ANNEX O

Supplement to PHREVO Framework Paper, Version 1.0
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PHREVO Platform: Technical Architecture and Machine Learning Methods

Systems, Data Infrastructure, and Algorithms for Impact Verification, Exchange, and Governance

Document version
2026.1
Platform
PHREVO — phrevo.io
Purpose
Comprehensive technical reference for the PHREVO platform. Covers the architecture of all major subsystems and the full catalogue of machine learning algorithms deployed across the Investor, project, verification, and exchange layers. Companion to the PHREVO Framework Paper (SSRN 6614438) and the PHREVO Public Manual.
Audience
Engineers, data scientists, impact investors, auditors, and academic reviewers evaluating the technical implementation of the PHREVO framework.
Relationship to framework
This annex operationalizes Annex H (Technological Sovereignty Architecture), Annex E (PHREVO-Exchange Economic Model), and the PHREVO-Score measurement system. Where Annex H specifies what the technology must achieve ethically, this annex specifies how it is built technically.
License

Platform Overview

The PHREVO platform is the technical infrastructure that makes the PHREVO framework operationally real. Every component of the framework — the PHREVO-Score, the Impact Exchange, the Basic Impact Income (RIB), the Liquid Governance mechanism, the MEP currency, the community data sovereignty architecture — requires a technology stack that is reliable, auditable, secure, and consistent with the ethical principles the framework espouses. This annex documents that stack in full.

The platform is structured as five interconnected subsystems forming a closed-loop pipeline: data about Investors and projects enters the system, is verified and scored against the 64 PHREVO-Score KPIs, then converted into investable impact portfolios traded on the Impact Exchange. Each subsystem is designed to satisfy the four non-negotiable technical requirements derived from the framework: radical transparency (all processes publicly auditable), community data sovereignty (data belongs to communities, not platforms), anti-speculation architecture (token prices anchored in verified impact, not market sentiment), and anti-bias AI (all algorithms subject to open audit for racial, gender, and class bias).

The ledger cannot lie. We replace trust in intermediaries with trust in code — but only when the code is open, auditable, and governed by the communities it serves. Technology is not the solution to the social problem: it is the infrastructure of truth that makes the social solution verifiable.

PART I — TECHNICAL ARCHITECTURE

O.1 Cloud Infrastructure

The PHREVO platform runs a multi-cloud strategy to achieve geographic resilience, regulatory compliance across multiple jurisdictions, and access to specialized services. The multi-cloud approach also implements the technological sovereignty principle from Annex H: no single provider can shut down or subpoena the entire platform. Critical community data is stored on territorial nodes governed by communities, not on cloud providers governed by the Patriot Act or equivalent national security frameworks.

O.2 Database Architecture

A polyglot persistence model matches each data shape to the most appropriate storage engine, avoiding the impedance mismatch of a single-database approach. The architecture distinguishes between operational data (managed in cloud databases), community data (stored in territorial nodes), and the blockchain audit layer (immutable on-chain hashes with full data in IPFS).

O.3 Security Architecture

Security is enforced across eight layers, aligned with GDPR, PCI-DSS requirements, and the additional community data sovereignty requirements of Annex H. The critical distinction from standard enterprise security: the highest-security tier protects community data from institutional actors (state surveillance, corporate subpoena), not only from external attackers.

O.4 Development Stack

O.4.1 Backend

Python — data engineering, ETL, ML pipelines (NumPy, SciPy, Pandas, Scikit-learn, TensorFlow, Django, Flask)

Java / Spring ecosystem — Spring Boot, Spring Security, Spring Cloud, Spring Data, Jakarta EE, Hibernate ORM. Primary language for financial transaction processing and smart contract integration.

Node.js / Express.js — lightweight API services, event-driven microservices, real-time WebSocket connections for live PHREVO-Score dashboards.

PHP (Laravel, Symfony) — NGO-facing web portals and CMS integrations for community organizations with limited technical capacity.

C# / .NET Core — Microsoft-stack services and Azure Logic App integrations for enterprise investor interfaces.

Solidity / Rust — smart contract development for the Impact Exchange, RIB distribution, and MEP issuance mechanisms.

O.4.2 Frontend

Web: React (primary), Vue.js, Angular — responsive PWA with offline capability for low-connectivity territories.

iOS: Swift / Objective-C (Xcode, CodeRunner) — native apps for field data collection by project teams.

Android: Kotlin / Java (Android Studio) — field tools optimized for low-end devices in Global South deployment contexts.

Cross-platform: JavaScript / React Native — shared business logic for community governance voting interface.

O.4.3 IoT and Edge

Arduino — field sensor integration for water quality, soil health, air quality, and biodiversity monitoring.

Raspberry Pi 4/5 — edge gateway for remote project sites; also the hardware platform for territorial nodes (Annex H). Runs full PHREVO node stack including IPFS, encrypted storage, and local PHREVO-Score calculation.

Device Gateway + Device SDK — authentication, telemetry ingestion, OTA firmware updates with cryptographic signature verification.

LoRaWAN — long-range, low-power communication for sensors in areas without WiFi or cellular connectivity.

O.4.4 Blockchain and Smart Contract Layer

Ethical blockchain requirement: the PHREVO ledger is designed to be anti-speculative. Token prices are anchored to verified PHREVO-Score values, not to market sentiment. Derivatives, short-selling, and speculative lending are prohibited at the protocol level.

Byzantine Fault-Tolerant consensus — ensures data integrity across distributed verification nodes. Any node's data is cross-validated before entering the ledger. Community nodes participate in consensus; no single corporate node can dominate.

IPFS (InterPlanetary File System) — content-addressed distributed storage for full impact data. Blockchain stores only cryptographic hashes (fingerprints). Full data remains in IPFS, under community key control.

Smart contracts — self-executing agreements for: KPI-conditioned capital release; RIB automatic distribution (2% Smart Clearing on every transaction); MEP issuance against verified Evidence Packages; Legitimacy Panel veto execution; Impact Passport credential issuance and verification.

PART II — MACHINE LEARNING & ALGORITHMS

Each PHREVO subsystem deploys a tailored set of machine learning algorithms matched to the specific data shapes and decision tasks it handles. All algorithms are subject to three non-negotiable requirements derived from the ethical framework: auditability (all decisional logic must be explainable and publicly auditable); anti-bias verification (every model must be tested for racial, gender, and class bias before deployment, and re-tested at regular intervals); and community override (community members can challenge algorithmic outputs through the Legitimacy Panel mechanism, with the Panel having authority to override any algorithmic score).

O.5 Investor Data System

The Investor Data System builds rich, multi-dimensional profiles of altruistic investors — individuals and organizations — and matches them to projects aligned with their values, risk profile, and SDG/PHREVO priorities. It serves both individual Investors and institutional altruistic investors, generating the Impact Passport's investor-facing credentials and feeding the Altruistic Investor System's recommendation engine.

O.6 External Data System

The External Data System ingests project submissions from NGOs, community organizations, and external data providers and runs a multi-stage ML pipeline to classify, cluster, and score them before they enter the Project Verification System queue. It is the platform's primary interface with the global ecosystem of impact projects seeking PHREVO verification.

O.7 Project Verification System: The Three-Score Model

The Project Verification System is the methodological core of the PHREVO platform. It is the technical implementation of the PHREVO-Score measurement architecture: every project must be measured by specific, verifiable indicators against a pre-defined baseline. Results are composed into three hierarchical scores that together

produce the Total Project Value (TPV), which determines the project's eligibility for Exchange participation and smart contract capital release.

O.7.1 Score 1 — Influence Areas

Score 1 classifies the project by its domains of impact: which SDG categories, which PHREVO-Score dimensions, and which geographic and demographic influence zones it activates. This score establishes the taxonomy of the project's impact before attempting to measure its magnitude.

O.7.2 Score 2 — Benchmark

Score 2 situates the project relative to comparable verified projects in its category and geography. It estimates the project's scale (beneficiaries reached, duration, financing structure) and measures how it deviates from the cluster centroid — the typical performance profile of similar projects. Deviation from benchmark, rather than absolute scale, is the primary fairness mechanism: a small cooperative in a remote territory is not compared to a global NGO.

O.7.3 Score 3 — Impact

Score 3 is the most rigorous and the most directly connected to the PHREVO-Score's 64 KPIs. It applies standardized indicators with pre-defined baselines, measured against three performance thresholds: Lower Limit, Optimal, and Exceptional. The composite Score 3 aggregates indicator performance weighted by SDG criticality and macroeconomic context data. This is the score that determines smart contract capital release: no funds advance without verified Score 3 improvement.

O.8 Project Management System

The Project Management System supports on-the-ground data collection, volunteer scoring, and real-time IoT telemetry processing. It is designed to function in low-connectivity environments: all critical functions operate offline-first, with data syncing to the network when connectivity is available. The algorithms are

lightweight by design — suitable for edge inference on Raspberry Pi devices in remote territories.

O.9 Impact Exchange and Trading System

The Impact Exchange converts verified project scores into tradeable impact instruments. The algorithmic design is governed by the anti-speculation principle: all models are explicitly designed to prevent token prices from diverging from verified impact values. The price corridor mechanism (±5–10% around fundamental value, as specified in Annex E) is enforced at the protocol level, not by market convention.

O.9.1 Portfolio Composition

The Portfolio Combination System uses combinatorial optimization to select project bundles that maximize impact-adjusted return within Investor-specified PHREVO-Score dimension constraints. Unlike financial portfolio optimization (which maximizes risk-adjusted return), the PHREVO optimizer maximizes verified impact across the six dimensions subject to the lexicographic priority rule: any portfolio configuration that deteriorates SP relative to another is dominated and eliminated, regardless of its IC, CB, or TE performance.

O.9.2 Price Stability and Project Behavior Management

Time-series analysis (ARIMA, rolling statistics) — monitors project performance against historical price curves. Triggers Legitimacy Panel review if performance deviates significantly from the pre-registered trajectory.

Model-based stock value estimation — combines Score 1·2·3 outputs with macroeconomic and SDG criticality weights to produce a continuous project price anchored in verified impact.

Monte Carlo simulation — quantifies uncertainty in impact projections for investor disclosure. Produces confidence intervals, not point estimates.

Anomaly detection (Isolation Forest) — flags unusual trading patterns that may indicate attempted price manipulation. Automatic regulatory referral protocol for confirmed manipulation attempts.

O.9.3 Smart Clearing and RIB Distribution

Every transaction in the PHREVO economy triggers the Smart Clearing mechanism: an automatic 2% redirection to the local community's Basic Impact Income fund. This is implemented as a smart contract that fires on every transaction, requiring no human decision and admitting no exception. The distribution formula weights RIB allocation by Justice Weights — community members with documented care contributions receive supplementary RIB above the base distribution.

O.10 Altruistic Investor System: Integrated Algorithm Stack

The Altruistic Investor System integrates the most complex algorithm stack in the platform, combining profiling, recommendation, and portfolio optimization in a single investor-facing experience. It is the only subsystem where the output directly drives real-money investment decisions, making it also the subsystem with the most stringent bias audit requirements.

PART III — INTEGRATION WITH THE PHREVO FRAMEWORK

O.11 How the Technical Architecture Serves the Framework

The technical architecture described in this annex is not an independent engineering project. Every design decision is constrained by the ethical and philosophical requirements of the PHREVO framework. The following table maps the most critical framework requirements to their technical implementations, demonstrating that the architecture is not a generic impact-investment platform with PHREVO branding: it is a technical system specifically engineered to make the framework's principles operational.

O.12 Known Technical Gaps and Development Roadmap

This annex documents the current state of the PHREVO platform. Several components described above are design specifications rather than deployed systems. The following table is an honest inventory of what exists and what remains to be built, consistent with the transparency principle the framework demands.

Glossary of Technical Terms

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