

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

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Outline

Introduction & Motivation

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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.

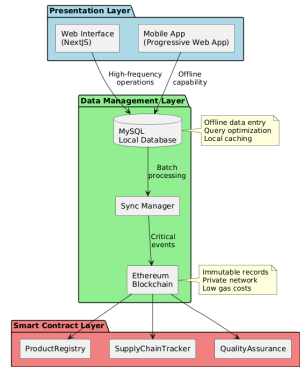
Opportunity:

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



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



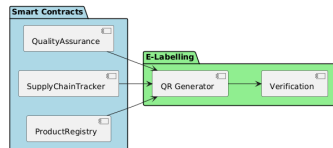
Smart Contracts & E-Labeling

Smart Contracts:

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

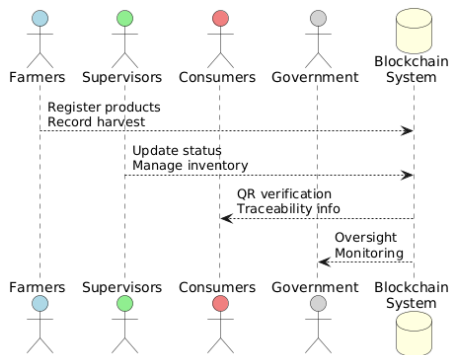
E-Labeling:

- ▶ 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

BLOCK	HASH ID	DATE	GAS USED	Transaction	
BLOCK 6	0x00	2023-08-22 18:18:02	6M GAS	25000	Transaction
BLOCK 5	0x00	2023-08-22 18:20:02	6M GAS	24800	Transaction
BLOCK 4	0x00	2023-08-22 17:50:02	6M GAS	22500	Transaction
BLOCK 3	0x00	2023-08-22 17:18:02	6M GAS	20700	Transaction
BLOCK 2	0x00	2023-08-22 17:18:02	6M GAS	21700	Transaction
BLOCK 1	0x00	2023-08-22 17:17:02	6M GAS	20800	Transaction
BLOCK 0	0x00	2023-08-22 18:10:00	6M GAS	0	Transaction

System in Action - Registration

- ▶ Comprehensive data capture
- ▶ Nutritional information
- ▶ Certification details

The screenshot shows a registration form for a product named 'Cassava Gari'. The form is organized into several sections:

- Product name:** Cassava Gari
- Seed or Culture:** Cassava roots, Palm oil
- Product category:** Staple Food
- Product type:** Sec
- Volume:** 150
- Weight:** 200
- Selling price:** 500
- Ingredients present in the product:** Cassava roots, Palm oil
- Product Description:** couscous substitute.
- Product packaging description:** Plastic bag with inner lining
- How the product can be used:** Preparation of gari porridge, couscous, or direct
- Storage instructions:** Keep dry and sealed, away from moisture
- Nutritional Information:** Energy: 350 kcal/100g, Carbs: 80g
- Product certification:** ABNORM Food Safety
- Country of origin:** Burkina Faso
- Specific City/Region:** Banfora
- Product accessibility:** Available

At the bottom of the form, there is a text area containing the preparation instructions: 'Peeling, grating, fermenting, roasting, drying'. A 'Submit' button is located at the bottom right of the form.

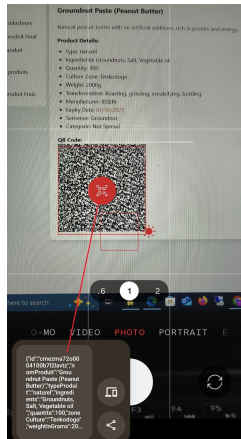
System in Action - Verification

Consumer Verification:

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

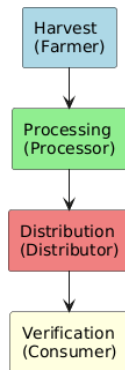
Mobile Scanning:

- ▶ 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