP levels and 0.333 at low ISAP levels. Remarkably, persistence in the High state is relatively weak at high ISAP levels (0.20) but stronger at low ISAP levels. Transitions involving the High state, particularly under high ISAP, are based on small empirical cell counts. Because Laplace smoothing (+1) was applied, even a single observed change can significantly affect estimated probabilities. The most reliable finding is that the likelihood of moving from Medium to High increases under high ISAP. Other results should be interpreted with caution due to limited data.

4.4. Forward probabilities

The forward probability matrix (α) was recursively estimated for each hidden state across all observation periods (t = 1, 2, …, T), where T is the number of annual observations for each LAZ. Each $\alpha_t(i)$ represents the filtered probability of being in hidden state i at time t, given all prior observations. Table 4 shows a sample scaled forward matrix for eight consecutive observations.

Table 4. Sample forward matrix (scaled α) for eight consecutive observations.

	Obs1	Obs2	Obs3	Obs4	Obs5	Obs6	Obs7	Obs8
Low Hidden State	0.400	0.045	0.002	0.001	0.003	0.000	0.000	0.000
Medium Hidden State	0.350	0.400	0.110	0.070	0.020	0.010	0.004	0.003
High Hidden State	0.250	0.555	0.888	0.929	0.977	0.990	0.996	0.997

Source*: Output from R statistical software compiled by the author (2025)*

The table indicates that, at the beginning of the observation sequence, probabilities are distributed among the Low, Medium, and High states. As the sequence progresses, most of the probability shifts toward the High state. The scaled forward recursion for the entire sequence produced an overall log-likelihood of −22.41, indicating that the model fits the data effectively and retains most of the information relative to the actual distribution. These findings demonstrate that the estimated transition dynamics and emission probabilities collectively account for the observed efficiency patterns, consistent with the three-state structure. Analysis of forward probabilities from the complete dataset reveals that the three hidden states evolve: higher α-values correspond to the High state in later periods, while lower α-values align with the Low and Medium states as the sequence advances.

4.4 Viterbi Decoding

The decoded Viterbi path indicated that most LAZs were primarily situated in the Medium efficiency state (approximately 43.5%), followed by the Low (approximately 30.4%) and High (approximately 26.1%) efficiency states. The sequence paths illustrated progressive transitions among these states over the years, with notable upward mobility among LAZs reflecting sustained ISAP improvement. For example, LAZs such as Dompet Dhuafa and Rumah Yatim exhibited Medium to High patterns, demonstrating the stabilizing influence of consistent sustainability accounting practices. In contrast, temporary regressions (from High to Medium to Low) were observed in LAZs experiencing ISAP stagnation, highlighting the temporal vulnerability of LAZ efficiency in the absence of enhanced governance.

5.Discussions

5.1.Efficiency States, Observed Performance, and ISAP Dynamics

The initial state distribution (π = [0.00, 0.78, 0.22]) indicates that none of the LAZs begin in the low-performance state. Most LAZs are situated in the Medium performance state, with a smaller proportion starting in the high-performance state. Although this distribution may appear promising, it primarily reflects that by 2021–2023, the majority of LAZs had already established fundamental reporting and operational systems, thereby avoiding persistent "low efficiency traps" (Mahat et al., 2024). In light of this, the primary policy challenge now is to facilitate the transition from Medium to High efficiency, rather than just moving institutions from Low to Medium efficiency. This focus aligns with the "middle-institution" problem, which posits that organizations may achieve basic operational functionality but struggle to implement robust accountability and governance mechanisms (Prakash & Potoski, 2016; Huising & Silbey, 2021). As such, Medium-state LAZs have the most significant potential to benefit from ISAP-induced improvements and thus represent the largest and most strategically significant group. This finding is further supported by previous DEA-based studies on zakat institution efficiency, which demonstrate that Indonesian zakat institutions (OPZs) tend to cluster at moderate efficiency levels rather than maintain consistently high performance (Chumairoh & Rani, 2022; Egbulefu et al., 2025).

Observed performance, depicted by the emission matrix, makes these patterns clearer. In fact, this matrix indicates that low-performance states produce low outcomes 80% of the time, while high-performance states yield high outcomes 70% of the time. Medium-performance states are more variable, with outcomes distributed as 20% high, 60% medium, and 20% low, reflecting the variable performance of transitional LAZs. This probabilistic framework supports the ZME+WI indicator by demonstrating that, despite some noise, observed outcomes reliably represent underlying performance states. It also highlights the importance of decoding methods such as the Viterbi algorithm for distinguishing short-term fluctuations from structural changes (Chatterjee & Russell, 2012). Overall, these findings support viewing medium-performance states as transitional and indicate that better governance can simultaneously improve institutional performance and welfare outcomes (Barbier & Burgess, 2021; Gunawan et al., 2024).

The adoption of sustainability accounting practices further shapes these dynamics. High ISAP adoption substantially increases the probability of LAZs transitioning from a medium to a high-performance state to 0.50, compared with 0.20 under medium ISAP and 0.33 under low ISAP. This finding demonstrates that ISAP facilitates upward mobility among LAZs with baseline operational capacity. This effect is consistent with sustainability accounting theory, which posits that standardized reporting, accountability, and impact tracking enable organizations to consolidate and achieve high-efficiency operations (Sultan et al., 2024; Herath & Herath, 2024). A seemingly counterintuitive pattern emerges: high-state persistence decreases under high ISAP *(High to High = 0.20)* compared to low ISAP *(High to High = 0.40)*. This outcome likely results from methodological limitations, such as small cell counts and Laplace smoothing, which can cause a single observed drop to disproportionately influence the estimate (Kikuchi et al., 2017), especially given the limited data across ISAP and transition categories. Consequently, this result should not be interpreted as evidence that ISAP undermines high-state stability. Instead, the more robust conclusion is that ISAP strengthens the transition from medium to high performance, while conclusions regarding high-state stability require larger samples and confirmatory analysis. These results align with broader evidence on organizational resilience, including findings from the COVID-19 period, where organizations with strong governance and established networks maintained efficiency under pressure (Willems et al., 2022; Huang et al., 2025). In contrast, weak or partial ISAP adoption raises the risk of regression: the shift from medium to low under low ISAP levels (≈0.44) shows how incomplete reforms increase this risk.

5.2. Tracking Institutional Efficiency: Forward Probabilities and Viterbi Path Analysis

The forward algorithm yielded a log-likelihood of -22.41. Although this value is not directly interpretable due to the limited sample size, it serves as a benchmark for evaluating model fit relative to other alternatives, including an unconditional HMM or a random baseline (Athanasopoulou & Hadjicostis, 2011). Beyond model fit, the forward recursion revealed significant temporal dynamics. Probability mass shifted systematically in response to changes in ISAP levels. As illustrated in Figure 1, the forward probabilities indicate that under low ISAP intensity, LAZs remain predominantly in a low-efficiency state with negligible upward transition. When ISAP intensity increases to a medium level, the probability of remaining in a low-efficiency state gradually declines, reflecting early improvements from standardized accountability. With sustained high ISAP intensity, medium- and high-efficiency states become dominant, indicating a structural transformation rather than temporary improvements. Although short-term increases in ISAP produce modest, transient gains, the forward path shows that only sustained reforms enable long-term stability in high-efficiency states. Therefore, ISAP acts not as a temporary performance driver but as a long-term catalyst for institutional performance.

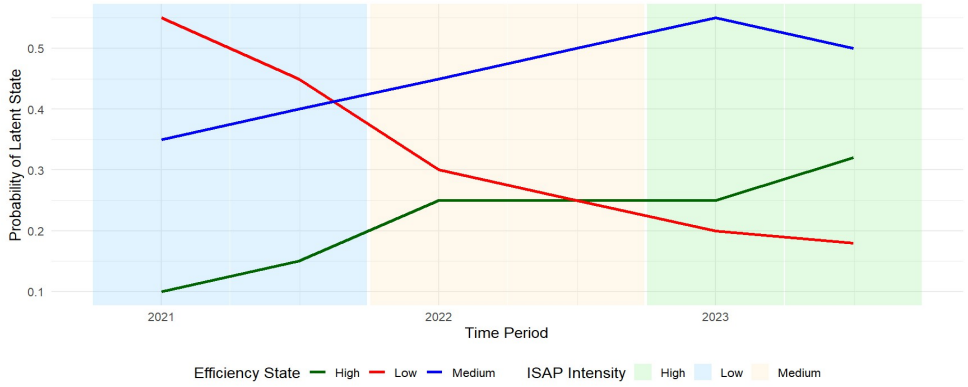

Figure 1: Forward Probabilities LAZ Efficiency under ISAP Conditioning (2021–2023)
Source:*: Output from R statistical software (tidyverse, ggplot2) compiled by the author (2025)*

These patterns confirm the path-dependent nature of institutional efficiency (Mahoney, 2000; Pierson, 2000). Policymakers should consider ISAP as an ongoing process rather than a one-off intervention. Ongoing reinforcement is necessary to prevent LAZs from regressing. Regulators and donor agencies should not only increase ISAP implementation but also establish mechanisms to ensure its sustained application. These findings

are consistent with welfare research demonstrating that BAZNAS program effectiveness relies on institutional capability and program design (Putri et al., 2024; Rusdi et al., 2024; Rasyid, 2025), reinforcing the critical role of LAZs and BAZNAS in collecting, allocating, and empowering Zakat at both local and national levels (Fadilah Ahmad et al., 2024).

The Viterbi algorithm improves this analysis by identifying the most probable sequences of hidden performance states behind observed institutional outcomes. While the forward algorithm estimates state distributions, Viterbi decoding maps the performance trajectories of individual institutions and provides policy-relevant insights over time (Brushe et al., 1996; Rajawat et al., 2021; Oszkinat et al., 2022). During the study period, decoded states were Medium (43.5%), Low (30.4%), and High (26.1%), indicating that zakat institutions primarily occupy transitional Medium states, consistent with the initial distributions. Both Low and High states also persisted for significant periods, indicating that institutional performance is dynamic. Institution-level analysis highlights the value of Viterbi decoding. For Dompet Dhuafa (2021–2023), performance moved from Medium to High, then dropped to Low, reflecting fluctuations despite high ISAP adoption. In contrast, Rumah Yatim (2021–2023) progressed from Medium to High and remained there, showing sustained improvement and consolidation. These results suggest that ISAP can help stabilize performance at higher efficiency levels, even when external shocks cause volatility.

Two main conclusions can be drawn from the analysis. First, the Medium performance state serves as a key "entry point": the time spent in this state determines whether Zakat institutions move to High efficiency or fall back to low efficiency. This underscores the strategic importance of strengthening institutional capacity during periods of medium performance (Maryam, 2023; Mozin & Nggilu, 2023; Rubanzana & Nyamboga, 2025). Secondly, Viterbi decoding provides path-level evidence of ISAP's impact, showing that periods of high ISAP conditioning are associated with more frequent upward transitions and greater persistence in high-performance states. The case of Rumah Yatim exemplifies how ISAP-driven organizational reinforcement can safeguard long-term gains in efficiency. Concurrently, these findings underscore that even well-managed institutions remain susceptible to external shocks, underscoring the need for accountability and transparency in Zakat management. The AAOIFI standards, which emphasize comprehensive documentation of Zakat collection and distribution along with the appointment of qualified supervisors, support this objective by strengthening governance integrity (Qutaiba et al., 2024).

5.3. Validating Transition Dynamics in Parametric Hidden Markov Models

To reinforce the preceding semi-empirical HMM findings, a parametric conditional HMM with an identical three-state structure was estimated using the Baum-Welch expectation-maximization algorithm and maximum likelihood. While parametric HMMs are generally more robust with larger sample sizes (Punzo et al., 2021), they can provide indicative evidence in this study context. The results detailed in Table 5 strongly support the central empirical patterns.

The comparative transition matrices show a consistent pattern in both modeling approaches. At low ISAP levels, the parametric HMM displays greater persistence in the low-efficiency state (0.80) than the semi-empirical HMM (0.33), indicating stronger path dependence. As ISAP increases to a medium intensity level, both models show less persistence in the low-efficiency state and more transitions to the high-efficiency state. The parametric HMM more strongly consolidates the high-efficiency state (0.60) than the semi-empirical HMM (0.33). At high ISAP levels, the parametric HMM maintains a dominant high-efficiency state (0.75), while the semi-empirical HMM shows more moderate probabilities (0.20), reflecting greater uncertainty due to limited data. Despite these differences, both models reach the same conclusion: higher ISAP intensity increases upward transitions and strengthens the high-efficiency state, confirming ISAP's role in enhancing institutional efficiency.

This triangulation holds analytical significance. Both the semi-empirical and parametric HMMs independently identify the medium-to-high transition as the most ISAP-responsive trajectory, demonstrating that the primary conclusion is robust to methodological bias. The semi-empirical HMM offers interpretability and transparency, which is particularly valuable in small-sample contexts, while the parametric HMM provides inferential stability and reduces noise (Song et al., 2018). The convergence of these two HMMs allows the irregular high-to-high decline to be dismissed as statistical noise. It emphasizes the policy-relevant inference: consistent adoption of ISAPs promotes upward mobility for LAZs, particularly those in states of medium efficiency. These dynamic findings build upon previous cross-sectional efficacy results (DEA, Tobit), suggesting that governance reforms

influence not only static efficiency scores but also the intertemporal development of institutional performance (Chan & Karim, 2016; Dos Santos et al., 2018; Nie & Ye, 2022).

Table 5. Parametric versus Semi-empirical HMM Conditioned ISAP Level Transition Matrices

ISAP Intensity	Method	From Efficiency State	To Low	To Medium	To High
Low	Parametric HMM	Low	0.80	0.15	0.05
		Medium	0.30	0.50	0.20
		High	0.20	0.40	0.40
	Semi-empirical HMM	Low	0.333	0.333	0.333
		Medium	0.444	0.222	0.333
		High	0.200	0.400	0.400
Medium	Parametric HMM	Low	0.60	0.30	0.10
		Medium	0.20	0.60	0.20
		High	0.10	0.30	0.60
	Semi-empirical HMM	Low	0.25	0.50	0.25
		Medium	0.60	0.20	0.20
		High	0.333	0.333	0.333
High	Parametric HMM	Low	0.40	0.30	0.30
		Medium	0.10	0.30	0.60
		High	0.05	0.20	0.75
	Semi-empirical HMM	Low	0.333	0.333	0.333
		Medium	0.25	0.25	0.50
		High	0.60	0.20	0.20

Source: *Estimations conducted using R software (using the depmixS4 package for Parametric HMMs and empirical smoothing techniques for Semi-empirical HMM transitions) based on zakat institutions data from 2021–2023 compiled by the author (2025)*

Collectively, the semi-empirical HMM and its parametric validation show that sustainability accounting drives organizational efficiency rather than just fulfilling a procedural requirement. The steady transition from medium to high performance in both models demonstrates that ISAP helps Zakat institutions establish robust governance and attain sustained efficiency. This pattern aligns with the existing literature, which finds that robust accountability enhances donor confidence, Zakat collection, and redistribution efficiency (Anas & Sigid, 2024; Setyorini, 2024; Baehaqi, Prabowo, et al., 2025). More broadly, the findings portray LAZs as evolving systems that often begin in medium-efficiency states, where internal practices determine whether performance stabilizes or improves. This interpretation aligns with previous research showing that effective Zakat and infaq management, supported by transparent financial reporting, significantly alleviates poverty (Meylianingrum, 2023; Tasnim et al., 2023; Sastraningsih et al., 2025). Further evidence shows that well-managed Zakat substantially reduces poverty (Bouanani & Belhadj, 2020; Wahyudi et al., 2024). These outcomes also fit within national and international frameworks that integrate governance, institutional capacity, and welfare outcomes, such as the CIBEST measures, the Indeks Zakat Nasional (IZN), the GRI reporting standards, and OJK's POJK 51/2017 sustainability disclosure requirements. Together, these results show that the HMM-identified efficiency trajectories reflect both statistical shifts and the practical effects of Zakat management on poverty alleviation. In summary, this study extends prior efficiency research by showing how governance quality shapes static performance and dynamic transitions between institutional states (Bambi et al., 2024. Husnain et al., 2024; Bonnite & Rafi, 2025).

These findings align with theoretical explanations of poverty, especially the Theory of Economic, Political, and Social Distortions (Bradshaw, 2007), which highlights institutional factors as fundamental to welfare distribution. The cyclical efficiency patterns identified through HMM–Viterbi analysis also correspond with the Cyclical Theory of Poverty (Addae-Korankye, 2019b; Vegirawati et al., 2023), reinforcing the argument that external shocks and governance constraints can reduce institutional efficiency. On the other hand, stability from strong ISAP adoption helps reduce these cycles. While individual behavior and cultural norms may influence donor engagement, the observed transition dynamics indicate that systemic governance factors, as measured by ISAP's quantifiable impact on state transition, provide the most comprehensive explanation for LAZs' performance. Together, these analytical insights provide a basis for a focused discussion of the study's theoretical and practical implications.

6.Research Implications

This study contributes to methodological advancements in the analysis of Zakat institution efficiency. Previous research has primarily employed static approaches, such as Tobit regression and DEA, to estimate efficiency scores and their determinants (Liu, 2022; Hartono et al., 2023; Istaiteyeh et al., 2024). This study advances knowledge by modeling latent efficiency states and systematically analyzing their transition dynamics across ISAP scenarios. This approach adds historical and probabilistic perspectives to Zakat governance, offering a novel research direction in Islamic finance and institutional economics. The dual methodological approach a semi-empirical method for interpretability and a parametric method for robustness creates a replicable framework for small-sample institutional contexts where policy relevance and rigor matter. This is significant, since most previous research, such as DEA and DEA+Tobit, has been cross-sectional and unable to capture the dynamics of latent states or transitions over time (Aarts & Haslbeck, 2025). The HMM model here addresses this gap by examining how ISAP shapes institutional trajectories and provides a dynamic complement to traditional efficiency studies.

This model offers practical guidance for practitioners in LAZs and regulators such as BAZNAS. The findings demonstrate that transitions from medium to high performance are essential for institutional growth. Consequently, resource allocation, monitoring, and training initiatives should prioritize supporting medium-level LAZs in strengthening governance and achieving sustained high performance, rather than focusing solely on low-level LAZs. The Viterbi trajectories indicate that institutional development is not linear; even high-capacity LAZs may regress without consistent ISAP embedment. Managers are advised to integrate ISAP elements, including sustainability disclosures, systematic reporting, and impact tracking, into core operations rather than treating them as mere compliance requirements. Although LAZs and BAZNAS have received official recognition, trust issues remain, as many muzakki prefer to donate zakat directly to individuals due to concerns about accountability (Owoyemi, 2020; Adiwijaya et al., 2024;Mukti & Bahri, 2025). By empirically demonstrating that ISAP enhances institutional efficiency and welfare distribution, this paper's framework establishes that strengthening reporting standards and transparency can directly restore community trust in LAZs. Increased efficiency also improves fundraising, muzakki confidence, and resource allocation, thereby supporting the long-term sustainability of zakat as a social safety net.

At the policy level, these findings suggest that supervisory bodies should see ISAP as a key driver of operational efficiency and welfare outcomes, rather than just an auxiliary factor. The evidence that strong ISAP practices significantly enhance institutional agility provides a solid foundation for integrating sustainability accounting standards across LAZs. Policy recommendations include encouraging best practices, such as acknowledging high ISAP adoption and linking funding eligibility to compliance with sustainability standards, as well as aligning Zakat governance with local poverty reduction efforts and the United Nations Sustainable Development Goals (UN-SDGs). Additionally, incorporating ISAP compliance into regulatory audits and licensing requirements can ensure that sustainability practices become integrated rather than optional. Public policy could be strengthened by making ISAP compliance a part of licensing, funding eligibility, and reporting frameworks. These actions have broader implications for the national Zakat ecosystem: strong governance standards are expected to expand the reach and impact of zakat, improve the redistribution of national welfare, and support state-led poverty alleviation initiatives (Egbulefu, Ghaisan, et al., 2025; Rinanda et al., 2025; Judijanto et al., 2025).

At the societal level, the findings show that ISAP adoption by Zakat institutions leads to broader welfare benefits. By facilitating medium-to-high transitions, ISAP indirectly enhances poverty alleviation outcomes, increases muzakki trust, and strengthens the perceived legitimacy of Zakat institutions. The model s inclusion of both ZME and WI enables the assessment of efficiency and welfare outcomes, indicating that robust ISAP practices improve institutional performance and the well-being of mustahik. These results corroborate studies such as those by Saoqi et al. (2025), which demonstrate that welfare gains from Zakat programs are contingent on effective program design and strong governance. Such improvements influence public attitudes toward Zakat compliance, potentially raising voluntary contributions and enhancing the mustahik's quality of life (Fauzi et al., 2024). The societal impact is twofold: first, by improving resource allocation and efficiency; and second, by reinforcing community confidence in religious institutions as credible development agents. These outcomes are consistent with Sustainable Development Goals (SDG 1: No Poverty; SDG 10: Reduced Inequalities), thereby positioning Zakat within global development frameworks.

These research findings can be integrated into educational programs on Islamic economics, sustainability accounting, and non-profit governance. The approach, which uses a semi-empirical HMM with confirmatory

reliability checks, offers a valuable tool for demonstrating how complex statistical patterns can reveal institutional dynamics in developing countries. For regulators and LAZ staff, training sessions could use the model s insights to demonstrate how ISAP adoption influences institutional trajectories, thereby enhancing learning with practical evidence. Additionally, the HMM ISAP model could be included in executive and practitioner workshops as a monitoring tool, helping LAZ managers pinpoint crucial transition phases where targeted interventions are most effective.

7.Conclusions

This study investigates whether integrating sustainability accounting practices (ISAP) influences the efficiency of Zakat management organizations (LAZs) in Indonesia and, thereby, ameliorates the social welfare of local communities. Using a semi-empirical, parametric Hidden Markov Model (HMM), the research yields novel insights into how sustainability-oriented reporting affects institutional transitions across efficiency states over time. The findings indicate that most LAZs exhibit a medium level of efficiency, signifying the presence of core reporting and operational capabilities, but also a lack of the structural maturity required for sustained high performance. This highlights robust foundational elements within Zakat institutions, while underscoring the necessity to further institutionalize accountability and sustainability frameworks to facilitate continuous progress and resilience. Additionally, the analysis reveals that higher levels of ISAP substantially increase the likelihood of transitioning from a medium-efficiency to a high-efficiency state, confirming the transformative potential of sustainability accounting. Conversely, inconsistent or weak commitment to ISAP is associated with declining institutional efficiency, highlighting the importance of consistently reinforcing governance quality to prevent such a decline. Forward and Viterbi algorithms highlight the time-dependent nature of institutional development, showing that sustainable progress relies on ongoing reinforcement of good governance rather than single, isolated efforts. This aligns with the Theory of Economic, Political, and Social Distortions, which attributes inefficiency and poverty to systemic imbalances rather than individual shortcomings.

By revealing how ISAP shapes the evolving performance of zakat institutions, this study establishes a critical link between governance theory and the practical realities of Islamic charity. While concepts like transparency and accountability are often perceived as distant and abstract, the dynamic modeling used in this research clearly demonstrates their tangible effects on institutional growth and community welfare through concrete, timely evidence. Consequently, this study not only advances academic discourse but also provides actionable, evidence-based guidance to zakat institutions, regulators, and muzakki to enhance the effectiveness of zakat as a tool for poverty alleviation. This work serves as a valuable resource for practitioners, scholars, and policymakers, demonstrating how innovative modeling can translate theoretical insights into practical solutions within Islamic social finance.

Although this study provides valuable contributions, its findings should be viewed with caution. The sample size was relatively small, including three years of data from a limited number of LAZs with complete records, which significantly restricts the statistical validity and reliability of the estimated transition probabilities. Moreover, the discretization of the study variables into categorical states may have introduced information loss and possible misclassification, particularly near category boundaries. In addition, the analysis was based on self-disclosed institutional data (publicly available), which may be subject to biases inherent in reporting or measurement inaccuracies. These concerns reflect pervasive challenges in the study of Zakat governance, including restricted access to internal data of Zakat institutions and dependence on publicly available information. Additional pertinent factors, such as geographic context, institutional scale, and human resource expertise, could not be fully considered, which may have introduced unacknowledged confounding variables. Furthermore, while the HMM detects temporal links between ISAP and effectiveness transitions, it cannot establish a causal relationship or rule out the possibility that these links reflect only simultaneous changes in regulation, funding, or local economic conditions. Also, the application of Laplace smoothing, although methodologically necessary to stabilize infrequent transition cells, may further bias transition matrices toward homogeneity. Accordingly, the results must be viewed as exploratory and hypothesis-generating only, rather than as providing definitive evidence of causal impacts.

However, even with those limitations, the current study contributes to examining temporal dynamics of sustainability accounting in its development of a more compelling empirical model of the sustainability accounting — institutional changes framework. Future research could expand the sample to multiple institutions

and over a longer period of time leading to a higher level of statistical confidence. Second, including covariates such as staff competencies, level of funding, regional characteristics and type of regulations, may strengthen the model's strength and explanatory power. Future studies should dis-aggregate welfare outcomes into economic, social and spiritual dimensions to explore whether ISAP effects differ by dimension. Utilizing a mixed-methods design that incorporates both quantitative and qualitative measures will begin to illuminate both the dynamic processes at the level of the organization that drive superior performance in a variety of external environments (Hitt et al. 2007). Third, differing forms of institutions, for example, government-related LAZs and community-based LAZs, might provide valuable comparison material to reveal structural traits influencing the relationship between ISAP and efficiency.

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