ASHESI

ICS 530 - Software Engineering Essentials

Project Title: An Integrated Digital Marketplace to Mitigate Post-Harvest Losses

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Executive Summary

This proposal outlines the design and implementation of **SmartAgro**, a digital intervention aimed at reducing the critical rate of post-harvest losses in Ghana's agricultural sector. Currently, the lack of market coordination costs the national economy approximately US$1.9 billion annually. SmartAgro addresses this by deploying a Progressive Web App (PWA) that connects smallholder farmers directly with commercial buyers, bypassing inefficient intermediaries. The project is designed not only as a software product but as a research instrument to explore the question: *"To what extent do digital market linkages and the removal of opaque middlemen reduce post-harvest spoilage for small-scale farmers in Ghana?"*

1. Introduction and Research Motivation

Agriculture is the economic bedrock of Ghana, yet it suffers from a paradox of high production and high waste. While infrastructural deficits like poor roads are often blamed, recent policy briefs (IGC, 2025) indicate that market coordination failure is a primary driver of spoilage. Farmers harvest produce without confirmed buyers, leading to distress sales or total loss.

The motivation for SmartAgro extends beyond simple e-commerce. It seeks to investigate the structural inequities in the supply chain where middlemen leverage information asymmetry to dictate unfair prices. By establishing a direct, transparent channel between the farm gate and the urban market, this project aims to quantify the impact of access on income stability and waste reduction.

2. Solution Overview and User Analysis

2.1 The Solution: SmartAgro

SmartAgro is a dual-faceted platform: a marketplace for immediate trade and an advisory system for long-term yield optimization. Unlike generic listing sites, it is engineered specifically for the resource-constrained African context, prioritizing offline capabilities and accessibility.

2.2 Stakeholder Dynamics & Personas

The system serves two distinct user groups whose needs currently conflict due to the interference of middlemen:

- **The Producer (Opanyin Kwame):** A 55-year-old tomato farmer in Techiman with low digital literacy. His primary pain point is the "uncertainty of the sale." He requires a system that is trusted, voice-activated (to bypass literacy barriers), and works on a basic smartphone.
- **The Aggregator (Auntie Esi):** A wholesale buyer in Accra who demands consistency. Her pain point is "verification." She needs assurance that the produce exists and is of good quality before she commits funds.

2.3 User Experience (UX) Strategy

To bridge the digital divide for users like Opanyin Kwame, the UX design focuses on inclusive interaction.

- **Voice-First Navigation:** Recognizing that text literacy is a barrier, the application integrates a Twi-language voice guidance system. Users are prompted audio-visually to "Speak" their listing details rather than type them.
- **Offline-First Architecture:** Using PWA service workers, the app caches critical data locally. This allows farmers to view orders and manage inventory even when cellular networks fail, synchronizing only when connectivity is restored.

3. Technical Architecture and Data Strategy

3.1 Architectural Style: Modular Monolith

To align with the project’s three-week timeline without sacrificing future scalability, the team has selected a Modular Monolithic Architecture. This approach structures the system into distinct, self-contained modules - Core (Identity), Commerce (Marketplace), and Finance (Escrow) -

within a single deployable unit. This eliminates the operational overhead of microservices while ensuring that code boundaries are respected, allowing for an easy transition to distributed services as the user base grows.

3.2 Programming Model

- **Frontend:** React.js is utilized to deliver a responsive, app-like experience accessible via any standard browser, eliminating the friction of app store downloads.
- **Backend:** Python (FastAPI) provides high-performance asynchronous processing, essential for handling concurrent market transactions.
- **Database:** A polyglot persistence layer is employed. PostgreSQL ensures ACID compliance for high-stakes financial and inventory records, while MongoDB handles unstructured datasets such as chat logs and varying produce attributes.

3.3 Data Flow and Security

The system relies on secure data pipelines to manage user trust. Financial integrity is enforced through a strictly isolated **Payment Schema** that manages an escrow logic state machine. Funds are virtually "locked" upon purchase and only released when the buyer confirms receipt, neutralizing the risk of fraud. Identity management leverages OAuth2 with JWT tokens, ensuring that farmer profiles and transaction histories remain private and tamper-proof.

4. Implementation Plan:

To meet the project deadline of December 17, 2025, the team will adopt an accelerated Agile schedule. The timeline spans 14 days, commencing on December 4, 2025.

Phase	Activity	Duration	Dates	Deliverable
Phase 1	Requirement Gathering & Analysis	1 Day	Dec 4	Finalized Requirements SRS

Phase 2	System Design (UI/UX & Database)	2 Days	Dec 5 – Dec 6	Wireframes, ER Diagrams & Schema Setup
Phase 3	Core Module & Frontend Development	5 Days	Dec 7 – Dec 11	Functional Marketplace & Identity System
Phase 4	Payment & Agri Module Integration	3 Days	Dec 12 – Dec 14	Payment Gateway & Expert Chatbot
Phase 5	Testing (Unit, Integration, UAT)	2 Days	Dec 15 – Dec 16	Test Reports & Bug Fixes
Phase 6	Documentation & Final Presentation	1 Day	Dec 17	Final Paper & Source Code

5. Impact Assessment and Ethical Considerations

5.1 Social and Ethical Impact

The disintermediation of the supply chain raises ethical questions regarding the displacement of traditional labor (middlemen). SmartAgro aims to reframe this relationship rather than destroy it, potentially integrating displaced intermediaries as logistics providers. Furthermore, the algorithms driving the advisory system must be audited for bias to ensure they do not systematically favour large-scale farms over small holders.

5.2 Legal Compliance

As a platform handling financial transactions, SmartAgro must adhere to the Data Protection Act, 2012 (Act 843) regarding the privacy of user data. Additionally, the escrow functionality operates within the regulatory framework of digital finance as outlined by the Bank of Ghana, ensuring that user funds are protected at all times.

6. Conclusion

SmartAgro represents a convergence of rigorous software engineering and social science research. By building a system that is architecturally robust yet accessible to the least digital-literate users, the project aims to provide empirical evidence that technology can solve the "coordination failure" in Ghanaian agriculture. The success of this pilot will not only reduce post-harvest losses for the participants but also provide a blueprint for digital intervention in other informal sectors.