DIPEX 2026

Exhibition-cum-Competition

A Project Report on

“GreenFuel Intelligence System AI-Driven Biogas Infrastructure Planning & Optimization Framework”

-: Submitted by:-

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2	Aditi Amrut Gangji
3	Tanishka Prashant Deshpande
4	Shruti Prakash Hiremath

-: Under the Guidance of :-

Mr.Chatake A.S.

Shri Siddheshwar Women’s Polytechnic,Solpaur

ACKNOWLEDGEMENT

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We would like to thank Project Guide **Mr.Chatake A.S.** who guided us through doing these project development process, provided with invaluable advice, helped us in difficult periods and provided practical assistant for our project. Their willingness to motivate us contributed tremendously to the success of this project.

We would like to express our special thanks of gratitude to our Head of Department **Mrs.Mane N.K.** who helped us a lot in finalizing this project. Besides we would like to thank all staff members who helped us by giving advice and providing equipment which we needed.

Last but not in least we would like to thank all who helped and motivated us

With Sincere Thanks,

1.Anushka Hitanalli

2.Aditi Gangji

3.Tanishka Deshpande

4. Shruti Hiremath

Index

Problem Statement

Millions of tons of organic waste from rural India is generated yearly where it largely remains as untapped source for biogas.

The core issues are:

● Waste supply: Biogas plants are most of the time set up in areas with too little reliable waste supply.

● Yield Uncertainty: Feedstock quality varies (moisture/carbon content) which can cause gas output to be inconsistent, rendering it useless for cooking or electricity.

● Manual Monitoring: Digester Failure (acidosis / alkalosis) due to Realtime Data Unaccessibility.

● PlanGap: There is no data-driven tool with government bodies to plan energy infrastructure at the Taluka/District level.

Abstract

GreenFuel Intelligence System (GFIS) is a national-scale AI-driven framework designed to revolutionize rural biogas infrastructure. Currently, biogas adoption in India suffers due to unoptimized plant placement, unpredictable methane yields, and a lack of centralized planning data. GFIS solves this using a multi-layered AI approach: 1. Geospatial AI: To identify optimal cluster locations for biogas hubs based on village waste generation heatmaps. 2. Predictive ML: XGBoost/LSTM models to forecast methane yield and energy output based on feedstock variables. 3. Computer Vision: To classify organic waste quality and detect contaminants automatically. 4. IoT Integration: For real-time monitoring of plant health (pH, temperature, pressure). This project proposes a "Waste-to-Energy Economy" model, providing a dashboard for government decision-makers and a mobile tool for plant operators, ensuring sustainable energy security for rural Maharashtra.

Introduction

3.1 Project Overview

GreenFuel Intelligence System (GFIS) is an AI-powered and optimizes the biogas infrastructure of rural area by enabling better locations for bio-gas plants, predicting methane yield, monitoring operations, etc. It is making a sustainable Waste-to-Energy ecosystem for rural Maharashtra using Geospatial AI, ML, Computer Vision and IOT.

3.2 Project plan

Phase 1: Research & Data Collection

Tasks:

Collect livestock census data

Gather village GIS data

Study existing biogas plants

Collect methane yield historical data

Government scheme analysis

Deliverables: ✓ Dataset

✓ Feasibility Report

✓ Requirement Document

Phase 2: System Design

Design Architecture:

Layers:

Data Layer (IoT + GIS + Sensors)

AI Layer (ML models)

Visualization Layer (Dashboard)

Alert System Layer

Deliverables: ✓ System architecture diagram

✓ Database design

✓ Sensor integration plan

Phase 3: AI Model Development

Develop:

✓ Location optimization model

✓ Clustering model (K-Means)

✓ Methane prediction model

✓ Predictive maintenance model

Evaluation Metrics:

MAE

RMSE

R^2 Score

Deliverables: ✓ Trained ML models

✓ Model accuracy report

Phase 4: IoT & Hardware Integration

Install:

Gas sensors

Temperature sensors

Pressure sensors

ESP32 / Raspberry Pi

Create: ✓ Real-time data pipeline

✓ Cloud storage

✓ Dashboard (Streamlit/Web App)

Phase 5: Dashboard Development

Features:

Live gas production graph

Village cluster map

Plant health score

Alert notification system

CO_2 reduction counter

Technology:

Python

Streamlit

Power BI

Firebase / AWS

Project Requirements

4.1 Hardware Requirements

Industrial-grade hardware is required to move beyond academic simulation:

* Sensors: NDIR sensors for CH4 and CO2; electrochemical sensors for H2S; industrial retractable pH

and ORP probes; and Thermal Mass Flow Meters for revenue-grade gas measurement.

* Gateways: Ruggedized Raspberry Pi CM4 or Teltonika IoT gateways housed in IP67-rated

enclosures.

* Compute Modules: ESP32/Arduino for low-level prototyping.

* Imaging: Ruggedized IP cameras for computer vision-based feedstock analysis.

* Networking: Modules supporting LoRaWAN for local sensor networks (10-15km range) and NB-

IoT/LTE-M for cloud backhaul.

4.2 Software Requirements

A cloud-native stack is essential for handling high-velocity data and ML pipelines:

* Frontend: React.js or Vue.js for high-concurrency dashboards and cross-platform mobile apps for

operators.

* Backend: Python (FastAPI or Django) to leverage data science libraries like Pandas and Scikit-

learn.

* Cloud Platform: AWS (Amazon Web Services) utilizing IoT Core for secure connectivity, AWS

IoT TwinMaker for 3D digital twins, and Amazon ECS/Kubernetes for container orchestration.

Databases: PostgreSQL for relational data, Amazon Timestream for time-series sensor logs, and S3

Data Lake for immutable audit trails.

* ML Tools: Frameworks for XGBoost, LSTM, CNNs, and Reinforcement Learning agents.

* Protocols: Industrial communication standards including MQTT over TLS, Modbus RS-485, and 4-

20mA loops

System Design

It follows a modular IoT architecture in four layers for reliable and scalable monitoring of biogas plants.

1. Perception Layer:

Nodes based on ESP32/STM32 are collecting real-time data using temperature, pH, ORP, gas-CH_4, CO_2, H_2S, flow, and pressure sensors. Actuators perform the role of mixing, pumping, and heating at optimized operational conditions

2. Network Layer:

A Raspberry Pi gateway aggregates sensor data and performs edge AI tasks. Data transmission is carried out by LoRaWAN for local coverage and 4G/LTE over MQTT for cloud communication.

3. Processing Layer: Time-series and NoSQL databases are hosted on cloud

Links Of Modules

1. https://aditi04122007-gfis-geospatial-gio3-fvobwz.streamlit.app/
2. https://taniishka21-biogas-health-monitoring-digestorstatus-gpjnen.streamlit.app/
3. https://shrutihiremath-25.github.io/Gfis/

Result

🌱 GFIS – Live Biogas Health Monitoring

National AI Digester Stability Engine

► Start Monitoring   ■ Stop Monitoring

📊 Live Sensor Readings

Temperature (°C)	Pressure (bar)	Methane %
35.0	1.9	62.0
pH Level	**Gas Flow**	**Feed Rate**
7.2	60.0	520.0

🧠 AI Health Assessment

Health Score (%)	Failure Risk (%)
99.5	0.5

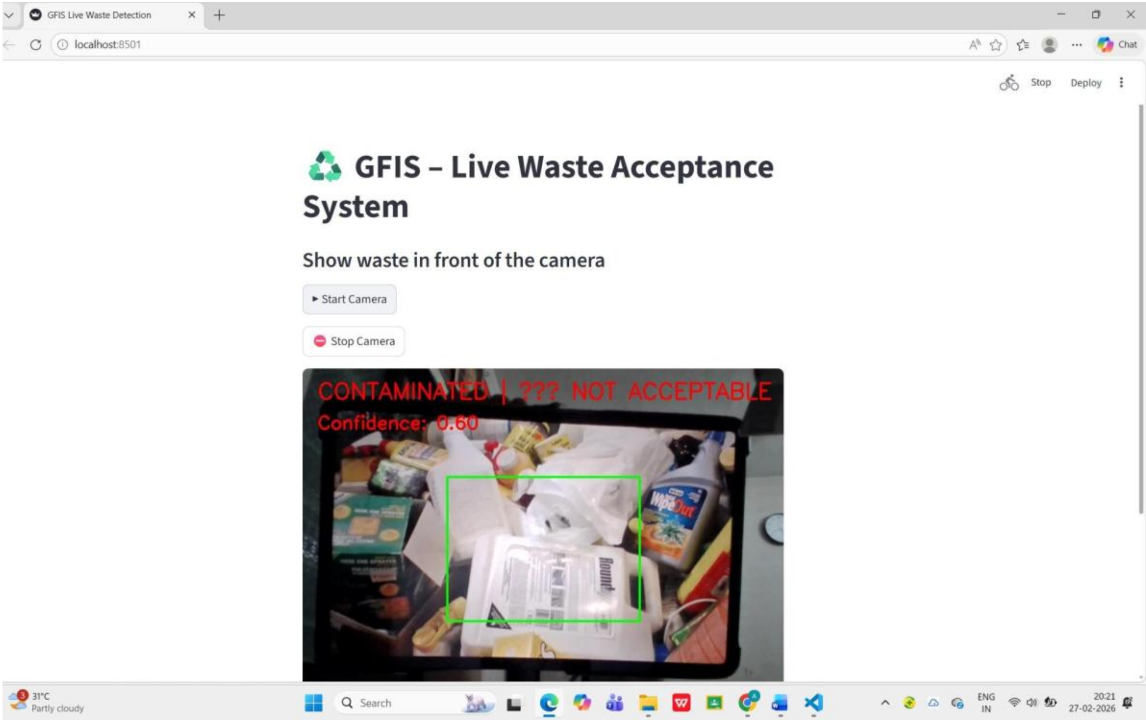
System Stable

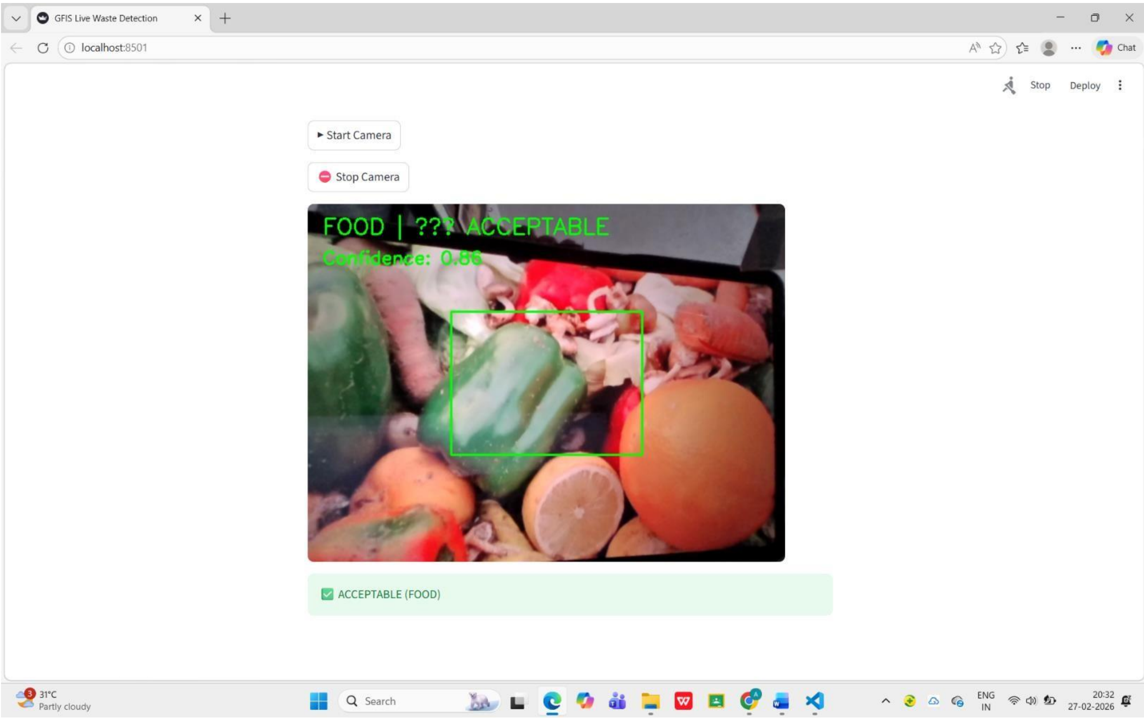
🚨 Alerts

All parameters within safe range

✅ ACCEPTABLE (MANURE)

Detected Class	Confidence
MANURE	0.80


GFIS Live Waste Detection
localhost:8501
Stop
Deploy
GFIS – Live Waste Acceptance System
Show waste in front of the camera
Start Camera
Stop Camera
CONTAMINATED | ??? NOT ACCEPTABLE
Confidence: 0.60
31°C
Partly cloudy
Search
20:21
27-02-2026


GFIS Live Waste Detection
localhost:8501
Stop
Deploy
Start Camera
Stop Camera
FOOD | ??? ACCEPTABLE
Confidence: 0.86
ACCEPTABLE (FOOD)
31°C
Partly cloudy
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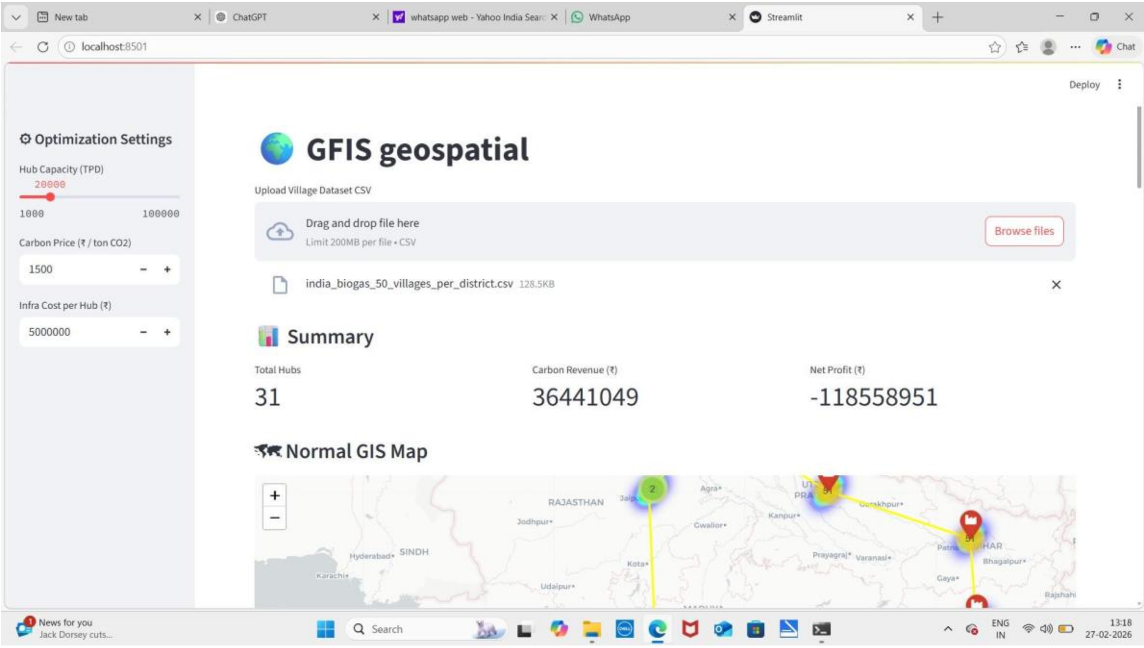
New tab
ChatGPT
whatsapp web - Yahoo India Searc
WhatsApp
Streamlit
localhost:8501
Deploy
⚙ Optimization Settings
Hub Capacity (TPD)
20000
1000
100000
Carbon Price (₹ / ton CO2)
1500
Infra Cost per Hub (₹)
5000000
GFIS geospatial
Upload Village Dataset CSV
Drag and drop file here
Limit 200MB per file • CSV
Browse files
india_biogas_50_villages_per_district.csv 128.5KB
Summary
Total Hubs
31
Carbon Revenue (₹)
36441049
Net Profit (₹)
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Normal GIS Map
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Search
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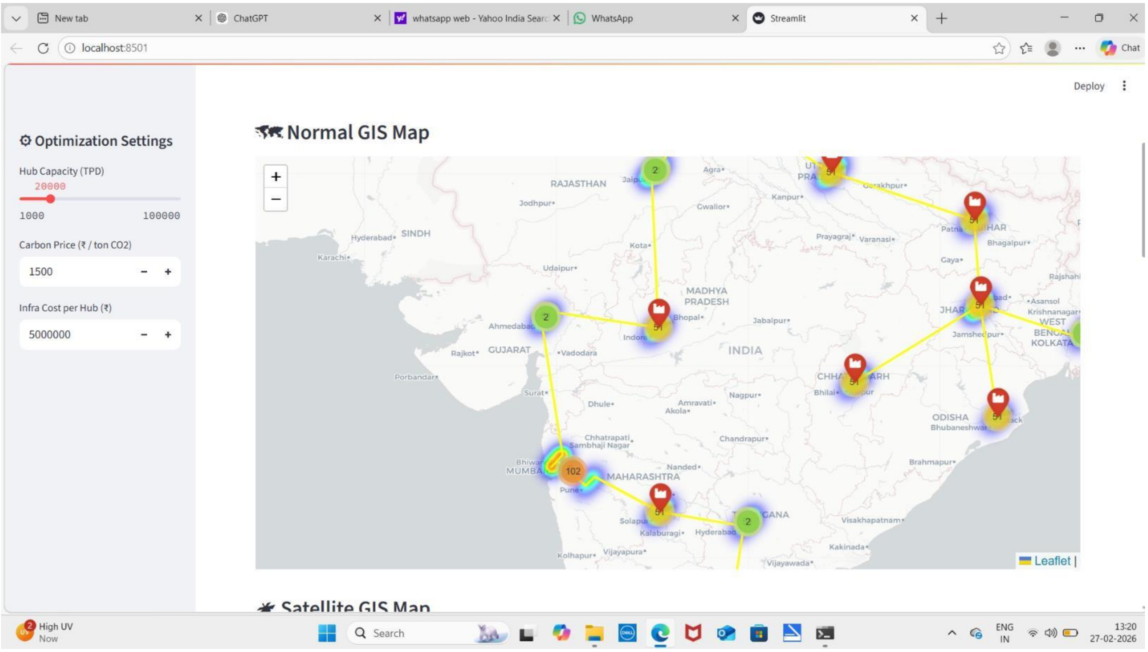
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WhatsApp
Streamlit
localhost:8501
Deploy
Normal GIS Map
⚙ Optimization Settings
Hub Capacity (TPD)
20000
1000
100000
Carbon Price (₹ / ton CO2)
1500
Infra Cost per Hub (₹)
5000000
Leaflet
Satellite GIS Map
High UV
Now
Search
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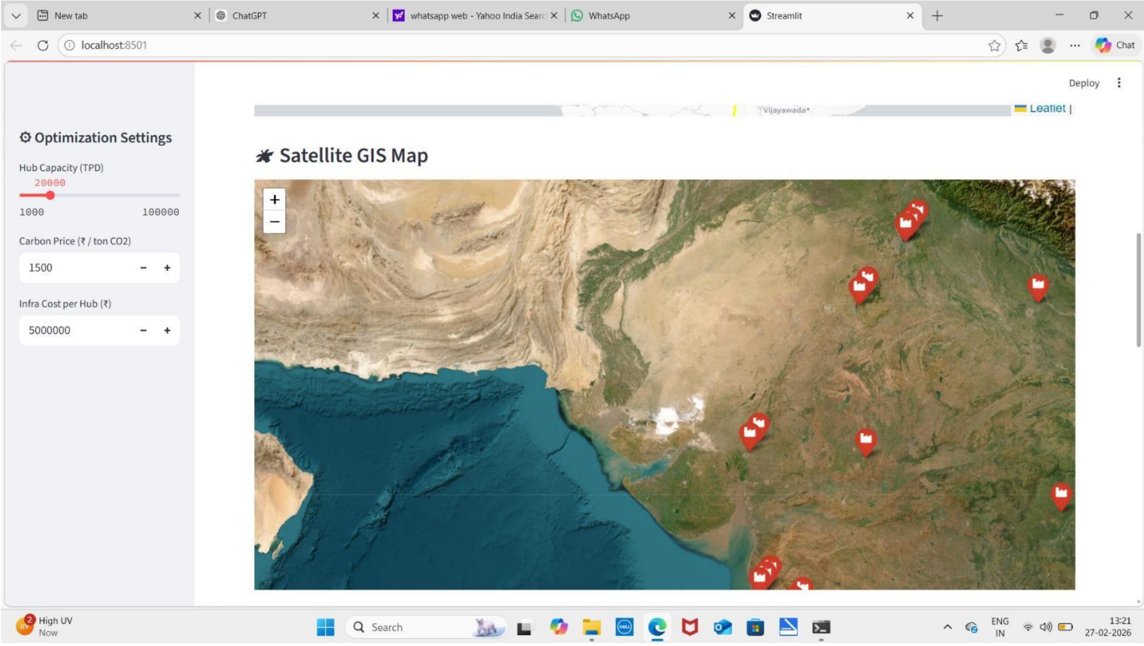
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Streamlit
localhost:8501
Deploy
Optimization Settings
Hub Capacity (TPD)
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1000
100000
Carbon Price (₹ / ton CO2)
1500
Infra Cost per Hub (₹)
5000000
Satellite GIS Map
Leaflet
High UV
Now
Search
ENG
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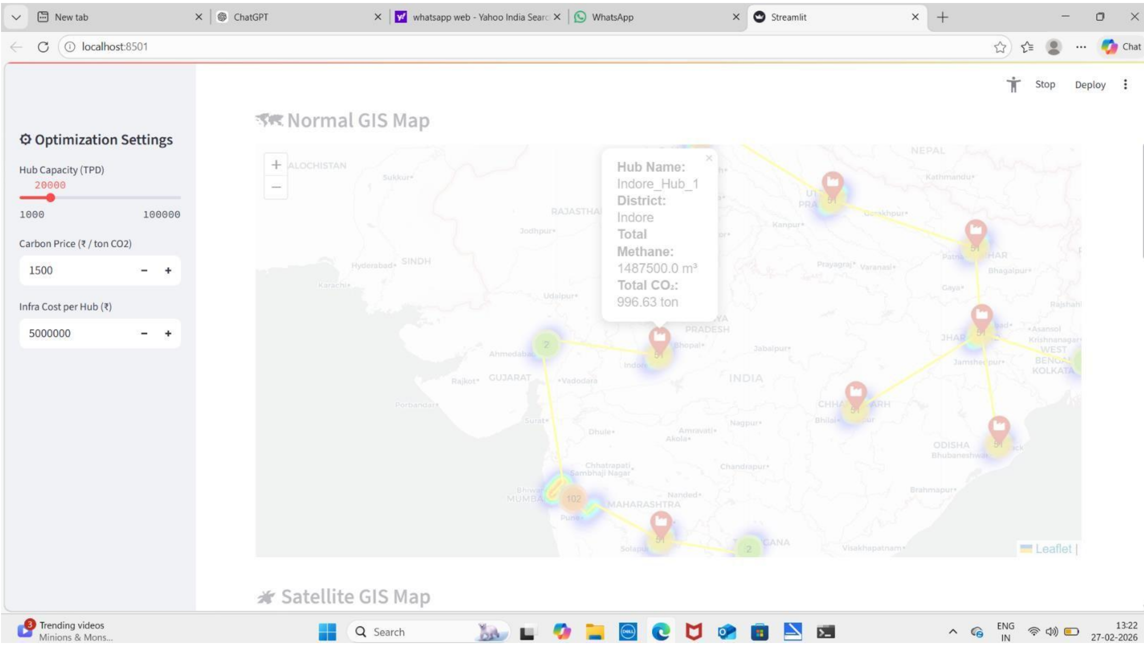
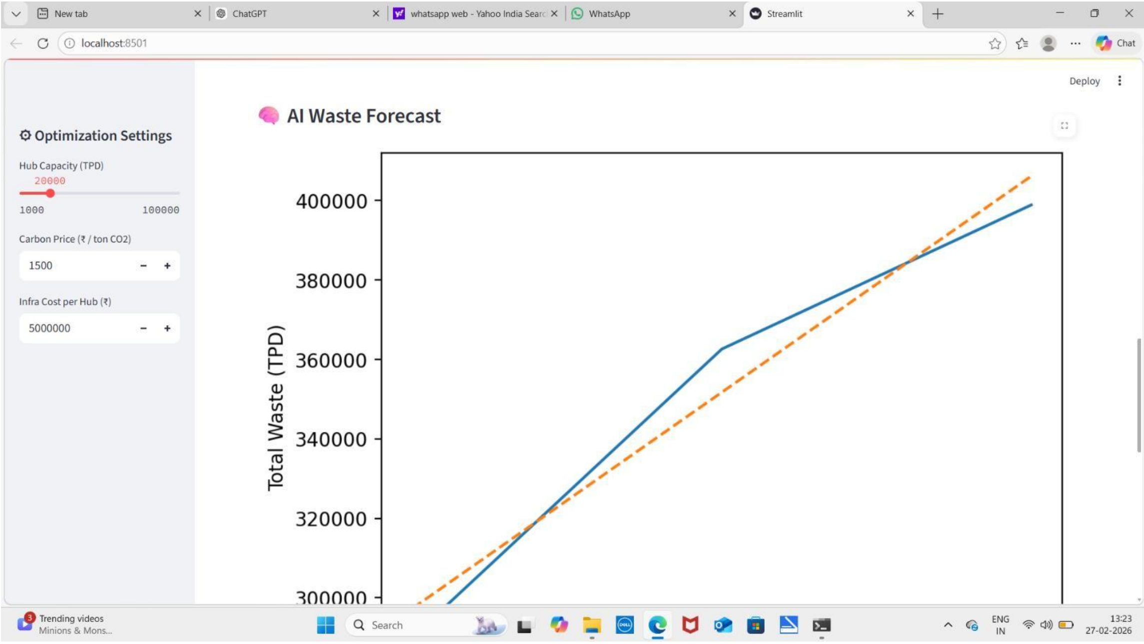
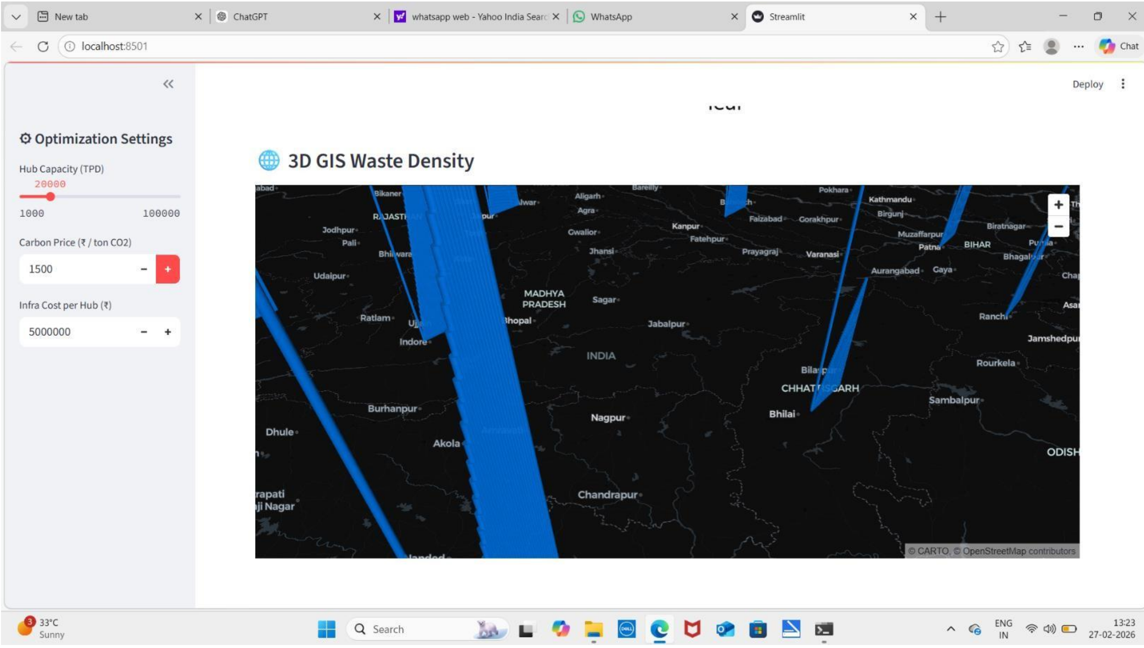

New tab
ChatGPT
whatsapp web - Yahoo India Searc
WhatsApp
Streamlit
localhost:8501
Stop
Deploy
Optimization Settings
Hub Capacity (TPD)
20000
1000
100000
Carbon Price (₹ / ton CO2)
1500
Infra Cost per Hub (₹)
5000000
Normal GIS Map
Hub Name:
Indore_Hub_1
District:
Indore
Total
Methane:
1487500.0 m³
Total CO₂:
996.63 ton
INDIA
NEPAL
GUJARAT
MAHARASHTRA
ODISHA
Leaflet
Satellite GIS Map
Trending videos
Minions & Mons...
Search
ENG
IN
13:22
27-02-2026



localhost:8501
Deploy
AI Waste Forecast
Optimization Settings
Hub Capacity (TPD)
20000
1000
100000
Carbon Price (₹ / ton CO2)
1500
Infra Cost per Hub (₹)
5000000
Total Waste (TPD)
400000
380000
360000
340000
320000
300000



localhost:8501
Deploy
Optimization Settings
Hub Capacity (TPD)
20000
1000
100000
Carbon Price (₹ / ton CO2)
1500
Infra Cost per Hub (₹)
5000000
3D GIS Waste Density
MADHYA PRADESH
INDIA
Nagpur
Jabalpur
Chandrapur
Akola
Indore
BIHAR
Ranchi
Sambalpur
Rourkela
Bhilai
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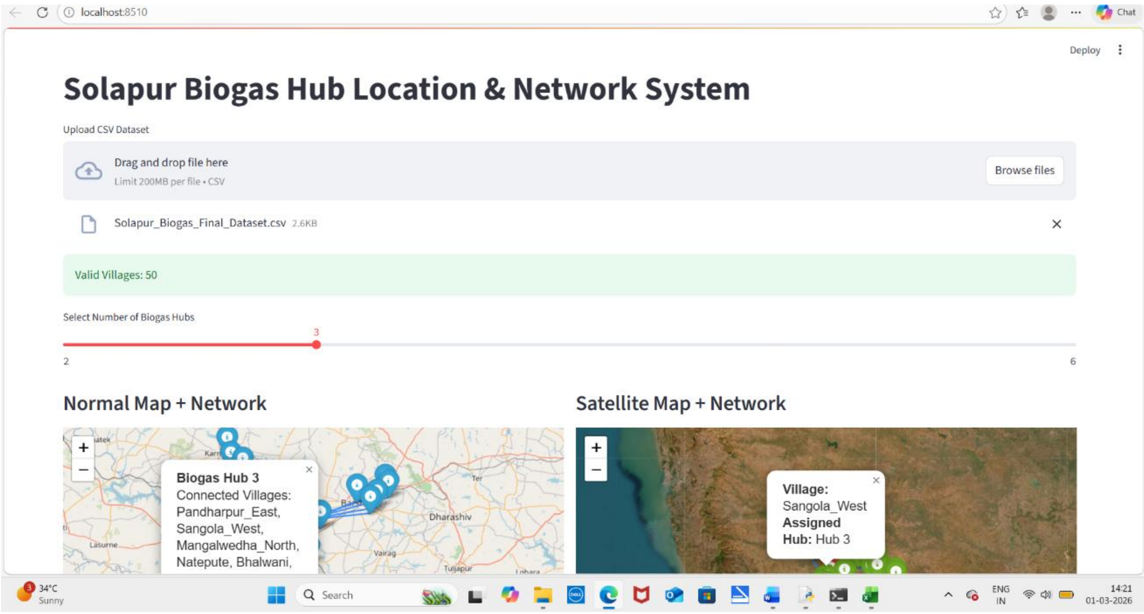
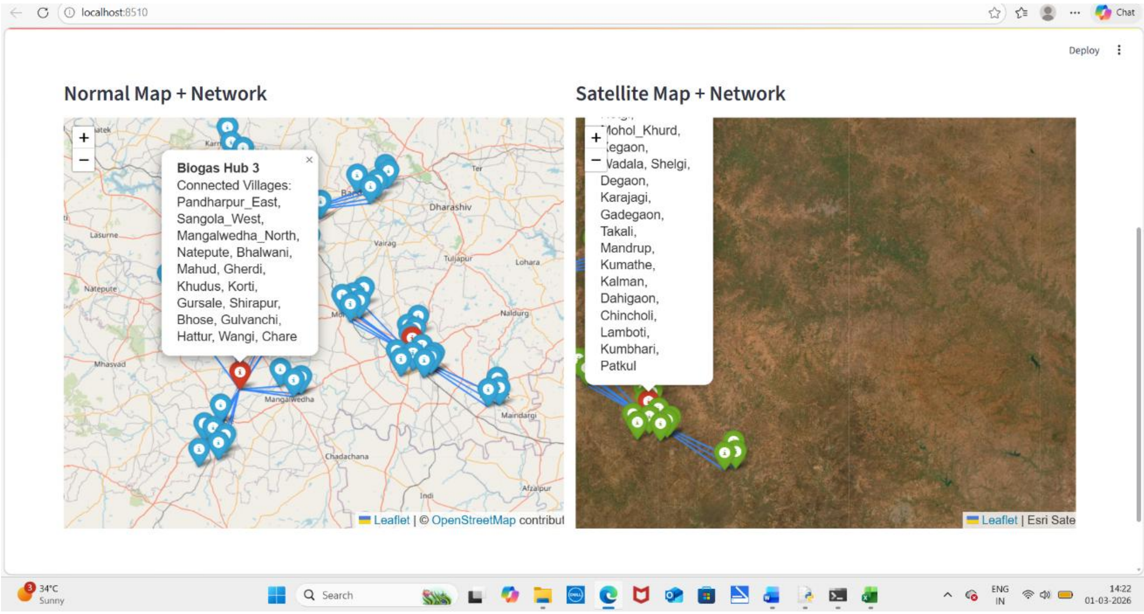
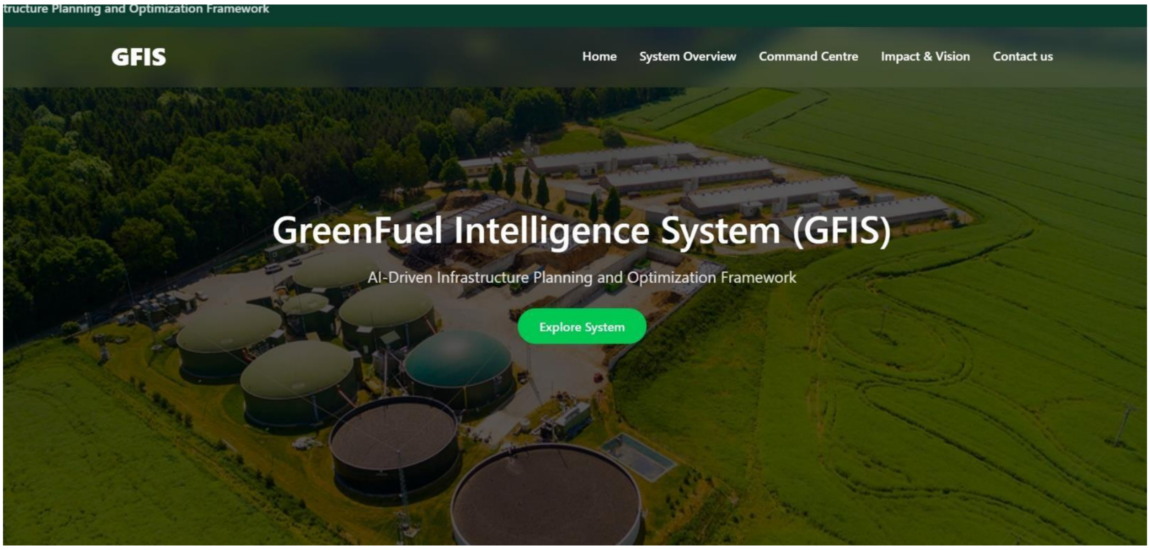
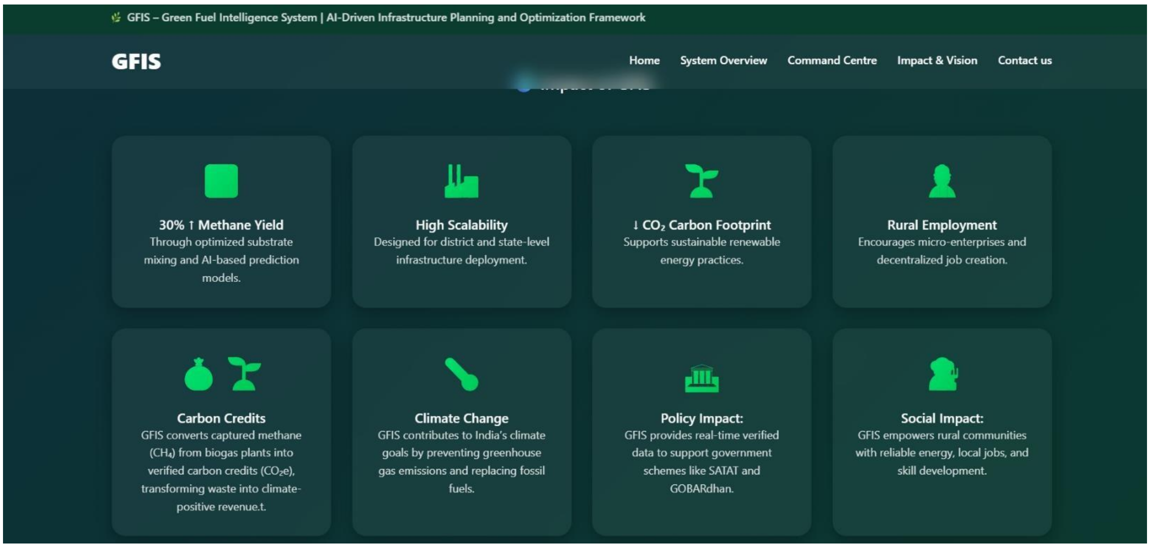

localhost:8510
Deploy
Solapur Biogas Hub Location & Network System
Upload CSV Dataset
Drag and drop file here
Limit 200MB per file • CSV
Browse files
Solapur_Biogas_Final_Dataset.csv 2.6KB
Valid Villages: 50
Select Number of Biogas Hubs
3
2
6
Normal Map + Network
Satellite Map + Network
Biogas Hub 3
Connected Villages:
Pandharpur_East,
Sangola_West,
Mangalwedha_North,
Natepute, Bhalwani,
Village:
Sangola_West
Assigned
Hub: Hub 3
34°C
Sunny
Search
14:21
01-03-2026

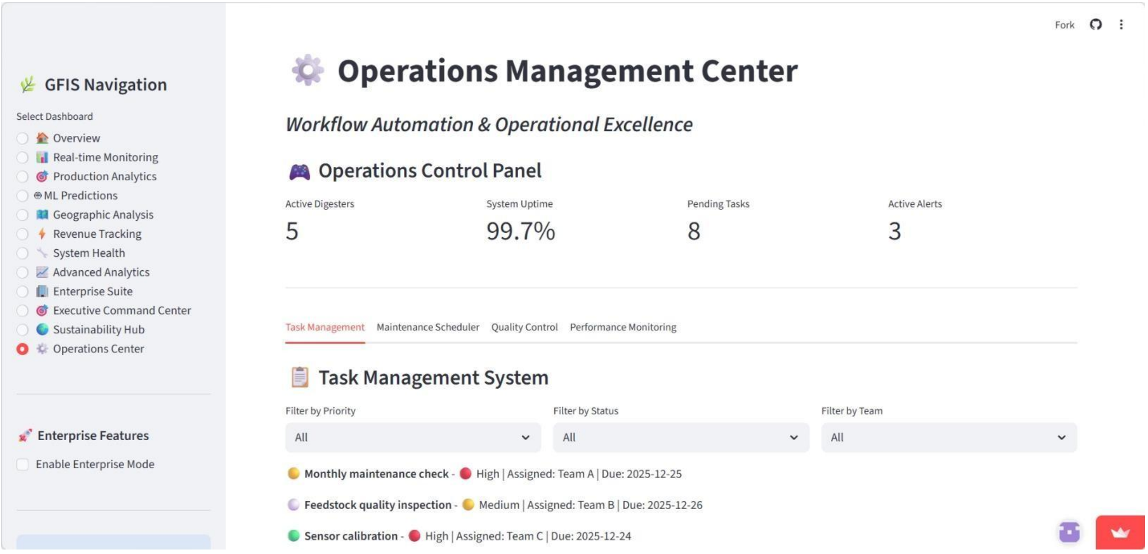

localhost:8510
Deploy
Normal Map + Network
Satellite Map + Network
Biogas Hub 3
Connected Villages:
Pandharpur_East,
Sangola_West,
Mangalwedha_North,
Natepute, Bhalwani,
Mahud, Gherdi,
Khudus, Korti,
Gursale, Shirapur,
Bhose, Gulvanchi,
Hattur, Wangi, Chare
Dharashiv
Tuljapur
Naldurg
Mangalwedha
Degaon,
Karajagi,
Gadegaon,
Takali,
Mandrup,
Kumathe,
Kalman,
Dahigaon,
Chincholi,
Lamboti,
Kumbhari,
Patkul
Leaflet | © OpenStreetMap contribut
Leaflet | Esri Sate
34°C
Sunny
Search
14:22
01-03-2026

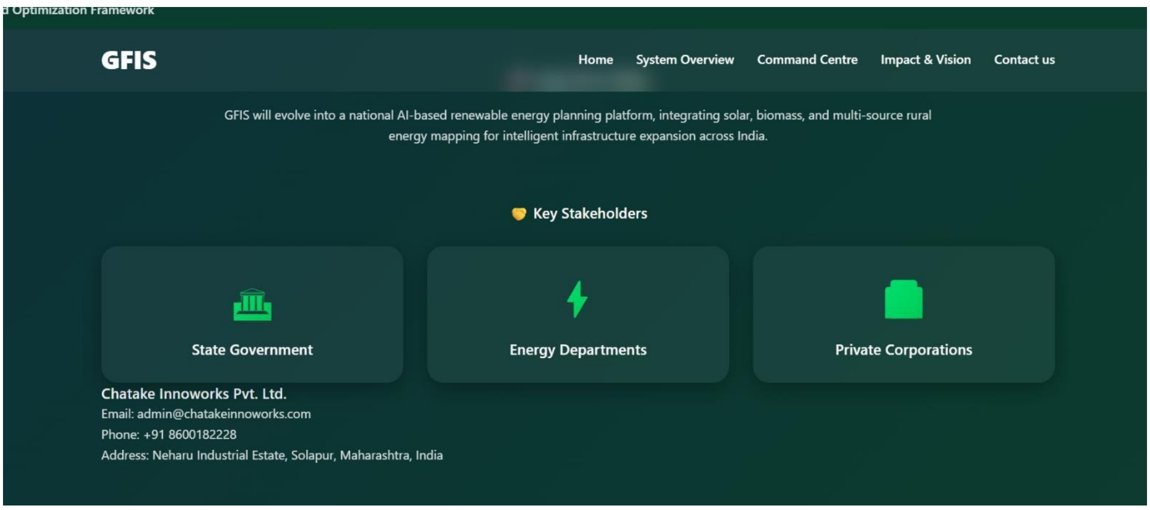

tructure Planning and Optimization Framework
GFIS
Home
System Overview
Command Centre
Impact & Vision
Contact us
GreenFuel Intelligence System (GFIS)
AI-Driven Infrastructure Planning and Optimization Framework
Explore System


GFIS – Green Fuel Intelligence System | AI-Driven Infrastructure Planning and Optimization Framework
GFIS
Home
System Overview
Command Centre
Impact & Vision
Contact us
30% ↑ Methane Yield
Through optimized substrate mixing and AI-based prediction models.
High Scalability
Designed for district and state-level infrastructure deployment.
↓ CO_2 Carbon Footprint
Supports sustainable renewable energy practices.
Rural Employment
Encourages micro-enterprises and decentralized job creation.
Carbon Credits
GFIS converts captured methane (CH_4) from biogas plants into verified carbon credits (CO_2e), transforming waste into climate-positive revenue.t.
Climate Change
GFIS contributes to India's climate goals by preventing greenhouse gas emissions and replacing fossil fuels.
Policy Impact:
GFIS provides real-time verified data to support government schemes like SATAT and GOBARdhan.
Social Impact:
GFIS empowers rural communities with reliable energy, local jobs, and skill development.


GFIS – Green Fuel Intelligence System | AI-Driven Infrastructure Planning and Optimization Framework
GFIS
Home
System Overview
Command Centre
Impact & Vision
Contact us
1 Methane Yield
Predictive analytics dashboard.
CH_4
Methane Yield
Open Dashboard
2 Health Monitoring
Live plant diagnostics dashboard.
NORMAL
CAUTION
ALERT
Open Dashboard


GFIS – Green Fuel Intelligence System | AI-Driven Infrastructure Planning and Optimization Framework
GFIS
Home
System Overview
Command Centre
Impact & Vision
Contact us
Geospatial
GIS and infrastructure planning dashboard.
Site Data
Yield 700g
300 m/ay
Temp
38°C
Computer Vision
Plant inspection and anomaly detection system.
Food Waste
Plastic
Paper
Yard Waste
Mater
Plastic
Organic


Fork
GFIS Navigation
Select Dashboard
Overview
Real-time Monitoring
Production Analytics
ML Predictions
Geographic Analysis
Revenue Tracking
System Health
Advanced Analytics
Enterprise Suite
Executive Command Center
Sustainability Hub
Operations Center
Enterprise Features
Enable Enterprise Mode
Operations Management Center
Workflow Automation & Operational Excellence
Operations Control Panel
Active Digesters
5
System Uptime
99.7%
Pending Tasks
8
Active Alerts
3
Task Management
Maintenance Scheduler
Quality Control
Performance Monitoring
Task Management System
Filter by Priority
All
Filter by Status
All
Filter by Team
All
Monthly maintenance check - High | Assigned: Team A | Due: 2025-12-25
Feedstock quality inspection - Medium | Assigned: Team B | Due: 2025-12-26
Sensor calibration - High | Assigned: Team C | Due: 2025-12-24


d Optimization Framework
GFIS
Home
System Overview
Command Centre
Impact & Vision
Contact us
GFIS will evolve into a national AI-based renewable energy planning platform, integrating solar, biomass, and multi-source rural energy mapping for intelligent infrastructure expansion across India.
Key Stakeholders
State Government
Energy Departments
Private Corporations
Chatake Innoworks Pvt. Ltd.
Email: admin@chatakeinnoworks.com
Phone: +91 8600182228
Address: Neharu Industrial Estate, Solapur, Maharashtra, India

Conclusion

The GreenFuel Intelligence System, or GFIS, is changing the game for India’s biogas industry. It finally closes the gap between old-school manual work and today’s smart energy technology. With Industrial IoT, Geospatial AI, and Predictive Machine Learning all working together, GFIS takes unpredictable waste management and turns it into a reliable, valuable source of energy.

Future Scope of Project

The future of the GreenFuel Intelligence System (GFIS) looks a lot bigger than its current regional pilot. The goal is to turn it into a powerful, nationwide digital network for renewable energy.

1.The national scaling and energy integration.

The team wants to take GFIS way beyond Solapur—rolling it out across districts, states, and eventually the whole country. This lines up with the SATAT initiative, which pushes for 5,000 biogas plants by 2030.

But it’s not just about biogas. GFIS is set to grow into a smart, all-in-one platform that pulls together different types of renewable energy—think solar, biomass, and more. The plan is to map everything out so rural areas have a complete digital picture of their energy resources.

2. Advanced Technical and Scientific Research

Hydrogen Production: Researchers are exploring new ways to split water and make hydrogen. They’re also figuring out how to capture it and use it as a valuable fuel. This isn’t just talk—there’s real work happening in labs, testing different techniques and gathering results.

Autonomous Optimization: The team keeps pushing the Reinforcement Learning (RL) module further. The goal? Let the system take over process control by itself. It’ll learn from experience, tweak mixing ratios on its own, and squeeze out as much methane as possible—even as the quality of what goes in keeps changing.

Dedicated Research Centers: The plan includes setting up specialized labs and research centers. These places will dig deep into analyzing all kinds of gas mixtures and fine-tuning the process to make everything run smoother and more efficiently.

3. Economic and Regulatory Formalization

Digital MRV Accreditation: For Year 2 (Phase 4), the big goal is to get the system’s digital Monitoring, Reporting, and Verification (MRV) method officially recognized by international carbon registries like Verra or the Gold Standard.

SaaS Model Expansion: The plan is to roll out the system as a scalable SaaS product, aiming for sugar factories, major dairies, and municipal corporations.

4. Urban and Social Integration

Smart City Alignment: GFIS can fit right into Smart City projects, especially in more focused spots like housing societies, vegetable markets, or managing urban food waste.

Waste-to-Wealth Valorization: The idea isn't just to stop at producing gas the project also uses the organic slurry or compost left over, turning it into an extra source of revenue and giving a real boost to soil fertility for farms.

Social & Animal Resource Management: There's a real chance to handle stray animal populations by setting up government-run sheds. These sheds collect biological waste, which then becomes a steady supply for energy production. It solves an urban headache and keeps the energy pipeline running.

Bibliography

1.Author: Mario Alejandro Rosato

https://www.kobo.com/in/en/ebook/optimising-biogas-plants