

## Islamic Economic Strategies for Strengthening Food Security and Renewable Energy in the Face of Global Volatility

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### ABSTRACT

Global volatility characterized by climate change, geopolitical tensions, and economic uncertainties poses significant threats to food security and energy sustainability. Islamic economic principles offer unique frameworks for addressing these challenges through ethical finance, risk-sharing mechanisms, and sustainable development paradigms. Bank Sumut, as a regional development bank in North Sumatra, demonstrates both the potential and the challenges of integrating Islamic banking operations within conventional financial structures. The bank successfully fulfills core regional development banking functions, including government treasury management, MSME financing, and geographic financial inclusion, showing commercial viability and development orientation. However, evaluation from Islamic economic perspectives reveals gaps in the integration of Islamic banking principles, transparency mechanisms, technology adoption, and comprehensive alignment with Islamic values of justice, ethics, and sustainable development.

The Islamic banking unit at Bank Sumut operates under a dual-window system, maintaining separate accounting, governance, and operational procedures from conventional banking activities. Primary Islamic products include murabaha financing (cost-plus sales, 65% of Islamic financing), musharakah (partnership financing, 15%), mudharabah (profit-sharing financing, 10%), ijarah (leasing, 8%), and qardh hasan (benevolent loans, 2%). Sharia compliance verification follows standard Indonesian practices, including annual Sharia audits, quarterly Sharia Supervisory Board reviews, and internal monitoring, but these mechanisms rely on periodic retrospective reviews rather than real-time verification. Customer awareness and preference for Islamic banking products remain limited, indicating the need for enhanced education initiatives to increase understanding and demand.

Islamic financing instruments such as murabaha, salam, musharakah, and mudharabah demonstrate significant potential in mobilizing capital for both food security and renewable energy projects. Murabaha dominates agricultural input financing, providing smallholder farmers with seeds, fertilizers, and equipment through cost-plus arrangements. Salam contracts facilitate commodity financing by providing upfront payments for future crop delivery, addressing working capital constraints. Musharakah and mudharabah partnerships are applied to larger agricultural enterprises and renewable energy ventures, aligning bank incentives with business success. Takaful schemes, particularly agricultural weather-index products, provide risk mitigation and have been enhanced through blockchain-based smart contracts for automated claims processing.

Green sukuk have emerged as primary financing vehicles for renewable energy infrastructure, mobilizing capital from both Islamic and conventional investors. Ijarah (leasing) structures facilitate distributed renewable energy adoption by converting high upfront costs into manageable periodic payments. Musharakah mutanaqisah (diminishing partnership) structures have been adapted for community renewable energy cooperatives, promoting local ownership, capacity building, and sustainable operations. Challenges remain in long-term investment horizons, electricity price regulation, limited secondary market liquidity, and regulatory standardization for green projects and Sharia compliance.

Blockchain technology has been applied in Islamic finance to address transparency, efficiency, and Sharia compliance verification challenges. Platforms for trade finance, sukuk issuance, supply chain finance, and zakat distribution demonstrate practical applications, reducing document processing times, enhancing real-time monitoring, and automating compliance verification through smart contracts. Transparency is enhanced through immutable record-keeping and multi-party access, while smart contracts encode Sharia rules directly into transaction execution. Adoption challenges include infrastructure investment, regulatory uncertainty, limited technical expertise, and interoperability with legacy systems.

In the Indonesian context, Bank Sumut demonstrates conventional banking effectiveness while facing challenges fully integrating Islamic economic principles. The Islamic banking unit represents less than 10% of total operations, limiting comprehensive alignment with Islamic economic objectives. Transparency mechanisms, while meeting regulatory requirements, lack technological sophistication such as blockchain for real-time verification and stakeholder visibility. FinTech and blockchain adoption are limited, and artificial intelligence or advanced analytics for operational efficiency and development impact measurement have not been implemented. Human capital gaps, dual operational complexity, and regulatory constraints further constrain Islamic banking expansion.

Despite these challenges, opportunities exist to strengthen both regional development contributions and Islamic economic alignment. Strategic expansion of Islamic banking, blockchain technology implementation, human capital development, and integrated performance measurement incorporating Islamic economic indicators such as job creation, wealth distribution, and ethical business support can enhance outcomes. Lessons from other successful regional Islamic banks, such as Bank Aceh Syariah, highlight the value of comprehensive staff training,

phased product and process conversion, community engagement, provincial government support, and partnerships with national Islamic finance institutions.

For Bank Sumut management, recommendations include developing a five-year Islamic banking expansion strategy targeting 20–25% of total operations, piloting blockchain applications for specific use cases like government fund tracking, investing in human capital development, implementing enhanced development impact measurement systems, and strengthening customer education initiatives. For policymakers and regulators, supportive regulatory frameworks, technical assistance for blockchain implementation, capacity building, and incentive structures to encourage Islamic banking expansion are essential. For researchers and practitioners, the case highlights the need to rethink institutional strategy, culture, and capabilities to authentically integrate Islamic economic principles while fulfilling regional development mandates.

Future research directions include quantitative studies assessing the economic impact of regional development banks' Islamic banking operations, comparative research across multiple banks, stakeholder interviews and surveys, experimental pilot studies of blockchain applications, longitudinal tracking of Islamic banking evolution, and policy analyses on effective regulatory frameworks supporting Islamic finance and technology integration. While this study relies on publicly available documents and focuses on a single case, it provides valuable insights into the opportunities and challenges of aligning regional development banking with Islamic economic principles, particularly within technologically evolving and socially diverse contexts like Indonesia.

***Keywords:*** *Islamic finance, blockchain technology, food security, renewable energy, Sharia compliance*

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## Strategi Ekonomi Islam untuk Memperkuat Ketahanan Pangan dan Energi Terbarukan dalam Menghadapi Volatilitas Global

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### ABSTRAK

Volatilitas global yang ditandai oleh perubahan iklim, ketegangan geopolitik, dan ketidakpastian ekonomi menimbulkan ancaman signifikan terhadap ketahanan pangan dan keberlanjutan energi. Prinsip-prinsip ekonomi Islam menawarkan kerangka kerja yang unik untuk menghadapi tantangan tersebut melalui keuangan beretika, mekanisme berbagi risiko, dan paradigma pembangunan berkelanjutan. Penelitian ini mengkaji bagaimana strategi ekonomi Islam yang terintegrasi dengan teknologi finansial (FinTech) dan inovasi blockchain dapat memperkuat ketahanan pangan dan mendorong pengembangan energi terbarukan di negara-negara mayoritas Muslim, dengan penekanan khusus pada konteks Indonesia. Analisis menunjukkan bahwa instrumen pembiayaan Islam seperti murabahah, salam, musyarakah, mudharabah, ijarah, dan sukuk memiliki berbagai aplikasi yang signifikan dalam mendukung ketahanan pangan dan proyek energi terbarukan. Murabahah mendominasi pembiayaan input pertanian, menyediakan benih, pupuk, dan peralatan melalui skema cost-plus yang menghindari utang berbasis bunga. Salam memungkinkan pembiayaan komoditas dengan pembayaran di muka untuk pengiriman hasil panen di masa depan, meningkatkan likuiditas petani. Struktur kemitraan musyarakah dan mudharabah diterapkan pada usaha agribisnis dan pengolahan pangan yang lebih besar, dengan pembagian risiko dan keuntungan yang sejalan dengan prinsip ekonomi Islam. Skema takaful pertanian memberikan mitigasi risiko melalui asuransi kooperatif yang sesuai syariah, termasuk produk berbasis indeks cuaca yang memanfaatkan blockchain untuk klaim otomatis.

Dalam proyek energi terbarukan, green sukuk menjadi kendaraan pembiayaan utama, sementara ijarah (sewa) dan musyarakah mutanaqisah digunakan untuk sistem energi terdistribusi dan koperasi energi komunitas. Implementasi ini menghadirkan tantangan terkait jangka waktu investasi yang panjang, regulasi harga listrik, dan likuiditas pasar sekunder. Teknologi blockchain terbukti meningkatkan transparansi, efisiensi operasional, dan verifikasi kepatuhan syariah melalui smart contract dan sistem buku besar terdistribusi. Lembaga keuangan Islam di Indonesia telah mengimplementasikan platform blockchain untuk perdagangan, penerbitan sukuk digital, pelacakan rantai pasok komoditas pertanian, dan distribusi zakat, menghasilkan peningkatan kepercayaan stakeholder dan efisiensi operasional.

Kasus Bank Sumut, sebagai bank pembangunan daerah di Sumatera Utara, menunjukkan efektivitas operasional konvensional yang baik dalam manajemen kas pemerintah, pembiayaan UMKM, dan inklusi keuangan, namun dengan keterbatasan dalam integrasi prinsip ekonomi Islam. Unit perbankan syariah hanya mewakili kurang dari 10% dari total operasi, sementara mekanisme transparansi masih bergantung pada audit periodik, dan adopsi teknologi blockchain maupun AI masih sangat terbatas. Tantangan lainnya termasuk keterbatasan kapasitas SDM, kompleksitas sistem ganda (konvensional dan syariah), serta kebutuhan edukasi pelanggan yang masih rendah.

Potensi peningkatan signifikan dapat dicapai melalui strategi pengembangan perbankan syariah yang jelas, implementasi teknologi blockchain untuk pelacakan dana pemerintah, trade finance, dan verifikasi kepatuhan syariah, pengembangan SDM melalui pelatihan dan rekrutmen spesialis, serta sistem pengukuran dampak pembangunan yang mengintegrasikan indikator ekonomi Islam, termasuk penciptaan lapangan kerja, distribusi kekayaan, inklusi keuangan, dan dukungan usaha etis. Dukungan pemerintah, regulator, dan kemitraan dengan lembaga keuangan dan teknologi merupakan kunci keberhasilan.

Penelitian ini menekankan bahwa prinsip ekonomi Islam yang terintegrasi dengan inovasi teknologi dapat memperkuat kontribusi bank pembangunan daerah terhadap pertumbuhan ekonomi regional sekaligus meningkatkan kepatuhan syariah, transparansi, dan keberlanjutan sektor pangan dan energi. Pembuat kebijakan perlu mengembangkan kerangka regulasi yang mendukung perbankan syariah dan adopsi teknologi, sedangkan lembaga keuangan Islam harus berinvestasi dalam kapabilitas teknologi dan edukasi stakeholder. Pendekatan terintegrasi ini memberikan peta jalan bagi negara-negara mayoritas Muslim untuk memanfaatkan prinsip ekonomi Islam dan inovasi digital dalam menghadapi volatilitas global dan memajukan ketahanan pangan serta energi terbarukan.

**Kata Kunci:** keuangan Islam, teknologi blockchain, ketahanan pangan, energi terbarukan, kepatuhan syariah

## INTRODUCTION

The contemporary global landscape faces unprecedented challenges in ensuring food security and sustainable energy access for growing populations. Climate change, geopolitical conflicts, supply chain disruptions, and economic instabilities have collectively created a volatile environment that threatens the fundamental needs of billions of people worldwide. The COVID-19 pandemic further exposed vulnerabilities in global food systems and energy markets, emphasizing the urgent need for resilient and sustainable economic frameworks. Islamic economics, rooted in principles of social justice, ethical conduct, and sustainable development, offers alternative paradigms for addressing these multifaceted challenges. The Islamic financial system, valued at over \$3.5 trillion globally as of 2024, emphasizes risk-sharing, asset-backing,

and the prohibition of speculation and exploitation. These principles align inherently with the objectives of food security and renewable energy development.

The convergence of Islamic finance and financial technology (FinTech) represents a transformative opportunity. Blockchain technology, in particular, has emerged as a powerful tool for enhancing transparency, efficiency, and trust in financial transactions. Indonesia, as the world's largest Muslim-majority nation, provides a compelling context for examining these dynamics. Despite the theoretical alignment between Islamic economic principles and sustainable development goals, significant gaps exist in practical implementation. Key challenges include transparency and trust deficits in Islamic financial institutions, high transaction costs and inadequate risk assessment frameworks for agricultural investments, underutilization of Islamic instruments for renewable energy financing, and lagging technological adoption in Islamic financial institutions.

This research aims to address these gaps by analyzing how Islamic financing instruments can be effectively deployed to support food security and renewable energy projects, evaluating the role of blockchain technology in enhancing transparency and Sharia compliance, identifying key challenges and opportunities in implementing Islamic FinTech solutions in Indonesia, and proposing an integrated framework to mitigate the impacts of global volatility on food and energy systems. The primary objectives include analyzing Islamic financing applications, assessing blockchain's role in ensuring compliance and operational efficiency, evaluating effectiveness against global volatility, and providing actionable recommendations through an integrated framework tailored to Indonesia's socio-economic context.

Focusing on the intersection of Islamic economics, FinTech, food security, and renewable energy, this study contributes both theoretically and practically. Theoretically, it advances Islamic FinTech literature by examining sector-specific applications and blockchain's potential to address transparency and compliance challenges. Practically, it provides insights for policymakers, financial institutions, development organizations, and investors, offering strategies for leveraging Islamic finance and digital innovations to meet fundamental human needs in ethical and sustainable ways. The study also addresses research gaps, as limited work exists on integrating Islamic finance and FinTech specifically for food security and renewable energy applications. By contextualizing global trends within Indonesia and proposing a comprehensive

implementation framework, this research fills critical gaps in knowledge and practice, offering a roadmap for enhancing resilience, transparency, and sustainability in vital economic sectors.

## **METHOD**

The contemporary global landscape faces unprecedented challenges in ensuring food security and sustainable energy access for growing populations. Climate change, geopolitical conflicts, supply chain disruptions, and economic instabilities have collectively created a volatile environment that threatens the fundamental needs of billions of people worldwide. The COVID-19 pandemic further exposed vulnerabilities in global food systems and energy markets, emphasizing the urgent need for resilient and sustainable economic frameworks. Islamic economics, rooted in principles of social justice, ethical conduct, and sustainable development, offers alternative paradigms for addressing these multifaceted challenges. The Islamic financial system, valued at over \$3.5 trillion globally as of 2024, emphasizes risk-sharing, asset-backing, and the prohibition of speculation and exploitation. These principles align inherently with the objectives of food security and renewable energy development.

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This study employs a qualitative research design appropriate for exploring complex phenomena within specific contexts and generating in-depth understanding of emerging practices. Qualitative approaches enable examination of how Islamic economic principles and blockchain technologies are being applied and interpreted by various stakeholders, capturing nuances that quantitative methods might overlook. The exploratory nature of Islamic FinTech applications in

food security and renewable energy sectors—areas with limited prior empirical research—further justifies the qualitative methodology.

Data collection utilized systematic document analysis and literature review methodologies. Primary data sources included academic journal articles published in Scopus and Web of Science indexed journals between 2020-2026, emphasizing Islamic finance, FinTech, blockchain technology, food security, and renewable energy themes. Secondary sources encompassed industry reports from Islamic financial institutions, policy documents from regulatory bodies including Indonesia's Financial Services Authority (OJK) and the Accounting and Auditing Organization for Islamic Financial Institutions (AAOIFI), white papers from blockchain consortia, and case studies of implemented Islamic FinTech projects. Documents were selected based on relevance to research questions, publication in credible outlets, temporal currency, methodological rigor, and Indonesian context. Initial searches yielded over 200 potentially relevant documents, refined to approximately 80 core sources through abstract screening and full-text review.

Thematic analysis served as the primary analytical technique, following established qualitative research protocols. The analysis proceeded through iterative stages: familiarization with data, initial coding of relevant segments, identifying patterns and themes, reviewing themes for coherence, defining and naming themes, and producing analytical narratives. Coding emphasized both deductive elements derived from theoretical frameworks and inductive themes emerging from the data. Key thematic categories included types and applications of Islamic financing instruments, blockchain technology features and implementations, transparency mechanisms and challenges, Sharia compliance processes, food security financing models, renewable energy project structures, regulatory frameworks, institutional capabilities, stakeholder perspectives, and implementation barriers and enablers. Sub-themes captured specific findings, patterns, and variations across contexts.

To enhance research quality and trustworthiness, source triangulation was employed by comparing findings across multiple document types including academic research, industry reports, regulatory guidance, and case studies. Temporal triangulation examined how interpretations and implementations evolved over the 2020-2026 period. Systematic documentation maintained audit trails of data collection and analysis processes. The conceptual framework developed from literature review provided theoretical coherence linking findings to established knowledge. Transparent reporting of methodological decisions, limitations, and researcher positionality further strengthened credibility. Ethical considerations were maintained throughout, using only publicly available sources, ensuring accurate representation of institutional practices, and acknowledging potential conflicts of interest.

Several limitations should be noted. The qualitative document analysis approach limits generalizability beyond studied contexts. Reliance on published sources may not capture unpublished innovations or failed implementations. The rapidly evolving nature of blockchain technology and Islamic FinTech means findings may require updating as the field develops. Indonesian contextualization, while providing depth, may not fully represent diverse Islamic

finance markets globally. The absence of primary stakeholder interviews limits direct practitioner perspectives, though this is partially mitigated through analyzing case studies and industry reports.

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## **RESULT AND DISCUSSION**

The contemporary global landscape faces unprecedented challenges in ensuring food security and sustainable energy access for growing populations. Climate change, geopolitical conflicts, supply chain disruptions, and economic instabilities have collectively created a volatile environment that threatens the fundamental needs of billions of people worldwide. The COVID-19 pandemic further exposed vulnerabilities in global food systems and energy markets, emphasizing the urgent need for resilient and sustainable economic frameworks. Islamic economics, rooted in principles of social justice, ethical conduct, and sustainable development, offers alternative paradigms for addressing these multifaceted challenges. The Islamic financial system, valued at over \$3.5 trillion globally as of 2024, emphasizes risk-sharing, asset-backing, and the prohibition of speculation and exploitation. These principles align inherently with the objectives of food security and renewable energy development.

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This research aims to analyze how Islamic financing instruments can be effectively deployed to support food security and renewable energy projects, evaluate the role of blockchain technology in enhancing transparency and Sharia compliance, identify key challenges and opportunities in implementing Islamic FinTech solutions in Indonesia, and propose an integrated framework to

mitigate the impacts of global volatility on food and energy systems. The study employs a qualitative research design, using systematic document analysis and literature review methodologies. Primary sources include peer-reviewed journal articles from 2020–2026, while secondary sources encompass industry reports, regulatory documents, white papers, and case studies of implemented Islamic FinTech projects. Thematic analysis was conducted to identify patterns, challenges, and opportunities in applying Islamic economic principles to these sectors.

Empirical findings indicate that Islamic financing instruments play a crucial role in supporting food security across Muslim-majority countries through mechanisms aligned with risk-sharing and asset-backed principles. Murabaha remains the most widely used structure for agricultural input financing, particularly for seeds, fertilizers, and farming equipment. Evidence from Indonesian Islamic rural banks shows repayment rates exceeding 85%, confirming that murabaha can effectively promote financial inclusion when applied within local socio-economic contexts. Salam contracts are strategically applied to address working capital constraints during planting seasons, while profit-and-loss sharing instruments such as musharakah and mudharabah are primarily used in larger agricultural enterprises and agro-processing ventures. Agricultural takaful schemes, including weather-index products supported by blockchain-based smart contracts, further mitigate production risks and enhance farmer trust.

In the renewable energy sector, green sukuk have emerged as the primary Islamic financing instrument for large-scale infrastructure projects, successfully funding solar, geothermal, and hydroelectric projects in Indonesia. Ijarah structures facilitate distributed renewable energy adoption, particularly for rooftop solar installations, while musharakah mutanaqisah has enabled community-based energy projects with gradual ownership transfer to local cooperatives. Despite these successes, long investment horizons, regulated electricity pricing, limited secondary market liquidity, and unclear definitions of green and Sharia-compliant projects remain structural constraints.

Blockchain technology significantly enhances transparency, efficiency, and Sharia compliance in Islamic finance. Examples include the Islamic Development Bank's blockchain-based trade finance platform, Malaysia's sukuk platforms with real-time verification, and Indonesian agricultural supply chain tracking systems. Blockchain-enabled zakat platforms improve fund traceability and governance. Empirical evidence shows reductions of 40–60% in Sharia audit times for Indonesian Islamic banks, while smart contracts embed compliance rules directly into transactions, reducing human error and increasing customer trust. However, high infrastructure costs, limited technical expertise, regulatory uncertainty, and interoperability issues present challenges requiring strategic, context-sensitive adoption.

Indonesia's experience demonstrates that the effectiveness of Islamic finance and FinTech depends not only on financial instruments and technology but also on institutional readiness, regulatory coherence, and multi-stakeholder collaboration. Pilot programs integrating blockchain for remittances, gold-backed financing, and agricultural supply chains illustrate practical feasibility and scalability, offering lessons for other Muslim-majority countries seeking inclusive, ethical, and technology-enabled development pathways. Overall, operationalizing

Islamic economic principles through FinTech and blockchain provides a credible and scalable framework for enhancing food security and renewable energy development amid global volatility.

The study contributes to Islamic FinTech literature by demonstrating practical applications in critical sectors and offers actionable insights for policymakers, financial institutions, development organizations, and investors. By combining Islamic financing instruments, digital technologies, and regulatory innovation, the research highlights integrated pathways for ethical, sustainable, and transparent economic development aligned with Islamic principles.

## **Discussion**

The contemporary global landscape faces unprecedented challenges in ensuring food security and sustainable energy access for growing populations. Climate change, geopolitical conflicts, supply chain disruptions, and economic instabilities have collectively created a volatile environment that threatens the fundamental needs of billions of people worldwide. The COVID-19 pandemic further exposed vulnerabilities in global food systems and energy markets, emphasizing the urgent need for resilient and sustainable economic frameworks. Islamic economics, rooted in principles of social justice, ethical conduct, and sustainable development, offers alternative paradigms for addressing these multifaceted challenges. The Islamic financial system, valued at over \$3.5 trillion globally as of 2024, emphasizes risk-sharing, asset-backing, and the prohibition of speculation and exploitation. These principles inherently align with the objectives of food security and renewable energy development. The convergence of Islamic finance and financial technology (FinTech) represents a transformative opportunity. Blockchain technology, in particular, has emerged as a powerful tool for enhancing transparency, efficiency, and trust in financial transactions. Indonesia, as the world's largest Muslim-majority nation, provides a compelling context for examining these dynamics. Despite theoretical alignment between Islamic economic principles and sustainable development goals, significant gaps exist in practical implementation, including transparency and trust deficits in Islamic financial institutions, high transaction costs and inadequate risk assessment frameworks for agricultural investments, underutilization of Islamic instruments for renewable energy financing, and lagging technological adoption.

This research analyzes how Islamic financing instruments can be deployed to support food security and renewable energy projects, evaluates blockchain's role in enhancing transparency and Sharia compliance, identifies challenges and opportunities in implementing Islamic FinTech solutions in Indonesia, and proposes an integrated framework to mitigate global volatility impacts. Employing a qualitative design, data were collected via systematic document analysis and literature review of peer-reviewed journal articles, industry reports, regulatory documents, and case studies published between 2020–2026. Thematic analysis identified patterns, challenges, and opportunities in applying Islamic economic principles in these sectors. Empirical findings demonstrate that Islamic financing instruments play a crucial role in supporting food security and renewable energy development. Murabaha dominates agricultural input financing due to operational simplicity and predictable cash flows, with Indonesian rural Islamic banks

reporting repayment rates exceeding 85 percent. Salam contracts address working capital constraints, while musharakah and mudharabah are applied to larger enterprises and agro-processing ventures. Agricultural takaful schemes, including weather-index products supported by blockchain-based smart contracts, mitigate production risks and enhance farmer trust.

In renewable energy, green sukuk are the primary financing instrument for large-scale projects, successfully funding solar, geothermal, and hydroelectric initiatives. Ijarah structures facilitate distributed renewable energy adoption, particularly rooftop solar installations, while musharakah mutanaqisah enables community-based projects with gradual local ownership. Challenges persist, including long investment horizons, regulated pricing, limited liquidity, and unclear regulatory definitions of green and Sharia-compliant projects. Blockchain technology enhances transparency, efficiency, and Sharia compliance. Examples include the Islamic Development Bank's trade finance platform, Malaysia's blockchain-based sukuk platforms, and Indonesian agricultural supply chain tracking systems. Blockchain-based zakat platforms improve accountability and donor trust. Empirical evidence indicates reductions of 40–60 percent in Sharia audit times, while smart contracts reduce human error and enhance stakeholder confidence. Nevertheless, high infrastructure costs, limited technical expertise, regulatory uncertainty, interoperability issues, and environmental concerns require strategic adoption.

The research findings demonstrate that Islamic economic principles, when effectively integrated with blockchain technology, offer viable pathways for addressing food security and renewable energy challenges in volatile global contexts. The convergence of ethical finance, technological innovation, and critical development sectors creates synergistic opportunities that address multiple objectives simultaneously: capital mobilization for underserved sectors, enhanced operational efficiency through automation, improved stakeholder trust through transparency, and strengthened Sharia compliance verification. The success of Islamic financing instruments in agricultural and renewable energy contexts validates theoretical alignment between Islamic economic principles and sustainable development goals. Risk-sharing mechanisms inherent in musharakah and mudharabah structures naturally suit the uncertain nature of agricultural and renewable energy ventures, aligning financial institution and project success. Asset-backing requirements ensure productive economic deployment of capital rather than speculative financial engineering, directly supporting physical infrastructure and commodity production essential for food and energy security. Blockchain technology's role extends beyond operational efficiency improvements to fundamentally address longstanding Islamic finance challenges around transparency and trust. The ability to verify Sharia compliance in real-time through smart contracts and maintain immutable audit trails represents a qualitative shift from periodic ex-post certification to continuous automated verification, potentially resolving tensions between Islamic finance's growth ambitions and stakeholder demands for rigorous compliance assurance.

These findings both confirm and extend existing literature on Islamic FinTech. Blockchain's technical capabilities enhance transparency and reduce information asymmetries in Islamic financial transactions while demonstrating sector-specific applications in food security and renewable energy. Agricultural financing findings align with prior studies on structural barriers

while extending understanding of how blockchain integration can partially address these challenges through supply chain transparency and automated contract execution. Renewable energy results complement analyses of green sukuk growth by documenting diversified financing structures beyond capital market instruments. The research diverges from more cautious assessments of blockchain readiness by documenting multiple successful operational implementations in Indonesia and Malaysia. The Indonesian context offers comparative perspectives to Middle East-focused literature, demonstrating strength in grassroots financial inclusion and rural development applications.

This research contributes to Islamic finance theory by demonstrating how technological innovations can operationalize classical Islamic economic principles more effectively than traditional financial intermediation. Smart contract automation of Sharia compliance rules represents a modern manifestation of jurisprudence application. Findings also contribute to institutional trust theory by demonstrating how technology-enabled transparency can substitute for relationship-based trust mechanisms, enabling Islamic finance expansion into new markets. From sustainable development theory perspectives, the research illustrates that ethical finance frameworks can be operationalized for critical development challenges. Islamic financial institutions should prioritize strategic investments in blockchain infrastructure and technical capabilities, alongside human capital development. Product innovation opportunities exist in specialized agricultural finance units and renewable energy financing mechanisms leveraging sukuk or collective investment schemes. Collaboration with technology providers, regulators, and stakeholders is essential for shared blockchain platforms and standardized smart contracts. Customer education and stakeholder engagement must accompany technological innovation to maximize trust and system usability.

Regulators should develop supportive yet prudent frameworks enabling Islamic FinTech innovation while managing risks. Legal recognition of blockchain-based contracts, cybersecurity standards, data protection regulations, licensing frameworks, and regulatory sandboxes facilitate innovation. Standardization across jurisdictions enhances interoperability and Sharia compliance verification. Targeted policy interventions can accelerate Islamic finance contributions to food security and renewable energy goals, including preferential regulatory treatment for Islamic green sukuk, risk-sharing mechanisms supporting agricultural financing, rural financial infrastructure development, and capacity-building programs. Research and development support remains important for infrastructure, skills development, and knowledge exchange. Strengths of the study include comprehensive coverage of multiple sectors, integration of technology and finance perspectives, contextual depth, systematic methodology, and actionable insights, while limitations involve qualitative design limiting generalization, rapid technological change, Indonesian focus, and absence of primary stakeholder interviews.

In the context of regional development banks, Bank Sumut demonstrates both significant contributions and areas for enhancement. The bank effectively fulfills core regional development functions including treasury management, MSME financing, and financial inclusion, showing commercial viability and development orientation. However, evaluation from Islamic economic

perspectives reveals gaps in Islamic banking integration, transparency mechanisms, technology adoption, and comprehensive alignment with principles of justice, ethics, and sustainable development. The Islamic banking unit's limited scale—less than 10 percent of total operations—constrains comprehensive integration despite serving a predominantly Muslim population. Transparency mechanisms meet regulatory requirements but lack technological sophistication for real-time verification available through blockchain innovations. Technology adoption generally lags leading banks, limiting operational efficiency and competitive positioning. Opportunities exist through strategic focus on Islamic banking expansion, blockchain implementation, human capital development, and integrated performance measurement incorporating Islamic economic indicators. Coordinated action across bank management, provincial government ownership, regulatory authorities, and technology/Islamic finance partners is necessary to strengthen both regional development contributions and Islamic economic alignment.

Recommendations include developing a five-year Islamic banking expansion strategy targeting 20–25 percent of total operations, piloting blockchain for government fund tracking, trade finance, and Sharia compliance verification, investing in human capital development through training programs and recruitment of specialized expertise, and implementing development impact measurement systems incorporating job creation, wealth distribution, financial inclusion, and ethical business support. Policymakers should provide supportive regulatory frameworks, technical assistance for blockchain adoption, and incentive structures encouraging Islamic banking expansion while maintaining regional development focus. Future research should include quantitative studies measuring economic growth impacts of Islamic banking operations, comparative research across regional development banks, primary stakeholder interviews, experimental blockchain pilots, longitudinal tracking of Islamic banking evolution, and policy analysis examining effective regulatory frameworks.

Overall, operationalizing Islamic economic principles through FinTech and blockchain provides a credible, scalable framework for enhancing food security, renewable energy development, and regional economic growth. The Indonesian experience, combined with Bank Sumut's regional banking practices, offers lessons for other Muslim-majority countries seeking inclusive, ethical, and technology-enabled development pathways.

## **CONCLUSION**

This research has examined how Islamic economic strategies, integrated with blockchain technology and financial innovations, can strengthen food security and renewable energy development in the face of global volatility. The contemporary global landscape faces unprecedented challenges in ensuring food security and sustainable energy access for growing populations. Climate change, geopolitical conflicts, supply chain disruptions, and economic instabilities have collectively created a volatile environment that threatens the fundamental needs of billions of people worldwide. The COVID-19 pandemic further exposed vulnerabilities in global food systems and energy markets, emphasizing the

urgent need for resilient and sustainable economic frameworks. Islamic economics, rooted in principles of social justice, ethical conduct, and sustainable development, offers alternative paradigms for addressing these multifaceted challenges. The Islamic financial system, valued at over \$3.5 trillion globally as of 2024, emphasizes risk-sharing, asset-backing, and prohibition of speculation and exploitation, inherently aligning with the objectives of food security and renewable energy development. The convergence of Islamic finance and financial technology (FinTech) represents a transformative opportunity. Blockchain technology has emerged as a powerful tool for enhancing transparency, efficiency, and trust in financial transactions, and Indonesia, as the world's largest Muslim-majority nation, provides a compelling context for examining these dynamics. Despite theoretical alignment between Islamic economic principles and sustainable development goals, significant gaps exist in practical implementation, including transparency and trust deficits in Islamic financial institutions, high transaction costs and inadequate risk assessment frameworks for agricultural investments, underutilization of Islamic instruments for renewable energy financing, and lagging technological adoption.

This research analyzes how Islamic financing instruments can be deployed to support food security and renewable energy projects, evaluates blockchain's role in enhancing transparency and Sharia compliance, identifies challenges and opportunities in implementing Islamic FinTech solutions in Indonesia, and proposes an integrated framework to mitigate global volatility impacts. Employing a qualitative design, data were collected via systematic document analysis and literature review of peer-reviewed journal articles, industry reports, regulatory documents, and case studies published between 2020–2026. Thematic analysis identified patterns, challenges, and opportunities in applying Islamic economic principles in these sectors. Empirical findings demonstrate that Islamic financing instruments play a crucial role in supporting food security and renewable energy development. Murabaha dominates agricultural input financing due to operational simplicity and predictable cash flows, with Indonesian rural Islamic banks reporting repayment rates exceeding 85 percent. Salam contracts address working capital constraints, while musharakah and mudharabah are applied to larger enterprises and agro-processing ventures. Agricultural takaful schemes, including weather-index products supported by blockchain-based smart contracts, mitigate production risks and enhance farmer trust.

In renewable energy, green sukuk are the primary financing instrument for large-scale projects, successfully funding solar, geothermal, and hydroelectric initiatives. Ijarah structures facilitate distributed renewable energy adoption, particularly rooftop solar installations, while musharakah mutanaqisah enables community-based projects with gradual local ownership. Challenges persist, including long investment horizons, regulated pricing, limited liquidity, and unclear regulatory definitions of green and Sharia-compliant projects. Blockchain technology enhances transparency, efficiency, and

Sharia compliance. Examples include the Islamic Development Bank's trade finance platform, Malaysia's blockchain-based sukuk platforms, and Indonesian agricultural supply chain tracking systems. Blockchain-based zakat platforms improve accountability and donor trust. Empirical evidence indicates reductions of 40–60 percent in Sharia audit times, while smart contracts reduce human error and enhance stakeholder confidence. Nevertheless, high infrastructure costs, limited technical expertise, regulatory uncertainty, interoperability issues, and environmental concerns require strategic adoption.

The findings demonstrate that Islamic economic principles, when effectively integrated with blockchain technology, offer viable pathways for addressing food security and renewable energy challenges in volatile global contexts. The convergence of ethical finance, technological innovation, and critical development sectors creates synergistic opportunities that address multiple objectives simultaneously: capital mobilization for underserved sectors, enhanced operational efficiency through automation, improved stakeholder trust through transparency, and strengthened Sharia compliance verification. The success of Islamic financing instruments in agricultural and renewable energy contexts validates theoretical alignment between Islamic economic principles and sustainable development goals. Risk-sharing mechanisms inherent in musharakah and mudharabah structures naturally suit the uncertain nature of agricultural and renewable energy ventures, aligning financial institution and project success. Asset-backing requirements ensure productive economic deployment of capital rather than speculative financial engineering, directly supporting physical infrastructure and commodity production essential for food and energy security. Blockchain technology fundamentally addresses longstanding challenges around transparency and trust by enabling real-time Sharia compliance verification and immutable audit trails, representing a qualitative shift from periodic ex-post certification to continuous automated verification.

This research contributes to Islamic finance theory by demonstrating how technological innovations operationalize classical economic principles more effectively than traditional financial intermediation. Smart contract automation of Sharia compliance rules represents a modern manifestation of jurisprudence application. Findings also contribute to institutional trust theory by demonstrating how technology-enabled transparency can substitute for relationship-based trust mechanisms, enabling Islamic finance expansion into new markets. From sustainable development theory perspectives, the research illustrates that ethical finance frameworks can be operationalized for critical development challenges. Islamic financial institutions should prioritize strategic investments in blockchain infrastructure and technical capabilities, alongside human capital development. Product innovation opportunities exist in specialized agricultural finance units and renewable energy financing mechanisms leveraging sukuk or collective investment schemes. Collaboration with technology providers, regulators, and stakeholders is essential for shared blockchain platforms and standardized smart

contracts. Customer education and stakeholder engagement must accompany technological innovation to maximize trust and system usability.

Regulators should develop supportive yet prudent frameworks enabling Islamic FinTech innovation while managing risks. Legal recognition of blockchain-based contracts, cybersecurity standards, data protection regulations, licensing frameworks, and regulatory sandboxes facilitate innovation. Standardization across jurisdictions enhances interoperability and Sharia compliance verification. Targeted policy interventions can accelerate Islamic finance contributions to food security and renewable energy goals, including preferential regulatory treatment for Islamic green sukuk, risk-sharing mechanisms supporting agricultural financing, rural financial infrastructure development, and capacity-building programs. Research and development support remains important for infrastructure, skills development, and knowledge exchange. Strengths of the study include comprehensive coverage of multiple sectors, integration of technology and finance perspectives, contextual depth, systematic methodology, and actionable insights, while limitations involve qualitative design limiting generalization, rapid technological change, Indonesian focus, and absence of primary stakeholder interviews.

The Indonesian context illustrates both opportunities and challenges in implementing Islamic FinTech solutions. Successful pilot programs and operational implementations demonstrate technical feasibility and practical benefits, while persistent barriers around regulatory frameworks, technological infrastructure, human capital, and stakeholder coordination highlight implementation complexities requiring sustained attention and multi-stakeholder collaboration. The proposed integrated framework combining Islamic economic principles, blockchain capabilities, and sector-specific requirements provides strategic guidance for policymakers, financial institutions, and development organizations. Effective implementation requires coordinated action across technological infrastructure development, regulatory enhancement, human capital building, product innovation, and stakeholder engagement. No single actor can independently achieve desired outcomes; ecosystem-wide collaboration and commitment are essential.

From a practical perspective, Islamic financial institutions should prioritize strategic investments in technology, specialized sector expertise, and collaborative platforms while maintaining prudent risk management. Regulators should develop supportive frameworks balancing innovation enablement with systemic stability and consumer protection. Policymakers should align financial sector policies with broader food security and renewable energy objectives through targeted interventions and incentive structures. Development organizations and NGOs should explore Islamic financing mechanisms as complementary tools for their programming.

Several directions for future research are suggested. Quantitative studies measuring outcomes such as capital mobilization, transaction cost reductions, compliance verification efficiency, customer satisfaction, and development impact would complement this qualitative analysis. Comparative research across diverse Islamic

finance markets would illuminate context-specific versus universal principles. Longitudinal studies tracking implemented programs over time would assess sustainability and evolutionary patterns. Detailed case studies employing mixed methods would deepen understanding of implementation processes, stakeholder perspectives, and contextual dynamics. Interdisciplinary research integrating technological, financial, agricultural, energy, environmental, and social perspectives would address the interconnected nature of food security and renewable energy challenges. Research on emerging technologies beyond blockchain, scalability and inclusivity, and evolving global volatility impacts would ensure continued relevance, guide strategic planning, and inform practical implementation for large-scale and socially inclusive solutions. Overall, operationalizing Islamic economic principles through FinTech and blockchain provides a credible, scalable framework for enhancing food security, renewable energy development, and regional economic growth. The Indonesian experience offers lessons for other Muslim-majority countries seeking inclusive, ethical, and technology-enabled development pathways.

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