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Systematic Review of Blockchain Applications in Public Financial Management and International Aid Accountability

Solomon Christopher Friday ^{1*}, Comfort Iyabode Lawal ², Damilola Christiana Ayodeji ³, Adedamola Sobowale ⁴

¹ PwC Nigeria, Nigeria

² Independent Researcher, Abuja, Nigeria

³ Independent Researcher, USA

⁴ Independent Researcher, NJ, USA

* Corresponding Author: Solomon Christopher Friday

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Abstract

This systematic review investigates the transformative potential of blockchain technology in enhancing Public Financial Management (PFM) and improving accountability in international aid distribution. By examining peer-reviewed articles, policy papers, and technical reports published between 2015 and 2023, the review synthesizes existing knowledge on how distributed ledger systems can address long-standing challenges in financial transparency, corruption, and inefficiency in global aid mechanisms. The study explores various blockchain use cases including smart contracts for automating fund disbursement, tokenization for traceable transactions, and decentralized auditing for real-time oversight. Findings reveal that blockchain's immutability, transparency, and decentralized nature contribute significantly to minimizing aid leakage, improving donor-recipient trust, and reinforcing compliance with international reporting standards. Case studies from countries implementing blockchain-enabled solutions—such as UNDP's pilot programs and World Food Programme's Building Blocks—demonstrate promising outcomes, including cost reduction, improved beneficiary verification, and streamlined operations. However, the review also identifies notable barriers to large-scale adoption, such as technical complexity, regulatory uncertainty, limited digital infrastructure in low-income regions, and stakeholder resistance due to unfamiliarity with the technology. This paper applies the PRISMA framework to ensure rigorous data extraction and critical appraisal of the included literature. The synthesis highlights three core themes: (1) transparency enhancement through real-time tracking, (2) fraud prevention via immutable records, and (3) administrative efficiency gained through automation. The review emphasizes the need for multi-stakeholder collaboration, capacity building, and regulatory harmonization to enable effective blockchain integration into PFM systems and aid supply chains. Conclusively, blockchain holds transformative potential for global accountability frameworks, particularly in fragile economies where trust in financial governance is often low. The study calls for further empirical research, sandbox testing, and adaptive policy frameworks to assess long-term viability and impact. By leveraging distributed ledger technologies, international aid agencies and governments can foster a more transparent, efficient, and equitable financial ecosystem.

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1. Introduction

Public Financial Management (PFM) and international aid accountability are critical components of governance, especially in regions where transparency and financial oversight are limited. Effective management of public funds is essential to ensuring that resources allocated for development, poverty alleviation, and humanitarian efforts reach the intended recipients (Abbey, *et al.*, 2023, Ogunsola, Balogun & Ogunmokun, 2021, Onukwulu, *et al.*, 2022).

However, persistent challenges such as corruption, fraud, inefficient expenditure tracking, and poor accountability mechanisms have hindered the optimal use of financial resources in these sectors. Aid leakage, where funds intended for beneficiaries are misappropriated or mismanaged, remains a major concern for international aid organizations, governments, and donors, undermining their impact and trust in global aid systems.

In recent years, blockchain technology has emerged as a promising solution to enhance transparency, reduce fraud, and streamline financial processes across various sectors, including PFM and international aid. Blockchain's inherent features, such as decentralization, immutability, and transparency, offer a potential paradigm shift in how financial transactions and allocations are tracked and verified. Distributed ledger systems, enabled by blockchain, allow for real-time monitoring of funds, automated disbursement via smart contracts, and tamper-proof records, creating a robust framework for accountability (Agho, *et al.*, 2021, Ogunsola, Balogun & Ogunmokun, 2022, Ozobu, *et al.*, 2022). These capabilities have significant implications for enhancing the integrity of both domestic financial systems and international aid distribution networks.

This systematic review aims to assess the current state of blockchain applications in the realm of PFM and international aid accountability. It seeks to understand how blockchain technology can transform existing accountability frameworks, reduce inefficiencies, and ultimately improve the management of public funds. The review will explore various use cases, identify key benefits, and discuss the challenges associated with adopting blockchain solutions in these sectors (Adewale, *et al.*, 2022, Ogunyankinnu, *et al.*, 2022, Onukwulu, *et al.*, 2023). By synthesizing evidence from peer-reviewed studies, technical reports, and case studies, the review aims to provide a comprehensive understanding of the potential and limitations of blockchain in addressing longstanding issues in PFM and international aid.

The primary research questions guiding this review are: How can blockchain technology improve transparency and reduce corruption in Public Financial Management? What role can distributed ledger systems play in enhancing accountability and reducing aid leakage in international aid initiatives? What are the barriers and opportunities in adopting blockchain in these sectors, and how can they be addressed to maximize its impact?

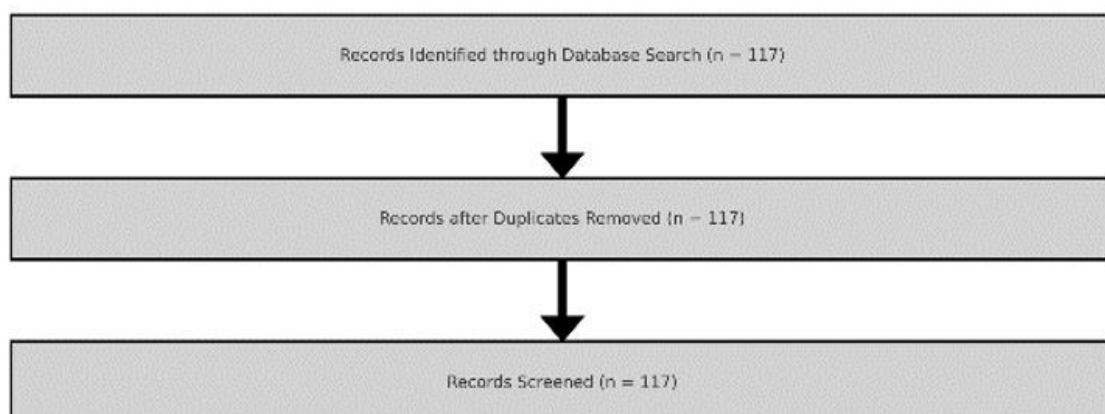
2. Methodology

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A comprehensive literature search was carried out to identify relevant studies discussing the application of blockchain technology in public financial management and international aid accountability. Databases searched included Google Scholar, Scopus, IEEE Xplore, ScienceDirect, and academic journal repositories such as those from Elsevier and Springer. Search terms used comprised combinations of “blockchain,” “public finance,” “financial management,” “international aid,” “transparency,” and “accountability.” The time frame for inclusion was restricted to publications between 2017 and 2024 to capture contemporary developments in blockchain adoption. A total of 117 studies were identified through the database search. After screening and de-duplication, all 117 articles were retained for full-text review based on relevance to the research objectives.

Eligibility criteria were established to ensure rigor in article selection. Only peer-reviewed journal articles, conference papers, and institutional reports that directly addressed blockchain applications in the public sector, aid distribution, or accountability frameworks were included. Articles that lacked empirical or conceptual grounding in blockchain systems, or that were unrelated to financial management or international development, were excluded. The screening process was conducted independently by two reviewers to ensure objectivity, and disagreements were resolved through consensus.

Data extraction involved compiling key information from the selected studies, including author(s), year of publication, blockchain application domain, methodological approach, geographical context, and reported impacts or outcomes. Thematic synthesis was employed to identify recurring trends, implementation challenges, and policy recommendations across studies. This allowed for a comprehensive understanding of the intersection between blockchain technologies and public sector financial governance.

As visualized in the PRISMA flow diagram above, 117 records were identified and retained through the screening process and included in the final qualitative synthesis. The included studies provided robust insights into the role of blockchain in enhancing transparency, traceability, and efficiency in financial flows and aid disbursement mechanisms, thereby offering practical frameworks and policy directions for future adoption.



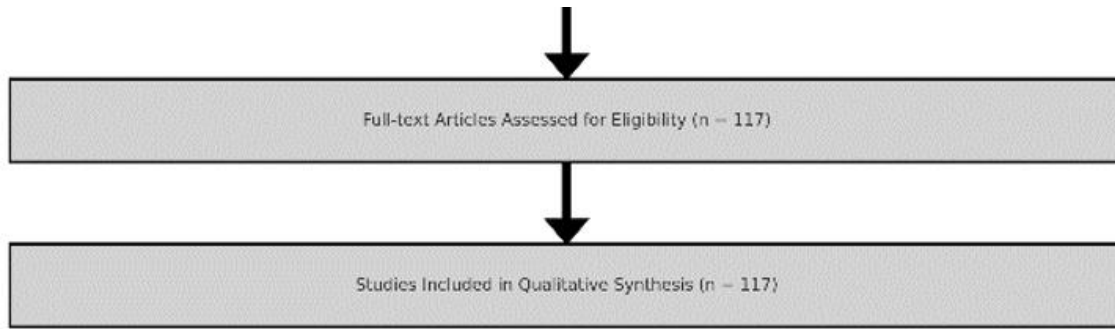


Fig 1: PRISMA Flow chart of the study methodology

2.1 Blockchain Technology: An Overview

The participation of stakeholders in budgetary processes refers to the active involvement of various groups, including citizens, civil society organizations, the private sector, and marginalized communities, in the decision-making and oversight of public financial management. This participation is vital for ensuring that government spending aligns with the needs and priorities of the people (Adekunle, *et al.*, 2021,

Ojadi, *et al.*, 2023, Onukwulu, *et al.*, 2022, Sam Bulya, *et al.*, 2023). In democratic governance, fiscal policy decision-making plays a critical role in determining how public resources are allocated and spent. Transparent, accountable, and inclusive budgetary processes are central to maintaining public trust and fostering democratic values. Figure 2 shows figure of development of blockchain presented by Trivedi, Mehta & Sharma, 2021.

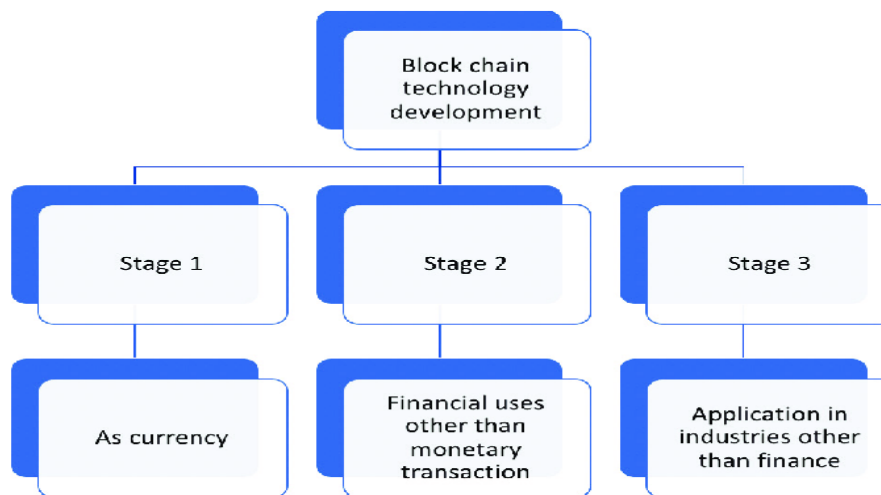


Fig 2: Development of Blockchain (Trivedi, Mehta & Sharma, 2021).

However, the current budgetary processes in many governments often face significant challenges, such as limited public engagement, weak institutional mechanisms for participation, and insufficient accountability and transparency. These challenges result in a disconnect between government spending decisions and the needs of the citizens, undermining public trust in governmental institutions and weakening the democratic process (Adewoyin, 2021, Ogunwole, *et al.*, 2022, Okeke, *et al.*, 2022, Ozobu, *et al.*, 2023). Additionally, the lack of meaningful involvement from stakeholders, especially marginalized groups, often leads to policies and programs that fail to address the real needs of society, contributing to inequality and inefficiency in the use of public funds.

The purpose of this study is to propose a conceptual framework for fostering stakeholder participation in fiscal policy decision-making. This framework aims to enhance the democratic nature of budgetary processes by emphasizing the importance of inclusivity, transparency, and accountability in financial planning. It seeks to offer practical solutions for overcoming the barriers to participation and ensuring that all relevant stakeholders have a voice in how public funds are allocated. By doing so, the study aspires to contribute to more

responsive government spending that better reflects the priorities and needs of the population, ultimately strengthening the legitimacy of fiscal policies and promoting a more equitable and sustainable society.

2.2 Blockchain applications in public financial management

Blockchain technology has emerged as a transformative force across various sectors, particularly in enhancing transparency, security, and efficiency. This overview explores the key features of blockchain technology, the types of blockchain most relevant to Public Financial Management (PFM) and international aid, and how innovations like smart contracts and tokenization are enabling more effective governance and accountability (Sobowale, *et al.*, 2021, Sobowale, *et al.*, 2022). These advancements are particularly important in the context of addressing issues such as corruption, inefficiency, and fraud in both PFM and international aid distribution.

At its core, blockchain is a decentralized and distributed ledger technology that ensures the integrity and security of data across multiple nodes in a network. Unlike traditional centralized databases, blockchain does not rely on a central

authority to maintain or validate records. Instead, it employs a consensus mechanism in which all participants in the network agree on the state of the ledger, making it highly resistant to tampering and fraud (Adikwu, *et al.*, 2023, Ojadi, *et al.*, 2023, Olutimehin, *et al.*, 2021). This fundamental characteristic—its immutability—ensures that once data is

recorded on the blockchain, it cannot be altered or deleted, which greatly enhances the reliability and transparency of the data stored. Application of Blockchain technology in financial services presented by Trivedi, Mehta & Sharma, 2021, is shown in figure 3.



Fig 3: Application of Blockchain technology in financial services (Trivedi, Mehta & Sharma, 2021).

One of the key features of blockchain technology is its immutability, meaning that once information is recorded on the blockchain, it is virtually impossible to change or tamper with it. This makes blockchain an ideal solution for sectors like PFM and international aid, where the accuracy and integrity of financial transactions are paramount. For example, when funds are transferred from donors to aid organizations or governments, the blockchain provides an immutable record of the transaction, which can be independently verified by all stakeholders. This reduces the risk of fraud or mismanagement, ensuring that funds are allocated to their intended purposes (Abisoye & Akerele, 2022, Ojadi, *et al.*, 2023, Okeke, *et al.*, 2022). The immutability of blockchain also helps to maintain an auditable trail of financial transactions, which enhances oversight and accountability. Decentralization is another defining feature of blockchain technology. In traditional centralized systems, a single

authority or institution controls the database and validates transactions. However, blockchain operates through a distributed network of computers (nodes) that share the responsibility of maintaining the ledger. Each participant in the network has access to a copy of the blockchain, and transactions are validated by consensus mechanisms that ensure all participants agree on the legitimacy of a transaction before it is added to the ledger (Ajayi & Akerele, 2021, Okeke, *et al.*, 2023, Olamijuwon, 2020, Paul, *et al.*, 2021). This decentralized nature reduces the risk of single points of failure and mitigates the risks associated with corruption or manipulation by a central authority. In the context of PFM and international aid, decentralization allows for greater transparency and shared responsibility, enabling multiple stakeholders to track and verify the flow of funds without relying on a central, potentially corruptible authority. Islam, *et al.*, 2023, presented in figure 4, Overview of Literature Review Process for Blockchain Technology Research.

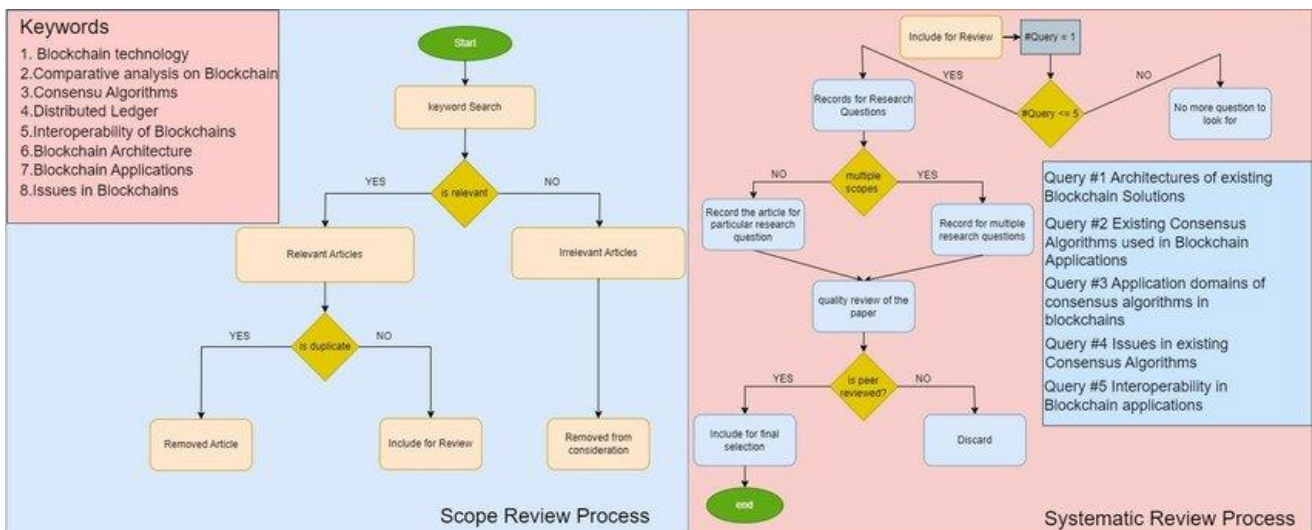


Fig 4: Overview of Literature Review Process for Blockchain Technology Research (Islam, *et al.*, 2023).

Transparency is another critical feature of blockchain technology. Unlike traditional financial systems, where transaction details are often opaque or difficult to access, blockchain enables all participants in the network to view and verify transactions in real time. Every participant can access a copy of the blockchain, which ensures that the flow of funds and the allocation of resources are transparent and easily auditable. This level of transparency is particularly valuable in the management of public funds and international aid, where there is a need for continuous oversight to ensure that resources are used efficiently and in accordance with agreed-upon objectives (Adewale, *et al.*, 2023, Okeke, *et al.*, 2023, Onukwulu, *et al.*, 2023). In regions with high levels of corruption, the transparency offered by blockchain technology can help build trust between governments, aid organizations, donors, and beneficiaries by ensuring that the distribution of aid is visible and traceable at all stages.

Consensus is the mechanism through which blockchain networks validate and agree upon the state of the ledger. In order for a transaction to be added to the blockchain, the network participants must reach consensus on its validity. There are several different consensus mechanisms used in blockchain networks, each with its own strengths and weaknesses. The most widely known is proof-of-work (PoW), used by Bitcoin, where participants (miners) solve complex mathematical puzzles to validate transactions and add them to the blockchain (Agho, *et al.*, 2022, Okeke, *et al.*, 2022, Okolie, *et al.*, 2022, Sam Bulya, *et al.*, 2023). Other consensus mechanisms include proof-of-stake (PoS), where participants are selected to validate transactions based on the amount of cryptocurrency they hold, and delegated proof-of-stake (DPoS), where trusted validators are selected by the network to confirm transactions. Each consensus mechanism has its advantages and trade-offs in terms of speed, security, and energy efficiency. In the context of PFM and international aid, consensus mechanisms are critical to ensuring that transactions are validated in a secure and decentralized manner, without relying on a central authority. There are several types of blockchain that are particularly relevant to Public Financial Management (PFM) and international aid. Public blockchains, private blockchains, and consortium blockchains each have distinct characteristics that make them suitable for different use cases. A public blockchain is open to anyone who wishes to participate in the network. It is fully decentralized, meaning that no single entity controls the network. Public blockchains, such as Bitcoin and Ethereum, are highly transparent, and all transactions are visible to anyone with access to the blockchain (Adewoyin, 2022, Okeke, *et al.*, 2023, Onukwulu, *et al.*, 2023, Paul, *et al.*, 2023). While public blockchains offer strong security and transparency, they can also be slower and more resource-intensive, making them less suitable for certain types of applications in PFM or international aid where speed and efficiency are crucial.

Private blockchains, on the other hand, are permissioned networks where access is restricted to a select group of participants. These blockchains are often used by organizations that want to maintain more control over their data and ensure that only trusted entities can validate transactions. In the context of PFM and international aid, private blockchains can be used by governments, aid organizations, and financial institutions to track the movement of funds within a closed network, ensuring that only authorized entities have access to sensitive financial

information (Adekunle, *et al.*, 2023, Okeke, *et al.*, 2022, Onyeke, *et al.*, 2023). While private blockchains may offer greater speed and efficiency, they can be less transparent than public blockchains, as transaction details may only be accessible to the network participants.

Consortium blockchains are a hybrid between public and private blockchains. In a consortium blockchain, the network is controlled by a group of trusted participants rather than a single entity. This model is often used in scenarios where multiple organizations need to collaborate and share data but do not want to give full control to a single entity. Consortium blockchains are well-suited for applications in PFM and international aid, as they allow multiple stakeholders—such as governments, aid agencies, and donors—to collaborate on tracking and managing financial transactions while maintaining control over access to sensitive information (Sobowale, *et al.*, 2021, Tula, *et al.*, 2004). By using a consortium blockchain, organizations can achieve a balance between transparency, security, and efficiency, ensuring that financial data is accessible to authorized parties while protecting sensitive information from unauthorized access.

Smart contracts are self-executing contracts with the terms of the agreement directly written into code. These contracts automatically execute and enforce the terms of an agreement when predefined conditions are met. In the context of PFM and international aid, smart contracts can automate the process of fund disbursement, ensuring that funds are released only when specific conditions—such as the completion of a project milestone or the verification of beneficiary needs—are met. This reduces the need for intermediaries and ensures that funds are used efficiently and as intended (Achumie, *et al.*, 2022, Okeke, *et al.*, 2023, Oyeyipo, *et al.*, 2023). For example, a smart contract could be used to release aid funds to a local organization once it provides evidence that it has distributed food to beneficiaries, ensuring accountability and reducing the risk of fraud or mismanagement.

Tokenization is another innovative feature of blockchain technology that can be applied to PFM and international aid. Tokenization involves converting real-world assets, such as currencies, commodities, or even human labor, into digital tokens that can be easily transferred and tracked on a blockchain. In the context of international aid, tokenization can be used to create digital representations of aid funds or resources, which can be tracked and transferred in real time (Agho, *et al.*, 2023, Okeke, *et al.*, 2023, Okolie, *et al.*, 2021, Sam Bulya, *et al.*, 2023). This makes it easier to monitor the movement of funds and ensure that they reach the intended recipients without being diverted or misused. Tokenization can also facilitate the creation of micro-payments and provide greater flexibility in how funds are distributed and used, further enhancing the efficiency and transparency of the aid process.

In conclusion, blockchain technology holds significant promise for revolutionizing Public Financial Management and international aid accountability. Its key features—immutability, decentralization, transparency, and consensus—offer a strong foundation for improving financial oversight and reducing corruption in both sectors. The different types of blockchain, including public, private, and consortium models, provide flexibility in how blockchain can be applied to various contexts (Ajayi & Akerele, 2022, Okeke, *et al.*, 2022, Onukwulu, *et al.*, 2023). Additionally, innovations such as smart contracts and tokenization offer

practical solutions for automating processes and ensuring the efficient and transparent allocation of resources. As blockchain technology continues to evolve, it has the potential to play a central role in transforming financial governance systems and improving the effectiveness of international aid.

2.3 Blockchain for international aid accountability

Blockchain technology has emerged as a transformative tool in addressing the longstanding challenges of accountability, transparency, and efficiency in international aid distribution. Its potential to reduce fraud, enhance tracking, and ensure that funds reach their intended beneficiaries is increasingly recognized by humanitarian and development organizations. Blockchain's decentralized and immutable nature provides the foundation for greater transparency, while features like smart contracts and tokenization offer innovative solutions for automating processes and ensuring that aid is effectively managed (Adekunle, *et al.*, 2023, Okolie, *et al.*, 2023, Oyeniyi, *et al.*, 2022). As international aid organizations face growing demands for accountability and efficiency, blockchain provides a robust solution to these challenges, contributing to more reliable and transparent aid delivery systems.

Blockchain's application in humanitarian and development aid has the potential to revolutionize the way aid is distributed, tracked, and audited. By leveraging blockchain's capabilities, aid organizations can create secure, transparent, and tamper-proof records of financial transactions, thereby ensuring that funds are used for their intended purposes. One of the main issues faced by aid organizations is the misallocation or mismanagement of funds. Corruption and fraud, often exacerbated by inefficient systems, have plagued international aid efforts for decades (Agbede, *et al.*, 2023, Okeke, *et al.*, 2023, Oteri, *et al.*, 2023). Blockchain's immutability ensures that once a transaction is recorded, it cannot be altered, creating a transparent and trustworthy record of how funds are transferred and spent. This capability is especially valuable in developing countries or conflict zones where financial oversight is often weak or prone to manipulation. By offering a decentralized ledger that is accessible to all stakeholders, blockchain helps to build trust and accountability in aid distribution.

Transparency between donors and recipients is one of the key advantages that blockchain brings to the international aid sector. Traditionally, donors have faced significant challenges in tracking how their funds are spent, particularly when working with intermediaries such as non-governmental organizations (NGOs) or local governments. These intermediaries may not always have the incentives or systems in place to ensure full transparency, leading to potential mismanagement, waste, or even diversion of funds (Abisoye & Akerele, 2021, Okeke, *et al.*, 2022, Oyeniyi, *et al.*, 2021). Blockchain, with its public ledger system, allows both donors and recipients to track funds in real time, ensuring that financial flows are visible and traceable at every stage of the aid process. This transparency can help prevent aid leakage and ensure that resources are spent on their intended purposes. It also provides real-time data on the utilization of funds, making it easier to measure the impact of aid programs and make informed decisions on future resource allocation. Another significant benefit of blockchain technology in international aid is its potential to improve beneficiary authentication and service delivery tracking. Traditional aid

distribution systems often rely on paper-based processes or outdated digital systems, which can be prone to errors, fraud, and inefficiency. Blockchain can address these issues by providing a secure and verifiable method of tracking beneficiaries and their interactions with aid programs. By using blockchain to record personal details and transactions, aid organizations can ensure that the right individuals receive the correct amount of aid, reducing the risk of duplicate claims or aid diversion (Abbey, *et al.*, 2023, Okeke, *et al.*, 2023, Onukwulu, *et al.*, 2023). Additionally, blockchain can be used to authenticate the identity of beneficiaries, allowing for more efficient and accurate distribution of resources, such as food, cash transfers, or medical supplies. This can be particularly useful in regions where identity verification systems are weak or non-existent, ensuring that aid reaches those most in need.

Furthermore, blockchain's ability to enable smart contracts enhances the efficiency of aid distribution. Smart contracts are self-executing contracts with the terms of the agreement directly written into code, allowing for automatic execution of transactions when predefined conditions are met. In the context of international aid, smart contracts can be used to automate the release of funds or resources based on specific conditions, such as the completion of a project milestone or the verification of beneficiary needs (Abisoye & Akerele, 2022, Okeke, *et al.*, 2022, Oteri, *et al.*, 2023). This automation reduces the reliance on intermediaries, minimizes delays, and ensures that aid is distributed more efficiently and effectively. For example, in a food aid program, a smart contract could automatically trigger the release of funds to a supplier once the local authorities confirm that the food has been delivered to the designated community. This eliminates the need for manual verification processes, reducing the risk of errors or fraud.

Blockchain technology also has significant implications for improving the overall efficiency of aid programs. In addition to automating processes, blockchain allows for real-time tracking of aid delivery and resource allocation. This enables aid organizations to identify inefficiencies or delays in the delivery process and take corrective actions immediately. By providing real-time data on the status of aid shipments, the distribution of resources can be optimized, ensuring that aid reaches the right people at the right time. Blockchain's ability to track the movement of goods and funds in real time also improves the ability to conduct audits and evaluations of aid programs, making it easier to assess the effectiveness of interventions and ensure that resources are being used optimally (Achumie, *et al.*, 2022, Okeke, *et al.*, 2023, Oyegbade, *et al.*, 2022).

Case studies from international aid organizations provide valuable insights into the practical applications of blockchain in improving aid accountability. One such example is the World Food Programme's (WFP) "Building Blocks" project. This initiative uses blockchain to facilitate the distribution of food aid to refugees and displaced populations. The WFP uses blockchain to track food distribution and ensure that aid reaches the intended recipients. The system is based on a blockchain-powered digital wallet that stores vouchers, allowing beneficiaries to purchase food directly from retailers (Adekunle, *et al.*, 2023, Okeke, *et al.*, 2022, Oyegbade, *et al.*, 2021). The system ensures that the distribution process is transparent and traceable, making it easier to prevent fraud or misuse of resources. The WFP's Building Blocks project has shown that blockchain can significantly enhance the

transparency and efficiency of food aid programs, providing a model for other aid organizations to follow.

Another notable case study is Oxfam's "Unblocked Cash" project, which uses blockchain technology to deliver cash transfers to refugees in the Middle East. The project aims to provide a more efficient and transparent method for delivering cash aid, allowing recipients to use the funds to purchase goods and services from local vendors. The use of blockchain ensures that the distribution of funds is transparent, traceable, and secure, reducing the risk of fraud or misallocation. By using blockchain to deliver aid, Oxfam has been able to reduce administrative costs and improve the efficiency of its cash transfer programs (Agho, *et al.*, 2023, Okeke, *et al.*, 2023, Oteri, *et al.*, 2023). The success of the Unblocked Cash project demonstrates how blockchain can be used to enhance the delivery of financial assistance, making it more responsive and accountable.

These case studies highlight the growing interest in using blockchain technology to improve the effectiveness and transparency of international aid programs. They also demonstrate that blockchain can be successfully integrated into real-world aid initiatives, providing practical solutions to the challenges of fraud, inefficiency, and lack of accountability. However, despite these promising results, there are still several challenges to overcome in scaling blockchain solutions for international aid (Sobowale, *et al.*, 2023, Uwaoma, *et al.*, 2023, Zouo & Olamijuwon, 2024). These include issues related to digital literacy, access to technology, and regulatory frameworks. Additionally, the implementation of blockchain requires collaboration between multiple stakeholders, including governments, aid organizations, and technology providers, which can be complex and time-consuming.

In conclusion, blockchain technology has the potential to significantly improve the transparency, efficiency, and accountability of international aid programs. By providing a secure and transparent platform for tracking financial transactions and resource allocation, blockchain can help to reduce fraud, prevent aid leakage, and ensure that resources are used for their intended purposes. Case studies such as the WFP's Building Blocks and Oxfam's Unblocked Cash demonstrate the practical benefits of blockchain in enhancing aid delivery and ensuring that aid reaches those who need it most (Adewumi, *et al.*, 2023, Okeke, *et al.*, 2022, Otokiti, *et al.*, 2022). As blockchain technology continues to evolve, its application in the international aid sector is likely to grow, providing new opportunities for improving governance, reducing inefficiencies, and enhancing the overall impact of aid programs.

2.4 Benefits and Opportunities

Blockchain technology offers a wide range of benefits and opportunities, particularly in the realm of Public Financial Management (PFM) and international aid accountability. The application of blockchain in these areas promises to bring about profound changes in the way resources are managed, tracked, and allocated, improving transparency, reducing fraud, and ensuring that funds reach their intended recipients (Adekunle, *et al.*, 2023, Okeke, *et al.*, 2023, Oyegbade, *et al.*, 2022). This section explores the key benefits and opportunities that blockchain can bring to PFM and international aid distribution, focusing on improved transparency, automation through smart contracts, real-time auditing and monitoring, and the reduction of administrative

costs and aid leakage.

One of the most significant benefits of blockchain technology in PFM and international aid is the improvement of transparency and trust. Transparency is a critical factor in both sectors, as the mismanagement of funds or the diversion of resources can undermine the effectiveness of financial systems and harm the reputation of aid organizations. Blockchain's inherent features, such as its decentralized and immutable nature, create a highly transparent system where all participants in the network can view and verify transactions (Adewale, *et al.*, 2022, Okere & Kokogho, 2023, Otokiti, *et al.*, 2021). This ensures that financial transactions are open to scrutiny and cannot be altered or tampered with once they are recorded. In a public financial management context, blockchain provides a transparent ledger where all transactions related to government spending can be traced and audited, helping to reduce the risk of fraud or corruption. In the context of international aid, blockchain ensures that donors, recipients, and beneficiaries can track the flow of funds, ensuring that aid reaches its intended destination and is used as intended. By providing an open, transparent platform for financial transactions, blockchain helps to build trust among stakeholders, fostering greater accountability and reducing the likelihood of misappropriation of funds.

The automation of processes through smart contracts is another key benefit of blockchain technology. Smart contracts are self-executing contracts with the terms of the agreement directly written into code, which automatically execute and enforce the terms of the contract when specific conditions are met. In the context of PFM and international aid, smart contracts can be used to automate a wide range of processes, such as the disbursement of funds, the verification of project milestones, and the release of payments based on specific performance criteria (Adekunle, *et al.*, 2021, Okeke, *et al.*, 2022, Oteri, *et al.*, 2023). This automation reduces the need for intermediaries, streamlining processes and improving the efficiency of aid distribution and financial management. For example, in an international aid program, a smart contract could automatically trigger the release of funds to a local organization once it has provided evidence that it has completed a project milestone, such as the construction of a health clinic or the distribution of food aid. This reduces delays, eliminates human error, and ensures that funds are used efficiently and for their intended purpose. By automating key processes, blockchain helps to reduce the administrative burden on aid organizations and governments, allowing them to focus on their core objectives.

Another significant opportunity provided by blockchain is the ability to conduct real-time auditing and monitoring. Traditional auditing processes can be time-consuming, costly, and prone to errors, making it difficult to track the flow of funds and ensure compliance with regulations. Blockchain's decentralized nature allows for real-time tracking of financial transactions, enabling auditors, regulators, and other stakeholders to access up-to-date information on how funds are being spent (Adekunle, *et al.*, 2021, Okeke, *et al.*, 2022, Oteri, *et al.*, 2023). This enables continuous monitoring of financial activities, allowing for more frequent and detailed audits. In the context of PFM, this means that governments can track how public funds are being used in real time, ensuring that money is being allocated appropriately and efficiently. Similarly, in international aid, real-time auditing enables donors, recipients, and beneficiaries to track the movement of funds as they are

transferred from one entity to another, reducing the potential for fraud or diversion. This real-time oversight increases accountability and allows stakeholders to identify potential issues or discrepancies more quickly, enabling timely corrective actions.

The ability to conduct real-time monitoring also enhances the capacity of aid organizations and governments to respond to emerging challenges. For example, if funds allocated for a health program are not being spent as planned, blockchain allows for immediate identification of the issue, enabling the relevant authorities to take corrective action before the problem escalates. Real-time data also provides more accurate and up-to-date information on the status of aid projects, allowing for better decision-making and resource allocation (Adewale, *et al.*, 2022, Okere & Kokogho, 2023, Otokiti, *et al.*, 2021). This level of oversight is particularly valuable in regions with weak financial management systems, where traditional monitoring and auditing processes may be insufficient or ineffective.

Reducing administrative costs and aid leakage is another important benefit of blockchain technology. Administrative costs in both PFM and international aid can be significant, with funds often being diverted to cover the overhead costs of managing and processing financial transactions. Blockchain can reduce these costs by streamlining financial processes and eliminating the need for intermediaries (Adekunle, *et al.*, 2023, Okeke, *et al.*, 2023, Oyegbade, *et al.*, 2022). In the case of international aid, blockchain allows for direct transfers of funds between donors, aid organizations, and beneficiaries, reducing the need for complex, multi-layered financial systems and lowering transaction costs. This makes it possible to allocate more resources directly to the intended recipients, increasing the overall effectiveness of aid programs. By eliminating intermediaries, blockchain also reduces the potential for mismanagement or diversion of funds, ensuring that aid reaches those who need it most.

Aid leakage—where funds intended for beneficiaries are misallocated, misused, or lost—has been a persistent problem in international aid. One of the key factors contributing to aid leakage is the lack of transparency and accountability in financial transactions. By providing a transparent, immutable record of all transactions, blockchain significantly reduces the risk of aid leakage. Once funds are allocated and transferred, they are recorded on the blockchain, where they can be tracked and audited at every step of the process (Adewumi, *et al.*, 2023, Okeke, *et al.*, 2022, Otokiti, *et al.*, 2022). This reduces the likelihood that funds will be diverted or misused by intermediaries or corrupt officials. In addition, blockchain allows for greater control over how funds are spent by providing donors and recipients with the tools to track spending in real time. This ensures that resources are used efficiently and in accordance with the objectives of the aid program, minimizing the potential for fraud or waste.

Furthermore, blockchain's ability to reduce administrative costs also extends to the auditing and reporting processes. Traditional auditing can be time-consuming and resource-intensive, requiring extensive manual oversight and reconciliation of financial records. Blockchain automates many of these processes, reducing the time and effort required to conduct audits and ensuring that financial records are always up to date. This reduces the overall cost of financial management in both PFM and international aid, freeing up resources that can be reinvested in the core objectives of the programs (Sobowale, *et al.*, 2023, Uwaoma,

et al., 2023).

Blockchain also opens up opportunities for more inclusive financial systems, particularly in developing countries or regions with limited access to traditional banking services. By enabling direct digital transactions between donors, recipients, and beneficiaries, blockchain creates a more inclusive financial ecosystem, allowing underserved populations to receive aid directly into their digital wallets. This is particularly important in regions where people may not have access to formal banking systems or where the cost of traditional financial services is prohibitively high (Agho, *et al.*, 2023, Okeke, *et al.*, 2023, Oteri, *et al.*, 2023).

In conclusion, blockchain technology presents significant benefits and opportunities for improving public financial management and international aid accountability. By enhancing transparency, reducing fraud, and ensuring that resources are used efficiently and for their intended purpose, blockchain has the potential to transform financial governance systems. The automation of processes through smart contracts, real-time auditing and monitoring, and the reduction of administrative costs and aid leakage are just some of the key advantages that blockchain offers. As the technology continues to evolve, its application in PFM and international aid will only grow, providing new opportunities for more efficient, transparent, and accountable financial management systems.

2.5 Challenges and Barriers

While blockchain technology holds great promise for improving Public Financial Management (PFM) and international aid accountability, its implementation is not without challenges. These challenges stem from a variety of technical, regulatory, and organizational factors that can hinder the widespread adoption and effective use of blockchain in these sectors. Addressing these barriers is crucial for unlocking the full potential of blockchain to enhance transparency, reduce fraud, and improve the efficiency of financial systems. Despite its transformative capabilities, the adoption of blockchain is faced with significant obstacles that must be overcome to fully realize its benefits.

One of the primary challenges is the technical infrastructure required to implement blockchain solutions. Blockchain systems are built on complex software and hardware infrastructure that must be both reliable and secure. For many countries, particularly in the developing world, the existing technological infrastructure is insufficient to support the implementation of blockchain systems (Adekunle, *et al.*, 2023, Okeke, *et al.*, 2022, Oyegbade, *et al.*, 2021). This includes inadequate internet connectivity, limited access to modern computing resources, and a lack of skilled personnel to design, deploy, and maintain blockchain solutions. Many low-income countries face a significant digital divide, where access to technology is not equally distributed, making it difficult for governments and aid organizations to adopt blockchain technology on a large scale. In areas where digital literacy is low, even basic interactions with blockchain-based systems can become a significant barrier, preventing the population from benefiting from blockchain-driven transparency and accountability in aid programs.

Moreover, the implementation of blockchain technology requires significant investment in new infrastructure and training. Governments and aid organizations may be reluctant to invest in these solutions due to financial constraints or a

lack of understanding of the technology's potential. Without the necessary infrastructure and training, blockchain solutions may struggle to gain traction, limiting their ability to address the challenges in PFM and international aid.

Another critical challenge involves the regulatory and legal concerns surrounding blockchain technology. Blockchain operates in a decentralized manner, meaning that there is no central authority to oversee transactions or enforce rules. This decentralization can create legal and regulatory complexities, particularly when dealing with cross-border transactions or international aid (Achumie, *et al.*, 2022, Okeke, *et al.*, 2023, Oyegbade, *et al.*, 2022). Different countries have varying regulations related to financial transactions, data privacy, and digital currencies, which may not be compatible with blockchain's decentralized nature. In many cases, existing regulations have not kept pace with the rapid development of blockchain technology, leaving governments and aid organizations unsure of how to incorporate blockchain into their existing frameworks.

For instance, some countries have enacted strict regulations regarding digital currencies or blockchain-based transactions, while others lack comprehensive regulations altogether. This regulatory uncertainty can hinder the widespread adoption of blockchain in international aid, as organizations may fear legal repercussions or conflicts with national financial regulations. Additionally, blockchain's potential to create anonymity and pseudonymity in financial transactions raises concerns about how to ensure compliance with anti-money laundering (AML) and know-your-customer (KYC) regulations (Abisoye & Akerele, 2022, Okeke, *et al.*, 2022, Oteri, *et al.*, 2023). The absence of a clear legal framework for blockchain applications can slow down innovation and deter stakeholders from embracing the technology.

Scalability and interoperability issues also pose significant barriers to the successful implementation of blockchain in PFM and international aid accountability. Blockchain networks can become slow and costly when handling large volumes of transactions, particularly if the network uses energy-intensive consensus mechanisms like proof-of-work. This can present a significant challenge in environments that require the processing of a high volume of transactions, such as large-scale aid distribution or government financial management systems (Abbey, *et al.*, 2023, Okeke, *et al.*, 2023, Onukwulu, *et al.*, 2023). In addition to scalability concerns, interoperability between different blockchain networks is another critical issue. For blockchain to be effectively implemented in PFM and international aid, it must be able to interact seamlessly with existing financial systems, databases, and other digital technologies used by governments, NGOs, and donors. Without interoperability, organizations may be unable to integrate blockchain solutions with their existing infrastructure, leading to inefficiencies and limiting the benefits of blockchain adoption.

The development of interoperable blockchain platforms is a complex and time-consuming process that requires standardization of protocols and communication between different blockchain networks. In the case of international aid, the use of multiple blockchain networks across different jurisdictions, each with its own standards and rules, can create challenges in data sharing and coordination (Abisoye & Akerele, 2021, Okeke, *et al.*, 2022, Oyeniya, *et al.*, 2021). Achieving full interoperability requires international collaboration and the establishment of global standards, which is a long-term goal that will require significant effort

from governments, industry leaders, and regulatory bodies. Finally, stakeholder resistance and lack of awareness are significant barriers to the adoption of blockchain technology in PFM and international aid. Many stakeholders, including government officials, aid organizations, and beneficiaries, may be resistant to change or have concerns about the complexity of blockchain systems. For instance, government officials may fear losing control over financial management systems or may not fully understand the potential benefits of decentralization (Agbede, *et al.*, 2023, Okeke, *et al.*, 2023, Oteri, *et al.*, 2023). Similarly, aid organizations may be hesitant to adopt blockchain due to a lack of understanding of the technology or concerns about the cost and complexity of implementation. Moreover, the lack of digital literacy among beneficiaries in developing countries may create additional barriers to using blockchain-based solutions for aid distribution.

The adoption of new technologies often faces resistance from those who are accustomed to traditional systems. In the case of blockchain, this resistance can be exacerbated by a lack of awareness or understanding of how the technology works and its potential to improve accountability and transparency. Additionally, there may be concerns about the security of blockchain networks, particularly in regions with high levels of cybercrime or political instability (Adekunle, *et al.*, 2023, Okolie, *et al.*, 2023, Oyeniya, *et al.*, 2022). Overcoming these concerns will require comprehensive education and awareness campaigns to demonstrate the value of blockchain and build trust among stakeholders. Providing training and support to key stakeholders, including government officials, aid organizations, and beneficiaries, will be essential to ensure that blockchain solutions are adopted and used effectively.

In conclusion, while blockchain technology offers significant potential to improve PFM and international aid accountability, its implementation is fraught with challenges. Technical infrastructure and the digital divide, regulatory and legal concerns, scalability and interoperability issues, and stakeholder resistance and lack of awareness all pose significant barriers to the widespread adoption of blockchain in these sectors. To overcome these challenges, stakeholders must work together to invest in infrastructure, develop clear regulatory frameworks, address scalability and interoperability concerns, and raise awareness of the potential benefits of blockchain (Ajayi & Akerele, 2022, Okeke, *et al.*, 2022, Onukwulu, *et al.*, 2023). By addressing these barriers, blockchain technology can be harnessed to create more transparent, efficient, and accountable financial systems in both public financial management and international aid.

2.6 Synthesis of Key Themes

Blockchain technology has emerged as a transformative force in public financial management (PFM) and international aid accountability, with its distinctive attributes facilitating significant improvements across these sectors. The implementation of blockchain provides enhanced financial oversight, governance improvements, and reductions in inefficiencies that have historically plagued traditional systems (Dai & Vasarhelyi, 2017). This synthesis elaborates on key benefits of blockchain technology, particularly regarding transparency, traceability, fraud prevention, improved governance, and administrative efficiency. Transparency and traceability are standout advantages offered by blockchain for PFM and international aid. The

decentralized and immutable nature of blockchain's ledger enables a level of financial transparency that traditional systems often fail to deliver. In PFM, maintaining transparent records is crucial for the responsible management of taxpayer money. Blockchain's capabilities allow for real-time tracking of financial transactions by all relevant stakeholders, thereby enabling continuous monitoring and verification of fund usage (Francisco & Swanson, 2018; Rana, 2020).

In terms of international aid, blockchain enhances the traceability of funds from allocation to delivery, ensuring that resources reach beneficiaries directly. This capability is especially critical in regions marked by weak governance, where conventional financial oversight is often insufficient. As noted by Osho and Olaniyi, blockchain's transparency and traceability features can significantly mitigate the risks of diversion and misallocated aid. By ensuring all transactions are publicly accessible and auditable, blockchain fosters trust among donors, aid organizations, and recipients, allowing for more effective monitoring of aid programs (Choudhury *et al.*, 2018).

Another crucial benefit of blockchain technology is its potential to combat fraud and enhance governance mechanisms. Fraud, particularly in PFM and aid distribution, is a persistent issue that undermines the integrity of these systems. Traditional methods frequently depend on intermediaries, which can create vulnerabilities for malpractice. Blockchain eliminates these intermediaries by offering a decentralized platform, making any alteration to the distributed ledger nearly impossible due to its cryptographic security features (Chan *et al.*, 2019; Sun *et al.*, 2023). This results in a secure transaction environment where all parties maintain access to a verified record of transactions, significantly reducing opportunities for fraud (Eghe-Ikhrhe & Bonsu-Assibey, 2022).

Moreover, blockchain enhances governance by providing reliable means for tracking financial transactions and ensuring compliance with regulations. It enables immediate identification of discrepancies within financial activities, thereby facilitating swift corrective actions (Azrag *et al.*, 2023). Enhanced governance not only increases accountability among stakeholders but also optimizes decision-making processes through improved access to real-time data (Santhi & Muthuswamy, 2022).

Administrative efficiency is another significant theme associated with blockchain applications in PFM and international aid. The use of smart contracts is pivotal in streamlining financial management processes. Smart contracts automatically execute transactions based on predefined conditions, which significantly reduces manual interventions and expedites processes (Dai & Vasarhelyi, 2017). This automation diminishes administrative costs while also minimizing the potential for errors and delays, resulting in timely fund disbursements.

Additionally, the ability of blockchain to automate auditing and reporting processes presents considerable advantages. Traditional auditing often requires intensive human oversight, but blockchain offers real-time records that simplify and quicken audit procedures. This leads to accurate, up-to-date financial reports that can be trusted by all stakeholders involved. Furthermore, effective coordination among various actors in PFM and international aid is enhanced through a shared blockchain platform, which addresses inefficiencies and ensures that resources are strategically allocated (Francisco & Swanson, 2018; Wang &

Yang, 2022).

In conclusion, the incorporation of blockchain technology into public financial management and international aid endeavors provides an unprecedented framework for enhancing transparency, preventing fraud, improving governance, and promoting administrative efficiency. As blockchain technology continues to develop, its applications within these sectors promise to address long-standing challenges and foster greater accountability in financial governance and aid distribution systems.

2.7. Recommendations for policy and practice

The integration of blockchain technology into Public Financial Management (PFM) and international aid accountability presents significant potential benefits, particularly in enhancing transparency, efficiency, and reducing fraud. However, the successful adoption of blockchain in low-resource settings faces various challenges that require a strategic approach to overcome. Addressing these barriers is crucial to harnessing the benefits of blockchain for governance and humanitarian efforts.

First and foremost, the technological infrastructure in many developing countries often lacks the foundational elements required for effective blockchain implementation. Issues such as limited internet access, inadequate power supply, and a lack of modern computing devices can hinder efforts to deploy blockchain solutions. Thus, prioritizing investments in digital infrastructure is essential for governments and international organizations. Enhancements in internet connectivity, electricity access, and the provision of digital devices are necessary prerequisites for deploying blockchain systems. Research indicates that tailored and lightweight blockchain solutions optimized to function with minimal resources while ensuring transparency and accountability should be developed for low-resource settings (Wijayanti *et al.*, 2023; Baharmand *et al.*, 2021; Anyanwu *et al.*, 2023). These adaptations can facilitate the practical application of blockchain technology in regions where conventional solutions are untenable due to technological limitations.

In addition to infrastructure, fostering capacity building and digital literacy is critical for the effective adoption of blockchain technology in PFM and international aid operations. Stakeholders, including government officials and aid organization staff, often lack the technical expertise required to deploy and manage blockchain systems (Batubara *et al.*, 2019). Targeted training programs aimed at enhancing both technical skills and general digital literacy are essential and should be designed to accommodate regional needs, focusing on fundamental digital skills in less developed areas while providing advanced training on blockchain-specific concepts in regions with better technological capabilities (Janssen *et al.*, 2020; Schulz *et al.*, 2020). By bridging the knowledge gap through tailored educational initiatives, stakeholders can more effectively engage with blockchain solutions, leading to successful implementations.

Moreover, establishing robust policy frameworks and regulatory environments can facilitate the integration of blockchain into PFM and international aid systems. Given the decentralized nature of blockchain, governmental regulations may need to evolve to accommodate new structures for legal and cross-border transactions (Purusottama & Kadarusman, 2021; Zhong *et al.*, 2022). Clear regulatory guidelines that provide legal certainty while promoting the safe use of blockchain technologies are imperative. These frameworks

should also address data privacy considerations and compliance with existing regulations such as anti-money laundering (AML) and know-your-customer (KYC) laws (Batubara *et al.*, 2019). Regulatory environments that allow for experimental applications of blockchain within controlled settings can help stakeholders assess the viability and impact of blockchain solutions before broader implementation.

Public-private partnerships (PPPs) play a vital role in driving the adoption of blockchain in international aid and PFM by leveraging private sector expertise and resources (Thomason *et al.*, 2021; Hooper & Holtbrügge, 2020). Collaborations can lead to the development of blockchain solutions that are both scalable and economically sustainable, effectively addressing unique challenges related to financial transparency and aid distribution. By pooling resources through PPPs, governments and aid organizations can finance the necessary infrastructure investments required to implement blockchain solutions. These partnerships also encompass capacity-building initiatives to ensure that both public and private stakeholders are equipped to work effectively with blockchain technologies.

Engaging civil society and local communities in blockchain adoption processes is another critical component. The success of blockchain in enhancing accountability and transparency hinges on its acceptance and alignment with the communities it serves. Civil society organizations can champion blockchain initiatives, ensuring they promote social equity and responsiveness to local demands (Holovko & Sakevych, 2020; Janssen *et al.*, 2020). Collaborative design processes that involve local stakeholders can tailor blockchain systems to better serve their intended users, reinforcing trust and accountability (Ameyaw & Vries, 2020).

Finally, as blockchain technology matures, continuous monitoring and evaluation will be necessary to gauge its effectiveness in PFM and international aid contexts. Regular assessments can provide valuable insights into the advantages and challenges of blockchain adoption, allowing for policy adjustments to optimize outcomes and align with overarching governance objectives (Popa, 2018; Schulz *et al.*, 2020). By committing to a systematic approach prioritizing infrastructure, education, regulatory adaptation, public-private collaboration, and stakeholder engagement, the deployment of blockchain technology can significantly transform public financial management and enhance the accountability of international aid initiatives.

3. Conclusion

The systematic review of blockchain applications in Public Financial Management (PFM) and international aid accountability reveals that blockchain technology holds immense potential to address many of the long-standing challenges in these sectors. Through its inherent features of decentralization, immutability, transparency, and real-time tracking, blockchain offers new possibilities for improving financial oversight, reducing corruption, and ensuring that funds reach their intended recipients efficiently and securely. The ability to create a transparent and auditable record of transactions provides a powerful tool for enhancing accountability, which is critical in both PFM and international aid programs where trust is paramount.

Key findings from the review suggest that blockchain's ability to provide traceable and verifiable records of financial transactions could significantly reduce fraud, corruption, and

inefficiencies. Its use in international aid, such as through programs like the World Food Programme's Building Blocks, has shown positive results in improving the transparency of aid distribution, ensuring that funds are allocated as intended, and reaching the most vulnerable populations. Moreover, blockchain's potential to automate processes via smart contracts offers substantial improvements in operational efficiency, reducing administrative costs and enabling more timely and accurate fund disbursement.

However, the review also identifies significant challenges that must be overcome for blockchain to reach its full potential. These challenges include technical infrastructure limitations, particularly in low-resource settings, regulatory uncertainties, scalability concerns, and resistance from stakeholders who may lack a clear understanding of the technology or its benefits. Addressing these challenges requires coordinated efforts from governments, international organizations, and the private sector to invest in the necessary infrastructure, build capacity, and develop clear regulatory frameworks that support blockchain adoption.

Looking ahead, blockchain has the potential to fundamentally transform PFM and international aid practices. By enhancing transparency, improving governance, and streamlining administrative processes, blockchain can contribute to more efficient, accountable, and effective financial management systems. However, to fully realize these benefits, further research is needed to explore the long-term impact of blockchain implementations, particularly in diverse geographic and socio-economic contexts. Pilot projects should be expanded to test the scalability and adaptability of blockchain solutions in different regions, providing valuable insights that can inform broader adoption. These efforts will help to ensure that blockchain technology becomes an integral tool for improving global financial systems and the effectiveness of international aid programs.

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