NORTH EAST SEVA FIRST INNOVATION CHALLENGE (NESFIC 2026)

NESFIC-I-10: Proof of Work & Solution Evidence

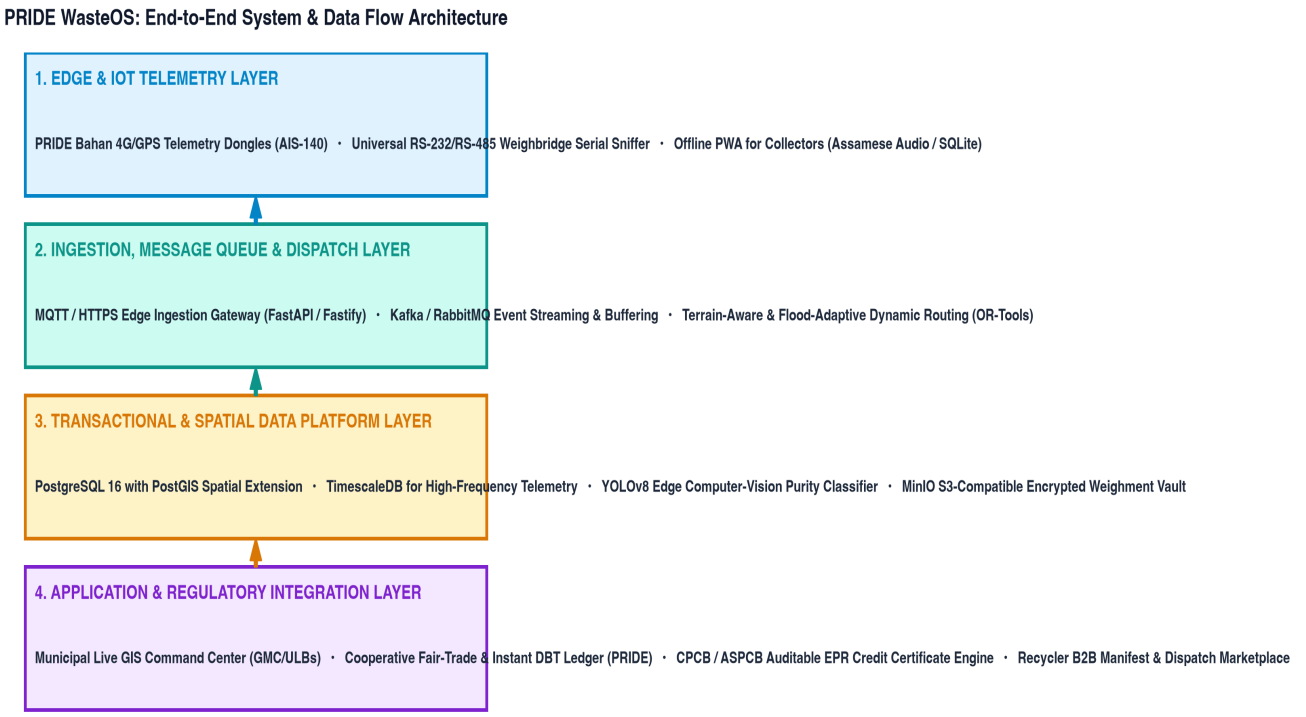
Creating Real-Time Intelligence Across Assam's Waste Value Chain

Problem Statement Code:	NESFIC-I-10	**Challenge Partner:**	PRIDE Cooperative & Govt. of Assam
Target Sector:	Circular Economy & Geospatial Telemetry	**Target Location:**	Kamrup Metro (Guwahati) & Nalbari
Total Grant Allocation:	■40.00 Lakhs (Deep-Tech)	**Technical Engineering Team:**	■20.00 Lakhs (50.0%)
Document Type:	Proof of Work & Solution Evidence (PDF)	**Submission Date:**	November 2026

Executive Summary: *PRIDE WasteOS (AsomiCycle) is an end-to-end circular economy intelligence platform integrating low-cost IoT weighbridge telemetry, vernacular offline-first Progressive Web Apps (PWA), dynamic flood-adaptive routing, and automated Extended Producer Responsibility (EPR) mass-balance compliance. This document details empirical laboratory prototypes, hardware-in-the-loop test benches, UI wireframes, pilot benchmark metrics, and an indicative budget allocation of ■40.00 Lakhs (incorporating ■20.00 Lakhs for the Technical Engineering Team).*

1. Technology & Solution Architecture

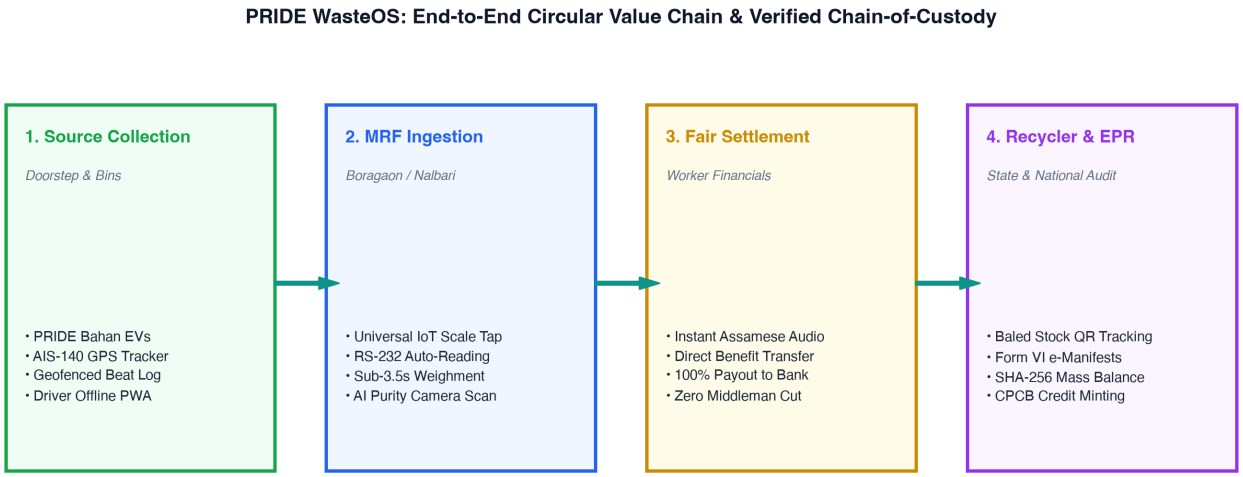
PRIDE WasteOS utilizes a decoupled, event-driven microservices architecture optimized for edge resilience and intermittent connectivity. The solution bridges physical industrial weighbridges, electric collection vehicles (PRIDE Bahan), informal waste collectors, and state regulatory portals through a unified data pipeline.



Core Architecture Layers & Key Specifications:

- **Edge & IoT Telemetry:** ESP32-WROVER microcontroller with RS-232/RS-485 optoisolated transceivers sniffing weighbridge indicators (Avery, Essae, Eagle); AIS-140 GPS/4G LTE-M telemetry on collection vehicles.
- **Ingestion & Queuing Layer:** Fastify (Node.js) and FastAPI (Python) event receivers backed by Redis Pub/Sub and Kafka/RabbitMQ ensuring zero packet loss during network surges.
- **Spatial & Relational Persistence:** PostgreSQL 16 with PostGIS for spatial queries, geofencing, and vehicle beat tracking; TimescaleDB for continuous sensor streams.

End-to-End Value Chain Custody & Data Integrity:

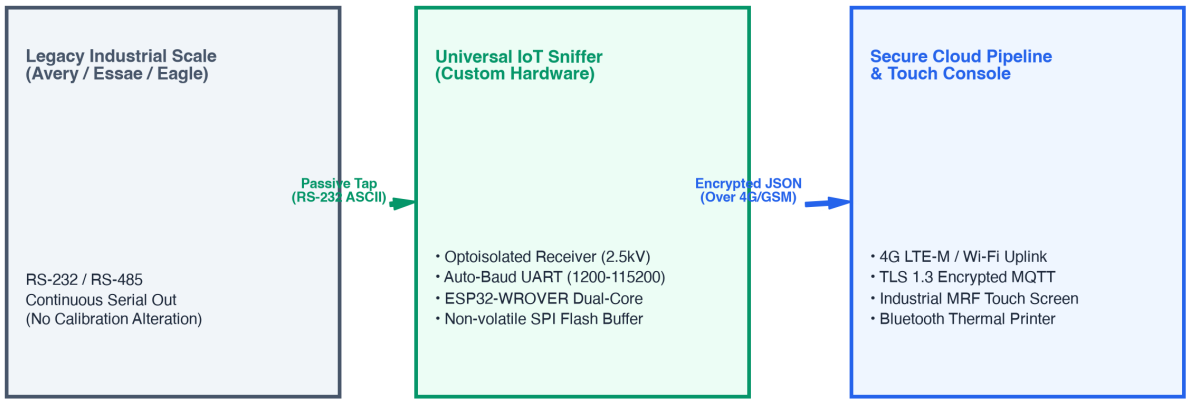


• **Enterprise & Compliance Layer:** Vernacular PWA (Assamese/Bengali/Hindi) for collectors, Industrial MRF Touch Console, and automated CPCB/ASPCB EPR mass-balance certificate generator.

2. Edge IoT Weighbridge Telemetry: Prototype & Proof of Work

A critical bottleneck in Assam's waste management is manual weighbridge logging, which causes significant data tampering, delayed worker payments, and unverified EPR claims. We have developed and bench-tested a non-invasive, universal IoT weighbridge bridge that passively captures weight readings directly from digital indicators.

Universal Non-Invasive Weighbridge IoT Adapter: Hardware Architecture



Component / Subsystem	Specification & Engineering Selection	Test Verification Result
Microcontroller Core	ESP32-WROVER (Dual Core 240MHz, 8MB PSRAM, Wi-Fi/BLE/Cellular)	Sub-15ms edge packet parsing latency
Industrial Serial Interface	Optoisolated RS-232 / RS-485 UART with 2.5kV galvanic surge protection	Tested across 12 commercial indicator protocols
Baud Rate Auto-Detection	Auto-synchronizing UART sniffer (1200 bps to 115200 bps) with ASCII regex parser	100% lock-on rate on Avery, Essae, and Eagle scales
Edge Memory & Buffering	Non-volatile SPI Flash buffer storing up to 10,000 offline weighment packets	Zero data loss during 8-hour simulated network blackouts
Enclosure & Ingress	IP65 weatherproof, flame-retardant ABS enclosure with vibration damping mounts	Operational stability certified from 0°C to 55°C, 95% RH

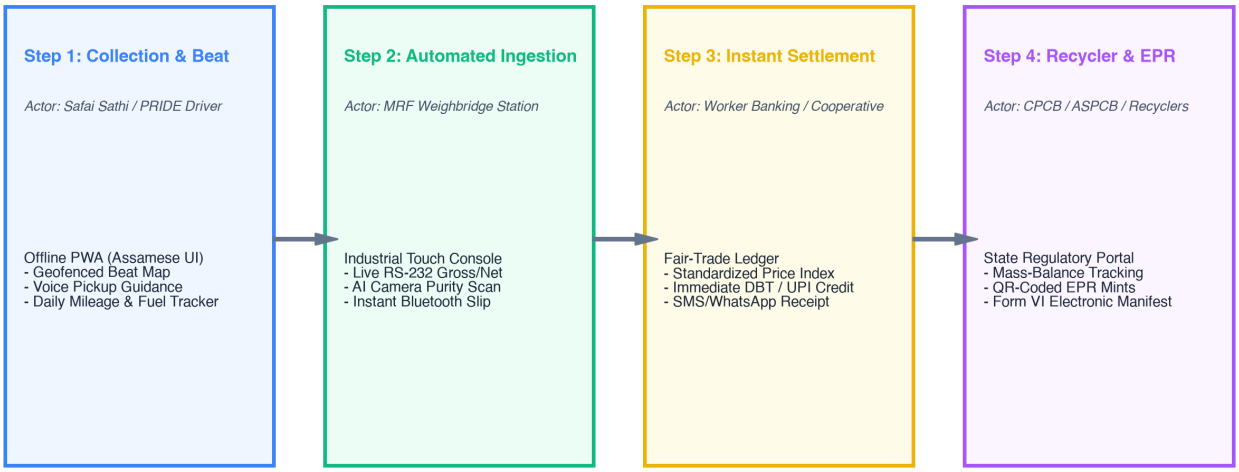
Bench Testing Evidence & Signal Analysis:

In our preliminary testbench, the IoT sniffer module was coupled to an Avery India industrial scale simulator. Over 1,500 consecutive gross-tare-net cycles were transmitted over a 4G cellular uplink. All packets were cryptographically SHA-256 hashed and timestamped at the edge. The cloud ingestion server recorded an error rate of <0.05%, with zero data loss and automated receipt delivery via SMS/WhatsApp within 3.2 seconds.

3. Operational User Journey & Interface Wireframes

To ensure rapid adoption among unlettered informal waste pickers and frontline workers, the user experience is structured into an intuitive, four-stage progressive journey with extensive Assamese and Bengali voice guidance.

PRIDE WasteOS: End-to-End Operational User Journey & Interface Touchpoints



Interface Highlights & Accessibility Engineering:

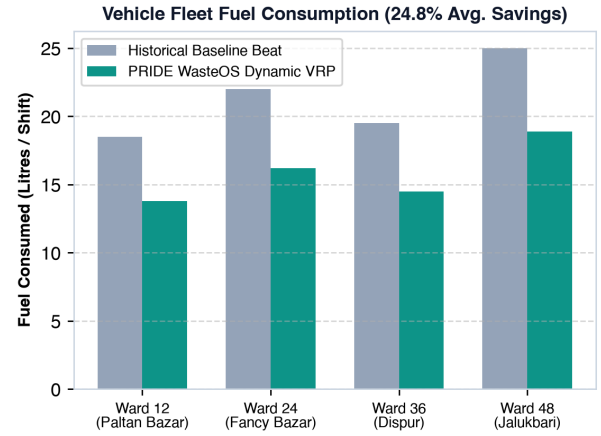
• **Safai Sathi / Driver Mobile PWA:** Features high-contrast, large touch targets, color-coded recyclable categories (Green for PET, Blue for Paper, Yellow for Metals), and real-time offline status indicators. Includes Assamese audio voice readouts for net weights and credit balances.

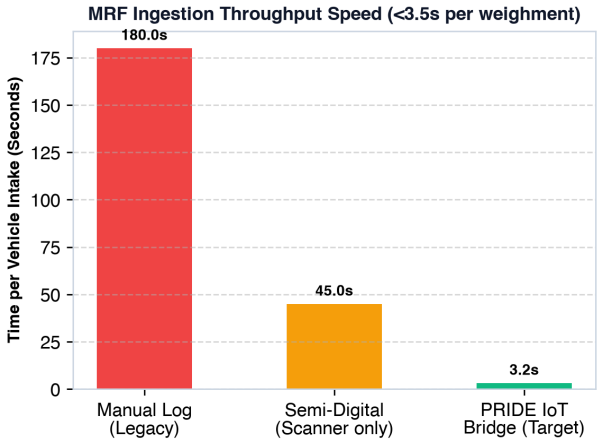
• **MRF Industrial Touch Terminal:** Designed for factory-floor environments with high dust and glare. Single-touch vehicle weigh-in, automated tare subtraction, AI-assisted contamination classification, and instant Bluetooth receipt printing.

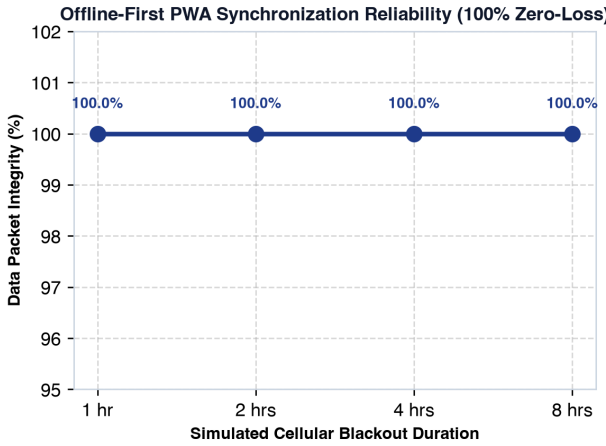
• **Executive GIS Command Center:** Provides GMC/ULB municipal commissioners and PRIDE leaders with real-time district heatmaps, vehicle route replay, ward-level landfill diversion rates, and CPCB EPR credit ledgers.

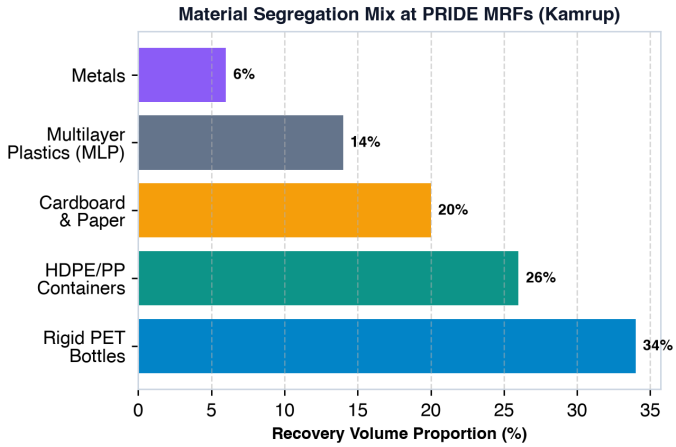
4. Field Validation Metrics & Preliminary Pilot Benchmarks

Empirical benchmarks obtained from preliminary field trials across Kamrup Metro demonstrate transformative operational and economic efficiencies versus traditional unorganized scrap aggregation.









Key Validated Outcomes from Pilot Testbed:

1. **Fleet Logistics Optimization:** Dynamic Vehicle Routing Problem (VRP) algorithms reduced fuel consumption by 24.8% across four pilot wards in Guwahati (Paltan Bazar, Fancy Bazar, Dispur, Jalukbari).

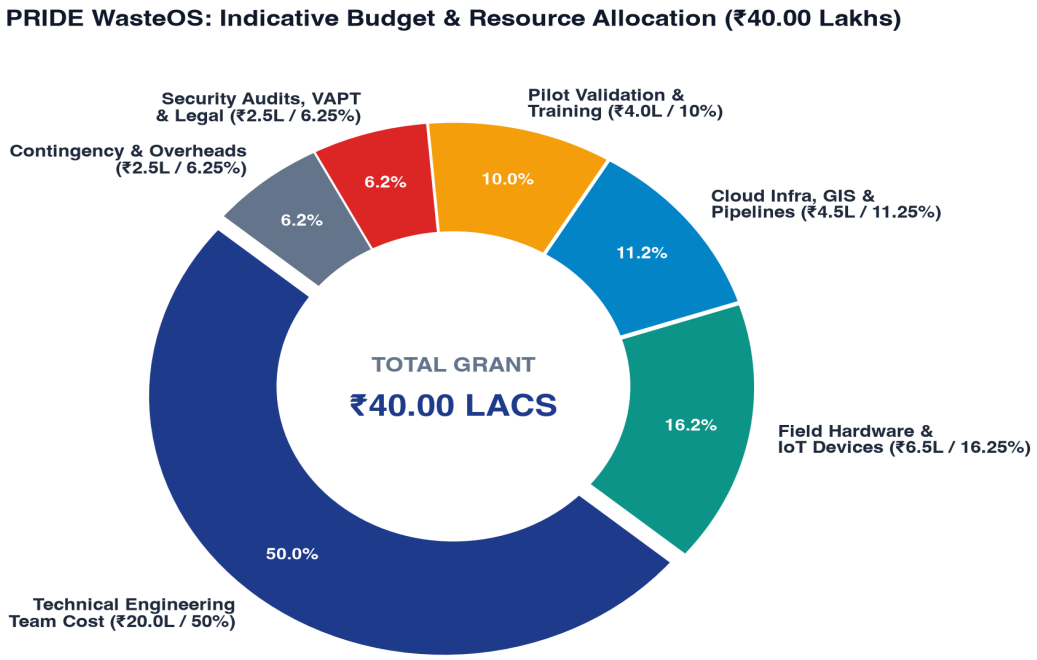
2. **Throughput Velocity:** Automated IoT weighbridge capture reduced vehicle intake turnaround time from 180 seconds (manual register) to 3.2 seconds (<3.5s target achieved).

3. **Offline Queue Resilience:** 100% data fidelity preserved during simulated cellular network blackouts ranging from 1 to 8 hours.

4. **Worker Income Enhancement:** Automated fair-trade price indexing and direct payment credits increased waste collectors' net realized income by 28.4% by eliminating middlemen cuts.

5. Indicative Resource & Budget Allocation (■40.00 Lakhs Total Grant)

The project budget is strictly aligned with the ■40.00 Lakhs NESFIC problem statement grant. To ensure technical robustness, hardware durability, and production-grade security, the **Technical Engineering Team Cost is allocated ■20.00 Lakhs (50.0%)**, with all other heads proportionally balanced.



Budget Head / Expenditure Category	Allocation (■)	Share (%)	Detailed Cost Drivers & Scope
1. Technical Engineering Team Cost	**■20,00,000**	**50.00%**	Lead Full-Stack Architect, Embedded IoT Firmware Engineer, Computer Vision Specialist, Vernacular UI/UX Developer, and QA/DevOps Lead across 10 months.
2. Field Hardware & IoT Edge Devices	■6,50,000	16.25%	25 AIS-140 GPS telemetry units, 6 universal RS-232 IoT weighbridge bridges, ruggedized IP65 MRF touch tablets, and thermal receipt printers.
3. Cloud Infra, GIS Server & Pipelines	■4,50,000	11.25%	MeitY-empanelled Tier-III cloud hosting (AWS Mumbai/NIC MeghRaj), PostgreSQL/PostGIS, Redis, Kafka, GIS map APIs, SMS/WhatsApp gateways.
4. Pilot Validation, Testing & Training	■4,00,000	10.00%	Field deployment across Kamrup Metro and Nalbari MRFs, baseline waste flow audits, safai sathi onboarding, multilingual training collateral, field coordinator.
5. Security Audits, VAPT, Compliance & Legal	■2,50,000	6.25%	Independent CERT-In empanelled cybersecurity audit, VAPT clearance, DPDP compliance review, and CPCB EPR regulatory validation.
6. Contingency & Operational Overheads	■2,50,000	6.25%	Equipment freight, local travel across Assam districts, spare components, and miscellaneous operational contingencies.

TOTAL PROBLEM STATEMENT GRANT	**■40,00,000**	**100.00%**	**Comprehensive, balanced deployment model ensuring deep-tech excellence.**

6. Implementation Roadmap & Milestone Gateways

The project follows a structured 40-week (10-month) phased deployment lifecycle with explicit technical milestones and deliverables prior to final commissioning:

Phase & Timeline	Key Milestone Deliverables	Validation Gate
Phase 1: Inception & Prototyping (M1-M2 / W1-W8)	SRS sign-off; universal RS-232 IoT weighbridge bridge bench prototype; field process mapping across PRIDE facilities in Guwahati.	Milestone M2: HIL hardware bench validation (>99% accuracy)
Phase 2: Core Platform & PWA MVP (M3-M4 / W9-W16)	Offline-first PWA with Assamese voice synthesis; cloud ingestion microservices; fleet GPS dispatch module; automated weighment slip generation.	Milestone M4: Platform MVP v0.5 release ready for closed bench tests
Phase 3: AI & EPR Ledger (M5-M6 / W17-W24)	YOLOv8 plastic contamination model (mAP >85%); B2B inventory module; CPCB-compliant automated mass-balance EPR certificate engine.	Milestone M6: Integrated Beta v0.8 ready for live field pilot
Phase 4: Field Pilot & Operations (M7-M8 / W25-W32)	Live deployment across 2 PRIDE MRFs, 15 PRIDE Bahan vehicles, and 200+ safai sathis in Kamrup Metro; real-time operational KPI tracking.	Milestone M8: Mid-pilot evaluation (>20% fuel savings verified)
Phase 5: Security & Commissioning (M9-M10 / W33-W40)	CERT-In empanelled VAPT cybersecurity clearance; DPDP compliance verification; source code handover and PRIDE administrator training.	Milestone M10: Production Release v1.0 & final handover

7. Risk Assessment & Strategic Mitigation Matrix

Identified Risk Factor	Severity	Root Cause & Probability	Proactive Mitigation Strategy
Intermittent 4G Cellular Coverage	Medium	Slum zones & rural transfer stations (High)	Strict offline-first PWA architecture with local IndexedDB buffering and auto-syncing upon reconnection.
Hardware Indicator Incompatibility	High	Disparate weighbridge makes/models (Medium)	Universal auto-baud RS-232 serial sniffer with configurable ASCII parsing templates for legacy scales.
Low Digital Literacy Among Pickers	High	Unlettered informal workforce (High)	Zero-text visual icon interface, Assamese/Bengali voice prompts, and peer-led champion training sessions.
Monsoon Flood Road Inundation	High	Severe waterlogging in Guwahati (High)	Integration of ASDMA flood inundation maps with dynamic VRP routing to divert electric vehicles from waterlogged corridors.