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ZenAgro PS: An Integrated Digital Platform for Agricultural Research and Plant Science Management

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***Abstract*–** A farmer who grows a crop for a seed or agri-science company often cannot see the numbers that decide the payment: which sample was taken, how it was tested, what price was agreed and why a deduction was made. Companies have the opposite problem, since they struggle to find dependable farmers and land for trials and procurement. ZenAgro PS (Plant Science) is a digital platform designed to put both sides on the same page. Farmers register, build verified profiles and add geotagged land records. Companies search for suitable farmers, send trial or procurement proposals and agree terms on the platform. After harvest the farmer creates a lot, a sample is collected and logged, a laboratory records the quality result (for cotton, the ginning out turn, GOT), and the price, deductions and payment status are shown to the farmer in the same place. Produce that is not covered by a contract can be offered in an open marketplace, so the farmer keeps a choice of buyers.

Key events are kept in an append-only audit log, and an optional blockchain layer with smart contracts can apply agreed payment rules once a quality result is verified. The paper describes the problem, the related literature, the proposed architecture, the stakeholder workflows and the data model, together with a plan for evaluating the platform in a pilot.

Keywords— ZenAgro PS, Digital Agriculture, Farmer Financial Transparency, Seed Testing, Land Discovery, Post-Harvest Procurement, Traceability, Contract Farming, Blockchain, AgriTech.

I. INTRODUCTION

Agricultural markets run on information that is unevenly shared. A farmer may not know who finally buys the produce, how quality will be judged, what the applicable price is, when payment will arrive or how a deduction was worked out. A company, meanwhile, may have little reliable knowledge about the farmers, land, crop history and harvest it depends on. When each side sees only part of the picture, trust is low, payments are delayed and disputes are common.

Contract farming and better market access can raise farm income, but the gains are not guaranteed or evenly spread. A Campbell systematic review by Ton et al. reported average income effects of roughly 23 to 54 per cent, while warning that survivor bias probably inflates that range, and found that better-off farmers are the ones most often included in such schemes [8], [9]. In other words, the design of the arrangement, the capacity of the farmer and the openness of the market all matter. Tools that make terms and results visible are one practical way of improving the design.

ZenAgro PS is proposed as a farmer-centred platform that links farmers with seed and agri-science companies and makes financial and quality information visible to both. The working cycle is straightforward. Farmers register and create verified profiles. They add land details, crop plans and expected harvest dates. Companies discover suitable farmers and parcels, send proposals and agree terms. After harvest, samples are drawn from defined lots and tested, and the company records the agreed price per qualified lot together with a payment record the farmer can follow. Any produce outside the contract can be sold on the open market.

The platform does not replace companies, buyers, laboratories or markets. What it adds is a shared and dependable record of who did what, when, at what price and with what quality result. That record is useful to the farmer who wants to understand a payment, to the company that wants to show it dealt fairly, and to the laboratory whose results should stand up to checking.

The rest of the paper reviews the literature, states the problem and objectives, describes the methodology and the proposed system, sets out the advantages and future scope, and concludes.

II. LITERATURE SURVEY

The ideas behind ZenAgro PS draw on work in digital agriculture, research data management, seed quality assurance, traceability and contract farming.

A. Digital Agriculture

The Food and Agriculture Organization (FAO) treats digital agriculture as a way to improve productivity, research, data management and sustainable farming [1]. Its emphasis on tools that ordinary farmers can use shapes our decision to

give farmers a simple mobile application and to keep company-side functions on a separate web dashboard.

B. Agricultural Research Networks

CGIAR coordinates research on food security, innovation and sustainable farming across many centres and crops [2]. Work at that scale shows why data and methods need to be documented in a form others can follow, and why trials should be recorded in a consistent way. AgTrials, a related resource on field trials and experimental data, makes the same point about location, season, crop and variety [3].

C. Seed Quality and Certification

The OECD Seed Schemes describe international arrangements for seed certification and quality assurance in trade [4]. ZenAgro PS does not certify seed, but it borrows the idea that every lot needs a documented identity and history, from the parcel it was grown on to the test result attached to it. India's national research system under ICAR adds a local setting for this thinking, since its work on crop science, breeding and farm technology depends on records that many teams must share [5].

D. Data-Driven Decision Making

The CGIAR Big Data Platform promotes organised, shareable agricultural data and decisions based on it [6]. This supports a basic design principle here: a payment calculation or a trial comparison is only as sound as the records that feed it.

E. Blockchain and Transparency in Agri-Food Chains

Information in agri-food chains is usually spread among farmers, traders, processors, laboratories and buyers. Peng et al. reviewed 78 studies on blockchain smart contracts in this industry and grouped the work under four themes: data storage, information management and control, traceability, and confirmation of data rights [7]. The review also proposes a general framework for research in the area. These findings encourage the use of an auditable record in ZenAgro PS. They also suggest treating blockchain as an option to be used where it earns its extra cost and complexity, which is why the design starts with an append-only audit log.

F. Contract Farming and Market Access

Ton et al. found that contract farming can raise smallholder income substantially, yet the evidence comes mainly from arrangements that had already survived their early years, and the poorest farmers were rarely included [8], [9]. They also note that farmers face an incentive to side-sell when the benefits of a contract are small. For ZenAgro PS this means that contracted lots and uncontracted surplus must be clearly separated, so that a farmer is never tied to a single buyer for the whole harvest.

G. Research Gap

Existing digital tools usually cover one stage: registration, an e-marketplace, traceability or payment. Few connect the whole path from land discovery and seed testing through harvest, quality testing and payment to the sale of surplus produce. ZenAgro PS is designed to cover that complete path on shared records.

III. PROBLEM STATEMENT AND OBJECTIVES

A. Problem Statement

Farmers and agri-science companies lack one trusted system that follows a transaction from the first search for land to the final payment. As a result:

- Farmers do not have transparent records of trials, sample collection, test results, agreed prices and payments.
- Companies find it hard to identify suitable farmers and parcels for seed trials or procurement.
- Test results and payment calculations do not always reach farmers on time.
- Farmers may be unsure whether surplus produce can be sold independently once a contract is fulfilled.
- Manual records lead to disputes over lot identity, sampling, quality results, deductions and payment.
- Farmers see little of their own transaction history or financial performance.

B. Objectives

ZenAgro PS therefore aims to:

- create verified digital profiles for farmers and their land;
- let companies discover farmers and parcels for seed testing and trials;
- give farmers and companies a structured channel for communication and agreements;
- manage seed-sample distribution, crop monitoring, harvest lots and sample collection digitally;
- record quality results, including GOT for cotton;
- make pricing, deductions, payment status and history visible at lot level; and
- allow farmers to list and sell uncontracted produce in open markets.

IV. METHODOLOGY

The work follows a design-science approach: requirements are identified, the workflows and data model are designed, a minimum viable product is built, and the result is evaluated with users and improved.

A. Requirement Analysis

Requirements are collected from farmers, seed and agri-science companies, laboratories and collection agents. The recurring needs are verified identity, trustworthy land and crop records, a clear way to propose and accept terms, a defined lot and sample procedure, visible test results and a payment trail that can be followed.

B. System Architecture

The platform has four layers, shown in Fig. 1. A farmer mobile application, a company web dashboard, an admin console and a tool for laboratories and collection agents form the user layer. An API layer connects the services to payment gateways, SMS or WhatsApp notifications, mapping services and laboratory systems. Six service modules carry the business logic, and an encrypted database with an append-only audit log stores the records.

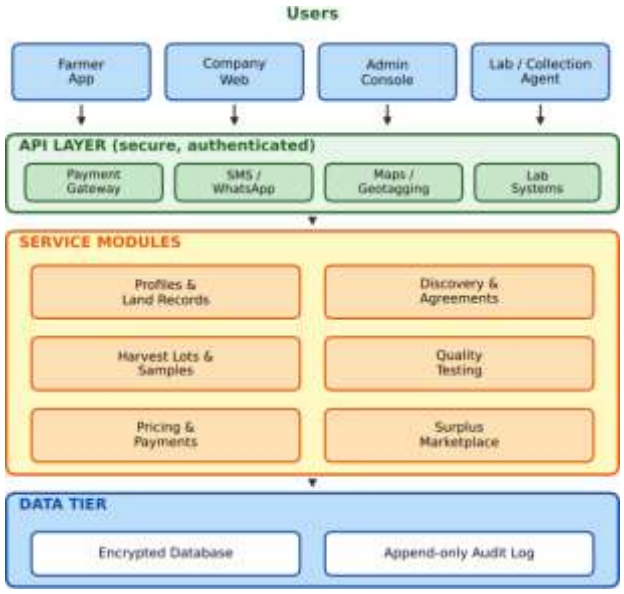


Fig. 1. Layered architecture of ZenAgro PS.

C. User Roles and Access Control

Six roles use the platform: farmer, company, laboratory, collection agent, buyer and administrator. Each sees only the functions that belong to it, as Fig. 2 and Table I show. The farmer decides which companies can see which information. A company can view anonymised land and crop suitability data before making contact, and the farmer's personal contact details stay private until the farmer accepts a request.

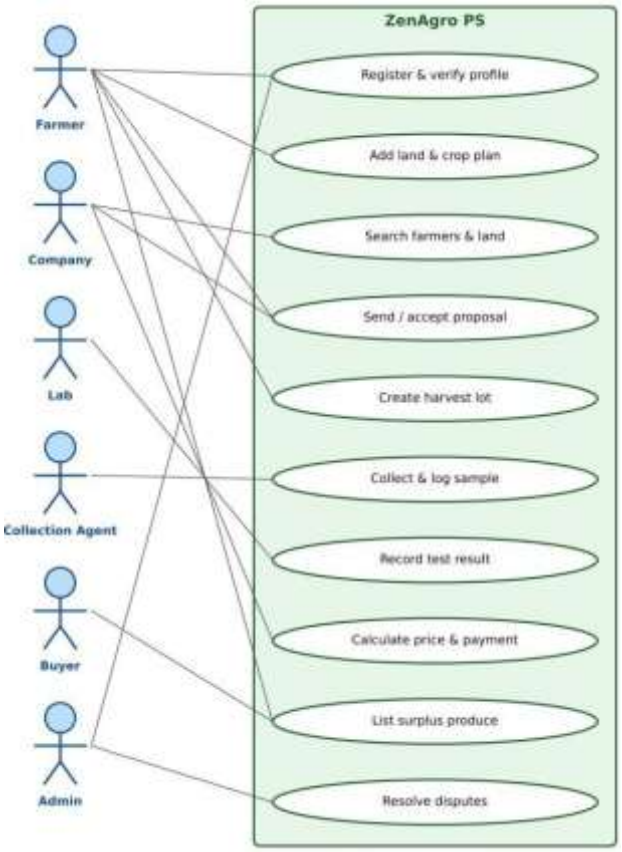


Fig. 2. Use-case diagram showing user roles and platform functions.

TABLE I
PROPOSED ACCESS BY ROLE (W = WRITE, R = READ, – = NONE)

Role	Prof.	Disc.	Lots	Test	Pay	Mkt
Farmer	W	R	W	R	R	W
Company	R*	W	R	R	W	R
Laboratory	–	–	R	W	–	–
Coll. agent	–	–	W	–	–	–
Buyer	–	–	–	–	–	R
Admin	W	W	W	W	W	W

*Prof. = profiles and land; Disc. = discovery and agreements; Pay = payments; Mkt = marketplace. *Anonymised until the farmer accepts.*

D. Data Model

The core entities are farmer, land parcel, crop plan, company, seed trial, sample, harvest lot, quality test, agreement, payment, market listing, dispute and audit event. Fig. 3 shows how the main ones relate. Each record carries the identifier of its parent, which is what later makes tracing possible.



Fig. 3. Simplified data model.

E. Events Recorded in the Audit Log

The following events are time-stamped and stored in an append-only form: farmer registration and verification; creation or update of a land parcel; proposals sent and accepted; seed samples issued; crop-stage updates; harvest-lot creation; sample collection; laboratory submission and result publication; price and deduction calculation; payment initiation and completion; marketplace listings; and disputes raised and resolved.

F. Pilot Design and Evaluation

An initial pilot is planned with 30 to 50 farmers, two to five companies, one or two testing laboratories, one or two local buyers and a small number of collection agents, working with a single crop, preferably cotton where GOT-based procurement is central. Data collected would include land parcels registered, trials started, lots created, samples collected, tests completed, the time from sample to published result and from result to payment, the share of payments settled on time, farmer-reported trust and satisfaction, and farmer income from contracted and surplus produce. Table II lists the main indicators.

TABLE II
PROPOSED EVALUATION INDICATORS

Indicator	Proposed measurement
Result turnaround	Days from sample collection to published test result.
Payment timeliness	Share of payments settled within the agreed period.
Dispute rate	Disputes raised per 100 lots, and time taken to resolve them.
Farmer trust	Questionnaire ratings of clarity, fairness and confidence.
Market choice	Share of surplus produce sold through open channels.
Company efficiency	Time and cost to identify farmers and complete procurement.

G. Deployment and Maintenance

The mobile and web applications are deployed on a cloud host with scheduled backups. Maintenance covers defect fixes, updates to test templates and laboratory integrations, user support, and refinements based on feedback gathered in the pilot.

V. EXISTING SYSTEM

Today's arrangements are mostly manual or split across separate tools. Farmers are found through personal contacts, agents or field visits. Agreements are often verbal or on paper. Sample collection, weights and test results are noted in registers or spreadsheets, and payment details are shared by phone or message. Online marketplaces and farmer-registration tools exist, but each handles one stage and does not link it to the others.

The drawbacks follow from this:

- Farmers cannot see how a quality result and price turned into a payment.
- Lot identity and sample custody are hard to prove, which invites disputes.
- Companies spend time and money finding suitable farmers and land.
- Records are scattered, so history cannot be reviewed or reused.
- Surplus produce is often sold without clear information on options or prices.

VI. PROPOSED SYSTEM

ZenAgro PS has four connected parts: farmer and land registration, seed testing and land discovery, harvest and quality testing, and payment transparency with a surplus-produce marketplace. Fig. 4 shows the overall flow.

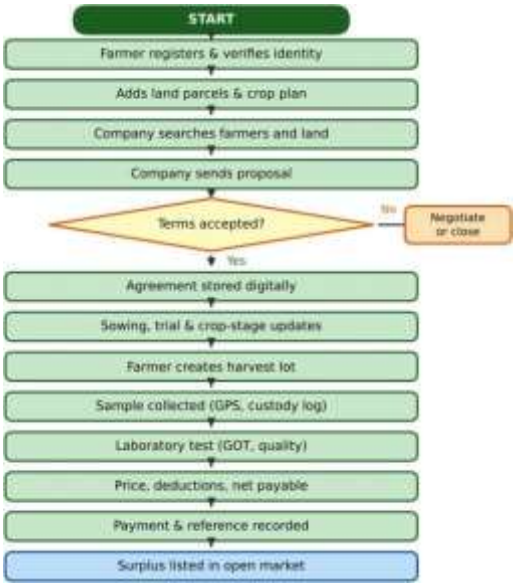


Fig. 4. End-to-end workflow of ZenAgro PS.

A. Farmer Registration and Land Profiles

A farmer registers with a name and mobile number, a legally valid identity or KYC check, address and district, payment details such as a bank account or UPI, preferred crops and consent for data sharing. Each land parcel carries a GPS location or geotagged boundary, area, soil type where known, irrigation source, crop grown, sowing and expected harvest dates, previous crop history and ownership or lease status.

B. Seed Testing and Land Discovery

Companies search by crop, district, land size, soil type, irrigation, previous crop, farmer experience and willingness to join trials. A company can then send a proposal stating the seed variety or treatment, the trial objective, the land needed, any input support, expected sowing and harvest dates, the sampling method, the quality parameters to be tested, the payment terms per qualified lot and the data-sharing terms. The farmer can accept, negotiate or reject. Accepted terms are stored as a digital agreement.

C. Harvest Lots, Sampling and Quality Testing

After harvest the farmer creates a lot with crop and variety, harvest date, weight, field or plot identifier, collection point, photographs and the company or buyer assigned. A company or authorised agent collects a representative sample, and the system records the date and time, the collector, the GPS location, lot and sample weights, photographs and each custody step up to the laboratory result (Fig. 5).

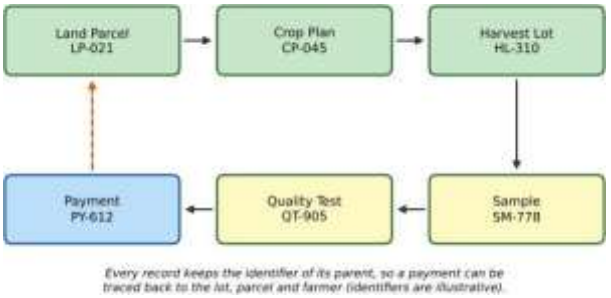


Fig. 5. Lot lifecycle from land parcel to payment.

For cotton, the platform stores seed cotton weight, lint weight, GOT, fibre-quality parameters where available, moisture content if measured, any contractual deductions and the final payable amount. GOT is the percentage of lint obtained from seed cotton after ginning:

$$GOT\ (\%) = (Lint\ wt. \div Seed\ cotton\ wt.) \times 100 \quad (1)$$

Showing the formula and every input value to the farmer is meant to remove a common source of disagreement over payment calculations.

D. Financial Transparency

For each lot the farmer can see the items in Table III. A dashboard summarises lots created, under testing, approved and rejected, total contracted value, amount received, pending payments and surplus produce available for sale. Payment moves through the states shown in Fig. 6.

TABLE III
INFORMATION SHOWN FOR EVERY LOT

Item	Description
Base price	Agreed price per unit for the lot.
Quality result	Grade or test value, with inputs and formula.
Deductions	Amount and reason for each deduction.
Charges	Transport or handling charges, if any.
Net payable	Amount due after deductions and charges.
Payment record	Date, reference number and status.



Fig. 6. Payment status flow, including disputes.

E. Surplus-Produce Marketplace

Once a company has collected its contracted quantity, the rest of the harvest counts as uncontracted surplus. The farmer may sell directly to a local buyer, list it on the ZenAgro PS marketplace, accept a company offer or hold it for later. A listing shows crop and variety, quantity, harvest date, location, asking price, available quality information and, where permitted, the farmer's transaction history. This keeps the farmer's market choice intact.

F. Data Security, Privacy and Audit

Personal and financial data are encrypted and access-controlled, and farmers grant consent for each kind of sharing. Critical events go to an append-only audit log. An optional blockchain layer can hold selected records, and smart contracts can apply agreed payment rules once a result has been verified. The choice between a secure audit log and a blockchain can be made according to cost and need.

G. Proposed Technology Stack

The stack uses common, widely supported tools, summarised in Table IV.

TABLE IV
PROPOSED TECHNOLOGY STACK

Layer	Proposed technology
Farmer app	Mobile application with low-bandwidth screens and local-language support.
Company / admin	Responsive web dashboards.
Back end	Web application framework exposing module APIs.
Database	Encrypted relational database with append-only audit tables.
Integrations	Payment gateway, SMS / WhatsApp, mapping and laboratory systems.
Optional ledger	Permissioned blockchain for selected critical records.

H. Stakeholder Workflows

Farmer. The farmer registers, adds parcels and crop plans, reviews incoming proposals, accepts or negotiates terms, follows crop-stage updates, creates the harvest lot, and then tracks sample status, test results, payment and surplus listings from a single dashboard. Notifications by SMS or WhatsApp keep the process moving for users who do not open the application every day.

Company. The company filters farmers and parcels, sends proposals, issues seed samples where a trial requires them, schedules collection, reviews laboratory results and records the agreed price and deductions. Payment is initiated from the same screen, and the reference number is stored against the lot.

Laboratory and collection agent. The agent logs the sampling visit with location, weights, photographs and custody steps. The laboratory receives the sample identifier, records the result with the analyst's name and date, and publishes it to the authorised parties. Neither role needs to see price or payment information.

Administrator. The administrator verifies profiles, manages users and roles, reviews the audit log and handles disputes. A dispute freezes the affected payment record until it is resolved, and the full trail of events is available to both sides.

I. Illustrative Scenario

Consider a cotton farmer who agrees to grow a company's trial variety on one parcel. At harvest the farmer creates a lot, and a collection agent logs the sampling visit. Suppose the laboratory records 100 kg of seed cotton yielding 34 kg of lint for the sample; Equation (1) then gives a GOT of 34 per cent. The company applies the agreed price for that quality band, notes any deduction with its reason, and the net payable figure appears on the farmer's dashboard together with the inputs. Once the contracted quantity has been collected, the farmer lists the remaining cotton on the marketplace and receives offers from local buyers. The figures here are only an illustration of the calculation.

VII. ADVANTAGES

ZenAgro PS is expected to offer these advantages:

1. **Visibility for Farmers:** trials, test results, prices, deductions and payments can be followed in one place.

2. **Fewer Disputes:** recorded sample identity, custody and calculations give both sides something to check.
3. **Faster Discovery:** companies can find suitable farmers and parcels without repeated field visits.
4. **Traceability:** a payment can be traced to its lot, parcel and farmer.
5. **Market Choice:** surplus produce can be offered openly, so farmers are not tied to one buyer.
6. **Financial History:** a clear transaction record can later support credit, insurance or input-financing services.
7. **Controlled Data Sharing:** farmers decide who sees their information.
8. **Scalable Model:** the same structure can link more crops, laboratories and buyers over time.

VIII. FUTURE SCOPE

The platform leaves room for several extensions:

- A pilot with farmers, companies, laboratories and buyers, evaluated against the indicators in Table II.
- Offline data capture in the mobile application, with synchronisation when a connection returns.
- QR-coded lot and sample labels to speed up data entry and reduce errors.
- Direct integration with laboratory instruments and testing systems.
- Support for further crops and their quality parameters.
- Credit, insurance and input-financing services built on the transaction history.
- Multilingual interfaces and assisted onboarding through local agents.

IX. CONCLUSION

ZenAgro PS proposes a practical way to connect farmer registration, land discovery, seed testing, post-harvest sampling, quality testing, payment and the sale of surplus produce on one set of shared records. By making key transaction information visible to farmers and companies alike, it aims to narrow the information gap that lies behind late payments, disputes and mistrust in agricultural procurement.

The approach is most useful for crops where quality decides value, such as cotton, where GOT and fibre parameters directly affect price. With secure data handling, laboratory integration and a carefully run pilot, ZenAgro PS can become a dependable link between farmers, agri-science companies, laboratories and buyers.

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