CropSense

# YieldRank™ Scientific & Underwriting Methodology

## Institutional Technical Whitepaper for Agricultural Credit Risk Scoring

**White Paper**

www.cropsense.africa

# Executive Summary

Agricultural lending in Africa presents a fundamental underwriting challenge: the financial information traditionally used to assess creditworthiness is often incomplete, while the operational and environmental factors that determine a farmer's ability to generate income are highly variable.

YieldRank™ addresses this information gap by incorporating agricultural, environmental and alternative financial data into a forward-looking assessment of farm-level credit risk.

Unlike conventional credit scores that primarily evaluate historical repayment behaviour, YieldRank evaluates the underlying conditions that influence a borrower's capacity to **produce, generate agricultural income and ultimately repay financing.**

YieldRank combines three principal data domains:

1. **Agronomic Intelligence**: the productive capacity and observed performance of the financed farm.
2. **Climate & Environmental Risk**: the exposure of the farm to weather and environmental conditions that can materially affect production.
3. **Alternative Financial & Behavioural Signals:** available evidence of financial activity, input use, market participation and other indicators of economic behaviour.

These signals are transformed into a standardized **300–850 YieldRank score**, accompanied by a risk band, confidence level, key risk factors and underwriting recommendations.

YieldRank is designed to function as d**ecision-support infrastructure for financial institutions.** It does not originate loans, make lending decisions on behalf of institutions, or assume credit risk. The lender retains responsibility for credit approval, pricing, collateral requirements, loan structuring and portfolio management.

The methodology is designed around five principles:

- Agricultural reality over financial proxies alone
- Forward-looking risk assessment
- Evidence-based scoring
- Explainability and auditability
- Continuous monitoring rather than point-in-time assessment

YieldRank is therefore best understood not as a replacement for conventional credit assessment, but as an **agricultural risk intelligence layer that complements existing underwriting systems.**

## 1. THE UNDERWRITING PROBLEM YIELDRANK SOLVES

Traditional credit underwriting is optimized for borrowers with established financial histories. Agricultural borrowers frequently present a different information profile.

Conventional scoring infers future repayment from a documented financial past. Most smallholder and emerging commercial farmers do not have that past in a form a bank can read: no bureau file, no audited statements, informal transaction history, and collateral that is either absent or legally difficult to perfect.

Lenders respond by pricing for uncertainty, requiring guarantees, or declining. Where they do lend, monitoring is retrospective: the lender learns that a harvest failed when a repayment is missed, months after the field itself showed the failure.

YieldRank addresses both halves of that problem. It substitutes **observed and modelled** productive capacity for absent financial history at origination, and **continuous field observation** for retrospective monitoring after disbursement.

The underwriting question it answers is deliberately narrow:

> Given the current productive, environmental and financial conditions of the farm, how capable is this borrower of generating the agricultural cash flow required to service the proposed financing?

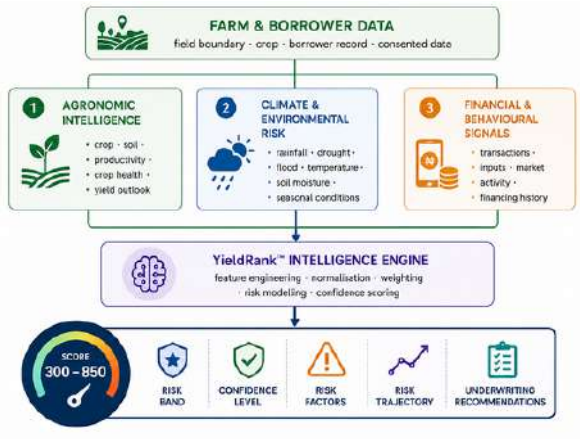
YieldRank is built around the concept of **productive capacity as a credit signal**. For agricultural borrowers, the ability to repay is often closely linked to the ability to successfully produce and commercialize agricultural output. It does not answer questions of borrower identity, willingness to repay, diversion risk, fraud, or side-selling.

The methodology therefore considers the relationship between:

**Farm → Production → Revenue Potential → Repayment Capacity → Credit Risk**

## 2. YIELDRANK METHODOLOGY ARCHITECTURE AT A GLANCE

YieldRank ingests heterogeneous data streams, executes automated feature engineering, and processes indicators through specialized scoring pipelines to produce structured, institutional-grade risk outputs.




The scientific foundation of YieldRank rests on three core analytical pillars coupled with a strict data quality framework.

**Pillar 1: Agronomic Intelligence**
Quantifies the physical production capacity, bio-structural health, and expected yield of target fields.

- **Crop-Soil Suitability:** Evaluates historical soil chemistry, soil texture, elevation, slope, and pH compatibility with selected crop varieties.
- **Crop Health & Vegetation Dynamics:** Extracts multi-spectral vegetation indices via European Space Agency (ESA) Sentinel-2 satellite imagery (10m resolution), including Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI), Normalized Difference Moisture Index (NDMI) and Normalized Difference Red Edge (NDRE).
- **Structural Canopy Monitoring:** Utilizes cloud-penetrating Sentinel-1 Synthetic Aperture Radar (SAR) backscatter (VV/VH polarizations) to monitor biomass accumulation, canopy structure, and crop lodging independent of cloud cover.
- **Historical Productivity:** Analyzes 3-to-5-year historical baseline performance curves for specific geofenced field boundaries.
- **Yield Outlook:** Estimates seasonal harvest volume in metric tonnes per hectare as a range, combining an empirical relationship between season-integrated vegetation indices and observed yields, calibrated per crop and agro-ecological zone, with a water-limited ceiling derived from the field's seasonal water balance.
- **Production Trajectory:** Classifies in-season development against the field's expected curve for its crop, zone and growth stage as improving, stable, deteriorating, or insufficient evidence.

**Pillar 2: Climate & Environmental Risk**
Quantifies weather-related hazards and thermal or hydrologic stress factors impacting crop survival.

- **Precipitation & Rainfall Anomalies:** Tracks localized cumulative rainfall against multi-decadal historical norms to identify precipitation deficits or excessive rainfall.
- **Drought & Flood Exposure:** Models spatial exposure to catastrophic inundation or extended dry spells using multi-spectral water indices and digital elevation models (DEM).
- **Soil Moisture Dynamics:** Estimates root-zone soil moisture depletion rates using satellite thermal infrared telemetry and microwave sensor readings.
- **Temperature & Heat Stress:** Tracks daily max/min temperatures to calculate Growing Degree Days (GDD) and detect crop-damaging thermal stress during critical physiological phases (e.g., flowering/silking).

**Pillar 3: Financial & Behavioral Signals**
Constructs alternative creditworthiness profiles for borrowers lacking formal financial statements.

- **Transaction Velocity:** Assesses mobile money (M-Pesa, MTN MoMo, bank wallet) cash flow consistency, monthly turnover, and balance volatility.
- **Input Purchasing History:** Verifies commercial seed, fertilizer, and agrochemical purchases through partner input distributor ledgers.
- **Cooperative & Offtake Relationships:** Evaluates farmer membership in formal agricultural cooperatives, delivery records, and formal off-taker contract agreements.

- **Historical Agricultural Financing:** Tracks past credit repayments across micro-lenders, input-credit providers, and digital loan platforms.

## 3. SCORING & RISK ASSESSMENT FRAMEWORK

YieldRank converts complex physical and behavioral features into a standardized credit metric for institutional credit decision-making.

**Raw Multi-Modal Data → Feature Engineering → Normalization → Risk Engine → Score (300-850) → Risk Band → Underwriting Output**

**Core Scoring Pipeline Components**

- **Standardized Score (300–850):** A single composite credit score measuring overall agricultural risk and productive capacity.
- **Risk Band:** Categorizes numerical scores into five actionable risk grades (Grade A through Grade E) with calibrated risk boundaries.
- **Risk Factors:** Isolates major negative or positive contributors driving the score (e.g., severe rainfall deficit, high historical yield baseline).
- **Underwriting Recommendations:** Generates automated loan execution parameters, including maximum loan-to-value (LTV), tenor limits, and required risk mitigation instruments.

Each financial institution calibrates YieldRank risk bands against its historical loan performance, loss-given-default (LGD) metrics, and risk appetite to assign formal Basel-compliant probability of default (PD) percentages.

| Risk Grade | YieldRank Score | Probability of Default |
|---|---|---|
| Grade A | 740 - 850 | < 3.0% |
| Grade B | 630 - 739 | 3.0% - 7.5% |
| Grade C | 520 - 629 | 7.5% - 15.0% |
| Grade D | 410 - 519 | 15.0% - 25.0% |
| Grade E | < 410 | > 25.0% |

## 4. CONFIDENCE, EXPLAINABILITY & RISK TRAJECTORY

These three outputs answer a single question that any credit officer asks of any model: how much should this score be trusted, and which way is the risk moving.

### 4.1 Score Confidence

Data availability across African cropland is uneven, and it is uneven in structured rather than random ways. Presenting scores of materially different reliability in identical form would transfer that unevenness silently into the lending book. YieldRank therefore issues a confidence level with every score, computed from data completeness, principally the count of valid cloud-free observations across the season and the largest gap between them; data recency, meaning the age of the most recent usable observation relative to the score date; geographic accuracy, covering boundary quality and its screening outcome; the depth of historical observation available for the field and its crop-zone reference population; and internal consistency across the pillars, where contradiction between independent sources reduces confidence in all of them.

- **High confidence** indicates dense observation in a well-calibrated crop and region with corroborating data present, and supports use as a primary underwriting input within the institution's policy.
- **Medium confidence** indicates adequate observation with gaps or limited local calibration, and warrants supplementary verification or tighter limits.
- **Low confidence** indicates sparse observation or weak calibration, and the score should be treated as indicative rather than decisional.

### 4.2 Model Explainability

Every score decomposes into pillar sub-scores and from there into ranked positive and negative contributors, each expressed in terms a credit officer and a borrower can both act on — that planting fell three weeks after the climatological onset for the zone, that canopy development sits in the eighty-eighth percentile for the crop and region, that a dry spell of a stated length coincided with flowering.

This is a design constraint, not a reporting feature. Model architectures that cannot support decomposition of this kind are excluded from consideration regardless of any accuracy advantage they offer, because a score that cannot be explained cannot be defended to a credit committee, contested by a borrower, or examined by a regulator.

### 4.3 Intra-Season Risk Trajectory Tracking

Unlike static consumer credit reports, YieldRank updates on a bi-weekly or monthly schedule throughout the growing season to output a dynamic risk trajectory:

- **Improving:** Vegetation vigor exceeding seasonal averages; favorable rainfall forecasted.
- **Stable:** Crop growth following expected historical baseline trajectory.
- **Deteriorating:** Vegetative stress detected via SAR/NDVI; drought/flood events emerging.
- **Insufficient Evidence:** Inadequate fresh telemetry due to sustained environmental interference.

This intra-season trajectory monitoring helps lenders catch early warning signals, optimize field monitoring, and manage risk proactively before loan default occurs.

## 5. UNDERWRITING & PORTFOLIO APPLICATIONS

YieldRank supports both frontend credit origination and long-term portfolio management through direct integration into core banking workflows.

### 5.1 Credit Origination Applications

- **Automated Applicant Screening:** Fast-track high-scoring applicants (Grade A/B) for rapid digital loan approvals.
- Optimized Loan Sizing & Tenor: Align loan principle strictly to projected harvest value, preventing borrower over-indebtedness.
- **Risk-Based Pricing:** Offer competitive interest rate discounts to low-risk producers while applying risk premiums to higher-risk bands.
- **Targeted De-Risking Requirements:** Automatically trigger requirements for crop insurance or third-party guarantees for Grade D applications.

### 5.2 Portfolio Management Applications

- **Early Warning System (EWS):** Receive instant alerts when crop stress or severe climate events degrade a borrower's seasonal risk trajectory.

- **Geographic & Crop Concentration Risk:** Monitor aggregate portfolio exposure across specific climate zones, regions, and crop types in real time.
- **Climate Shock Stress-Testing:** Simulate regional drought or flood scenarios to project portfolio-level impairment and capital reserve requirements.

### 5.3 Institutional Workflow

YieldRank occupies the assessment step and the monitoring loop. Verification of borrower identity, legal capacity and security, and the credit decision itself, remain within the institution's process and authority throughout.

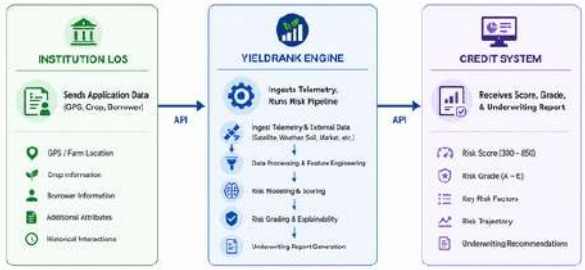
## 6. RESPONSIBLE AI, DATA GOVERNANCE & LIMITATIONS

YieldRank uses robust model governance to ensure ethical data handling, transparency, and effective risk management.

- **Data & Sensing Limitations:** Persistent cloud cover during heavy rainy seasons can reduce optical satellite imagery availability. YieldRank mitigates this by using Sentinel-1 cloud-penetrating synthetic aperture radar (SAR) telemetry. Unverified or inaccurate farm boundary polygons will reduce score confidence ratings.
- **Model Scope & Boundaries:** YieldRank isolates and quantifies agricultural, environmental, and productive risk. It does not replace holistic credit evaluation, nor does it guarantee borrower loan repayment. Non-agricultural default drivers (e.g., health emergencies, macro market collapse) fall outside the model's scope.
- **Algorithmic Fairness:** YieldRank is designed to avoid biased scoring. Borrowers with limited digital footprints are not automatically penalized; instead, missing alternative proxy variables trigger lower data confidence indicators while keeping the primary score grounded in physical Earth Observation telemetry.
- **Human-in-the-Loop Governance:** YieldRank serves as an institutional decision-support system. Final credit approval, risk acceptance, and loan disbursement remain governed by the lender's credit committee and underwriting guidelines.
- **Data Privacy & Compliance:** All spatial, personal, and financial data processing complies with the Nigeria Data Protection Regulation (NDPR), General Data Protection Regulation (GDPR), and relevant national banking data-sovereignty mandates.

## 7. INSTITUTIONAL DEPLOYMENT & INTEGRATION

YieldRank integrates seamlessly with existing core banking software, loan origination systems (LOS), and digital risk consoles.




**Technical Integration Tiers**

- **REST API Integration:** Low-latency API endpoints deliver JSON payloads containing scores, risk bands, risk factors, and underwriting recommendations directly into loan origination systems (LOS) and core banking platforms.
- **Batch Portfolio Assessment:** Ingests CSV/JSON datasets to score large borrower pools or back-test historical loan portfolios asynchronously.
- **Enterprise Web Console:** A secure web platform designed for credit officers, risk managers, and field underwriters. Features interactive map layers, multi-temporal crop health charts, downloadable PDF Credit Committee Packs (CCP), and real-time portfolio dashboards.

## 8. METHODOLOGY GOVERNANCE AND DISCLAIMER

This methodology is owned by CropSense AI, a venture of CipherSense AI Technologies Limited (RC 7970684), and is issued under methodology version 1.0 covering model version 1.5, effective 1st of September, 2026. It is reviewed semi-annually and on any material model change.

Score versioning follows a principle of reproducibility: every issued score records the model version, the methodology version and a hash of its pinned input snapshot, so that any historical score can be regenerated identically and any decision it informed can be reconstructed exactly as it stood at the time. Scores are never silently restated under a newer model; a rescore is issued as a new score with its own version record.

**Appropriate use.** YieldRank is intended as decision support within an institution's existing credit-risk governance framework, applied to agricultural exposures within its calibrated crop and geographic scope, at the confidence levels stated in Section 4.1, and subject to the limitations stated in Section 6.

**Disclaimer.** YieldRank provides agricultural credit-risk intelligence and decision support. It does not constitute a lending decision, a guarantee of repayment, an insurance product, or a substitute for an institution's credit-risk governance framework. Scores are estimates carrying quantified uncertainty and are not warranties of outcome.

## REFERENCES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- Climate Hazards Center, UC Santa Barbara. CHIRPS Rainfall Estimates and Operational Climate Monitoring.
- Basel Committee on Banking Supervision. International Convergence of Capital Measurement and Capital Standards (Basel II/III).