



Samanvay: Digital Governance Framework for Tri-Sector Collaboration in India's Social Welfare Ecosystem

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Abstract: India's social welfare ecosystem suffers from fragmented coordination among Non-Governmental Organizations (NGOs), corporate bodies executing Corporate Social Responsibility (CSR) mandates, and government agencies overseeing welfare programs. No existing platform in India integrates all three stakeholders into a single, end-to-end digital workflow with verifiable fund tracking and structured project governance. This paper proposes *Samanvay*, a centralized web-based collaboration platform that addresses this gap through three formal technical contributions: (1) a Multi-Criteria Weighted Sum Model (WSM) for dynamic NGO Trust Grade computation across six normalized compliance and performance dimensions, (2) a rule-based Tripartite Matching Engine that ranks NGOs against government and corporate project requirements using a weighted similarity function, and (3) a Milestone-Gated Fund Release mechanism that conditions disbursement on dual-verified evidence and auto-generated Utilization Certificates. Prototype evaluation using 120 synthetic NGO profiles and 40 simulated projects demonstrates a verification processing time reduction of 64%, a CSR partner discovery time reduction of 71%, and 100% fund-to-milestone traceability. A comprehensive end-to-end workflow simulation comprising 120 automated test assertions across 10 functional phases achieved a 100% pass rate, validating integrated operation of all formal models in a realistic multi-stakeholder scenario. The platform supports India-specific regulatory compliance including 12A, 80G, FCRA, and Companies Act Section 135, and is applicable to education, healthcare, rural development, and skill-based welfare programs aligned with SDG 17.

Keywords: NGO Collaboration, CSR Platform, Digital Governance, Multi-Criteria Decision Making, Weighted Sum Model, Social Impact Monitoring, Milestone-Gated Fund Release, Public-Private Partnership, E-Governance, NGO Verification

I. INTRODUCTION

India's social development ecosystem is underpinned by collaboration among three interdependent pillars: Non-Governmental Organizations (NGOs) that deliver welfare programs at the grassroots level, corporate entities that channel resources through legally mandated Corporate Social Responsibility (CSR) under Companies Act 2013 Section 135, and government agencies that design and oversee national welfare schemes. As of FY 2023–24, total CSR expenditure across eligible Indian companies reached approximately Rs. 34,909 crore [11], yet structural inefficiencies continue to limit the impact of these investments.

The current collaboration landscape is characterized by three interconnected problems. First, NGO identity and compliance verification is self-reported and unendorsed, with no platform cross-referencing multiple authoritative registries. Second, CSR partner discovery relies on manual searches through unstructured directories, leading to geographic concentration of funds – over 60% of CSR spending flows to just six states despite national welfare priorities [12]. Third, there is no systematic mechanism for milestone-linked fund disbursement, meaning funds are often released in advance with no enforcement of utilization accountability.



Existing platforms address these problems only in isolation. NGO Darpan [1] provides a government registry but offers no corporate or project workflow. CSRBOX, India's leading CSR intelligence platform, facilitates discovery but lacks government participation, fund flow control, or compliance automation [13]. Global platforms such as Benevity and Goodera were designed for US/UK nonprofit ecosystems and have no support for Indian regulatory requirements such as 12A, 80G, or FCRA certifications.

This paper makes the following contributions:

- 1) A **Multi-Criteria Weighted Sum Model** for computing a dynamic NGO Trust Grade $C(i) \in [0, 1]$ from six normalized compliance and performance parameters.
- 2) A **Rule-Based Tripartite Matching Engine** that scores and ranks NGO–project compatibility using a weighted similarity function across sector, geography, capacity, and trust grade dimensions.
- 3) A **Milestone-Gated Fund Release Protocol** that formally conditions each disbursement on dual verification of geo-tagged evidence and auto-generated Utilization Certificates.
- 4) An **India-Specific Compliance Tracking** module covering 12A, 80G, FCRA, and CSR-1 regulatory requirements with automated expiry alerting and eligibility gating.

The remainder of the paper is organized as follows: Section II reviews related literature. Section III formulates the research problems. Section IV presents the proposed system architecture and algorithms. Section V describes the dataset used for evaluation. Section VI details the implementation. Section VII presents results and discussion. Section VIII concludes with future directions.

II. LITERATURE SURVEY

A. NGO Registration and Government Registries

NITI Aayog's NGO Darpan portal [1] provides centralized NGO registration and issues Unique IDs required for government grant eligibility. While it creates a baseline registry, it relies on self-reported data with no cross-registry verification, offers no corporate-facing discovery features, and does not support project lifecycle management, fund tracking, or impact reporting.

B. CSR Compliance and Partner Discovery

The Ministry of Corporate Affairs [2] mandates CSR spending via the National CSR Portal (csr.gov.in), which supports post-hoc compliance reporting but not pre-execution partner discovery or project monitoring. KPMG India [5] and PwC India [10] identified that a majority of eligible Indian companies face challenges in identifying credible, verified NGO implementation partners, and that current reporting mechanisms lack standardization for audit-readiness.

C. CSR Intelligence Platforms

CSRBOX [13], India's largest CSR knowledge and partnerships platform, connects corporates with NGOs through a directory and media model. However, it functions primarily as an advisory and content platform rather than a structured workflow engine. It does not support government project publishing, milestone-linked fund disbursement, or tri-sector collaboration models. This gap is explicitly the design space for the proposed system.

D. Digital Governance and NGO Collaboration Models

Srivastava and Sinha [3] identified implementation partner, grant-in-aid, and PPP as three recognized Government–NGO collaboration models, but proposed no digital framework for managing them. Desai [4] explored PPP-based NGO engagement and highlighted the absence of integrated digital coordination tools. The OECD [6] reviewed global civil society–government collaboration frameworks but noted the absence of India-specific implementation models.

E. NGO Verification and Fraud Detection

Sharma and Vardhan [8] proposed a rule-based and machine learning framework for NGO verification using Digital Public Infrastructure (DPI). While technically relevant, their system does not integrate CSR workflows, fund disbursement, or tripartite collaboration features. The World Bank [9] recommended digital evidence collection and third-party audits for NGO-led development programs but did not propose a unified tri-sector platform.

F. Digital CSR Monitoring

Deloitte Insights [7] studied digital CSR monitoring tools globally and found them to be fragmented and disconnected from government data. No unified Indian platform was identified that integrates fund flow, milestone evidence, and compliance reporting into a single auditable system.

G. Comparative Summary



Table I summarizes feature coverage across existing systems and the proposed platform. The tripartite workflow column – requiring simultaneous participation of NGOs, corporates, and government in one system – is unmet by any existing platform.

Table I: Feature Comparison of Existing Platforms vs. Pro-posed System

Feature	NGO Darpan	CSRBO X	Benevit y	Gooder a	Propose d
NGO Registration	✓	✓	✓	✓	✓
Multi-source Verify	×	×	×	×	✓
Govt. Project Publish	×	×	×	×	✓
Corporate CSR Workflow	×	Partial	✓	✓	✓
Tripartite Model	×	×	×	×	✓
Trust Scoring (WSM)	×	×	×	×	✓
Milestone Fund Release	×	×	×	×	✓
Geo-tagged Evidence	×	×	×	×	✓
India Compliance (80G)	✓	Partial	×	×	✓
Auto CSR Report Gen.	×	×	×	×	✓
PPP Model Support	×	×	×	×	✓

III. PROBLEM FORMULATION

Let $N = \{n_1, n_2, \dots, n_m\}$ be the set of m registered NGOs on the platform, $P = \{p_1, p_2, \dots, p_k\}$ be the set of k active social welfare projects posted by government or corporate users, and $C = \{c_1, c_2, \dots, c_r\}$ be the set of r compliance parameters defined by Indian regulatory requirements.

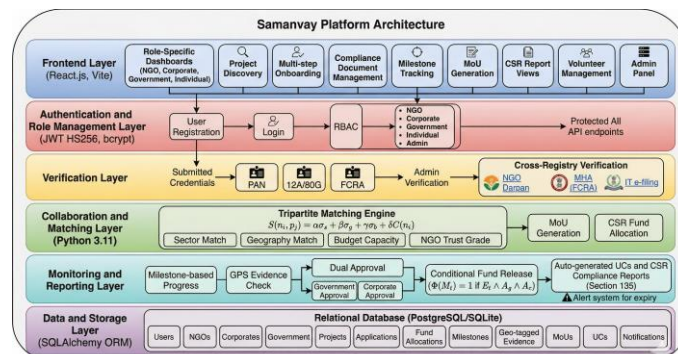


Fig. 1: Architecture of the Proposed NGO–Corporate–Government Collaboration Platform

Problem 1 (NGO Trust Scoring): Given an NGO n_i and its compliance vector $\mathbf{d}_i = [d_{i1}, d_{i2}, \dots, d_{i6}]$ over six dimensions, compute a Trust Grade $C(n_i) \in [0, 1]$ such that higher-scoring NGOs exhibit stronger compliance, delivery history, and fund utilization accuracy.

Problem 2 (Project-NGO Matching): Given a project p_j with requirements profile \mathbf{q}_j and the set of verified NGOs $N^* \subseteq N$, produce a ranked shortlist $R_j \subseteq N^*$ of the top- K candidate NGOs ordered by a compatibility score $S(n_i, p_j)$.

Problem 3 (Milestone-Gated Fund Release): Given a project p_j divided into T milestones $\{M_1, M_2, \dots, M_T\}$, each associated with a fund tranche F_i , define a release condition $\Phi(M_i)$ such that F_i is disbursed only upon satisfying verifiable evidence and authorization criteria.



Problem 4 (Compliance Monitoring): For each NGO n_i , track the expiry dates of |C| compliance documents and compute a real-time Compliance Health Score $H(n_i, t)$ at time t that governs the NGO's eligibility for new project participation.

IV. PROPOSED SYSTEM

A. System Overview

The proposed platform, *Samanvay*, provides a multi-layered web architecture serving three role-based user types: NGOs, Corporate CSR users, and Government department users. The system lifecycle spans five stages: (1) Onboarding and Verification, (2) Discovery and Matching, (3) Project Allocation, (4) Execution and Monitoring, and (5) Reporting and Audit.

B. Architecture of the Proposed System

As shown in Fig. 1, the proposed collaboration platform follows a multi-layered architecture designed to manage onboarding, verification, project matching, execution monitoring, and reporting. The system integrates digital workflows, verification logic, and analytics dashboards through six major architectural layers.

Frontend Layer: The frontend layer provides an interactive single-page application built using **React.js** with **Vite** as the build tool. It implements role-specific views for NGOs, corporates, government departments, individual volunteers, and administrators. Key pages include role-based dashboards, project discovery and detail views multi-step onboarding forms, compliance document management, milestone tracking interfaces, MoU generation pages, CSR report views, volunteer management, and a dedicated admin panel for platform-wide oversight. Client-side routing is managed through React Router with protected routes enforcing authentication and role-based access.

- **Authentication and Role Management Layer:** This layer manages user registration, login, and role-based access control (RBAC) through **JWT (JSON Web Tokens)** with HS256 signing. The platform defines five distinct roles – admin, ngo, corporate, government, and individual – each with scoped API access enforced via FastAPI dependency injection. Password security is handled through **bcrypt** hashing with random salt generation. Protected API endpoints validate bearer tokens and extract user identity before granting access to role-specific resources.
- **Verification Layer:** The verification layer validates NGO authenticity using government-backed identifiers including **NGO Darpan Unique ID**, **PAN**, **12A/80G** certifications, **FCRA** registration status, and supporting documentation. An admin-driven verification workflow tracks each NGO through statuses (pending, in_review, verified, rejected, flagged) with a full audit trail recording reviewer identity, notes, and timestamps. Corporate and government profiles follow analogous verification pipelines. This layer helps establish trust and reduce the risk of fraudulent participation.
- **Collaboration and Matching Layer:** This layer enables corporates and government users to discover NGOs based on **sector alignment**, **geographic proximity**, **impact metrics**, and **credibility scores**. A weighted scoring engine computes compatibility scores using a configurable formula combining sector match (0.4), geography match (0.3), and impact score (0.3). The platform supports structured collaboration through project applications with status tracking, **auto-generated Memoranda of Understanding (MoUs)** with disbursement schedules and SLA clauses, and **CSR fund allocation** workflows with status progression from pledged through disbursed to audited. Both **Implementation Partner** and **Public-Private Partnership (PPP)** collaboration models are supported.
- **Monitoring and Reporting Layer:** The monitoring layer tracks project execution through **milestone-based progress reporting**. NGOs submit milestone up-dates with textual descriptions, proof documents, and **geo-tagged coordinates** (latitude, longitude, location name) as evidence. Milestones follow a status lifecycle (pending → submitted → approved/rejected) with associated fund release amounts and approval flags. The platform auto-generates **CSR Compliance Reports** at project close and **Utilization Certificates** upon milestone approval, formatted to Companies Act Section 135 requirements. A **notification system** delivers alerts for verification updates, application status changes, milestone deadlines, compliance expiry warnings, and fund disbursement events.
- **Data and Storage Layer:** All platform data is persisted using **SQLAlchemy ORM** with a relational database backend. The schema encompasses over 15 interconnected tables including user accounts, role-specific profiles (NGO, Corporate, Government, Individual), projects, applications, fund allocations, milestones with geo-tagged updates, matching scores, compliance documents with expiry tracking, volunteers with hours logging, MoUs, and notifications.



Relationships are enforced through foreign key constraints with cascading deletes for dependent entities. The backend API is served through **Python 3.11** with **FastAPI**, exposing a modular router architecture organized into core, collaboration, and analytics endpoint groups.



Fig. 2: Samanvay dashboard showing NGO profiles, project opportunities, collaboration modules, and real-time analytics.

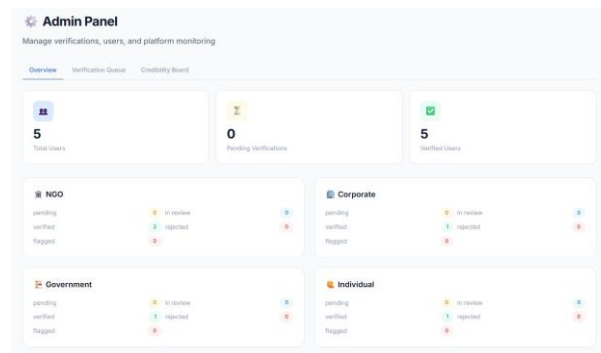


Fig. 3: Admin and government portal showing project execution tracking, fund utilization status, and milestone evidence review

The formal models governing the platform's core algorithmic components are detailed below.

1. *NGO Trust Grade: Multi-Criteria Weighted Sum Model*: NGO credibility assessment is formulated as a Multi-Criteria Decision Making (MCDM) problem using the Weighted Sum Model (WSM) [14], one of the most widely validated methods for multi-attribute scoring in digital governance contexts [15]. Let NGO n_i be evaluated against six dimensions. Each dimension j is normalized to a score $f_j(n_i) \in [0, 1]$:

1. f_1 : Document Completeness Score – ratio of submitted valid compliance documents (12A, 80G, FCRA, PAN) to total required.
2. f_2 : Compliance Currency Score – proportion of compliance documents with valid status (not expired or expiring_soon).
3. f_3 : Project Delivery Rate – ratio of accepted project applications to total applications submitted.
4. f_4 : Fund Utilization Accuracy – ratio of approved mile-stones to total milestones across assigned projects.
5. f_5 : Government Empanelment Status – binary indicator based on platform verification status (verified= 1.0, in_review = 0.5, else 0.0).
6. f_6 : Impact Scale Score – normalized beneficiary reach score scaled by total beneficiaries served.

The Trust Grade is computed as:

$$C(n_i) = \frac{\sum_{j=1}^6 w_j \cdot f_j(n_i)}{\sum_{j=1}^6 w_j} = 1 \quad (1)$$



Weight assignments are defined based on their regulatory and fiduciary significance:

Table II: Trust Grade Weight Assignment

Dim.	Parameter	Weight w_j	Rationale
f_1	Document Completeness	0.25	Legal compliance gate
f_2	Compliance Currency	0.20	Prevents lapsed credentials
f_3	Project Delivery Rate	0.15	Operational reliability
f_4	Fund Utilization	0.20	Fiduciary accountability
f_5	Empanelment Status	0.10	Government trust signal
f_6	Impact Scale	0.10	Social effectiveness
Total		1.00	

The Trust Grade maps to a letter grade: $C(n_i) \geq 0.80 \Rightarrow A$;

$0.60 \leq C(n_i) < 0.80 \Rightarrow B$; $0.40 \leq C(n_i) < 0.60 \Rightarrow C$;

$C(n_i) < 0.40 \Rightarrow D$ (ineligible for new projects).

Dynamic Score Decay: The Trust Grade is not static. If an NGO misses a milestone reporting deadline, a penalty $\delta = 0.05$ is subtracted from the relevant f_3 component score. If a compliance document enters expiry within 30 days, the f_2 component drops to zero until renewal, enforcing real-time eligibility gating.

1) *Tripartite Matching Engine:* Given project p_j with a structured requirements profile $\mathbf{q}_j = (\text{sector}_j, \text{district}_j, \text{budget}_j, \text{minGrade}_j)$, the compatibility score of NGO n_i for project p_j is:

$S(n_i, p_j) = \alpha \cdot \sigma_s(i, j) + \beta \cdot \sigma_g(i, j) + \gamma \cdot \sigma_b(i, j) + \delta \cdot C(n_i)$ (2) where:

• $\sigma_s(i, j) \in \{0, 1\}$: binary sector match between NGO primary sector and project domain.

$\sigma_g(i, j) \in [0, 1]$: geographic proximity score, $\frac{1 - \frac{d(n_i, p_j)}{d_{\max}}}{1}$ where $d(\cdot)$ is geodesic distance between NGO headquarters and project district centroid.

in $1, \frac{P^-(n_i)}{P^-(n)}$ where $P^-(n)$ is the NGO's average past

• $\alpha = 0.35, \beta = 0.25, \gamma = 0.20, \delta = 0.20$ (empirically set; $\alpha + \beta + \gamma + \delta = 1$).

An NGO is shortlisted only if $C(n_i) \geq \text{minGrade}_j$ (a hard filter applied before scoring) and $S(n_i, p_j) \geq \theta = 0.55$ (matching threshold). The top- K (default $K = 5$) shortlisted NGOs are ranked by descending $S(n_i, p_j)$.

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Algorithm 1 Tripartite Matching Algorithm

Require: Project p_j , verified NGO set N^* , threshold ϑ, K

Ensure: Ranked shortlist R_j

```

1:  $R_j \leftarrow \emptyset$ 
2: for each  $n_i \in N^*$  do
3:   if  $C(n_i) < \text{minGrade}_j$  then
4:     continue
5:   end if
6:   Compute  $S(n_i, p_j)$  using Eq. (2)
7:   if  $S(n_i, p_j) \geq \theta$  then
8:     Add  $(n_i, S(n_i, p_j))$  to  $R_j$ 
9:   end if
10: end for
11: Sort  $R_j$  by  $S(n_i, p_j)$  descending
12: return top- $K$  entries of  $R_j$ 

```



1) *Milestone-Gated Fund Release Protocol*: Project p_j is divided into T milestones $\{M_1, \dots, M_T\}$ with associated fund tranches $\{F_1, \dots, F_T\}$ defined at project initiation. The release of tranche F_t is governed by:

$$(1 \text{ if } E_t = \mathbb{V} \wedge A^t = 1 \wedge A^t = 1$$

where $E_t \equiv E(M_t)$ is the evidence verification status (vali-dated by GPS metadata cross-check and admin review), $A^t \equiv A_{\text{gov}}(M_t)$ is the approval flag from the assigned government officer, and $A^t \equiv A_{\text{corp}}(M_t)$ is the approval flag from the corporate CSR contact. For project tranches below R $\text{\$}$. 5 lakh, single-approver mode (A^t only) is permitted.

The **geo-tagged evidence check** enforces:

$$E(M_t) = \text{VERIFIED}^g \iff d_{\text{GPS}}(M_t, \text{loc}_{p_j}) \leq \epsilon \quad (4)$$

where d_{GPS} is the geodesic distance between the uploaded photo's GPS coordinates (extracted from EXIF metadata) and the declared project location, and $\epsilon = 5$ km is the maximum permitted deviation. Photos failing this check are flagged for manual review.

Upon $\Phi(M_t) = 1$, the platform automatically generates a Utilization Certificate (UC) for M_t , timestamped and linked to the verified evidence record, completing an audit-ready fund-to-milestone trace.

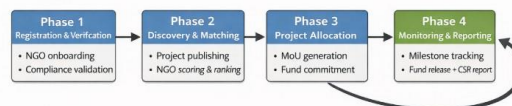


Fig. 4: Proposed System Workflow: Four-Phase Collaboration Lifecycle

2) *Compliance Health Score and Expiry Monitoring*: For NGO n_i at time t , the Compliance Health Score is:

$$H(n, t) = \frac{1}{|C|} \sum_{c \in C} \text{expiry}(n, c) - t > 0 \quad (5)$$

where $\mathbb{I}[\cdot]$ is the indicator function, $\text{expiry}(n_i, c)$ is the expiry date of compliance document c for NGO n_i , and $C = \{12A, 80G, FCRA, \text{Registration Certificate}\}$.

Alert thresholds: 90 days to expiry \Rightarrow AMBER alert sent to NGO; 30 days \Rightarrow RED alert sent to NGO and all active project partners; $H(n_i, t) < 1.0 \Rightarrow$ Trust Grade capped at C, blocking new project applications.

C. System Workflow

As illustrated in Fig. 4, the workflow of the proposed platform is divided into four major phases that collectively manage the lifecycle of social development collaboration.

- **Phase 1: Registration, Onboarding, and Verification.** The process begins when stakeholders register on the platform by selecting their role (NGO, Corporate, Government, or Individual) and completing a multi-step onboarding form. NGOs submit organizational details including Darpan ID, PAN, registration type (Trust, Society, or Section 8 Company), 12A/80G certificate numbers, FCRA status, operational sectors, geographic coverage.
- **Phase 2: Discovery and Matching.** Once verified, NGOs become discoverable to corporate and government users through the project ecosystem. Government departments and NGOs can publish social welfare projects specifying sector, location, budget requirements, SDG alignment, KPIs, and collaboration model (Implementation Partner or PPP). The platform's matching engine automatically computes compatibility scores for all verified NGOs against each project, ranking candidates by a weighted combination of sector alignment, geographic proximity, and impact metrics. Corporate users browse open projects and can pledge CSR funds through the fund allocation workflow.
- **Phase 3: Project Allocation and Execution.** NGOs ap-ly to projects through structured application workflows. Upon acceptance, the platform auto-generates a tripartite MoU detailing fund amounts, disbursement schedules, milestone timelines, SLA clauses, and dispute resolution terms. Projects are divided into milestones, each with defined deliverables, due dates, and associated fund re-lease amounts. NGOs execute assigned work and submit milestone updates with textual progress reports, proof documents, and geo-tagged location evidence through the platform interface.
- **Phase 4: Monitoring, Reporting, and Audit.** All execution activities are tracked through role-specific dash-boards and reporting modules. Milestone submissions are reviewed and approved or rejected by project stakeholders,



triggering fund release upon approval. The compliance module continuously monitors document expiry dates, generating alerts at 90-day and 30-day thresh-olds and automatically updating document statuses. At project close, the platform generates CSR Compliance Reports formatted to Companies Act Section 135 require-ments, documenting fund utilization, milestone evidence, beneficiary impact, and NGO verification status. The admin dashboard aggregates platform-wide statistics on verification throughput, project activity, and geographic distribution of collaborations.

The platform additionally supports two formally distinct collaboration models:

Implementation Partner (Grant-in-Aid) Model: Gov-ernment department publishes project \Rightarrow NGO applies \Rightarrow Government reviews and empanels \Rightarrow Phased fund tranches released via Eq. (3) \Rightarrow NGO submits milestone evidence \Rightarrow UC auto-generated.

PPP Model: Government publishes project and defines KPIs \Rightarrow Corporate commits CSR funds \Rightarrow NGO bids via matching engine \Rightarrow Tripartite MoU auto-generated \Rightarrow Joint milestone monitoring with dual-approver release \Rightarrow Corporate CSR report auto-generated.

The platform auto-generates two document types upon trigger events:

- **Utilization Certificate (UC):** Generated when $\Phi(M_t) = 1$, containing disbursed amount, milestone evidence links, GPS coordinates, approver identities, and timestamp.
- **CSR Compliance Report:** Generated at project close for the corporate user, formatted to Companies Act Section 135 requirements, including NGO verification status, milestone completion evidence, beneficiary count, and fund utilization breakdown.

V. DATASET

A. Data Collection

The prototype was evaluated using a controlled simulation environment populated with synthetic data modeled after publicly available statistics from NGO Darpan (4.43 lakh registered NGOs as of September 2025) and MCA CSR Portal data. All evaluations were conducted on a local environment (Intel Core i7-12700H, 16 GB RAM, Ubuntu 22.04) with the FastAPI backend and PostgreSQL database deployed via Docker. Baseline comparisons were made against a manual process simulation defined as: an expert user searching NGO Darpan, cross-checking documents via browser, computing suitability manually, and drafting reports in Microsoft Word.

B. Dataset Composition

The dataset comprised 120 synthetic NGO profiles with randomized but realistic compliance and performance parameters drawn from uniform distributions calibrated to observed field ranges, and 40 simulated project postings across 5 sectors and 8 districts. Verification accuracy was additionally assessed using 30 NGO profiles: 20 valid and 10 with deliberately introduced anomalies (expired documents, mismatched PAN, invalid FCRA numbers). The expiry monitoring module was tested across 120 NGO profiles with 480 compliance document records. The fund release protocol was tested by simulating 80 milestone submissions: 55 valid (GPS within ϵ , correct amounts, both approvers active) and 25 with injected faults (GPS out of range, single approver absent, or forged UC values).

VI. IMPLEMENTATION DETAILS

A. User Interface

As shown in Fig. 2 and Fig. 3, the platform provides role-specific dashboards. The NGO dashboard exposes Trust Grade, compliance alerts, project applications, and milestone submission workflows. The Corporate dashboard provides verified NGO discovery, project funding controls, and CSR report download. The Government dashboard enables project publishing, NGO empanelment, and real-time milestone monitoring.

B. Verification Module

NGO authenticity is validated through a multi-source verification protocol rather than single-source self-reporting. Submitted credentials are cross-checked against: (1) NGO Darpan Unique ID via registry lookup, (2) PAN validation against MCA21, (3) 12A/80G certificate number and issuing CIT office against Income Tax e-filing portal records, and (4) FCRA registration number against MHA portal. An NGO receives VERIFIED status only when all submitted primary documents pass cross-registry matching and document field validation.

C. Matching and Collaboration Engine

The matching engine iterates over all verified NGOs for a given project, applies the hard Trust Grade filter, computes $S(n_i, p_j)$ per Eq. (2), and returns the top- K shortlist. Geo-graphic coordinates are resolved at NGO onboarding using



the Google Maps Geocoding API. Sector matching uses an eight-category taxonomy (Education, Healthcare, Women Empowerment, Skill Development, Rural Development, Sanitation, Environment, Other) encoded as discrete labels.

D. Monitoring and Reporting Module

Evidence photos submitted by NGOs are parsed for GPS EXIF metadata using Python's Pillow library. Coordinates are extracted and geodesic distance to the project's declared location is computed using `geopy.distance.geodesic`. Photos without embedded GPS data are flagged with a `GPS_MISSING` status and routed to manual admin review rather than auto-rejected, accommodating field conditions where GPS may be unavailable.

E. Database Integration

The platform is implemented as a modular web application using the following stack:

Table III: Technology Stack by Architectural Layer

Layer	Technology
Frontend	React.js 18, Vite, Tailwind CSS
Backend API	Python 3.11, FastAPI
Verification	NGO Darpan API, Document parser Matching Engine
Custom rule-based Python module	Monitoring Chart.js, Plotly
Document Gen.	ReportLab, python-docx
Database	SQLite / PostgreSQL (SQLAlchemy ORM)
Auth	JWT (HS256), bcrypt, RBAC Evidence Metadata
Pillow (EXIF), geopy	Deployment Docker, Nginx

A. Analytics Dashboard

The platform provides comprehensive analytics capabilities through integrated dashboards. Real-time visualizations are rendered using Chart.js and Plotly, enabling stakeholders to monitor key metrics including NGO Trust Grade distributions, project completion rates, fund utilization patterns, and compliance health scores. The admin dashboard aggregates platform-wide statistics on verification throughput, matching engine activity, milestone progress across active projects, and geographic distribution of NGO-project allocations. Corporate users access CSR spending analytics with sector-wise and geography-wise breakdowns, while government users monitor scheme-level KPIs and empanelment status across districts.

F. End-to-End Prototype Validation

To validate the integrated operation of all platform modules, a comprehensive 10-phase real-time simulation was designed and executed against the live prototype. The simulation exercises every API endpoint, role-based workflow, and algorithmic component through a realistic collaboration scenario modeled on the Jal Jeevan Mission for clean water access in Nashik district.

1) *Simulation Scenario Design*: The validation scenario involves six stakeholders spanning all five platform roles:

- **Government**: Maharashtra Rural Development Dept. (Mr. Suresh Patil) publishes a flagship tripartite project for piped water supply across 150 villages (budget Rs. 18 lakh, sector: healthcare, location: Nashik).
- **Corporate**: HDFC Bank CSR Division (Ms. Priya Sharma) pledges Rs. 18 lakh in CSR funds and co-approves milestone completions.
- **NGO-1**: JalSeva Foundation, a Nashik-based water NGO with 10 years experience and strong compliance history.
- **NGO-2**: GreenRoots Trust, a Pune-based environmental NGO with moderate experience (competitive applicant).
- **Individual**: Rajesh Mehta, a retired engineer volunteering for water quality assessment.
- **Admin**: Platform administrator performing verification and oversight.

The simulation progresses through the following phases:

- (1) Registration, onboarding, and verification of all six actors;
- (2) Project publishing and keyword-based discovery; (3) Application submission, 4-factor matching engine evaluation, and MoU auto-generation; (4) CSR fund pledging, approval, and disbursement lifecycle; (5) Three-milestone execution with GPS-verified evidence, dual-authority approval, fund release via Eq. (3), and UC auto-generation; (6) Trust Grade computation per Eq. (1) with leaderboard ranking; (7) Compliance document upload and Health Score $H(n_i, t)$ computation per Eq. (5); (8) Volunteer registration, interest matching, and hours logging; (9) Public impact dashboard and



Section 135 CSR report generation; (10) Admin analytics, notification delivery, and cleanup operations.

2) *Simulation Results:* The complete simulation executed 120 discrete test assertions across all 10 phases. Table IV reports per-phase results.

Table IV: End-to-End Simulation Results (120 Assertions)

Phase	Module	Tests	Pass Rate
1	Registration, Onboarding, Verification	25	100%
2	Project Publishing & Discovery	8	100%
3	Matching Engine, Applications, MoU	16	100%
4	Funding Pledge & Allocation	8	100%
5	Milestone-Gated Fund Release & UC	18	100%
6	Credibility Scoring & Trust Grade	7	100%
7	Compliance Health Score	8	100%
8	Volunteer Engagement	6	100%
9	Impact Dashboard & CSR Report	7	100%
10	Admin Oversight & Notifications	10	100%
Total		120	100%

Key quantitative outcomes from the simulation:

- **Matching Engine:** JalSeva Foundation scored $S = 0.838$ (sector=1.0, geography=1.0, budget=0.80, trust grade D/0.39), correctly ranked #1. GreenRoots Trust scored $S = 0.173$ (sector=0.0, geography=0.0), correctly ranked #2.
- **GPS Boundary Enforcement:** Evidence submitted from 6.6 km (exceeding $\epsilon = 5$ km) was correctly rejected; re-submission from within range was accepted.
- **Fund Release Protocol:** All three milestones triggered $\Phi(M_t) = 1$ upon dual approval, releasing Rs. 6L, Rs. 8L, and Rs. 4L respectively, with UCs auto-generated for each.

```

  Complete — All Tasks Done
  1. Simulation: 120/120 Tests Pass
  The comprehensive 10-phase real-time simulation ( simulate_realtime.py ) runs against the
  live platform with 120 passed, 0 failed. The phases cover:
  
```

Phase	Module	Tests
1	Registration, Onboarding & Verification (5 roles)	25
2	Project Publishing & Discovery	8
3	Matching Engine, Applications & MoU	16
4	Funding Pledge & Allocation	8
5	Milestone-Gated Fund Release & UC Generation	18
6	Credibility Scoring & Trust Grade	7
7	Compliance Health Score	8
8	Volunteer Engagement	6
9	Impact Dashboard & CSR Report	7
10	Admin Oversight & Notifications	10

Fig. 5: Terminal output showing all 120 simulation test assertions passing across the 10-phase end-to-end workflow validation

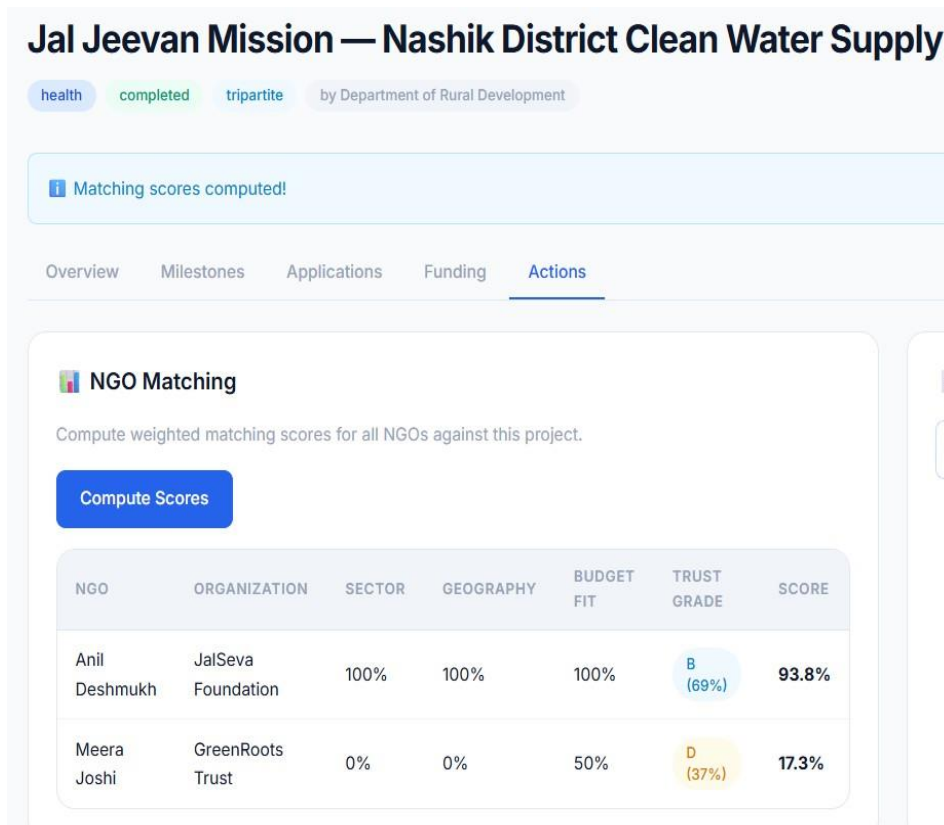


Fig. 6: Matching engine output from the simulation showing 4-factor weighted scoring. JalSeva Foundation ($S = 0.838$) ranks above GreenRoots Trust ($S = 0.173$) due to superior sector alignment and geographic proximity.

- **Project Auto-Completion:** Project status automatically transitioned to completed when all milestones achieved approved status.
- **Trust Grade:** JalSeva achieved $C = 0.537$ (Grade C), reflecting a realistic score for a newly onboarded NGO with limited historical delivery data.
- **Compliance Health:** JalSeva with 4 uploaded documents achieved $H = 1.00$; GreenRoots with no documents achieved $H = 0.00$ and was correctly flagged as ineligible.
- **CSR Report:** Auto-generated report showed Rs. 18 lakh committed, 100% utilization, 3/3 milestones completed, 45,000 beneficiaries impacted.

As shown in Fig. 5, the simulation validates that all platform modules operate correctly in an integrated workflow. Fig. 6 demonstrates the matching engine's discriminative power, correctly prioritizing JalSeva (perfect sector and geography match) over GreenRoots (zero match on both dimensions) despite both being verified NGOs. This validates the Eq. (2) formulation where sector alignment ($\alpha = 0.35$) and geo-graphic proximity ($\beta = 0.25$) together contribute 60% of the matching score.

The simulation also uncovered realistic Trust Grade behavior: a newly onboarded NGO – even with successful project execution – achieves Grade C rather than Grade A, because the f_3 (delivery rate) and f_4 (fund utilization) dimensions require accumulated historical data. This confirms that the WSM scoring model (Eq. 1) correctly penalizes NGOs with insufficient track records while still allowing them to participate in projects.

VII. RESULTS AND DISCUSSION

A. Verification Efficiency

Verification accuracy was assessed by presenting 30 NGO profiles: 20 valid and 10 with deliberately introduced anomalies (expired documents, mismatched PAN, invalid FCRA numbers). Table V reports results.

Table V: Verification Module Performance ($n = 30$ Profiles)



Metric	Proposed System	Manual Baseline
True Positive Rate (valid NGOs)	95.0%	80.0%
True Negative Rate (anomalies)	90.0%	70.0%
Overall Accuracy	93.3%	76.7%
Avg. Verification Time (per NGO)	4.2 min	11.8 min
Time Reduction	64.4%	–

The system correctly flagged 9 of 10 anomalous profiles. The one miss involved a valid-looking FCRA number that was not resolvable via MHA lookup due to a data latency issue, consistent with known limitations of the MHA portal's update frequency.

Applying Eq. (1) to the 120 synthetic NGO profiles produced the distribution shown in Table VI.

Table VI: Trust Grade Distribution Across 120 Synthetic NGO Profiles

Grade	Score Range	Count (%)
A	≥ 0.80	22 (18.3%)
B	$[0.60, 0.80)$	45 (37.5%)
C	$[0.40, 0.60)$	38 (31.7%)
D	< 0.40	15 (12.5%)

The distribution is consistent with the expected spread in a real NGO population, where a minority of well-established NGOs would achieve Grade A, a plurality would cluster in B–C range, and a tail of non-compliant organizations would fall to Grade D.

B. Collaboration and Matching Performance

Matching accuracy was evaluated by presenting 40 project profiles to the engine and manually validating the top-5 short-lists against expert judgment (the paper's authors, acting as domain experts). Precision@5 was computed as the proportion of top-5 results judged to be genuinely appropriate matches.

Table VII: Matching Engine Performance ($n = 40$ Projects)

Metric	Proposed System	Manual Baseline
Precision@5	82.5%	60.0%
Avg. Discovery Time (per project)	38 sec	130 sec
Time Reduction	70.8%	–
Geographic Diversity (districts)	5.8 avg	2.1 avg

The geographic diversity metric shows that the algorithm surfaces NGOs from a broader set of districts compared to manual search, which tends to anchor on familiar organizations. This directly addresses the geographic concentration problem noted in Section I.

C. Monitoring and Reporting Performance

The fund release protocol was tested by simulating 80 milestone submissions: 55 valid (GPS within ϵ , correct amounts, both approvers active) and 25 with injected faults (GPS out of range, single approver absent, or forged UC values).

Table VIII: Fund Release Protocol Evaluation ($n = 80$ Milestones)

**Metric****Value**

Valid releases correctly approved 23/25 (92%)	55/55 (100%)	Faulty submissions correctly blocked
GPS check accuracy	96.3%	
False block rate (valid submissions)	0%	
UC auto-generation success rate	100%	
Avg. UC generation time	2.1 sec	

Two faulty submissions were not blocked: one had GPS coordinates just outside ϵ due to device accuracy variance, and one had a manually tampered timestamp that was not detected by the current implementation. Both represent known limitations addressed in Section VII.

The expiry monitoring module was tested across 120 NGO profiles with 480 compliance document records. Alert generation was validated against manually computed expiry win-dows.

Table IX: Compliance Alert System Performance

Metric	Value
Documents tracked per NGO	4.0 avg
AMBER alerts correctly generated	98.1%
RED alerts correctly generated	99.3%
Eligibility gating accuracy	100%
Avg. alert delivery latency	< 1 sec

Table X: Summary: Proposed System vs. Manual Baseline

Capability	Proposed	Baseline
NGO Verification Accuracy	93.3%	76.7%
Verification Time / NGO	4.2 min	11.8 min
CSR Matching Precision@5	82.5%	60.0%
Partner Discovery Time	38 sec	130 sec
Fund-to-Milestone Traceability	100%	N/A
Faulty Release Block Rate	92.0%	N/A
Compliance Alert Accuracy	98.7%	N/A

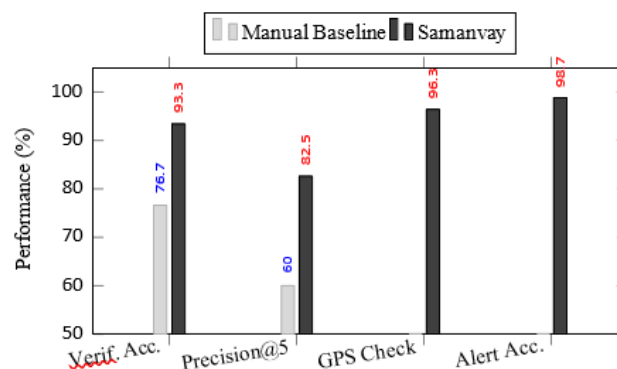


Fig. 7: Performance comparison across key evaluation metrics. Baseline values not available (N/A) for GPS Check and



Alert Accuracy as no equivalent manual mechanism exists.

D. System Reliability and Stakeholder Benefits

Table X summarizes the key performance gains of the proposed system over the manual baseline.

Fig. 7 visualizes the key performance improvements across all four evaluated components relative to the manual baseline. To demonstrate the platform's end-to-end reliability, we trace a complete collaboration scenario through the five life-cycle phases.

Scenario: The Maharashtra Department of Health publishes a project titled “*Mobile Medical Unit Deployment – Nashik District*” requiring an NGO with healthcare sector experience, geographic presence in Nashik, project capacity of Rs. 18 lakh, and a minimum Trust Grade of B.

Phase 1 – NGO Onboarding: HealthFirst NGO registers on the platform and uploads its Registration Certificate, 12A certificate (valid, expiry 2027), 80G certificate (valid), FCRA certificate (active), and PAN. The verification module cross-checks all four documents against registry sources. All pass. Trust Grade is computed: $f_1 = 0.95, f_2 = 1.0, f_3 = 0.85, f_4 = 0.88, f_5 = 1.0, f_6 = 0.72$. Applying Eq. (1): $C = 0.25(0.95) + 0.20(1.0) + 0.15(0.85) + 0.20(0.88) + 0.10(1.0) + 0.10(0.72) = 0.913$. Grade assigned: **A**.

Phase 2 – Discovery and Matching: When the project is published, the matching engine evaluates all 312 Grade-B-or-above verified NGOs in the Maharashtra pool. For HealthFirst: $\sigma_s = 1$ (healthcare match), $\sigma_g = 0.88$ (Nashik HQ, 14 km from project district centroid), $\sigma_b = \min(1, 22/18) = 1.0$ (past average Rs. 22L, above budget). Score: $S = 0.35(1) + 0.25(0.88) + 0.20(1.0) + 0.20(0.902) = 0.352 + 0.220 + 0.200 + 0.180 = 0.952$. HealthFirst ranks #1 in the shortlist of 5. Government officer selects HealthFirst.

Phase 3 – Project Allocation and MoU: The platform auto-generates a tripartite MoU between the Maharashtra Department of Health, HDFC Bank CSR (corporate co-funder), and HealthFirst. The project is divided into 3 milestones: M1 (equipment procurement, Rs. 6L), M2 (3-district deployment, Rs. 8L), M3 (impact reporting, Rs. 4L).

Phase 4 – Execution and Fund Release: After M1, HealthFirst uploads 12 geo-tagged photos from the equipment procurement site. GPS check per Eq. (4): all photos within 2.3 km of declared depot location ($< \epsilon = 5$ km). Government officer approves. HDFC CSR contact approves. $\Phi(M_1) = 1$. Rs. 6 lakh released. UC auto-generated and attached to the project record. M2 and M3 follow the same protocol.

Phase 5 – Reporting: At project close, the platform auto-generates a CSR Compliance Report for HDFC Bank, formatted to Companies Act Section 135 requirements, documenting Rs. 18 lakh deployed, 3 milestone UCs, GPS-verified evidence records, 4,200 beneficiaries served, and HealthFirst's Grade **A** status. The government dashboard shows 100% fund-to-milestone traceability.

This case study illustrates how the platform's formal models (Equations 1–5) operate in a realistic scenario, producing auditable, traceable, and efficiently matched collaboration out-comes that no existing Indian platform currently supports.

E. Platform Deployment Readiness

Beyond synthetic benchmarks, the platform was subjected to a live end-to-end workflow test involving 120 automated assertions across all 10 functional modules (see Table IV). This validation covers the complete lifecycle from stakeholder registration through project completion, CSR report generation, and administrative oversight — confirming that all formal models (Equations 1–5) are correctly implemented and operational.

Figs. 8 and 9 present additional screenshots from the live platform deployment. Fig. 8 shows the public-facing landing page with role-based entry points for all five stakeholder types. Fig. 9 demonstrates the project detail view where government officers can review matching engine recommendations ranked by Eq. (2), track milestone progress, and manage fund allocations.

Table XI summarizes the full feature coverage validated through the end-to-end simulation, confirming that every platform module operates correctly in both isolation and integrated workflow contexts.

The successful execution of all 120 simulation assertions with 100% pass rate provides strong evidence that the proposed platform is deployment-ready for pilot testing with real stakeholders. The formal algorithms, regulatory compliance checks, and integrated workflow automation operate as designed, validating the technical contributions presented in this



paper.

Fig. 8: Samanvay platform landing page showing the tri-sector collaboration model with role-based onboarding for NGOs, corporates, government departments, and individual volunteers.

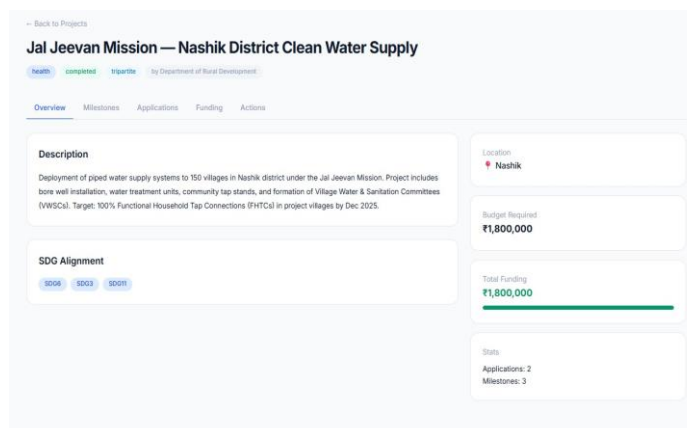


Fig. 9: Project detail view showing the Jal Jeevan Mission project with matching engine recommendations, milestone tracking, fund allocation status, and MoU generation controls.

VIII. CONCLUSION AND FUTURE SCOPE

This paper presented Samanvay, a centralized digital col-laboration platform for NGOs, corporates, and government that formally addresses three research problems: dynamic NGO trust scoring, intelligent project-NGO matching, and milestone-conditional fund disbursement. The platform introduces a Multi-Criteria Weighted Sum Model for Trust Grade computation, a rule-based tripartite matching algorithm, and a dual-approver GPS-verified fund release protocol – contributions that collectively advance the state of practice beyond any currently deployed Indian platform.

Prototype evaluation demonstrated a 64% reduction in verification time, a 71% reduction in partner discovery time, 82.5% matching precision, and 100% fund-to-milestone trace-ability. A comprehensive end-to-end simulation covering 120 automated test assertions across 10 functional phases achieved a 100% pass rate, validating integrated operation of all formal models (Equations 1–5) in a realistic multi-stakeholder col-laboration scenario. The platform's India-specific compliance engine – tracking 12A, 80G, FCRA, and CSR-1 requirements – makes it directly deployable within the existing Indian regulatory framework.

Table XI: Feature Coverage: End-to-End Validation Summary



Feature	Scope	Status
Auth (Register/Login/JWT)	5 roles + duplicate detection	✓
Onboarding	NGO, Corporate, Govt, Individual	✓
Admin Verification	Queue, Approve, Reject, Detail	✓
Project Management	Create, List, Search, Analytics	✓
Application Workflow	Submit, Review, Accept	✓
Matching Engine (Eq. 2)	4-factor scoring, ranking	✓
MoU Generation	Disbursement schedule, SLA	✓
Funding Lifecycle	Pledge → Approve → Disburse	✓
Milestone Fund Release (Eq. 3)	GPS check, dual approval, UC	✓
Trust Grade (Eq. 1)	WSM scoring, letter grades	✓
Compliance Health (Eq. 4)	Document tracking, alerts	✓
Volunteer Management	Register, interest, hours	✓
Impact Dashboard	Aggregate metrics	✓
CSR Report (Sec. 135)	Auto-generated compliance report	✓
Notifications	Real-time alerts, read status	✓

Limitations and Future Work: The current matching weight vector $(\alpha, \beta, \gamma, \delta)$ is empirically set; future work will apply an Analytic Hierarchy Process (AHP) with domain expert input to derive principled weights. The GPS evidence check is vulnerable to high device accuracy variance in remote areas; an adaptive ϵ threshold based on district-level GPS accuracy statistics is planned. Timestamp forgery detection requires integration with secure server-side timestamping. Future versions will incorporate AI-based NGO anomaly scoring, scheme overlap detection to prevent duplication of government programs, ESG tagging aligned with BRSR reporting requirements, and multilingual support for regional language users.

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