Project Title

SUSTAINABLE SMART CITY ASSISTANT USING IBM GRANITE LLM

Project Documentation

1. Introduction

- Project Title: **Sustainable Smart City Assistant Using IBM Granite LLM**
- Team Leader: **Venkatesh J**
- Team Members:
    1. **Harish Kumar R**
    2. **Vijay G**
    3. **Prem Dinesh Khetal**

2. Project Overview

Purpose

The purpose of the Sustainable Smart City Assistant is to empower cities and their residents to thrive in a more eco-conscious and connected urban environment. By leveraging AI and real-time data, the assistant helps optimize essential resources energy, water, waste while guiding sustainable behaviors through personalized tips and digital services. For city officials, it delivers actionable forecasts, policy summarizations, and insights for strategic planning. Ultimately, this platform bridges technology, governance, and engagement to foster greener, more efficient, inclusive, and resilient cities.

Features

- Conversational Interface:
  Naturallanguage interaction for citizens/officials to ask questions, get updates, and receive guidance in plain language.
- Policy Summarization:
  Converts lengthy government documents into concise, actionable summaries for simplified understanding
- Resource Forecasting:
  Predictsfutureenergy,water, and waste usage using historical and real-time smart city data.
- Eco-Tip Generator:
  Offers personalizedsustainability advice with daily recommendations to reduce impact, based on user data.

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  Predicts future energy,water, and waste usage using historical and real-time smart city data.
- Eco-Tip Generator:
  Offers personalizedsustainability advice with daily recommendations to reduce impact, based on user data.
- Citizen Feedback Loop:
  Collects,analyzes,andpresents resident input for city planning and improvement.
- KPI Forecasting:
  Projects key performance indicators for city officials to track progress and plan ahead.
- Anomaly Detection:
  Identifies unusual patterns or sensor data to flag potential problems early.
- Multimodal Input Support:
  Accepts text,PDFs,andCSVs for document analysis and forecasting tasks.
- Streamlit UI
  User-friendly dashboard interface for citizens and officials to interact with the assistant.

3. Architecture

Frontend Streamlit

- **Built using Streamlit, with an interactive web UI containing multiple pages: dashboards, file uploads, chat interface, feedback forms, and report viewer.**
- **Navigation is via sidebar (streamlit-option-menu); pages are modular for scalability.**

Backend FastAPI

- **FastAPI powers REST endpoints for document processing, chat, eco tips, feedback, and vector embedding.**
- **Optimized for async performance and easy Swagger API inspection.**

LLM Integration IBM Watsonx Granite

- IBM Watsonx Granite LLMs used for natural language understanding/generation: summarization, tip generation, chat.

Vector Search Pinecone

- Uploaded policy docs embedded Sentence Transformers and stored in Pinecone; semantic search uses cosine similarity for queries.

ML Modules Forecasting/Anomaly Detection

- Lightweight ML models Scikit-learn perform forecasting and anomaly detection, visualized via pandas & matplotlib.

4. Setup Instructions

Prerequisites

- Python 3.9
- pip/virtual env tools
- API keys for IBM Watsonx & Pinecone
- Internet access to cloud services

Installation

- Clone repository
- Install dependencies via requirements.txt
- Configure credentials in .env
- Run backend server FastAPI
- Launch frontend Streamlit) Upload
- data & interact with modules

5. Folder Structure

Folder/File	Description
app/	FastAPI backend logic: routers, models, etc.
app/api/	Modular API routes: chat, feedback, document etc.
ui/	Streamlit frontend pages and components
smart_dashboard.py	Main script to launch the Streamlit dashboard
granite_llm.py	Handles IBM Watsonx Granite LLM integration
document_embedder.py	Embedding documents and Pinecone storage

Folder/File	Description
kpi_file_forecaster.py	Forecasts resource KPIs via regression
anomaly_file_checker.py	Flags anomalies in KPI uploads
report_generator.py	Generates AI sustainability reports

6. Running the Application

- Launch FastAPI backend for REST endpoints
- Start Streamlit frontend for dashboard access
- Navigate pages via sidebar
- Upload documents/CSVs, interact with chat, view summaries, predictions, and feedback analytics
- All actions update the interface in real time via API calls.

7. API Documentation

Endpoint	Method	Description
/chat/ask	POST	AI-powered conversation response
/upload-doc	POST	Embeds documents using Pinecone
/ search-docs	GET	Semantic search of embedded policies
/get-eco-tips	GET	Returns sustainability tips on request
/submit-feedback	POST	Stores citizen feedback

- All endpoints are documented and testable in Swagger UI.

8. Authentication

- Default: Open environment for demo purposes
- Secure deployment options: Token (JWT/API Keys), OAuth2, IBM Cloud credentials
- Role-based access: Admin, Citizen, Researcher
- Planned: Session and history tracking

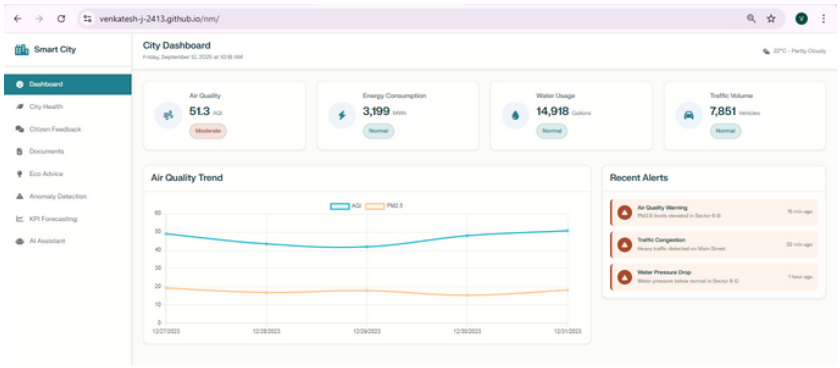
9. User Interface

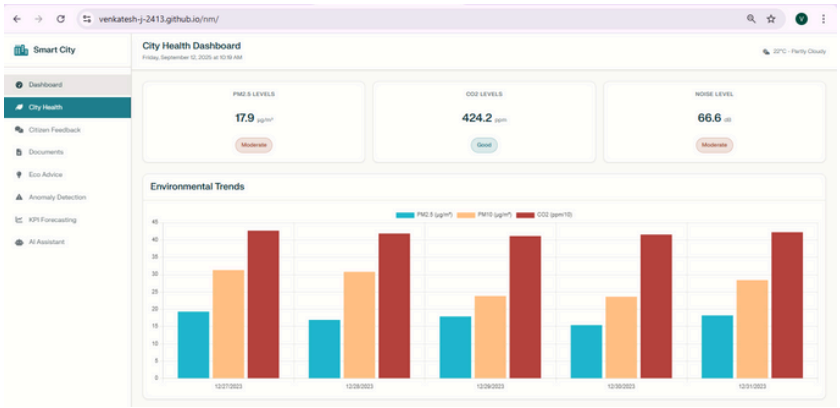
- Minimalist, accessible UI design for non-technical users
- Sidebar navigation
- KPI summary visualizations
- Tabbed layouts for chat/tips/forecasting
- Real-time forms
- PDF report downloads
- Help texts for guidance and clarity

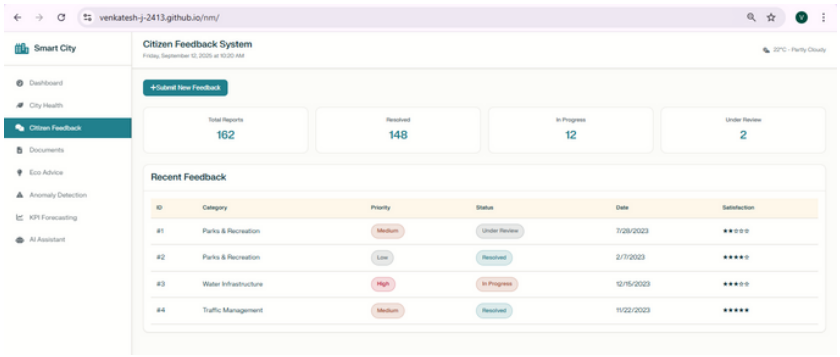
10. Testing

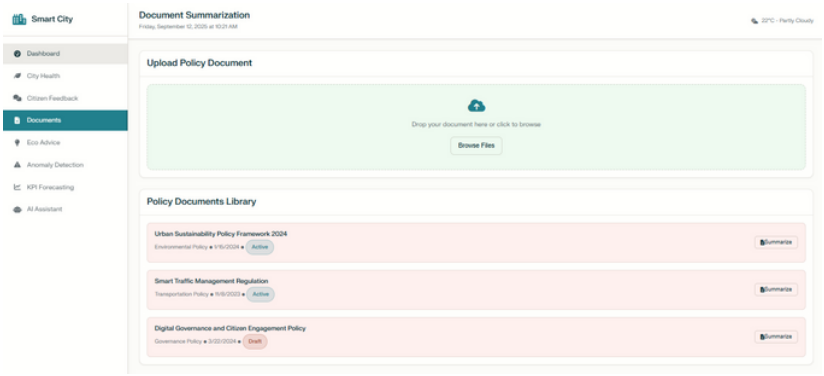
- Unit tests for prompt engineering/utilities
- API tests via Swagger/Postman
- Manual UI tests for uploads/chat/output
- Edge-case handling for input errors, large files, invalid
- credentials Functions validated in offline and connected modes

11. Screenshots








Smart City
Document Summarization
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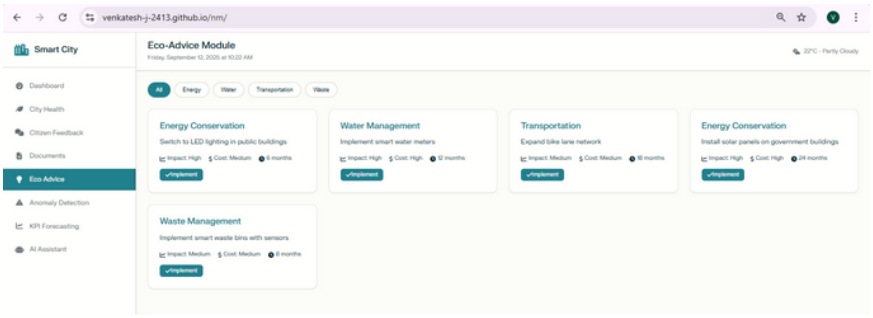
22°C - Partly Cloudy
Dashboard
City Health
Citizen Feedback
Documents
Eco Advice
Anomaly Detection
KPI Forecasting
AI Assistant
Upload Policy Document
Drop your document here or click to browse
Browse Files
Policy Documents Library
Urban Sustainability Policy Framework 2024
Environmental Policy • 1/15/2024 • Active
Summarize
Smart Traffic Management Regulation
Transportation Policy • 11/8/2023 • Active
Summarize
Digital Governance and Citizen Engagement Policy
Governance Policy • 3/22/2024 • Draft
Summarize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Smart City
Eco-Advice Module
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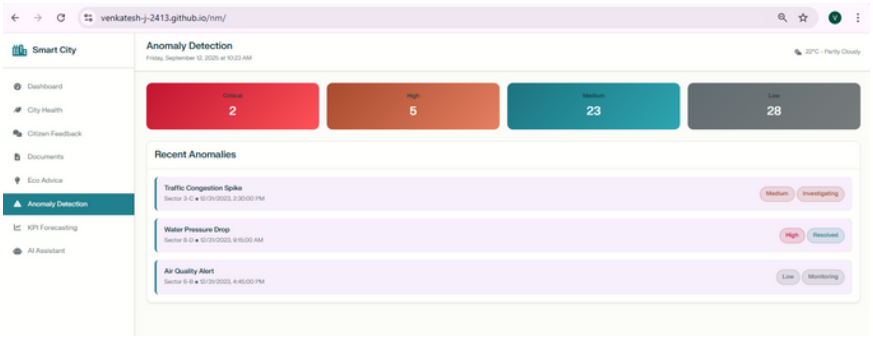
Dashboard
City Health
Citizen Feedback
Documents
Eco Advice
Anomaly Detection
KPI Forecasting
AI Assistant
All
Energy
Water
Transportation
Waste
Energy Conservation
Switch to LED lighting in public buildings
Impact: High
Cost: Medium
6 months
Implement
Water Management
Implement smart water meters
Impact: High
Cost: High
12 months
Implement
Transportation
Expand bike lane network
Impact: Medium
Cost: Medium
18 months
Implement
Energy Conservation
Install solar panels on government buildings
Impact: High
Cost: High
24 months
Implement
Waste Management
Implement smart waste bins with sensors
Impact: Medium
Cost: Medium
8 months
Implement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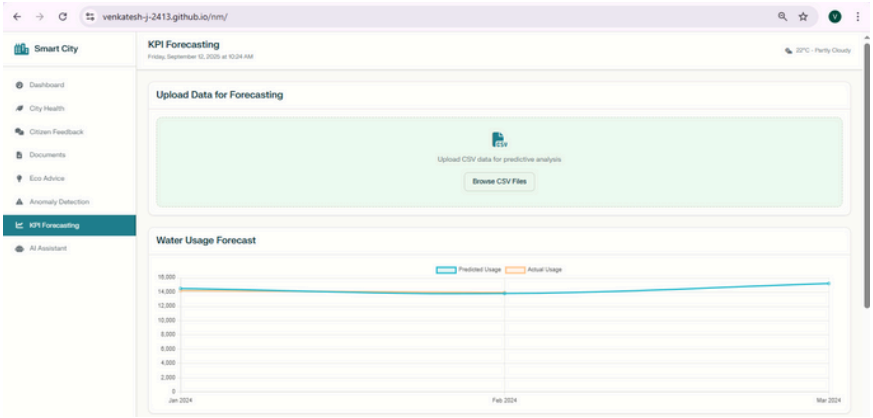
Smart City
Anomaly Detection
Friday, September 12, 2025 at 10:23 AM
22°C - Partly Cloudy
Dashboard
City Health
Citizen Feedback
Documents
Eco Advice
Anomaly Detection
KPI Forecasting
AI Assistant
Critical
2
High
5
Medium
23
Low
28
Recent Anomalies
Traffic Congestion Spike
Sector 3-C • 12/31/2023, 2:30:00 PM
Medium
Investigating
Water Pressure Drop
Sector 8-D • 12/31/2023, 9:15:00 AM
High
Resolved
Air Quality Alert
Sector 6-B • 12/31/2023, 4:45:00 PM
Low
Monitoring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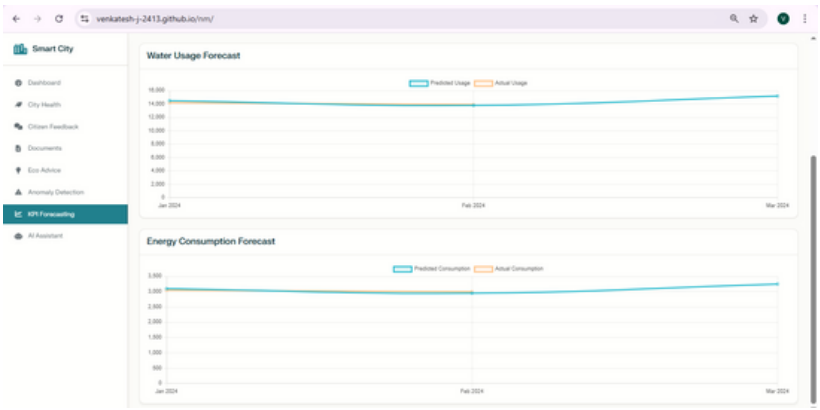
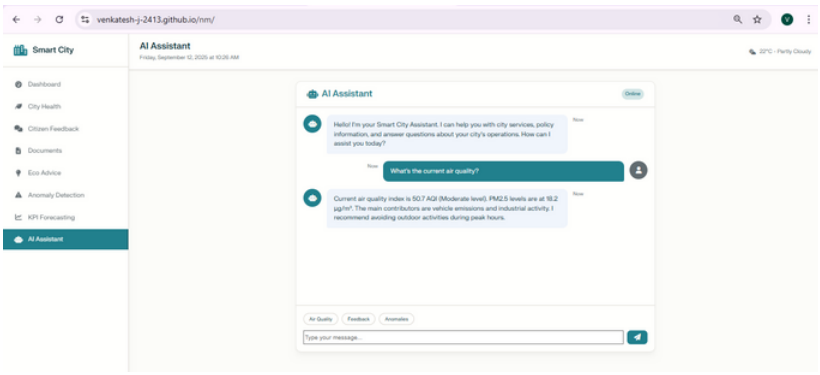
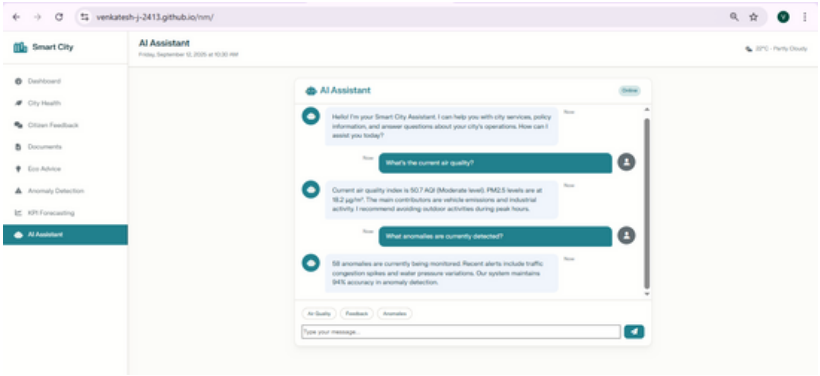
Smart City
KPI Forecasting
Friday, September 12, 2025 at 10:24 AM
22°C - Partly Cloudy
Dashboard
City Health
Citizen Feedback
Documents
Eco Advice
Anomaly Detection
KPI Forecasting
AI Assistant
Upload Data for Forecasting
CSV
Upload CSV data for predictive analysis
Browse CSV Files
Water Usage Forecast
Predicted Usage
Actual Usage
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan 2024
Feb 2024
Mar 2024







12. Known Issues

Some known issues faced in Sustainable Smart City Assistant projects (using Streamlit, FastAPI, IBM Watsonx, and related ML modules) include technical, integration, and operational challenges in real-world deployment.

Common Issues

Technical & Integration

Port Conflicts or Deployment Errors: When running both FastAPI and Streamlit servers, cloud deployments may face port allocation and configuration errors.

ML Model Limitations: Anomaly detection models suffer from limited labeled abnormal samples and struggles in handling high-dimensional city data, leading to false positives or missed anomalies.

File Handling Restrictions: Components like IBM Watsonx can fail on file uploads if there are spaces in CSV filenames, incompatible formats, or large file sizes.

System Interoperability: Integrating ML-based analytics, LLMs, and legacy city systems is complex and may require custom connectors and middleware for compatibility.

Usability & Access

Resource Demands: Running AI models (especially large LLMs) and real-time ML pipelines is expensive and may outstrip smaller city budgets or available infrastructure.

Role Management and Authentication: The project may lack robust user session management and multi-role access; planned enhancements include token-based authentication and role assignment for admin/citizen/researcher use cases.

Social Acceptability and Awareness: Adoption among city staff and residents may be slow due to unfamiliarity with tech or lack of transparency in AI-driven decision making.

Data & Security

Data Privacy and Governance: Handling citizen feedback and sensor streams requires strict data governance and privacy measures; solutions frequently lag behind implementation.

Model Drift and Insight Lag: Synthetic KPI forecasting and anomaly detection may not automatically retrain, causing delayed or inaccurate insights over time.

General Limitations

Lack of resources and strategic planning for continuous infrastructure upgrades, public engagement, and content development remain major obstacles in sustainable smart city transformation.

13. Future Enhancements

- Session/user history support
- Role management with advanced permissions
- Enhanced analytics and visualization modules
- Integration with additional city data sources
- Multilingual support and accessibility upgrades