DIGITAL TOOLS FOR MANAGING FINANCIAL SUSTAINABILITY IN UZBEKISTAN'S AGRICULTURE: FINANCIAL MONITORING, EARLY RISK WARNING, AND ENHANCED TRANSPARENCY

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Abstract. *The financial sustainability of Uzbekistan's agricultural sector remains sensitive to the seasonality of cash flows, price volatility, climatic risks, and gaps in information connectivity among farms, banks, insurers, and public support institutions. Under these conditions, digital tools for managing financial sustainability are viewed as an applied infrastructure that enables a transition from reactive, ex post control to a proactive model of financial monitoring, early risk warning, and enhanced transparency.*

Keywords: *financial sustainability, agriculture, Uzbekistan, digitalization, financial monitoring, early warning, risk-oriented approach, indicators, scoring, transparency, government support, agricultural insurance, big data, remote sensing.*

Introduction

The financial sustainability of Uzbekistan's agricultural sector is shaped under conditions of high uncertainty, including the seasonality of revenues and expenditures, dependence on export price conditions for certain crops, climatic and water-related risks, and heterogeneity in farm management practices. As a result, even economically viable producers face cash flow gaps, deterioration of debt indicators, and a decline in investment activity.

Research Methodology

The methodological foundation of the article is formed at the intersection of the risk-oriented approach, the concepts of managerial accounting and financial diagnostics, and digital transformation approaches (data-driven management). A systemic and process-based approach is applied, in which financial sustainability is interpreted as the result of consistency among the flows of **revenues–costs–financing–risks** across the production cycle (sowing–cultivation–harvesting–marketing) and the support frameworks (crediting, insurance, and subsidization). The risk-oriented approach is implemented through the construction of a **"sustainability risk map"** (liquidity, debt, interest rate risk, market risk, production and climatic risk, and the risk of unreliable reporting/information asymmetry), as well as by linking monitoring indicators to the probability of adverse events and the expected losses associated with them.

Main Part

The target logic of digital management of financial sustainability in the agricultural sector is built as a continuous cycle of **"data → indicators → early warning signals → managerial response → impact control."** Unlike traditional financial analysis, which is conducted periodically and based on a limited set of reporting forms, the digital framework is oriented toward regular updates of key indicators (daily/weekly/monthly), automated data quality checks, and the

generation of warnings before a crisis event occurs (debt default, liquidity gaps, or a sharp decline in margins).

Table 1. Data Map for Digital Financial Monitoring of an Agricultural Producer (Data Mart)

Data Block	**Examples of Indicators / Data Fields**	**Update Frequency**	**Responsible Unit**	**Quality Control (Validation)**	**Managerial Use**
Financial Statements and Managerial Accounting	Cash flow statement (inflows/outflows), accounts receivable/payable, cost structure, gross and operating margins	monthly (at a minimum), preferably weekly for cash flow (CF)	Accounting Department / Finance Department	reconciliation of line items, control of negative/anomalous values, bank reconciliation	calculation of liquidity indicators, cash flow gaps, and margin metrics
Banking Transactions and Debt Profile	account turnover, repayment schedule, interest, arrears, covenants	daily / weekly	bank + finance department	reconciliation of balances, verification of payment dates and amounts, control of duplicate transactions	early signals of debt burden, solvency forecasting
Government Support and Subsidies	applications, amount/status, earmarked purpose, disbursement timelines	event-based + weekly status updates	government support registries + finance department	control of duplicate applications, compliance with eligibility criteria, reconciliation with actual expenditures	enhanced transparency and liquidity forecasting
Insurance	coverage, insured amount, deductible, insured event/loss, claim settlement timelines	event-based + monthly updates	insurer + farm	verification of policy completeness, matching of crops and cultivated areas	reduction of the financial shock from yield-related risks

Production Proxy Factors	cultivated areas, crop type, production calendar, yield (actual/planned), stress indices and weather anomalies	weekly / monthly	agricultural service / agronomy	comparison with the plan, outlier control, cross-checking against actual sales data	factor-based diagnostics of margin risk and cash flow gaps
Counterparty Risks	buyer concentration, average payment period, share of overdue receivables	monthly	sales department / finance department	verification of contract accuracy and payment status compliance	early warning signals related to accounts receivable and liquidity

Source: compiled by the author based on the proposed methodology of digital financial monitoring and the practices of managerial accounting in agricultural enterprises.

The key organizational principle is the separation of the roles of **"data owner"** and **"risk owner."** The data owner is responsible for data completeness and quality (accounting, agronomic services, sales), while the risk owner (financial management, credit committee, supervisory framework) is responsible for interpreting signals and initiating response measures. This separation reduces the risk of formalistic "window-dressing" of indicators and increases the trust of banks and insurers in digital data.

Table 2. Digital Monitoring Indicators of Financial Sustainability and Early Warning Threshold Signals

Group	**Indicator**	**Formula / Logic**	**Green Zone**	**Yellow Zone (Warning)**	**Red Zone (Risk)**
Liquidity	Current liquidity ratio	Current assets / Current liabilities	≥ 1,2	1,0–1,19	< 1,0
Liquidity	"Cash buffer"	Cash and cash equivalents / Average daily payments	≥ 30 days	15–29 days	< 15 days
Seasonality	Seasonal cash gap index	Length of the period with negative net cash flow (days)	≤ 45	46–75	> 75
Debt	DSCR (debt service coverage by cash flow)	Available cash flow / (interest + principal)	≥ 1,2	1,0–1,19	< 1,0
Debt	Debt burden	Total debt / Equity	≤ 1,5	1,51–2,0	> 2,0
Profitability	Operating margin	Operating profit / Revenue	≥ 12%	6–11,9%	< 6%

Counterparties	Accounts receivable concentration	Share of the top 3 customers in accounts receivable	≤ 45%	46–60%	> 60%
Shocks	Margin sensitivity index	Change in margin under a ±10% price/cost shock (stress test)	low	medium	high
Transparency	Data Quality Index (DQ)	completeness, timeliness, consistency (0–100)	≥ 85	70–84	< 70
Transparency	Share of transactions with a digital footprint	transactions supported by documents or digital records / total transactions	≥ 90%	75–89%	< 75%

Source: compiled by the author; the thresholds are proposed as methodological benchmarks for early warning, with the possibility of sectoral and seasonal calibration. In practice, a **three-level early warning ladder** is most effective: **early symptoms → pre-crisis → crisis.** This structure ensures manageable responses: at the early-symptom stage, measures are soft (budget refinement, accelerated receivables collection); at the pre-crisis stage, financial maneuvering measures are applied (repayment schedule restructuring, insurance activation, targeted subsidies); at the crisis stage, an anti-crisis regime is introduced (payment prioritization, expenditure freezes, negotiations with creditors).

Table 3. Early Warning Ladder and Response Protocol

Signal Level	**Triggers (Examples)**	**Triggers (Examples)**	**Response Time**	**Response Time**
Early Symptoms	Yellow zone for 2–3 indicators; DQ 70–84; accounts receivable growth >15% per month	Adjustment of the cash flow budget; procurement limits; acceleration of customer payments; contract review	7–14 days	Finance function + Sales”
Pre-crisis	Red zone for one financial and one debt indicator, or DSCR < 1.0; cash buffer < 15 days	Negotiations with the bank to reschedule peak payments; launch of an insurance instrument; linking subsidies to specific cost bottlenecks; control of targeted use of funds	3–7 days	CFO / Credit Committee
Crisis	Red zone for 2+ key indicators; overdue payments; margin decline below 6% amid rising debt	Anti-crisis plan; payment prioritization; moratorium on non-core expenses; restructuring; sale/leaseback of part of the assets	24–72 hours	Senior management + Bank / Insurer

Source: compiled by the author based on a risk-oriented approach and financial management practices. The digital implementation of the protocol implies that each warning is recorded in a **decision log:** who made the decision, which action was assigned, what effect is expected, and which indicator should improve. This transforms monitoring into a managed system rather than a mere "dashboard of attractive charts." To demonstrate the operation of the methodology, three typical profiles of agricultural producers are defined: (A) **a farm** (small scale, high seasonality, limited digitalization); (B) **a cluster/medium-sized enterprise** (mixed financing, partial digital reporting); (C) **a large agribusiness enterprise** (diversification, higher data quality, access to hedging and insurance instruments).

The indicators are specified as model-based values reflecting typical proportions of seasonal agribusiness; the objective is to illustrate the logic of signals and the effects of managerial measures.

Table 4. Diagnostics Based on the Indicator System (Model-Based Data)

Profile	Current Liquidity	Cash buffer (days)	Cash gap index (days)	DSCR	Debt / Equity	Operating margin	DQ (0–100)	Overall risk level
A: farm	0,92	12	86	0,85	2,3	5,4%	62	high (red)
B: cluster / medium-sized	1,08	19	64	1,05	1,7	9,1%	78	medium (yellow)
C: large enterprise	1,34	33	41	1,28	1,2	13,6%	90	low (green)

Source: author's calculations based on the methodology presented in Table 2; the values are illustrative (model-based) and are used to demonstrate the operation of the early warning system.

Interpretation of the results shows that for Profile A, risk is formed simultaneously through three critical channels: liquidity (below 1.0), the seasonal cash flow gap (86 days), and debt servicing (DSCR < 1.0). An aggravating factor is the low data quality (DQ = 62). This implies that even in the presence of potential government support, financial institutions will incorporate an additional risk premium, since the available data do not allow for reliable cash flow forecasting or for confirming the targeted use of funds.

For Profile B, the situation is closer to the "pre-crisis zone": the indicators remain within the yellow thresholds, the cash flow gap is manageable, but the DSCR is close to 1.0 and data quality is moderate. With enhanced digital monitoring and adjustments to the repayment schedule, the risk can be reduced without resorting to severe anti-crisis measures. Profile C demonstrates stability: seasonality is offset by liquidity reserves, operating margins exceed threshold levels, and high data quality (DQ) reduces information asymmetry.

Next, a package of response measures consistent with the early warning protocol is modeled: for Profile A, rescheduling peak payments, linking part of the financing to verifiable transactions, providing insurance coverage for key risks, and improving data quality through standardized cash flow statements and digital accounting; for Profile B, accelerating receivables

turnover, restricting procurement during periods of negative net cash flow, configuring alerts, and implementing a basic dashboard; for Profile C, supportive measures such as stress testing and monitoring receivables concentration.

Table 5. Changes in Key Indicators after the Implementation of Digital Monitoring and Early Warning Measures (Model-Based)

Profile	**Indicator**	**Before measures**	**"After the measures (3–6 months)"**	**"Explanation of the improvement mechanism"**
A	Cash buffer (days)	12	22	"Rescheduling peak payments + control of cash flow (CF) and procurement limits"
A	Cash gap index (days)	86	62	"Reduction of the 'liquidity gap window' through schedule optimization and time-based subsidies"
A	DSCR	0,85	1,07	"Restructuring + reduction of non-priority expenses"
A	DQ (0–100)	62	78	"Restructuring + reduction of non-priority expenses"
B	Current liquidity	1,08	1,18	Acceleration of collections and control of accounts payable"
B	DSCR	1,05	1,16	Reduction of interest burden and improved payment manageability
B	Accounts receivable concentration	58%	47%	"Customer diversification and contractual limits"
C	Margin sensitivity index	medium	low	"Stress testing and cost management across key expense items"

Source: author's calculations; the indicators are illustrative (model-based) and reflect the expected dynamics under the implementation of the response protocol (Table 3). The table leads to a fundamental conclusion: digital tools do not "create money" by themselves, but they reduce the time required to detect risks and improve the accuracy of managerial decisions, which results in measurable improvements in indicators. In the agricultural sector, the most significant effect comes from shortening the duration of cash flow gaps and increasing the DSCR, since these indicators directly reflect the ability to withstand seasonality without falling into arrears. An additional economic effect is associated with transparency: improvements in data quality (DQ) and a higher share of operations with a digital footprint reduce uncertainty for banks and insurers, thereby enabling more flexible financing terms (e.g., seasonally adapted repayment schedules) and more accurate insurance pricing.

The outcome of the methodology is a structured digital monitoring dashboard that includes: risk status (color-coded scale), a list of active alerts, a cash flow forecast for 8–12 weeks, identified "bottlenecks" (receivables, costs, interest), a registry of subsidies and insurance events,

a log of managerial decisions, and an assessment of their impact (improvement or deterioration of indicators). For comparability and scalability, it is advisable to introduce a unified sustainability reporting format for farms within the same segment (crop/region/scale), which enables benchmarking and the design of targeted support measures.

Conclusion, Findings and Recommendations

The conducted research demonstrates that digital tools for managing financial sustainability in Uzbekistan's agricultural sector should be viewed not as an "IT add-on," but as an infrastructure for risk-oriented management that reduces the time lag between the emergence of financial imbalances and managerial response. The effect of digitalization manifests primarily in three outcomes: (1) a shift from periodic financial statement analysis to continuous monitoring of liquidity, debt, and margins with explicit consideration of seasonality; (2) the introduction of early warning mechanisms based on threshold signals and/or multifactor models; and (3) enhanced transparency and verifiability of data, which reduces information asymmetry among farms, banks, insurers, and public support institutions.

Limitations and Directions for Further Research. The results of the article are based on a methodological model and illustrative testing using representative farm profiles; to strengthen the robustness of the findings, pilot implementation on a sample of enterprises across crops and regions is required, along with the calibration of seasonal thresholds and the development of sectoral benchmarks. The most promising directions for further research include: calibrating early warning thresholds with explicit consideration of the agricultural calendar; assessing the impact of data quality (DQ) and the "digital footprint" on borrowing costs; integrating government support and insurance data into scoring models; and developing multi-stage early warning models (active → insolvent → distressed) using local datasets and contemporary machine learning approaches.

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