AI-Driven Geospatial Forecasting of Mandatory Biometric Update (MBU) Demand to Optimize Service Delivery

UIDAI Hackathon – 2026

Team Name: zero gem

Team Leader: Dipak shillak

Team Members: 1. Dipak shillak

2. Neeraj patil

3. Om kothavade

Institution: SVKM IOT, DHULE

Department: COMPUTER DEPARMENT

Year: 2026

ABSTRACT

Millions of residents are required to complete Mandatory Biometric Updates (MBU) at specific age milestones to maintain the accuracy of Aadhaar authentication and remain eligible for welfare services. However, uneven public awareness, infrastructure limitations, and population density variations create regional service overloads and inclusion risks.

This project presents an AI-driven geospatial forecasting and analytics platform that predicts district-wise MBU demand using historical biometric enrollment trends, population growth patterns, and demographic indicators. The system introduces an Inclusion Difficulty Index, an explainable metric that quantifies the deviation between predicted and actual enrollment, enabling the identification of hard-to-reach and underserved regions.

An interactive dashboard visualizes saturation gaps through a dynamic geospatial map, supporting proactive planning of mobile enrollment units, staffing, and service infrastructure. By shifting from reactive to predictive governance, the solution helps reduce service bottlenecks, prevent welfare exclusion caused by biometric mismatches, and optimize Aadhaar service delivery through data-driven decision-making.

1. INTRODUCTION

Aadhaar serves as India's foundational digital identity system, enabling access to welfare schemes, financial inclusion, and public service delivery. Mandatory Biometric Updates (MBU) at age milestones—particularly at ages 5 and 15—are critical to maintaining authentication accuracy and ensuring uninterrupted access to Aadhaar-linked services.

Despite its importance, biometric update coverage varies significantly across regions due to uneven infrastructure availability, lack of awareness, population density differences, and logistical challenges. Some districts experience overcrowding at enrollment centers, while others remain underserved, increasing the risk of exclusion from essential welfare schemes.

The absence of predictive planning mechanisms further limits authorities' ability to allocate resources efficiently. This project addresses these challenges by leveraging artificial intelligence and geospatial analytics to forecast demand, identify inclusion risk zones, and enable proactive service delivery planning.

2.📝 Problem Statement

Mandatory Biometric Updates (MBU) are required at specific age milestones to ensure accurate Aadhaar authentication and continued access to welfare services. However, uneven awareness, infrastructure limitations, and population density variations lead to inconsistent service delivery across districts.

The absence of predictive demand forecasting and geospatial visibility results in enrollment center congestion, delayed updates, and increased risk of welfare exclusion.

3.🎯 Objectives

- Forecast district-wise MBU demand using AI models
- Identify biometric saturation gaps across regions
- Compute an explainable *Inclusion Difficulty Index*
- Enable geospatial visualization of service demand
- Optimize deployment of mobile enrollment units

4.□ Existing System 📉 (Current Challenges)

- 📉 Resource planning based on **historical averages**
- ⏳ **Reactive deployment** after congestion appears
- ❌ No **AI-based demand forecasting**
- 🗺️ No **geospatial visibility** of saturation gaps
- 📝 Manual planning of mobile enrollment units
- ⚠️ Higher risk of **biometric exclusion** & DBT delays

5.□ Proposed System 📈 (Sentinel-Aadhaar)

- 📈 **AI-driven district-wise demand forecasting**
- 🚀 **Proactive planning** using future predictions
- 🔭 **Inclusion Difficulty Index** to detect hard-to-reach areas
- 🗺️ **Dynamic geospatial dashboard** with saturation maps
- 🚐 Optimized deployment of **mobile enrollment units**
- ✅ Reduced congestion & **improved welfare inclusion**

6.SYSTEM ARCHITECTURE DIAGRAM

7. METHODOLOGY

7.1 Data Collection

Historical UIDAI biometric enrollment datasets segmented by state and district were used as the primary data source.

7.2 Data Preprocessing

Data cleaning, normalization, missing value handling, and standardization were performed using Python libraries.

7.3 Demand Forecasting

Time-series forecasting was implemented using Facebook Prophet to predict future MBU demand at the district level.

7.4 Inclusion Difficulty Index

The Inclusion Difficulty Index is calculated as the deviation between predicted and actual enrollments, indicating accessibility and inclusion challenges.

7.5 Geospatial Visualization

Dynamic geospatial visualization was implemented using PyDeck, with centroid-based jittering to represent district-level data due to pincode-only availability.

8.IMPLEMENTATION & TOOLS

Tool / Technology	Purpose
Python	Core programming language for data processing and analytics
Streamlit	Web-based interactive dashboard development
Pandas	Data cleaning, aggregation, and preprocessing
NumPy	Numerical computations and statistical operations
Prophet (Meta)	Time-series forecasting of MBU demand
PyDeck	Geospatial visualization and dynamic map rendering
OS Module	Dataset loading and file handling

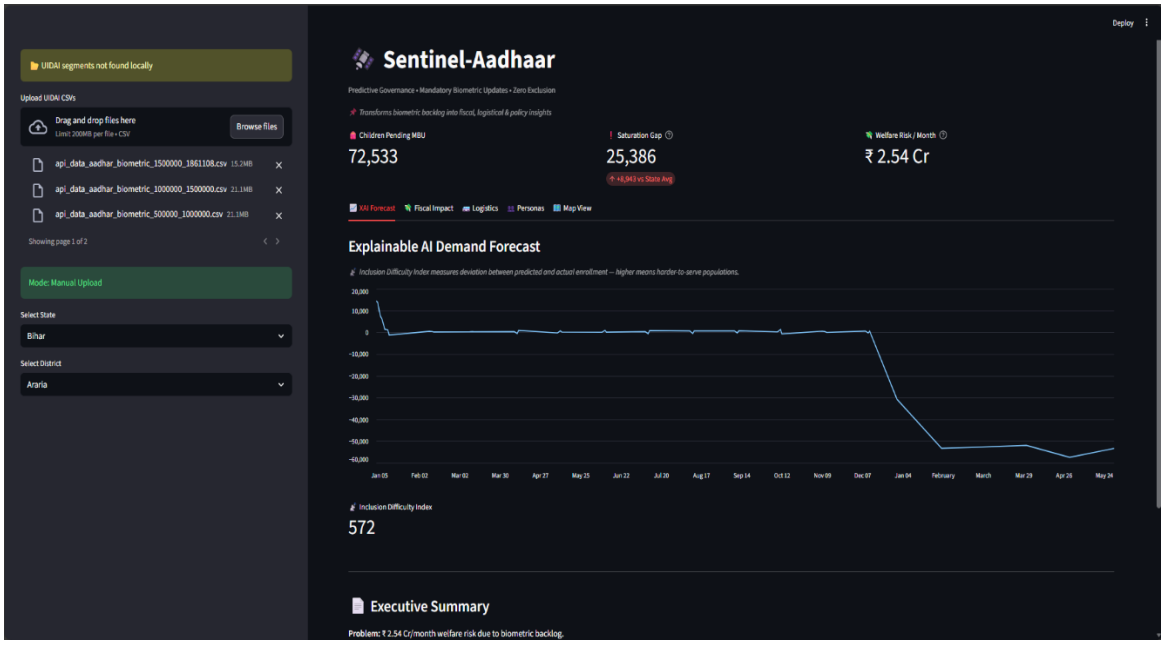
9.RESULTS & OUTPUT 📊

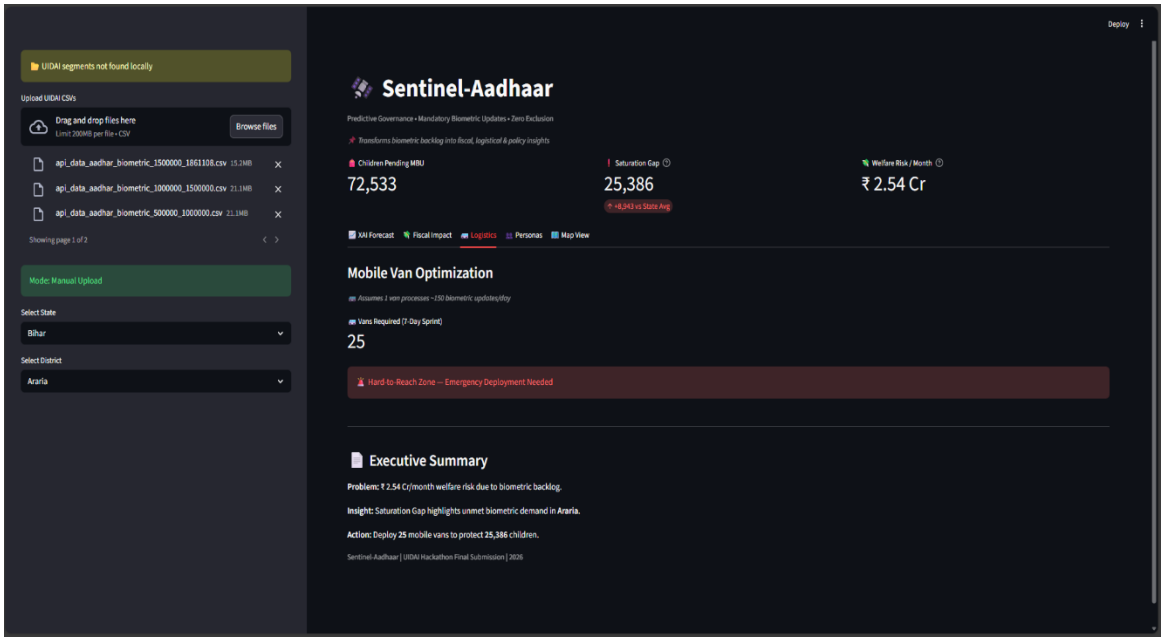
The proposed AI-Driven Geospatial Forecasting Platform was successfully implemented and evaluated using historical UIDAI biometric enrollment datasets. The system produced actionable insights across forecasting, fiscal impact, logistics planning, and geospatial visualization.

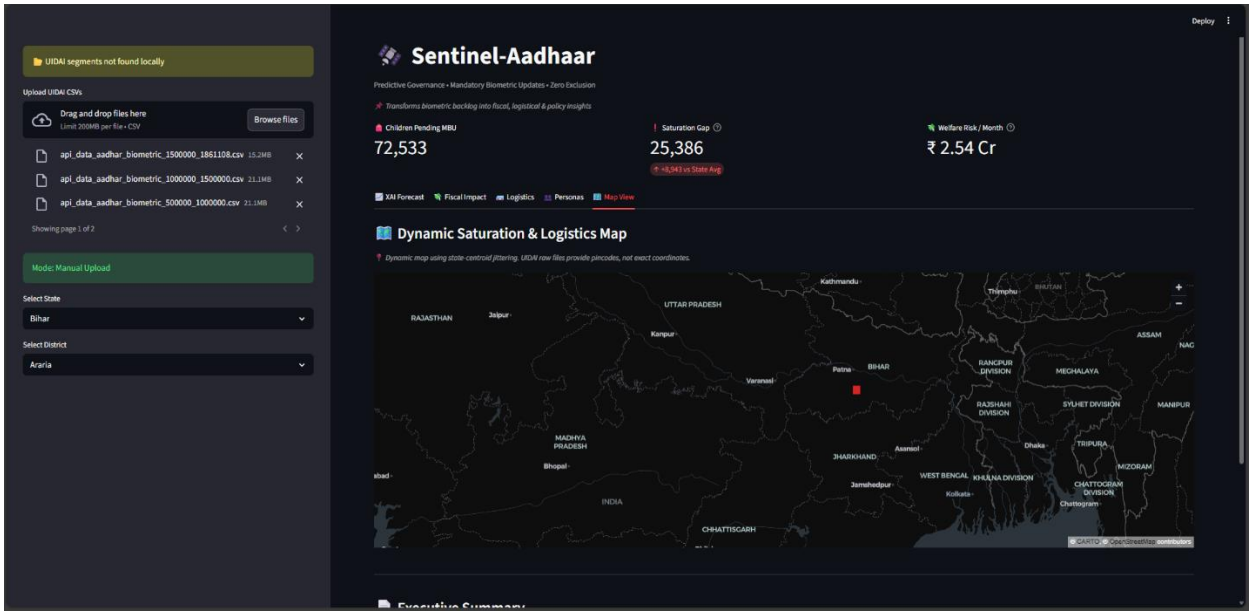
Key Results

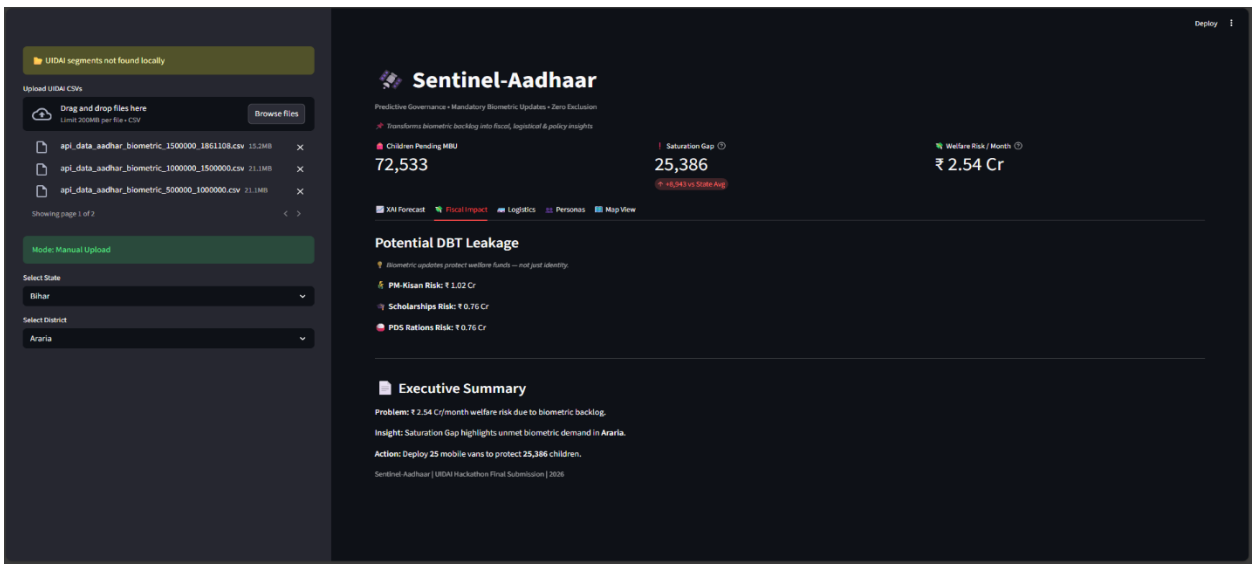
- **District-Wise Demand Forecasting:**
  The AI forecasting module accurately predicted future Mandatory Biometric Update (MBU) demand using time-series analysis. Seasonal trends and enrollment fluctuations were effectively captured, enabling proactive planning.
- **Inclusion Difficulty Index (IDI):**
  The system computed the Inclusion Difficulty Index, which quantified the deviation between predicted and actual enrollment. Higher IDI values clearly identified hard-to-reach districts requiring focused intervention.
- **Saturation Gap Identification:**
  A biometric saturation benchmark of 35% was used to calculate district-level saturation gaps. Districts with large gaps were flagged as high-risk zones for welfare exclusion.
- **Fiscal Impact Estimation:**
  The platform estimated monthly welfare funds at risk due to biometric backlog. The results highlighted potential financial exposure across schemes such as PM-Kisan, Scholarships, and PDS, reinforcing the economic importance of timely biometric updates.
- **Logistics Optimization:**
  Based on saturation gaps, the system calculated the number of mobile enrollment vans required for a 7-day operational sprint. This enabled data-driven deployment planning instead of reactive response.

- **Dynamic Geospatial Visualization:**
  An interactive map visualized district-wise demand using state-centroid jittering, allowing state-wide monitoring despite pincode-level data constraints. High-gap districts were clearly distinguishable through proportional markers.






UIDAI segments not found locally
Upload UIDAI CSVs
Drag and drop files here
Limit 200MB per file • CSV
Browse files
api_data_aadhar_biometric_1500000_1861108.csv 15.2MB
api_data_aadhar_biometric_1000000_1500000.csv 21.1MB
api_data_aadhar_biometric_500000_1000000.csv 21.1MB
Showing page 1 of 2
Mode: Manual Upload
Select State
Bihar
Select District
Araria
Deploy
Sentinel-Aadhaar
Predictive Governance • Mandatory Biometric Updates • Zero Exclusion
Transforms biometric backlog into fiscal, logistical & policy insights
Children Pending MBU
72,533
Saturation Gap
25,386
+8,543 vs State Avg
Welfare Risk / Month
₹ 2.54 Cr
XAI Forecast
Fiscal Impact
Logistics
Personas
Map View
Dynamic Saturation & Logistics Map
Dynamic map using state-centroid jittering. UIDAI raw files provide pincodes, not exact coordinates.
Kathmandu
Thimphu
BHUTAN
RAJASTHAN
Jaipur
UTTAR PRADESH
Kanpur
ASSAM
Patna
BIHAR
Varanasi
RANGPUR DIVISION
MEGHALAYA
RAJSHAHI DIVISION
SYLHET DIVISION
MANIPUR
MADHYA PRADESH
Asansol
Dhaka
TRIPURA
JHARKHAND
Bhopal
MIZORAM
WEST BENGAL
KHULNA DIVISION
Jamshedpur
Kolkata
CHATTOGRAM DIVISION
Chittagram
INDIA
CHHATTISGARH
© CARTO © OpenStreetMap contributors
Executive Summary


UIDAI segments not found locally
Upload UIDAI CSVs
Drag and drop files here
Limit 200MB per file • CSV
Browse files
api_data_aadhar_biometric_1500000_1861108.csv 15.2MB
api_data_aadhar_biometric_1000000_1500000.csv 21.1MB
api_data_aadhar_biometric_500000_1000000.csv 21.1MB
Showing page 1 of 2
Mode: Manual Upload
Select State
Bihar
Select District
Araria
Deploy
Sentinel-Aadhaar
Predictive Governance • Mandatory Biometric Updates • Zero Exclusion
Transforms biometric backlog into fiscal, logistical & policy insights
Children Pending MBU
72,533
Saturation Gap
25,386
+8,543 vs State Avg
Welfare Risk / Month
₹ 2.54 Cr
XAI Forecast
Fiscal Impact
Logistics
Personas
Map View
Potential DBT Leakage
Biometric updates protect welfare funds — not just identity.
PM-Kisan Risk: ₹ 1.02 Cr
Scholarships Risk: ₹ 0.76 Cr
PDS Rations Risk: ₹ 0.76 Cr
Executive Summary
Problem: ₹ 2.54 Cr/month welfare risk due to biometric backlog.
Insight: Saturation Gap highlights unmet biometric demand in Araria.
Action: Deploy 25 mobile vans to protect 25,386 children.
Sentinel-Aadhaar | UIDAI Hackathon Final Submission | 2026

10.✅ Conclusion

- **The Sentinel-Aadhaar platform demonstrates how AI-driven forecasting and geospatial analytics can transform Mandatory Biometric Update (MBU) planning.**
- **By introducing the Inclusion Difficulty Index, the system identifies hard-to-reach regions and biometric saturation gaps.**
- **Predictive demand estimation enables proactive deployment of mobile enrollment units, reducing congestion and welfare exclusion.**
- **The solution shifts Aadhaar service delivery from reactive planning 📉 to predictive governance 📈.**

11.🚀 Future Scope

- **🔗 Real-time integration with UIDAI APIs**
- **🏘️ Village & pincode-level demand forecasting**
- **🤖 AI-based staffing & logistics optimization**
- **📱 Citizen notification & appointment scheduling system**
- **🇮🇳 National-scale rollout for centralized monitoring**

12.📚 References

- **UIDAI Official Documentation**
- **Government of India DBT & Welfare Reports**
- **Facebook Prophet – Time Series Forecasting Documentation**
- **Streamlit & PyDeck Visualization Libraries**