GSC Advanced Research and Reviews

eISSN: 2582-4597 CODEN (USA): GARRC2

Cross Ref DOI: 10.30574/gscarr

Journal homepage: https://gsconlinepress.com/journals/gscarr/

(REVIEW ARTICLE)

Check for updates

Designing a traceable and transparent digital procurement framework using mobile offline systems for underserved markets

Simbiat Atinuke Lawal [1], Abdullahi Isiyaku [2, *] and Kevin Nnaemeka Ifiora [3]

[1] *University of Central Missouri, Warrensburg U.S.A.*

[2] *Raymond J. Harbets College of Business, Auburn University, Alabama, U.S.A.*

[3] *Boston Consulting Group, Houston, Texas, U.S.A.*

GSC Advanced Research and Reviews, 2025, 24(02), 182-195

Publication history: Received on 27 June 2025; revised on 11 August 2025; accepted on 13 August 2025

Article DOI: https://doi.org/10.30574/gscarr.2025.24.2.0226

Abstract

Underserved markets face significant challenges in procurement processes, characterized by limited internet connectivity, lack of digital infrastructure, and reduced access to transparent supply chain mechanisms. Traditional procurement systems, designed for well-connected urban environments, prove inadequate for addressing the unique constraints and requirements of underserved communities. This comprehensive review examines the transformative potential of mobile offline systems in creating traceable and transparent digital procurement frameworks specifically designed for resource-constrained environments. Our investigation reveals that mobile offline procurement systems demonstrate significant potential for improving supply chain transparency, reducing procurement costs, and enhancing market access for underserved populations through innovative distributed ledger technologies and offline-first architectural approaches. The research synthesizes evidence from multiple implementation contexts, demonstrating how mobile offline systems can address critical challenges in procurement transparency, vendor accountability, and supply chain traceability. By exploring emerging technologies, implementation strategies, and operational challenges, this review provides a balanced perspective on the opportunities and limitations of mobile offline procurement systems. The findings suggest that while mobile offline frameworks present promising solutions for underserved market procurement, successful implementation requires careful consideration of technological constraints, user adoption patterns, and regulatory compliance frameworks adapted to low-resource environments.

Keywords: Mobile Offline Systems; Digital Procurement; Underserved Markets; Supply Chain Transparency; Blockchain Technology; Distributed Systems; Mobile Computing; Digital Inclusion

1. Introduction

The global procurement landscape exhibits significant disparities between developed and underserved markets, with traditional digital solutions failing to address the unique challenges faced by resource-constrained environments. Underserved markets, characterized by limited internet connectivity, inadequate digital infrastructure, and reduced access to formal financial systems, require innovative approaches to procurement that transcend conventional online-dependent frameworks. The digital divide has created a procurement gap where communities most in need of transparent and efficient supply chain mechanisms are systematically excluded from modern procurement innovations[1].

Recent developments in mobile technology penetration, even in underserved regions, have created unprecedented opportunities for digital inclusion in procurement processes. Mobile devices have become ubiquitous even in areas with limited internet connectivity, presenting a platform for innovative offline-first procurement solutions[2]. This

* Corresponding author: Abdullahi Isiyaku.

technological foundation enables the development of procurement systems that can operate independently of continuous internet connectivity while maintaining the transparency and traceability benefits of digital systems.

The challenges facing procurement in underserved markets are multifaceted and interconnected[3]. Limited connectivity constrains the use of traditional cloud-based procurement platforms, while lack of digital literacy reduces user adoption of complex systems[4]. Additionally, informal market structures, limited regulatory frameworks, and reduced trust in digital systems create barriers to implementing conventional procurement solutions. These challenges necessitate a fundamental reimagining of digital procurement architecture, moving beyond connectivity-dependent models toward resilient, offline-capable systems.

Mobile offline systems represent a paradigm shift in digital procurement design, offering solutions that prioritize accessibility, resilience, and user-centric design principles[5]. These systems employ distributed architectures, local data storage, and synchronization mechanisms that enable procurement activities to continue even in connectivity-constrained environments[6]. By leveraging mobile-first design principles and offline-capable technologies, these systems can provide procurement transparency and traceability benefits while accommodating the realities of underserved market environments.

This research review aims to provide a comprehensive exploration of mobile offline systems for digital procurement in underserved markets, examining technological foundations, implementation strategies, and practical applications. By analyzing the intersection of mobile technology, procurement processes, and underserved market dynamics, this study seeks to offer insights into how innovative digital solutions can bridge the procurement gap and create more inclusive supply chain ecosystems.

2. Overview of Mobile Offline Procurement Systems

2.1. Conceptual Framework of Mobile Offline Systems

Mobile offline procurement systems represent a technological paradigm that prioritizes accessibility and resilience over traditional online-dependent architectures. These systems employ distributed computing principles, local data storage mechanisms, and sophisticated synchronization protocols to enable procurement activities in connectivity-constrained environments[7]. The fundamental architecture revolves around mobile devices as primary computing nodes, capable of storing, processing, and managing procurement data independently of continuous internet connectivity[8].

The conceptual framework integrates several key components including local database systems, peer-to-peer networking capabilities, and blockchain-inspired distributed ledger technologies adapted for offline operation[9]. These components work synergistically to create procurement ecosystems that can maintain transparency and traceability even when operating in isolation from central servers. The architecture emphasizes data integrity, security, and eventual consistency rather than real-time synchronization, reflecting the unique requirements of underserved market environments[10].

Mobile offline systems fundamentally re-conceptualize procurement workflows to accommodate intermittent connectivity patterns common in underserved markets[11]. Rather than requiring constant internet access, these systems enable procurement activities to occur offline, with data synchronization occurring when connectivity becomes available. This approach ensures that procurement processes can continue uninterrupted, regardless of infrastructure limitations, while maintaining the digital benefits of transparency and audit trails.

2.2. Technological Architecture and Components

The technological architecture of mobile offline procurement systems encompasses multiple layers of functionality designed to provide robust, resilient procurement capabilities[12]. The foundation layer consists of mobile-optimized databases capable of storing procurement data locally, including vendor information, product catalogs, transaction histories, and regulatory compliance documentation[13]. These databases employ efficient compression algorithms and data structures optimized for mobile hardware constraints.

The middleware layer implements synchronization protocols that enable data consistency across distributed nodes when connectivity becomes available[14]. This layer employs conflict resolution mechanisms, data validation algorithms, and security protocols that ensure data integrity during synchronization processes. Advanced implementations incorporate blockchain-inspired consensus mechanisms adapted for mobile environments, providing tamper-evident audit trails and distributed trust mechanisms[15].

The application layer focuses on user experience design optimized for diverse literacy levels and device capabilities common in underserved markets[16]. This includes intuitive interfaces, voice-based interactions, and multilingual support that accommodate the diverse user populations typical of underserved markets. The architecture emphasizes simplicity and reliability over feature complexity, ensuring that the system remains accessible to users with varying technical capabilities[17].

2.3. Offline-First Design Principles

Offline-first design principles fundamentally reshape how procurement systems approach connectivity and data management[18]. Unlike traditional online-first systems that degrade gracefully when connectivity is lost, offline-first systems are designed to provide full functionality without internet access, treating connectivity as an enhancement rather than a requirement. This philosophical shift requires rethinking fundamental assumptions about data consistency, user workflows, and system architecture.

Data management in offline-first systems emphasizes local storage, eventual consistency, and conflict resolution mechanisms that can handle the complexities of distributed, intermittently connected environments[19]. These systems employ sophisticated caching strategies, local indexing, and efficient data structures that enable fast searching and retrieval of procurement information without server dependencies[20]. The challenge lies in maintaining data accuracy and preventing inconsistencies while enabling distributed operations.

User experience design in offline-first systems prioritizes immediate responsiveness and continuous functionality regardless of connectivity status[21]. This requires careful consideration of workflow design, ensuring that all critical procurement activities can be completed offline while providing clear indicators of synchronization status and data freshness. The design philosophy emphasizes user empowerment through technology that works consistently in their environment rather than requiring environmental changes to accommodate technology[22].

2.4. Integration with Existing Systems

Successful mobile offline procurement systems must integrate with existing procurement ecosystems while providing bridges between formal and informal market structures[23]. This integration challenge requires sophisticated mapping between offline system data structures and conventional procurement platforms, enabling seamless data exchange when connectivity permits. The integration layer must accommodate diverse data formats, regulatory requirements, and business processes across different market contexts[24].

The integration architecture employs adaptable data transformation mechanisms that can convert between offline system formats and various external system requirements[25]. This includes integration with government procurement portals, supplier databases, financial systems, and regulatory compliance platforms. The challenge lies in maintaining data integrity and compliance requirements while enabling flexible integration patterns that accommodate diverse market structures.

Interoperability considerations extend beyond technical integration to encompass business process alignment and regulatory compliance. Mobile offline systems must provide audit trails, compliance documentation, and reporting capabilities that meet the requirements of various stakeholders including government agencies, donor organizations, and regulatory bodies[26]. This requires sophisticated reporting mechanisms that can generate compliance documentation from offline-collected data while maintaining the transparency benefits of digital systems.

3. Implementation Mechanisms

3.1. Technical Architecture and System Design

Implementing mobile offline procurement systems requires sophisticated architectural approaches that balance functionality, performance, and resource constraints typical of underserved market environments[27]. The system architecture employs modular design principles, enabling deployment flexibility across diverse hardware configurations and network conditions. Core architectural components include distributed data storage systems, peer-to-peer networking protocols, and consensus mechanisms adapted for mobile environments[28].

The data architecture emphasizes local-first storage with sophisticated replication and synchronization mechanisms. Local databases employ efficient indexing strategies and compression algorithms optimized for mobile hardware constraints while maintaining query performance necessary for procurement operations[29]. Data structures are designed to minimize storage requirements while preserving the relational integrity necessary for complex procurement workflows and audit trail maintenance[30].

Networking architecture incorporates multiple communication channels including cellular networks, Wi-Fi, Bluetooth, and near-field communication to maximize connectivity opportunities. The system employs opportunistic networking principles, utilizing any available connectivity for data synchronization while maintaining full operational capability during disconnected periods[31]. This multi-channel approach ensures maximum resilience and data synchronization opportunities in connectivity-constrained environments.

3.2. User Experience and Interface Design

User experience design for mobile offline procurement systems requires careful consideration of diverse user populations, varying literacy levels, and different cultural contexts common in underserved markets[32]. Interface design emphasizes intuitive navigation, clear visual hierarchies, and minimal cognitive load to ensure accessibility across diverse user capabilities[33]. The design philosophy prioritizes task completion efficiency over feature complexity, ensuring that essential procurement functions remain easily accessible.

Localization strategies extend beyond simple language translation to encompass cultural adaptation, local business practices, and regulatory requirements specific to different market contexts. This includes adaptation of workflow patterns, documentation requirements, and approval processes to align with local procurement customs and regulatory frameworks[34]. The interface design accommodates diverse input methods including touch, voice, and gesture-based interactions to maximize accessibility[35].

Accessibility features incorporate considerations for users with limited formal education, varying technical literacy, and different physical capabilities[36]. This includes voice-guided navigation, pictorial interfaces, and simplified workflows that reduce barriers to system adoption. The design emphasizes progressive disclosure of functionality, allowing users to gradually expand their system usage as comfort and proficiency increase.

3.3. Data Management and Synchronization

Data management in mobile offline procurement systems requires sophisticated approaches to maintain consistency, integrity, and security across distributed, intermittently connected environments[37]. The system employs conflict resolution algorithms that can handle simultaneous edits, version control mechanisms, and data validation protocols that ensure accuracy during synchronization processes[38]. These mechanisms must balance data consistency with system performance and user experience requirements.

Synchronization protocols incorporate prioritization mechanisms that ensure critical procurement data receives priority during limited connectivity windows[39]. The system employs differential synchronization, transmitting only changes rather than complete datasets, to maximize efficiency during connectivity opportunities. Advanced implementations incorporate compression and delta-encoding techniques to further optimize data transmission efficiency[40].

Security mechanisms ensure data integrity and privacy during synchronization processes while accommodating the resource constraints of mobile environments[41]. This includes lightweight encryption protocols, digital signatures, and access control mechanisms that protect sensitive procurement data without imposing excessive computational overhead. The security architecture must balance protection requirements with performance constraints typical of mobile hardware[42].

3.4. Deployment and Maintenance Strategies

Deployment strategies for mobile offline procurement systems must accommodate the infrastructure constraints and support limitations typical of underserved markets[43]. This includes deployment approaches that minimize dependencies on external technical support, provide local capacity building, and enable community-driven maintenance and support. The deployment architecture emphasizes simplicity and reliability to reduce ongoing maintenance requirements[44].

Training and capacity building programs form essential components of successful deployment strategies[45]. These programs must address varying technical literacy levels, provide ongoing support mechanisms, and create local expertise for system maintenance and troubleshooting. The training approach emphasizes peer-to-peer learning and community support networks that can sustain system adoption beyond initial deployment periods[46].

Maintenance strategies incorporate remote monitoring capabilities, automated error reporting, and over-the-air update mechanisms that can function within connectivity constraints. The system design emphasizes self-healing capabilities and graceful degradation to minimize maintenance requirements while providing mechanisms for remote diagnosis and support when connectivity permits[47].

4. Case Studies

4.1. Rural Agricultural Procurement Networks

Rural agricultural cooperatives in Sub-Saharan Africa have implemented mobile offline procurement systems to address challenges in accessing fair markets and transparent pricing for agricultural products[48]. These implementations demonstrate the practical application of offline-first design principles in environments characterized by limited connectivity, diverse literacy levels, and complex supply chain relationships[49]. The systems enable farmers to access market information, submit procurement requests, and participate in transparent bidding processes without requiring continuous internet connectivity.

Implementation results show significant improvements in market access, with participating farmers reporting enhanced price transparency and reduced transaction costs. The offline-first architecture enables procurement activities to continue during harvest seasons when network congestion typically disrupts traditional online systems. Local data storage capabilities allow farmers to maintain historical pricing information and track market trends even when connectivity is unavailable[50].

However, implementation challenges include user adoption barriers, particularly among older farmers with limited technology experience. The systems require ongoing community support and training programs to maintain adoption rates. Additionally, integration with existing agricultural supply chains requires careful coordination with traditional market intermediaries and regulatory compliance frameworks[51].

4.2. 4Healthcare Supply Chain Management

Rural healthcare facilities in Southeast Asia have deployed mobile offline procurement systems to address challenges in medical supply chain management and inventory tracking[52]. These implementations focus on ensuring reliable access to essential medications and medical supplies in environments where supply chain disruptions can have life-threatening consequences. The systems enable healthcare workers to track inventory levels, submit procurement requests, and maintain audit trails for regulatory compliance.

The offline-first architecture provides continuous operational capability during network outages, ensuring that critical supply chain functions remain available when needed most[53]. Local data storage enables comprehensive inventory tracking and automated reorder point notifications that function independently of internet connectivity[54]. The systems have demonstrated significant improvements in inventory management accuracy and reduced stockout incidents.

Implementation challenges include integration with existing healthcare information systems and compliance with medical supply chain regulations. The systems require specialized training for healthcare workers and ongoing technical support to maintain operational effectiveness. Additionally, synchronization with central medical supply databases requires careful coordination to ensure regulatory compliance and product authenticity verification[55].

4.3. Community-Based Procurement Initiatives

Community development organizations in Latin America have implemented mobile offline procurement systems to support transparent procurement processes for infrastructure development projects[56]. These implementations address challenges in ensuring accountability and transparency in community-managed development initiatives while accommodating limited technical infrastructure and varying literacy levels among community members.

The systems enable community members to participate in procurement processes, submit vendor proposals, and track project progress through intuitive mobile interfaces. Offline-first capabilities ensure that procurement activities can continue during infrastructure development periods when internet connectivity may be disrupted[57]. The systems provide comprehensive audit trails and reporting capabilities that support donor requirements and regulatory compliance.

Implementation results demonstrate improved community engagement in procurement processes and enhanced transparency in vendor selection and project management. The mobile-first design enables broader participation among community members, particularly those with limited access to traditional computing resources[58]. However, challenges include maintaining data accuracy across multiple user inputs and ensuring consistent application of procurement policies across diverse community contexts.

5. Benefits and Opportunities

5.1. Enhanced Market Access and Inclusion

Mobile offline procurement systems provide unprecedented opportunities for expanding market access in underserved regions by removing connectivity barriers that traditionally exclude these populations from digital procurement benefits[59]. The offline-first architecture enables participation in transparent procurement processes regardless of infrastructure limitations, creating more inclusive market ecosystems[60]. This democratization of procurement access can significantly impact economic development by enabling small-scale vendors and service providers to participate in formal procurement processes.

The systems provide access to broader market opportunities by connecting local suppliers with regional and national procurement networks through intermittent connectivity synchronization[61]. This expanded market access can increase competition, improve pricing transparency, and create economic opportunities for underserved communities. The mobile-first approach ensures that geographic isolation no longer prevents participation in formal procurement processes.

Market inclusion benefits extend beyond individual participants to encompass entire community economies[62]. By enabling transparent procurement processes, these systems can attract development funding, government contracts, and private investment that previously avoided underserved markets due to transparency concerns[63]. The audit trails and accountability mechanisms provided by these systems can build trust among external stakeholders and funding organizations.

5.2. Improved Transparency and Accountability

Mobile offline procurement systems significantly enhance transparency and accountability in procurement processes through comprehensive audit trails, tamper-evident record keeping, and distributed verification mechanisms[64]. The blockchain-inspired architecture provides immutable records of procurement activities, ensuring that all transactions and decisions can be traced and verified[65]. This transparency can reduce corruption, improve public trust, and enhance the effectiveness of procurement processes.

The distributed nature of offline systems ensures that procurement records exist across multiple nodes, preventing single points of failure or manipulation[66]. This distributed accountability creates resilient transparency mechanisms that can withstand attempts at data manipulation or system compromise. The peer-to-peer verification capabilities enable community-driven accountability processes that don't depend on centralized authorities[67].

Transparency benefits extend to enabling better performance monitoring and evaluation of procurement processes. The comprehensive data collection capabilities of these systems provide insights into procurement efficiency, vendor performance, and market dynamics that can inform policy decisions and process improvements. This data-driven approach to procurement management can significantly improve outcomes in underserved markets[68].

5.3. Cost Reduction and Efficiency Gains

Mobile offline procurement systems can generate significant cost reductions through automation of manual processes, reduction in transaction intermediaries, and improved procurement efficiency[69]. The digital nature of these systems reduces paperwork, streamlines approval processes, and eliminates many manual administrative tasks that increase procurement costs. Automation of routine procurement tasks enables organizations to allocate resources more effectively while reducing operational overhead.

The peer-to-peer networking capabilities of offline systems can reduce reliance on expensive intermediaries and traditional supply chain gatekeepers[70]. Direct connections between buyers and suppliers can eliminate markup costs while providing more competitive pricing through increased market transparency. This disintermediation effect can significantly reduce procurement costs while improving market access for both buyers and suppliers.

Efficiency gains result from improved information flow, reduced transaction times, and enhanced coordination among procurement stakeholders. The systems enable faster decision-making through improved access to relevant information and streamlined approval processes. Real-time inventory tracking and automated reorder processes can reduce stockouts and excess inventory costs while improving service delivery efficiency[71].

5.4. Technology Innovation and Adaptation

Mobile offline procurement systems drive innovation in distributed systems design, mobile computing, and resilient architecture development[72]. The unique challenges of underserved markets create opportunities for technological innovation that can benefit broader technology ecosystems. Solutions developed for connectivity-constrained environments often prove valuable in other contexts where resilience and reliability are priorities.

The systems contribute to advancing mobile-first design principles and offline-capable application architectures. These innovations can inform the development of other mobile applications designed for resource-constrained environments, creating broader technology ecosystems that prioritize accessibility and inclusion[73]. The technical solutions developed for offline procurement can be adapted for other applications including education, healthcare, and financial services.

Innovation opportunities extend to creating new business models and market structures that leverage the unique capabilities of offline-first systems[74]. The distributed nature of these systems enables new approaches to supply chain management, vendor relationships, and market organization that can create value for underserved communities while generating sustainable revenue models for technology providers.

6. Challenges and Considerations

6.1. Technical Challenges and Limitations

Implementing mobile offline procurement systems presents significant technical challenges related to data consistency, synchronization complexity, and resource constraints typical of mobile environments[75]. Maintaining data integrity across distributed, intermittently connected systems requires sophisticated conflict resolution algorithms and consensus mechanisms that can operate effectively under varying connectivity conditions. The technical complexity of these systems can create maintenance challenges and require specialized expertise that may be scarce in underserved markets.

Synchronization challenges become particularly acute when multiple users modify the same data during disconnected periods. Resolving conflicts while maintaining data accuracy requires sophisticated algorithms that can understand the semantic meaning of procurement data and make appropriate decisions about data precedence[76]. These technical challenges can create user experience issues and require careful system design to maintain usability while ensuring data integrity.

Resource constraints of mobile devices, including limited processing power, memory, and battery life, constrain the functionality and performance of offline procurement systems[77]. Balancing feature richness with performance requirements requires careful optimization and may limit the complexity of procurement workflows that can be supported. These constraints are particularly challenging in underserved markets where users may have older or less capable mobile devices.

6.2. User Adoption and Digital Literacy Barriers

User adoption represents a critical challenge for mobile offline procurement systems, particularly in underserved markets where digital literacy may be limited and technology adoption patterns differ from developed markets[78]. Overcoming resistance to digital systems requires comprehensive training programs, ongoing support mechanisms, and user interface designs that accommodate varying technical capabilities. The transition from traditional procurement methods to digital systems can be particularly challenging for users with limited technology experience.

Digital literacy barriers can prevent users from fully utilizing system capabilities and may create disparities in access to procurement opportunities[79]. Addressing these barriers requires investment in training programs, user support systems, and interface designs that minimize technical complexity while maintaining necessary functionality. The challenge is compounded by the need to accommodate diverse languages, cultural contexts, and business practices.

Sustaining user adoption over time requires ongoing support mechanisms and continuous system improvements based on user feedback[80]. The absence of reliable technical support infrastructure in underserved markets can create challenges for maintaining user engagement and system effectiveness. Creating self-sustaining support networks and peer-to-peer learning mechanisms becomes essential for long-term success.

6.3. Regulatory and Compliance Considerations

Implementing mobile offline procurement systems must navigate complex regulatory environments that vary significantly across different jurisdictions and market contexts. Compliance requirements for procurement processes, data protection, and financial transactions can create challenges for system design and implementation[81]. The distributed nature of offline systems can complicate regulatory compliance by creating uncertainty about data jurisdiction and regulatory authority.

Data protection and privacy regulations present particular challenges for systems that store sensitive procurement information locally on mobile devices. Ensuring compliance with data protection requirements while maintaining system functionality requires careful consideration of data encryption, access controls, and audit mechanisms[82]. The challenge is compounded by varying regulatory requirements across different jurisdictions where the system may operate.

Financial transaction regulations and anti-money laundering requirements can create complexity for procurement systems that facilitate payments or financial transactions[83]. Ensuring compliance while maintaining the accessibility and simplicity necessary for underserved markets requires careful balance between regulatory requirements and user experience. The offline nature of these systems can create challenges for real-time transaction monitoring and reporting required by financial regulations.

6.4. Sustainability and Scalability Issues

Ensuring the long-term sustainability of mobile offline procurement systems requires addressing challenges related to funding, maintenance, and technology evolution[84]. The initial investment in system development and deployment may be substantial, while ongoing operational costs can create sustainability challenges for organizations serving underserved markets. Developing sustainable business models that can support continued system operation and improvement requires careful consideration of revenue sources and cost structures.

Scalability challenges arise from the distributed nature of offline systems and the need to maintain performance as user bases grow. The peer-to-peer networking and synchronization mechanisms that enable offline operation can become performance bottlenecks as system scale increases[85]. Designing systems that can scale effectively while maintaining the resilience and accessibility benefits of offline operation requires sophisticated architectural approaches.

Technology evolution and device obsolescence create ongoing challenges for maintaining system compatibility and functionality. The rapid pace of mobile technology development can create pressure to continuously update and enhance systems while maintaining backward compatibility with older devices common in underserved markets. Balancing innovation with stability requires careful technology roadmap planning and sustainable development practices[86].

7. Future Directions

The future of mobile offline procurement systems presents significant opportunities for technological advancement and market expansion. Emerging technologies including artificial intelligence, machine learning, and advanced mobile computing capabilities will enable more sophisticated offline systems with enhanced functionality and user experience[87]. The integration of AI-powered features such as predictive analytics, automated vendor matching, and intelligent inventory management will transform procurement processes in underserved markets.

Edge computing developments will enable more powerful local processing capabilities, allowing offline systems to provide advanced analytics and decision support without requiring cloud connectivity[88]. This technological evolution will enable more sophisticated procurement optimization, risk assessment, and performance monitoring capabilities that can operate entirely offline. The combination of edge computing and mobile devices will create powerful distributed computing platforms capable of supporting complex procurement workflows.

Blockchain technology evolution will provide more efficient and mobile-friendly distributed ledger capabilities that can enhance the transparency and security of offline procurement systems[89]. Advanced consensus mechanisms optimized for mobile environments will enable more robust audit trails and verification capabilities while reducing computational requirements. The integration of blockchain technology with mobile offline systems will create new possibilities for decentralized procurement governance and automated compliance verification.

The convergence of Internet of Things (IoT) technologies with mobile offline systems will enable automated inventory tracking, supply chain monitoring, and quality verification capabilities[90]. Smart sensors and connected devices will provide real-time data that can enhance procurement decision-making and supply chain visibility. The integration of IoT capabilities will create more comprehensive and automated procurement ecosystems that can operate effectively in underserved markets.

Satellite connectivity improvements and Low Earth Orbit (LEO) satellite constellations will provide more ubiquitous connectivity options for underserved markets, enabling more frequent synchronization and enhanced system capabilities[91]. While maintaining offline-first principles, improved connectivity will enable more sophisticated collaboration features and real-time coordination capabilities that can enhance procurement effectiveness.

8. Conclusion

Mobile offline procurement systems represent a transformative approach to addressing procurement challenges in underserved markets, offering unprecedented opportunities for market inclusion, transparency, and efficiency. The offline-first design philosophy fundamentally reconceptualizes digital procurement architecture, prioritizing accessibility and resilience over traditional connectivity-dependent approaches. These systems demonstrate significant potential for bridging the digital divide in procurement processes while providing the transparency and accountability benefits of digital systems.

The technological innovations required for effective mobile offline procurement systems contribute to broader advances in distributed systems design, mobile computing, and resilient architecture development. The unique challenges of underserved markets drive innovations that can benefit broader technology ecosystems while creating more inclusive and accessible digital solutions. The peer-to-peer networking capabilities, distributed data management approaches, and consensus mechanisms developed for these systems represent significant advances in mobile computing architecture.

The implementation of mobile offline procurement systems requires careful consideration of technical constraints, user adoption challenges, and regulatory requirements specific to underserved markets. Successful deployment necessitates comprehensive training programs, ongoing support mechanisms, and user interface designs that accommodate diverse capabilities and contexts. The sustainability of these systems depends on developing appropriate business models, funding mechanisms, and maintenance strategies that can support long-term operation and improvement.

The transformative potential of mobile offline procurement systems extends beyond individual procurement processes to encompass broader economic development and community empowerment. By enabling transparent and efficient procurement processes, these systems can attract investment, improve service delivery, and create economic opportunities for underserved communities. The enhanced market access and inclusion enabled by these systems can contribute to reducing economic inequality and promoting sustainable development.

8.1. Recommendations

Successful implementation of mobile offline procurement systems requires a comprehensive approach that addresses technological, social, and regulatory challenges simultaneously. Organizations should prioritize user-centered design principles that accommodate diverse capabilities and contexts while maintaining the functionality necessary for effective procurement processes. Technology providers must focus on developing robust, scalable architectures that can accommodate the unique constraints of underserved markets, including investment in sophisticated synchronization mechanisms, conflict resolution algorithms, and security protocols that can operate effectively under varying connectivity conditions. Investment in training programs, support mechanisms, and community engagement initiatives is essential for achieving sustainable adoption and long-term success.

Policy makers and regulatory bodies should consider the unique characteristics of mobile offline procurement systems when developing regulatory frameworks and compliance requirements. This includes creating flexible approaches to data protection, financial transaction monitoring, and procurement oversight that accommodate the distributed nature of offline systems while maintaining necessary protections. Supporting regulatory sandboxes and pilot programs can facilitate innovation while ensuring appropriate oversight and protection. International development organizations and funding agencies should recognize the transformative potential of these systems and prioritize investment in their development and deployment, including supporting research and development initiatives, capacity building programs, and infrastructure development that can enable broader adoption.

The future success of mobile offline procurement systems depends on continued collaboration between technology providers, implementing organizations, regulatory bodies, and user communities. This collaborative approach should focus on addressing identified challenges while building on demonstrated successes to create more effective and sustainable systems. The development of standardized protocols and interoperability frameworks will facilitate broader adoption and integration with existing systems. Ongoing research and development efforts should prioritize user needs, technological innovation, and sustainable impact to ensure that these systems continue to evolve and improve over time while creating sustainable funding mechanisms and business models for long-term impact and scalability.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Bienhaus F, Haddud A. Procurement 4.0: factors influencing the digitisation of procurement and supply chains. Business Process Management Journal. 2018 Jun 26;24(4):965-84.

[2] Bökle S, Paraforos DS, Reiser D, Griepentrog HW. Conceptual framework of a decentral digital farming system for resilient and safe data management. Available at SSRN 3995105. 2022 Dec.

[3] Fredson G, Adebisi B, Ayorinde OB, Cynthia E, Onukwulu OA, Ihechere AO. Building resilient supply chains in emerging markets: Sustainable procurement and stakeholder engagement strategies. World Scientific News. 2025;201:57-95.

[4] Ahmad N, Jima A. Empowering Small and Medium-Sized Enterprises: Bridging Technology Gaps with Intelligent Cloud Solutions.

[5] Adewusi BA, Adekunle BI, Mustapha SD, Uzoka AC. Systematic Review of Human-Centered Design Approaches in Telecom and Public Sector Product Innovation.

[6] Agbeyangi A, Suleman H. Formalising solutions to network availability issues in low-resource environments: An offline storage design pattern for software systems. South African Computer Journal. 2024 Dec 1;36(2):1-30.

[7] Shiraz M, Gani A, Khokhar RH, Buyya R. A review on distributed application processing frameworks in smart mobile devices for mobile cloud computing. IEEE Communications surveys & tutorials. 2012 Nov 29;15(3):1294-313.

[8] Malik A, Om H. Cloud computing and internet of things integration: Architecture, applications, issues, and challenges. InSustainable cloud and energy services: Principles and practice 2017 Sep 21 (pp. 1-24). Cham: Springer International Publishing.

[9] Ellahi RM, Wood LC, Bekhit AE. Blockchain-based frameworks for food traceability: a systematic review. Foods. 2023 Aug 11;12(16):3026.

[10] Oloruntoba O. Architecting Resilient Multi-Cloud Database Systems: Distributed Ledger Technology, Fault Tolerance, and Cross-Platform Synchronization. International Journal of Research Publication and Reviews. 2025;6(2):2358-76.

[11] Feikema A. Digital Transformation in Procurement: Plan, Execute and Adopt a Successful Digital Procurement Programme. Kogan Page Publishers; 2025 Mar 3.

[12] Cooper M. Agile Procurement in a Changing Marketplace: Examining Adaptability and Responsiveness in Supply Chain Management.

[13] Joshi M. Intro to E-Commerce and Social Commerce. Educohack Press; 2025 Feb 20.

[14] Oloruntoba O. Architecting Resilient Multi-Cloud Database Systems: Distributed Ledger Technology, Fault Tolerance, and Cross-Platform Synchronization. International Journal of Research Publication and Reviews. 2025;6(2):2358-76.

[15] Uulu B. Optimizing Data Integrity and Transparency in Distributed Systems through Blockchain-Enhanced Big Data Management. Transdisciplinary Advances in Social Computing, Complex Dynamics, and Computational Creativity. 2024 Oct 4;14(10):1-1.

[16] Srivastava A, Kapania S, Tuli A, Singh P. Actionable UI design guidelines for smartphone applications inclusive of low-literate users. Proceedings of the ACM on Human-Computer Interaction. 2021 Apr 22;5(CSCW1):1-30.

[17] Silva BN, Khan M, Han K. Internet of things: A comprehensive review of enabling technologies, architecture, and challenges. IETE Technical review. 2018 Mar 4;35(2):205-20.

[18] Hoppenbrouwers P. *Deploying ICT Services in South African Townships* (Doctoral dissertation, Doctoral dissertation. University of Cape Town).

[19] Prasad Chatterjee SY, Kapur D. Reimagining State Management in Massively Distributed Systems.

[20] Mezzalira L. Building micro-frontends. " O'Reilly Media, Inc."; 2021 Nov 17.

[21] Tamire W. Evaluation of Progressive Web Application to develop an Offline-First Task Management App.

[22] Ladner RE. Design for user empowerment. interactions. 2015 Feb 25;22(2):24-9.

[23] Chandra P. Informality and invisibility: Traditional technologies as tools for collaboration in an informal market. InProceedings of the 2017 chi conference on human factors in computing systems 2017 May 2 (pp. 4765-4775).

[24] Van Der Lans R. Data Virtualization for business intelligence systems: revolutionizing data integration for data warehouses. Elsevier; 2012 Jul 25.

[25] Ogunwole O, Onukwulu EC, Joel MO, Adaga EM, Ibeh AI. Modernizing legacy systems: A scalable approach to next-generation data architectures and seamless integration. International Journal of Multidisciplinary Research and Growth Evaluation. 2023 Jan;4(1):901-9.

[26] Kalu A, Ochuba NA, Eyeregba ME, Onifade O, Ezeh FS. Advances in Regulatory Compliance and Grant Reporting Using Agile Tools in Mission-Focused Organizations. International Journal of Advanced Multidisciplinary Research Studies. 2024;4(6):1935-41.

[27] Yıldız E, Demir Z. The Impact of Artificial Intelligence on Financial Inclusion: Data-Driven Approaches for Expanding Access to Banking in Underserved Regions. International Journal of Advanced Theoretical and Applied Computer Science Research, Innovations, and Applications. 2024 Jul 4;14(7):1-6.

[28] Lao L, Li Z, Hou S, Xiao B, Guo S, Yang Y. A survey of IoT applications in blockchain systems: Architecture, consensus, and traffic modeling. ACM Computing Surveys (CSUR). 2020 Feb 5;53(1):1-32.

[29] Dhanagari MR. Scaling with MongoDB: Solutions for handling big data in real-time. Journal of Computer Science and Technology Studies. 2024 Dec 25;6(5):246-64.

[30] Singh B. Ensuring Data Integrity and Availability with Robust Database Security Protocols.

[31] Khabbaz MJ, Assi CM, Fawaz WF. Disruption-tolerant networking: A comprehensive survey on recent developments and persisting challenges. IEEE Communications Surveys & Tutorials. 2011 May 19;14(2):607-40.

[32] Choi WC, Chang CI. Enhancing the User Experience (UX) Development Life Cycle to Support Underrepresented Groups.

[33] Stephen F, Denise A. Cognitive Load and Visual Hierarchy: Enhancing Usability through Effective UI Design: Investigating How Users Process Content and Make Navigation Decisions.

[34] Okolo FC, Etukudoh EA, Ogunwole O, Omotunde G. Strategic Framework for Strengthening AML Compliance Across Cross-Border Transport, Shipping, and Logistics Channels.

[35] Vatavu RD. Gesture-based interaction. InHandbook of Human Computer Interaction 2023 Feb 9 (pp. 1-47). Cham: Springer International Publishing.

[36] Apostolidou E, Fokaides PA. Enhancing accessibility: a comprehensive study of current apps for enabling accessibility of disabled individuals in buildings. Buildings. 2023 Aug 17;13(8):2085.

[37] Caschetto R. *An integrated Web platform for remote control and monitoring of diverse embedded devices: A comprehensive approach to secure communication and efficient data management* (Doctoral dissertation, Politecnico di Torino).

[38] Ahmed-Nacer M, Urso P, Balegas V, Preguiça N. Concurrency control and awareness support for multi-synchronous collaborative editing. In9th IEEE International Conference on Collaborative Computing: Networking, Applications and Worksharing 2013 Oct 20 (pp. 148-157). IEEE.

[39] Rajkumar R. Synchronization in real-time systems: a priority inheritance approach. Springer Science & Business Media; 2012 Dec 6.

[40] Jindal R, Kumar N, Patidar S. IoT streamed data handling model using delta encoding. International Journal of Communication Systems. 2022 Sep 10;35(13):e5243.

[41] Kamau E, Myllynen T, Mustapha SD, Babatunde GO, Alabi AA. A conceptual model for real-time data synchronization in multi-cloud environments. Journal name missing. 2024 Jan.

[42] Ray S, Peeters E, Tehranipoor MM, Bhunia S. System-on-chip platform security assurance: Architecture and validation. Proceedings of the IEEE. 2017 Jul 21;106(1):21-37.

[43] Agbeyangi A, Suleman H. Advances and challenges in low-resource-environment software systems: A Survey. InInformatics 2024 Nov 25 (Vol. 11, No. 4, p. 90). MDPI.

[44] Soongpol B, Netinant P, Rukhiran M. Practical sustainable software development in architectural flexibility for energy efficiency using the extended agile framework. Sustainability. 2024 Jul 4;16(13):5738.

[45] Moroney JD, Grill B, Hogler J, Kennedy-Boudali L, Paul C. How Successful are US Efforts to Build Capacity in Developing Countries? A Framework to Assess the Global Train and Equip" 1206" Program.

[46] Meijer A, Grimmelikhuijsen S, Brandsma GJ. Communities of Public Service Support: Citizens engage in social learning in peer-to-peer networks. Government Information Quarterly. 2012 Jan 1;29(1):21-9.

[47] da Silva Cunha CA. *Self-healing Techniques for Video-streaming Applications* (Doctoral dissertation, Universidade de Coimbra (Portugal)).

[48] Morepje MT, Sithole MZ, Msweli NS, Agholor AI. The influence of E-commerce platforms on sustainable agriculture practices among smallholder farmers in Sub-Saharan Africa. Sustainability. 2024 Jul 30;16(15):6496.

[49] Mgowano A. Designing a Food Tracing App for Low-Connectivity Environments: A Case Study on the Honey Supply Chain in Tanzania.

[50] Ferris S, Robbins P, Best R, Seville D, Buxton A, Shriver J, Wei E. Linking smallholder farmers to markets and the implications for extension and advisory services. MEAS Brief. 2014 May;4(10):13-4.

[51] Singh V, Agrawal S, Kumar S. Is effective coordination the key to sustainable performance? A probe into integrated e-agri supply chains in India. International Journal of Productivity and Performance Management. 2025 May 28;74(5):1766-95.

[52] Yadav P. Digital transformation in the health product supply chain: a framework for analysis. Health Systems & Reform. 2024 Dec 17;10(2):2386041.

[53] Agbeyangi A, Suleman H. Advances and challenges in low-resource-environment software systems: A Survey. InInformatics 2024 Nov 25 (Vol. 11, No. 4, p. 90). MDPI.

[54] Benson-Emenike ME, Betrand CU, Onukwugha CG. Leveraging Advanced Technology in Inventory Control System for Tracking Goods. Journal of Research in Engineering and Computer Sciences. 2023 Dec 24;1(5):91-9.

[55] Hossain MI, Steigner T, Hussain MI, Akther A. Enhancing data integrity and traceability in industry cyber physical systems (ICPS) through Blockchain technology: A comprehensive approach. arXiv preprint arXiv:2405.04837. 2024 May 8.

[56] Kahn T, Baron A, Vieyra JC. Digital technologies for transparency in public investment: new tools to empower citizens and governments.

[57] Mgowano A. Designing a Food Tracing App for Low-Connectivity Environments: A Case Study on the Honey Supply Chain in Tanzania.

[58] Gbenle P, Abieba OA, Owobu WO, Onoja JP, Daraojimba AI, Adepoju AH, Chibunna UB. A Lightweight Mobile-First Conceptual Model for Smart Campus Applications Using Android SDK and Edge Computing.

[59] Onoja JP, Ajala OA. Innovative telecommunications strategies for bridging digital inequities: A framework for empowering underserved communities. GSC Advanced Research and Reviews. 2022;13(01):210-7.

[60] Vats T, Sailaja N, Anselmo Polido Lopes F. Exploration of user perspectives around software and data-related challenges associated with IoT repair and maintenance against obsolescence: User study on software and data interactions and considerations for IoT repair and maintenance against obsolescence. InProceedings of the 13th Nordic Conference on Human-Computer Interaction 2024 Oct 13 (pp. 1-17).

[61] Wang Y, Su Z, Ni J, Zhang N, Shen X. Blockchain-empowered space-air-ground integrated networks: Opportunities, challenges, and solutions. IEEE Communications Surveys & Tutorials. 2021 Dec 1;24(1):160-209.

[62] Lashitew AA, Branzei O, van Tulder R. Community inclusion under systemic inequality: How for-profit businesses pursue social purpose. Journal of Management Studies. 2024 Jan;61(1):230-68.

[63] Gardner TA, Benzie M, Börner J, Dawkins E, Fick S, Garrett R, Godar J, Grimard A, Lake S, Larsen RK, Mardas N. Transparency and sustainability in global commodity supply chains. World development. 2019 Sep 1;121:163-77.

[64] Khiari A, Osman A, Vecchio M, Antonini M, Pincheira M. Towards Compliance and Transparency in Raw Material Sourcing with Blockchain and Edge AI. IEEE Access. 2025 Jun 6.

[65] Mondal S, Wijewardena KP, Karuppuswami S, Kriti N, Kumar D, Chahal P. Blockchain inspired RFID-based information architecture for food supply chain. IEEE Internet of Things Journal. 2019 Mar 26;6(3):5803-13.

[66] Omar IA, Jayaraman R, Salah K, Debe M, Omar M. Enhancing vendor managed inventory supply chain operations using blockchain smart contracts. IEEE access. 2020 Sep 30;8:182704-19.

[67] Bansal D, Bhattacharya N. Technological Pillars of Decentralization: Catalysts for Change. InReshaping Marketing Science in Wholesaling and Retailing 2024 (pp. 280-308). IGI Global.

[68] Bakare IA. A data driven strategic framework for advancing inclusive trade policies to boost economic growth in underserved US communities.

[69] Nicoletti B. Procurement Finance: The Digital Revolution in Commercial Banking. Springer; 2018 Dec 24.

[70] Lee H. From Cloud to Crowds: Restoring Points of the Peer-to-Peer and Decentralized Internet. InAffective Capitalism: For a Critique of the Political Economy of Affect 2023 Dec 27 (pp. 149-171). Singapore: Springer Nature Singapore.

[71] Vaka DK. Integrating inventory management and distribution: A holistic supply chain strategy. the International Journal of Managing Value and Supply Chains. 2024 Jun;15(2):13-23.

[72] Luntovskyy A, Spillner J. Architectural Transformations in Network Services and Distributed Systems. Springer Fachmedien Wiesbaden; 2017 Mar 23.

[73] Agbeyangi A, Suleman H. Advances and challenges in low-resource-environment software systems: A Survey. InInformatics 2024 Nov 25 (Vol. 11, No. 4, p. 90). MDPI.

[74] Anning-Dorson T. Conclusion: Charting the Future of Africa's Digital Transformation. InDigital Business Transformation in Africa, Volume I: Business Model Innovation 2025 Jul 3 (pp. 295-303). Cham: Springer Nature Switzerland.

[75] Kamau E, Myllynen T, Mustapha SD, Babatunde GO, Alabi AA. A conceptual model for real-time data synchronization in multi-cloud environments. Journal name missing. 2024 Jan.

[76] Mishra S, Shinde M, Yadav A, Ayyub B, Rao A. An ai-driven data mesh architecture enhancing decision-making in infrastructure construction and public procurement. arXiv preprint arXiv:2412.00224. 2024 Nov 29.

[77] Agbeyangi A, Suleman H. Advances and challenges in low-resource-environment software systems: A Survey. InInformatics 2024 Nov 25 (Vol. 11, No. 4, p. 90). MDPI.

[78] Dakduk S, Van der Woude D, Nieto CA. Technological adoption in emerging economies: Insights from Latin America and the Caribbean with a focus on low-income consumers.

[79] Jaeger PT, Bertot JC, Thompson KM, Katz SM, DeCoster EJ. The intersection of public policy and public access: Digital divides, digital literacy, digital inclusion, and public libraries. Public library quarterly. 2012 Jan 1;31(1):1-20.

[80] Bristol-Alagbariya B, Ayanponle OL, Ogedengbe DE. Developing and implementing advanced performance management systems for enhanced organizational productivity. World Journal of Advanced Science and Technology. 2022;2(1):39-46.

[81] Addo SK. Challenges of E-procurement adoption in the ghana public sector: A survey of in the ministry of finance. Journal DOI. 2019;10:22501991.

[82] Fakeyede OG, Okeleke PA, Hassan A, Iwuanyanwu U, Adaramodu OR, Oyewole OO. Navigating data privacy through IT audits: GDPR, CCPA, and beyond. International Journal of Research in Engineering and Science. 2023 Nov;11(11):45-58.

[83] Khan A, Jillani MA, Ullah M, Khan M. Regulatory strategies for combatting money laundering in the era of digital trade. Journal of Money Laundering Control. 2025 Mar 31;28(2):408-23.

[84] Hungevu R, Ademola T, Yinusa S, Titiloye TA, Lasisi R, Okunola M. The impact of low-cost technological innovations on sustainable fisheries for economic development in developing countries. World Journal of Advanced Research and Reviews. 2025 Feb 28;25(2):1170-84.

[85] Milojicic DS, Kalogeraki V, Lukose R, Nagaraja K, Pruyne J, Richard B, Rollins S, Xu Z. Peer-to-peer computing [Internet]. 2002 Mar 8

[86] Ghobakhloo M, Iranmanesh M, Grybauskas A, Vilkas M, Petraitė M. Industry 4.0, innovation, and sustainable development: A systematic review and a roadmap to sustainable innovation. Business Strategy and the Environment. 2021 Dec;30(8):4237-57.

[87] Hua H, Li Y, Wang T, Dong N, Li W, Cao J. Edge computing with artificial intelligence: A machine learning perspective. ACM Computing Surveys. 2023 Jan 13;55(9):1-35.

[88] George AS, George AH, Baskar T. Edge computing and the future of cloud computing: A survey of industry perspectives and predictions. Partners Universal International Research Journal. 2023 Jun 20;2(2):19-44.

[89] Neway AS. Digital Supply Chain: Navigating the future operation. Abegaz Sahilu Neway; 2024 Nov 3.

[90] Sallam K, Mohamed M, Mohamed AW. Internet of Things (IoT) in supply chain management: challenges, opportunities, and best practices. SMIJ. 2023;2(2):32.

[91] Garrity J, Husar A. Digital connectivity and low Earth orbit satellite constellations: Opportunities for Asia and the Pacific.