Enhancing Agricultural Supply Chain Traceability with Blockchain, Smart Contracts, and E-Labelling

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BdKCSE'2025 – Big Data, Knowledge and Control Systems Engineering

Outline

Problem & Motivation

Problem:

- 280M Africans face food insecurity with inadequate traceability.
- Fraud and contamination risks.

African Challenges:

- Fragmented supply chains, limited infrastructure, low connectivity.
- Information asymmetries and informal market structures.

Opportunity:

- 85%+ mobile penetration and successful mobile money adoption.

Research Gap & Contributions

Existing Solutions Miss:

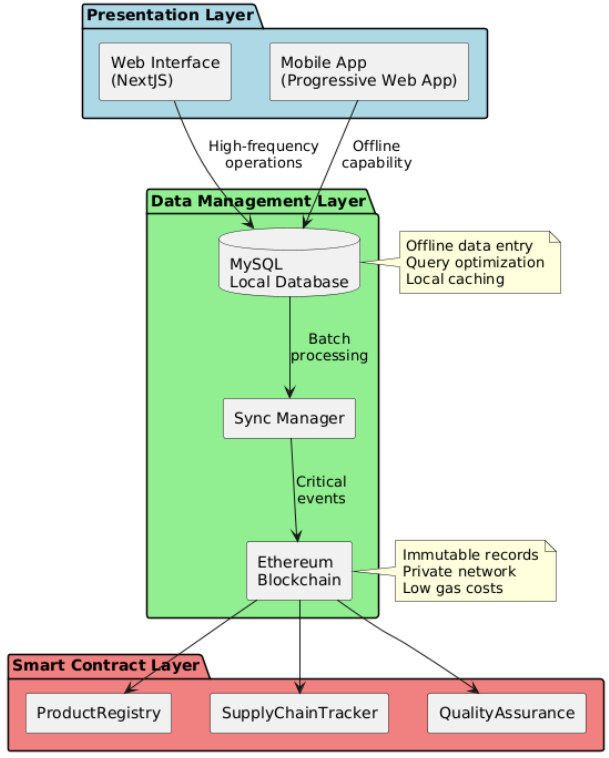
- African-specific constraints: low bandwidth, informal markets.
- High infrastructure requirements and technical expertise.

Our Contributions:

- Smart contracts + automated QR codes for accessibility.
- ADJENDE case study validation (Burkina Faso).
- Low-bandwidth optimization

System Architecture

- **Three-Layer Design:**
  - Web interfaces (smartphone-accessible)
  - Hybrid data: MySQL + Ethereum
  - Smart contract layer
- **Key Advantages:**
  - Offline capability
  - Low-bandwidth optimized
  - Private Ethereum network



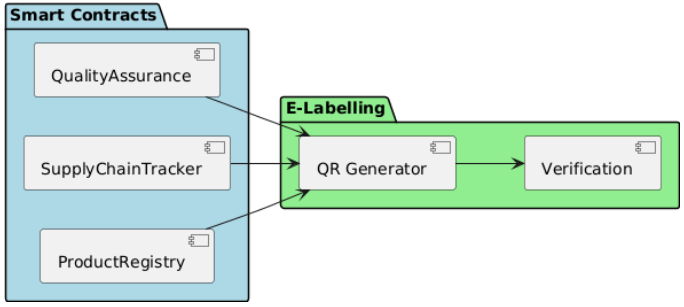
Smart Contracts & E-Labelling

Smart Contracts:

- ProductRegistry, SupplyChainTracker, QualityAssurance
- Gas-optimized for cost-sensitive operations
- Community-based verification

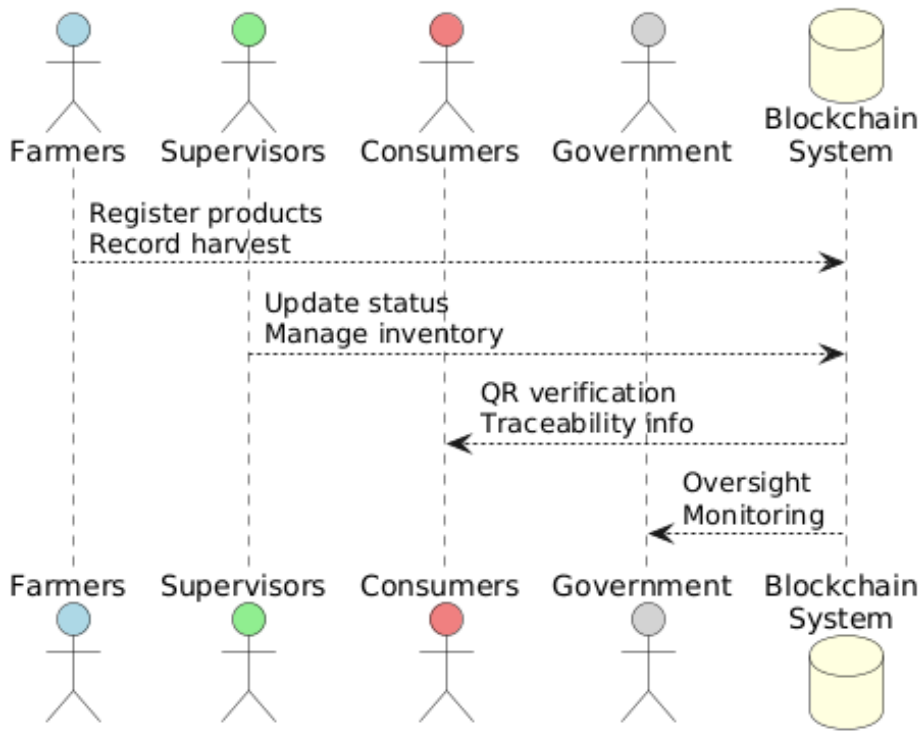
E-Labelling:

- Automated QR code generation
- Offline product information access
- Multilingual support



Stakeholder Model

- **Farmers:** Simplified mobile interfaces, minimal training
- **Supervisors:** Status updates, inventory management
- **Consumers:** QR scanning for product verification
- **Government:** Oversight dashboards, regulatory monitoring



Implementation - ADJENDE Case Study

Case Study:

- Location: Burkina Faso
- Scale: approximately 150 smallholder farmers
- Products: Cassava, Sesame, Shea

Technology Stack:

- NextJS, MySQL, Solidity 0.8.0
- Ganache testnet for validation
- Simulated low-bandwidth (2-10 Mbps)

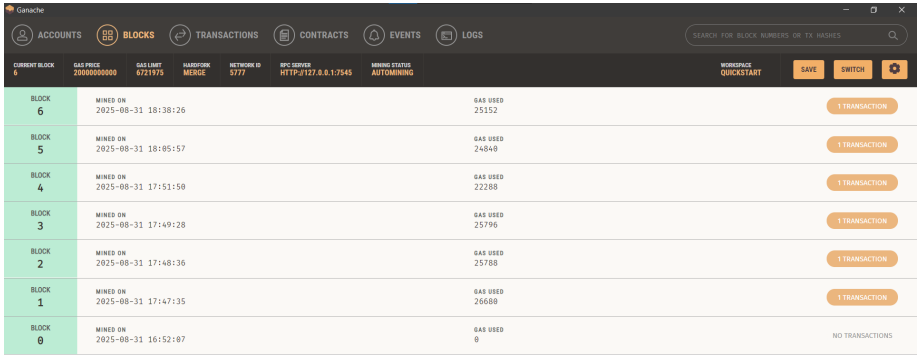
Performance Results

System Performance:

- Product Registration: 25s
- Status Updates: 20s
- Record Deletion: 17s

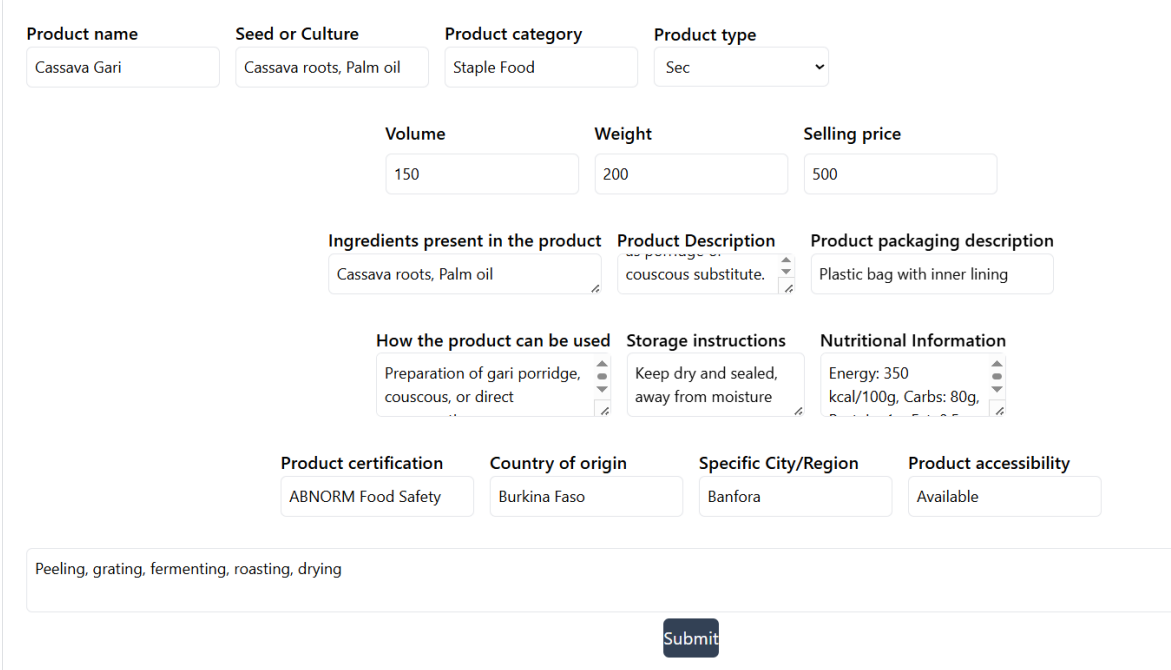
Blockchain Metrics:

- Gas cost: 6M units ($0.15-0.30)
- 0.6-15% of product value
- 89.2% utilization efficiency



System in Action - Registration

- Comprehensive data capture
- Nutritional information
- Certification details



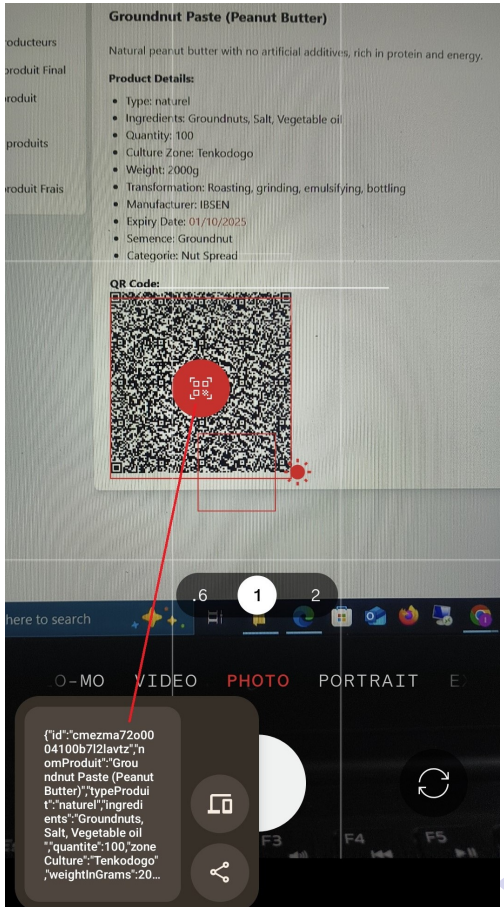
System in Action - Verification

Consumer Verification:

- Complete traceability
- Batch ID, origin verification
- Local pricing (XOF)

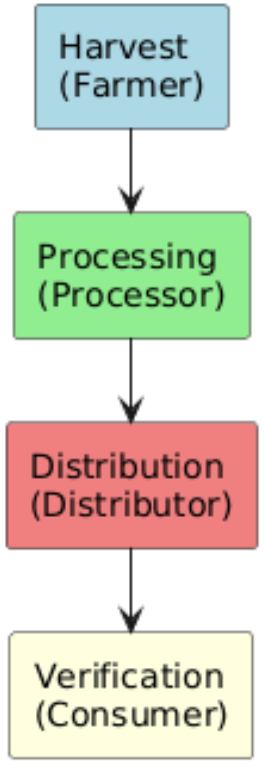
Mobile Scanning:

- Two-phase QR interaction
- Minimal training needed
- Accessible verification



Product Journey Tracking

- From production to distribution
- End-to-end transparency
- Real-time status updates



Key Findings & Discussion

- **Economically viable:** Transaction costs (0.6-15%) acceptable for smallholders
- **Technically feasible:** Response times align with agricultural workflows
- **Scalable:** Supports typical cooperative sizes
- **Accessible:** Offline functionality for connectivity challenges
- **Limitation:** Testnet validation, not production deployment with real farmers

Conclusion & Future Work

Conclusion:

- Demonstrated blockchain traceability feasibility for African agriculture
- Addresses food security through transparency
- Accommodates infrastructure constraints

Future Directions:

- Layer 2 scaling solutions for reduced costs
- Enhanced offline functionality
- Mobile money integration
- Expand to diverse crops and regions

Acknowledgments & Code Availability

- **Funding Sources:**
  - European Regional Development Fund
  - Bulgarian National Recovery and Resilience Plan (Project: BG-RRP-2.004-0005)
- **Material Support:**
  - ABIL Research Center (https://abil.ac.cd)
- **Code Availability:**
  - GitHub: https://github.com/vendkura/Sup-Prod-Track

Thank You

Thank you for your attention!

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Code Repository:
github.com/vendkura/Sup-Prod-Track