Sustainable Smart City Assistant

Project Documentation

1.Introduction

- Project title : **Sustainable Smart City Assistant using IBM Granite LLM**
- **Team leader : Abburi sriram**
- **Team member :** S Janardhan
- **Team member :** V Revanth Sai

2.project overview

- Purpose :

  The purpose of a 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 like energy, water, and waste, while also guiding sustainable behaviors among citizens through personalized tips and services. For city officials, it serves as a decision-making partner—offering clear insights, forecasting tools, and summarizations of complex policies to support strategic planning. Ultimately, this assistant bridges technology, governance, and community engagement to foster greener cities that are more efficient, inclusive, and resilient.

- Features:

Conversational Interface

Key Point: Natural language interaction

Functionality: Allows citizens and officials to ask questions, get updates, and receive guidance in plain language

Policy Summarization

Key Point: Simplified policy understanding

Functionality: Converts lengthy government documents into concise, actionable summaries.

Resource Forecasting
Key Point: Predictive analytics
Functionality: Estimates future energy, water, and waste usage using historical and real-time data.

Eco-Tip Generator
Key Point: Personalized sustainability advice
Functionality: Recommends daily actions to reduce environmental impact based on user behavior.

Citizen Feedback Loop
Key Point: Community engagement
Functionality: Collects and analyzes public input to inform city planning and service improvements.

KPI Forecasting
Key Point: Strategic planning support
Functionality: Projects key performance indicators to help officials track progress and plan ahead.

Anomaly Detection
Key Point: Early warning system
Functionality: Identifies unusual patterns in sensor or usage data to flag potential issues.

Multimodal Input Support
Key Point: Flexible data handling
Functionality: Accepts text, PDFs, and CSVs for document analysis and forecasting.

Streamlit or Gradio UI
Key Point: User-friendly interface
Functionality: Provides an intuitive dashboard for both citizens and city officials to interact with the assistant.

3. Architecture

Frontend (Stream lit):

The frontend is built with Stream lit, offering an interactive web UI with multiple pages including dashboards, file uploads, chat interface, feedback forms, and report viewers. Navigation is handled through a sidebar using the stream lit-option-menu library. Each page is modularized for scalability.

Backend (Fast API):

Fast API serves as the backend REST framework that powers API endpoints for document processing, chat interactions, eco tip generation, report creation, and vector embedding. It is optimized for asynchronous performance and easy Swagger integration.

LLM Integration (IBM Watsonx Granite):

Granite LLM models from IBM Watsonx are used for natural language understanding and generation. Prompts are carefully designed to generate summaries, sustainability tips, and reports.

Vector Search (Pinecone):

Uploaded policy documents are embedded using Sentence Transformers and stored in Pinecone. Semantic search is implemented using cosine similarity to allow users to search documents using natural language queries.

ML Modules (Forecasting and Anomaly Detection):

Lightweight ML models are used for forecasting and anomaly detection using Scikit-learn. Time-series data is parsed, modeled, and visualized using pandas and matplotlib.

4. Setup Instructions

Prerequisites:

- Python 3.9 or later
- pip and virtual environment tools
- API keys for IBM Watsonx and Pinecone

- Internet access to access cloud services

Installation Process:

- Clone the repository
- Install dependencies from requirements.txt
- Create a .env file and configure credentials
- Run the backend server using Fast API
- Launch the frontend via Stream lit
- Upload data and interact with the modules

5. Folder Structure

app/ – Contains all Fast API backend logic including routers, models, and integration modules.

app/api/ – Subdirectory for modular API routes like chat, feedback, report, and document vectorization.

ui/ – Contains frontend components for Stream lit pages, card layouts, and form UIs.

smart_dashboard.py – Entry script for launching the main Stream lit dashboard.

granite_llm.py – Handles all communication with IBM Watsonx Granite model including summarization and chat.

document_embedder.py – Converts documents to embeddings and stores in Pinecone.

kpi_file_forecaster.py – Forecasts future energy/water trends using regression.

anomaly_file_checker.py – Flags unusual values in uploaded KPI data.

report_generator.py – Constructs AI-generated sustainability reports.

6. Running the Application

To start the project:

- ➢ Launch the FastAPI server to expose backend endpoints.
- ➢ Run the Streamlit dashboard to access the web interface.
- ➢ Navigate through pages via the sidebar.
- ➢ Upload documents or CSVs, interact with the chat assistant, and view outputs like reports, summaries, and predictions.
- ➢ All interactions are real-time and use backend APIs to dynamically update the frontend.

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7. API Documentation

Backend APIs available include:

POST /chat/ask – Accepts a user query and responds with an AI-generated message

POST /upload-doc – Uploads and embeds documents in Pinecone

GET /search-docs – Returns semantically similar policies to the input query

GET /get-eco-tips – Provides sustainability tips for selected topics like energy, water, or waste

POST /submit-feedback – Stores citizen feedback for later review or analytics

Each endpoint is tested and documented in Swagger UI for quick inspection and trial during development.

8. Authentication

each endpoint is tested and documented in Swagger UI for quick inspection and trial during development.

This version of the project runs in an open environment for demonstration. However, secure deployments can integrate:

- Token-based authentication (JWT or API keys)
- OAuth2 with IBM Cloud credentials
- Role-based access (admin, citizen, researcher)
- Planned enhancements include user sessions and history tracking.8. Authentication

9. User Interface

The interface is minimalist and functional, focusing on accessibility for non-technical users. It includes:

Sidebar with navigation

KPI visualizations with summary cards

Tabbed layouts for chat, eco tips, and forecasting

Real-time form handling

PDF report download capability

The design prioritizes clarity, speed, and user guidance with help texts and intuitive flows.

10. Testing

Testing was done in multiple phases:

Unit Testing: For prompt engineering functions and utility scripts

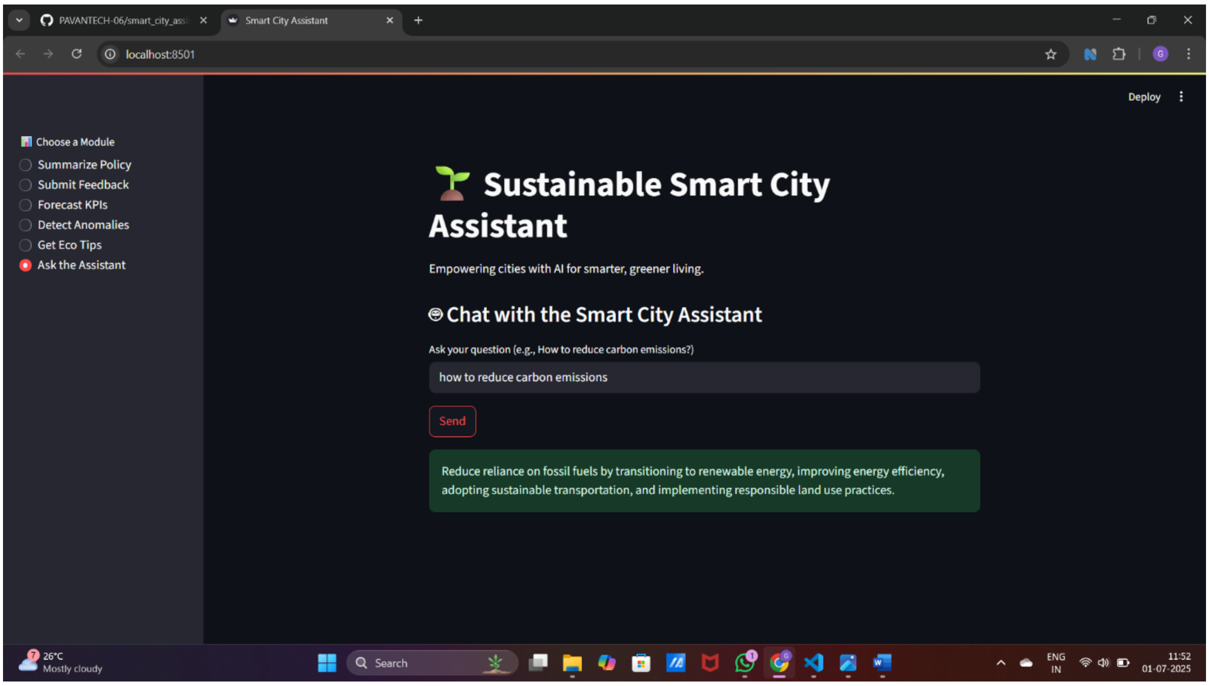
API Testing: Via Swagger UI, Postman, and test scripts

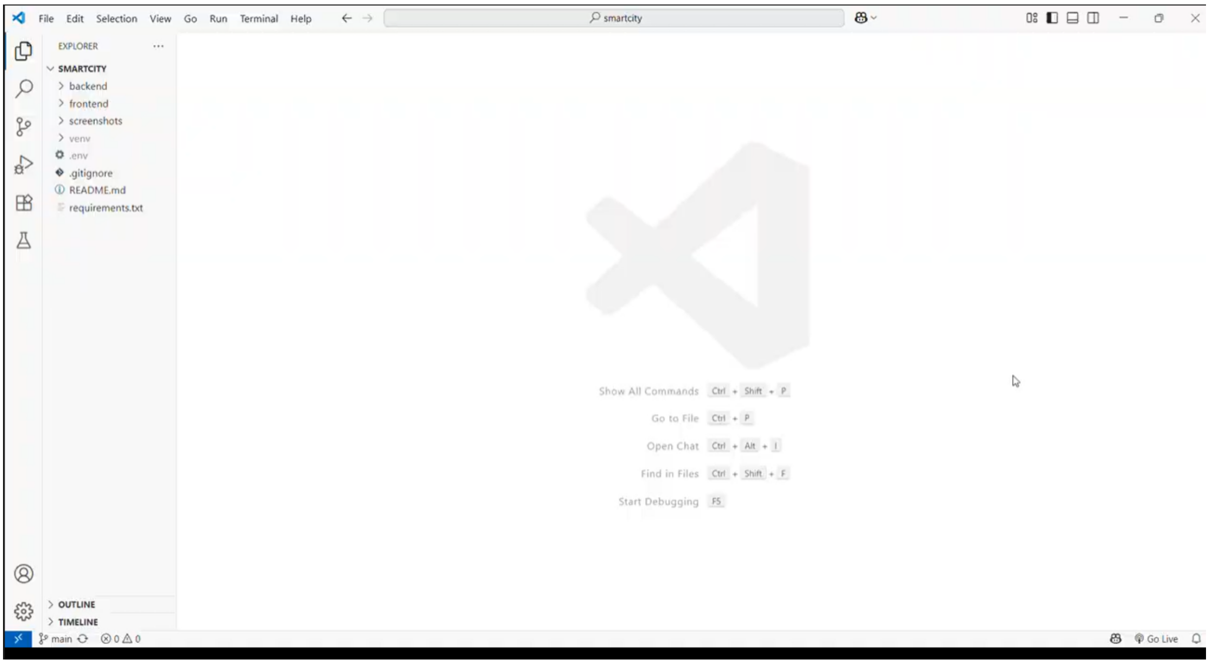
Manual Testing: For file uploads, chat responses, and output consistency

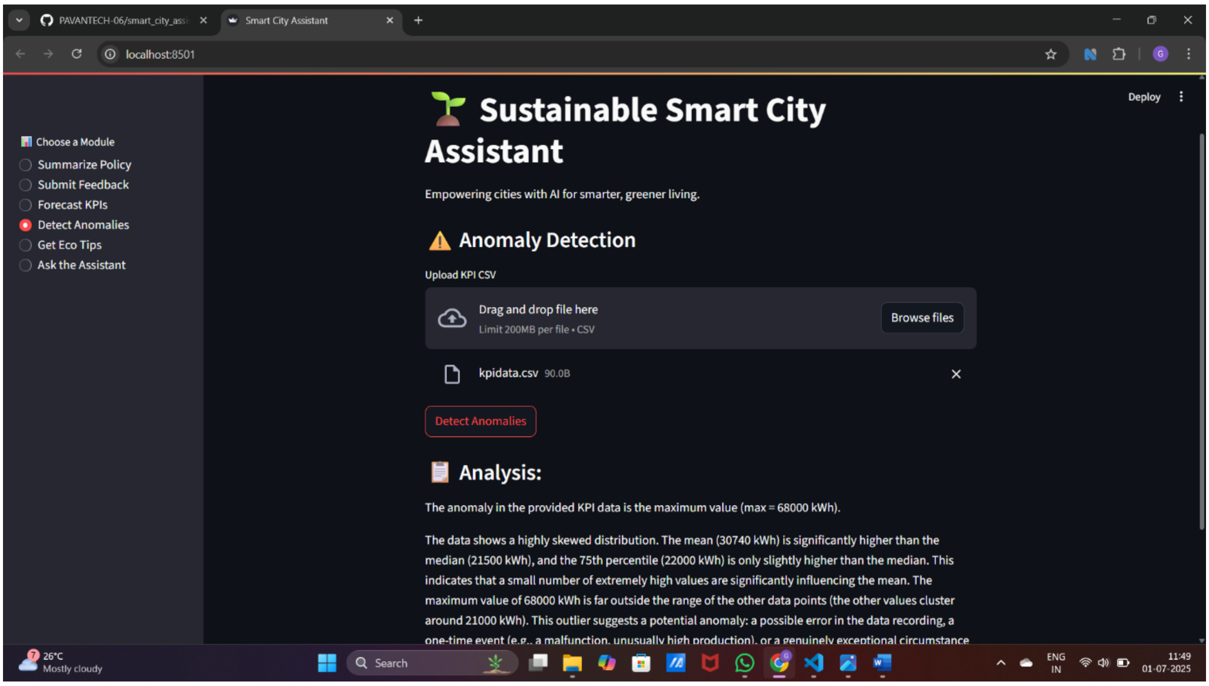
Edge Case Handling: Malformed inputs, large files, invalid API keys

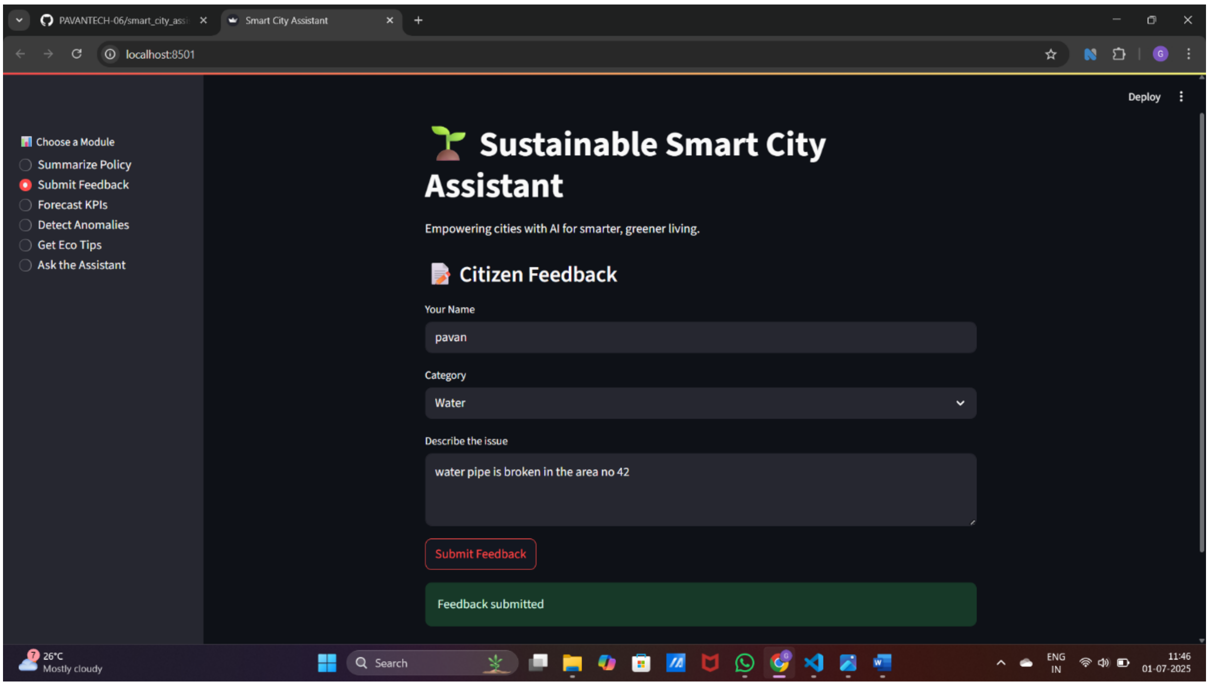
Each function was validated to ensure reliability in both offline and API-connected modes.

11.Screen Shots






PAVANTECH-06/smart_city_ass
Smart City Assistant
localhost:8501
Deploy
Choose a Module
Summarize Policy
Submit Feedback
Forecast KPIs
Detect Anomalies
Get Eco Tips
Ask the Assistant
Sustainable Smart City Assistant
Empowering cities with AI for smarter, greener living.
Anomaly Detection
Upload KPI CSV
Drag and drop file here
Limit 200MB per file • CSV
Browse files
kpidata.csv 90.0B
Detect Anomalies
Analysis:
The anomaly in the provided KPI data is the maximum value (max = 68000 kWh).
The data shows a highly skewed distribution. The mean (30740 kWh) is significantly higher than the median (21500 kWh), and the 75th percentile (22000 kWh) is only slightly higher than the median. This indicates that a small number of extremely high values are significantly influencing the mean. The maximum value of 68000 kWh is far outside the range of the other data points (the other values cluster around 21000 kWh). This outlier suggests a potential anomaly: a possible error in the data recording, a one-time event (e.g., a malfunction, unusually high production), or a genuinely exceptional circumstance
26°C
Mostly cloudy
Search
ENG
IN
11:49
01-07-2025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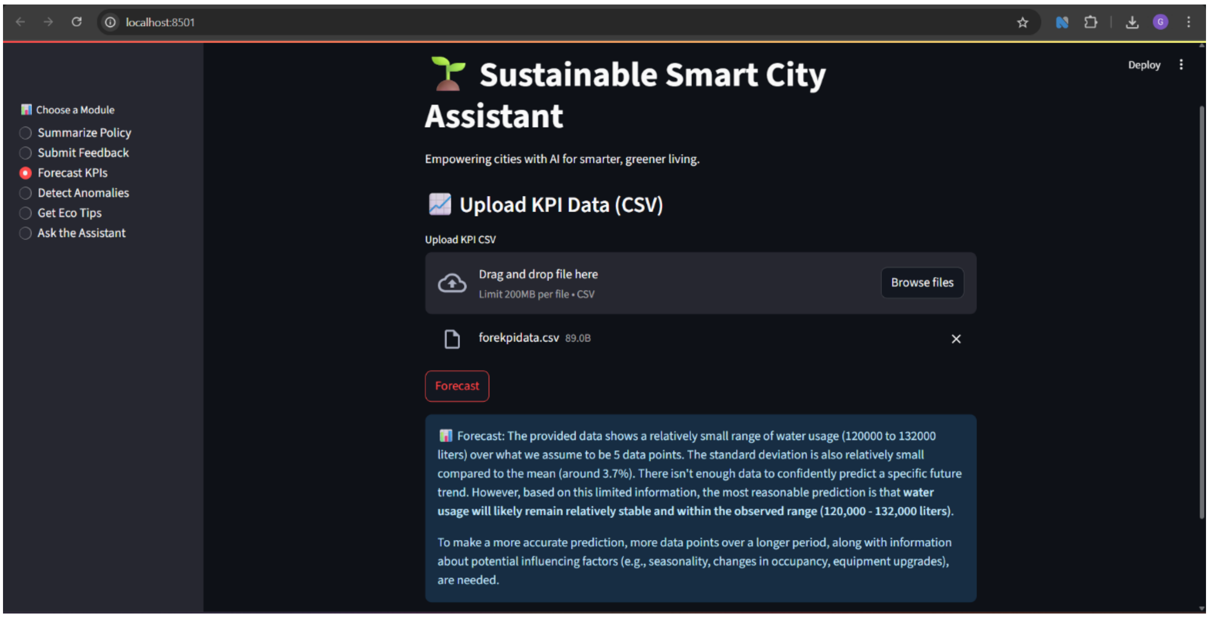
Empowering cities with AI for smarter, greener living.
Citizen Feedback
Your Name
pavan
Category
Water
Describe the issue
water pipe is broken in the area no 42
Submit Feedback
Feedback submitted
26°C
Mostly cloudy
Search
ENG
IN
11:46
01-07-2025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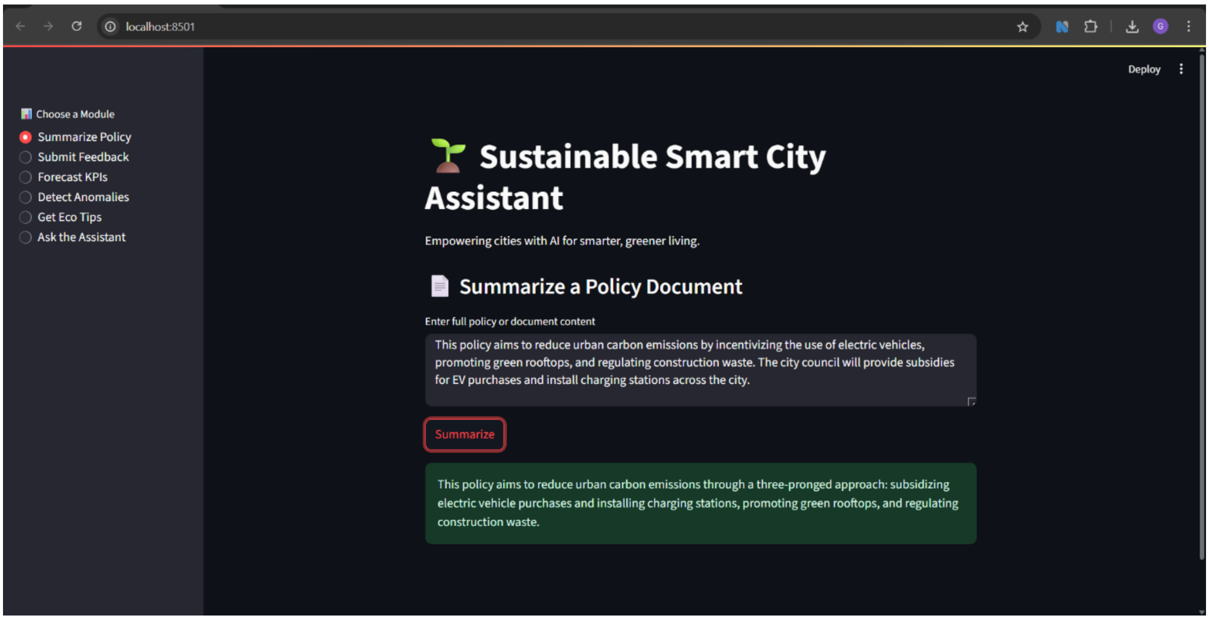
Ask the Assistant
Sustainable Smart City Assistant
Empowering cities with AI for smarter, greener living.
Upload KPI Data (CSV)
Upload KPI CSV
Drag and drop file here
Limit 200MB per file • CSV
Browse files
forekpidata.csv 89.0B
Forecast
Forecast: The provided data shows a relatively small range of water usage (120000 to 132000 liters) over what we assume to be 5 data points. The standard deviation is also relatively small compared to the mean (around 3.7%). There isn't enough data to confidently predict a specific future trend. However, based on this limited information, the most reasonable prediction is that water usage will likely remain relatively stable and within the observed range (120,000 - 132,000 liters).
To make a more accurate prediction, more data points over a longer period, along with information about potential influencing factors (e.g., seasonality, changes in occupancy, equipment upgrades), are needed.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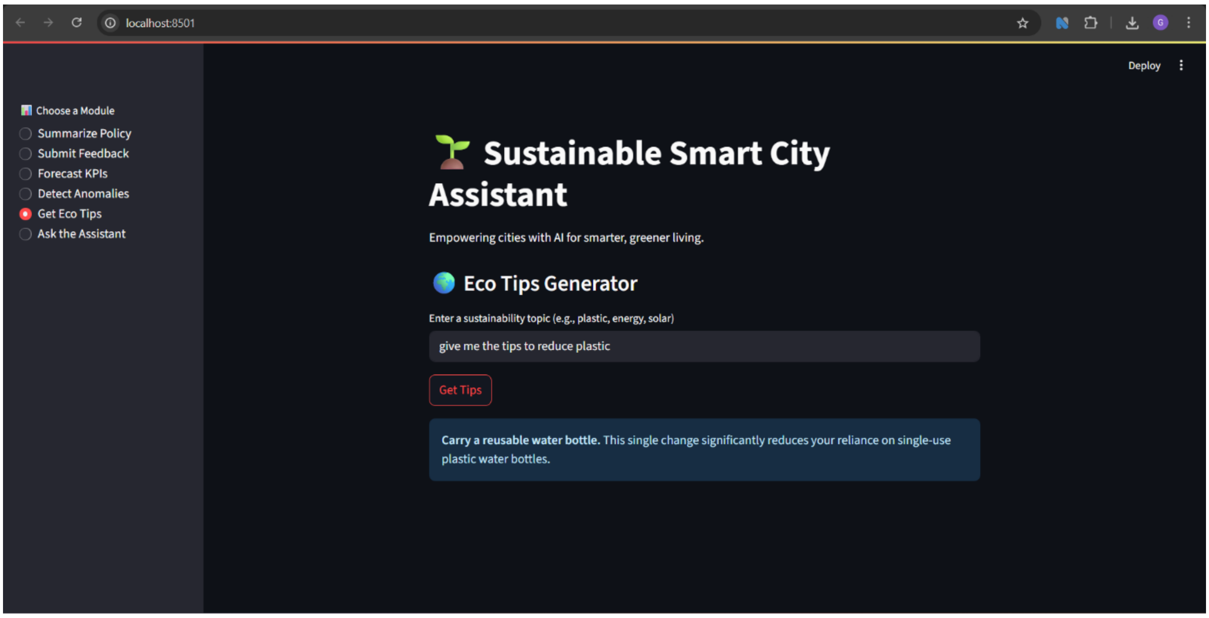
Choose a Module
Summarize Policy
Submit Feedback
Forecast KPIs
Detect Anomalies
Get Eco Tips
Ask the Assistant
Sustainable Smart City Assistant
Empowering cities with AI for smarter, greener living.
Summarize a Policy Document
Enter full policy or document content
This policy aims to reduce urban carbon emissions by incentivizing the use of electric vehicles, promoting green rooftops, and regulating construction waste. The city council will provide subsidies for EV purchases and install charging stations across the city.
Summarize
This policy aims to reduce urban carbon emissions through a three-pronged approach: subsidizing electric vehicle purchases and installing charging stations, promoting green rooftops, and regulating construction waste.



12. Known Issues

High latency if Watsonx API quota is reached

Pinecone index size may hit limit in free tier

No persistent database for feedback collection

No built-in data validation for file types and schema mismatch

Doesn't support multiple concurrent users in demo version

These issues are known and documented for future patching.

13. Future enhancement

- **Adaptive Learning Models**
  Functionality: Continuously improve recommendations and predictions by learning from user behavior, seasonal trends, and policy changes.
- **Multilingual & Cultural Adaptation**
  Functionality: Support diverse populations by offering localized content, language options, and culturally relevant eco-tips.
- **Real-Time IoT Integration**
  Functionality: Seamlessly connect with smart meters, traffic systems, and environmental sensors for live decision-making.

- **Automated Policy Drafting**
  Functionality: Assist city officials in drafting sustainability policies using AI-generated templates and insights.
- **Climate Resilience Modeling**
  Functionality: Simulate the impact of climate scenarios on infrastructure and suggest adaptive strategies.
- **Participatory Budgeting Tools**
  Functionality: Enable citizens to vote on sustainability projects and track funding transparency.
- **Explainable AI (XAI)**
  Functionality: Provide clear justifications for AI decisions to build trust among citizens and officials.
- **Satellite Data Integration**
  Functionality: Use satellite imagery for urban heat mapping, green cover analysis, and disaster monitoring.
- Integrate real-time IoT sensors and GIS maps
- Expand language support
- Use Docker and GitHub Actions for deployment
- Add analytics dashboard for city officials
- Store and visualize trends over months/years
- Allow policy document OCR and PDF parsing
- This project is scalable and ready for real-world extension, making it a strong foundation for smart city innovation.