Sustainable Smart City Assistant Using IBM Granite LLM

1. Introduction

Project Title: Sustainable Smart City Assistant Using IBM Granite LLM

Team ID : LTVIP2025TMID20299

Team Members:

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2. Project Overview

The Sustainable Smart City Assistant is an AI-powered platform built using IBM Watsonx Granite LLM and Streamlit. It enhances citizen interaction, sustainability monitoring, and urban data understanding.

Key Features:

• Policy Summarization:

Upload city policy PDFs and receive citizen-friendly summaries.

• KPI Forecasting:

Upload historical data to predict city performance metrics.

• Anomaly Detection:

Detect unusual patterns in consumption or KPI data.

• Eco Tips Generator:

Get AI-generated sustainable living tips.

• Feedback Reporting:

Citizens can report issues under categories like water, electricity, roads, etc.

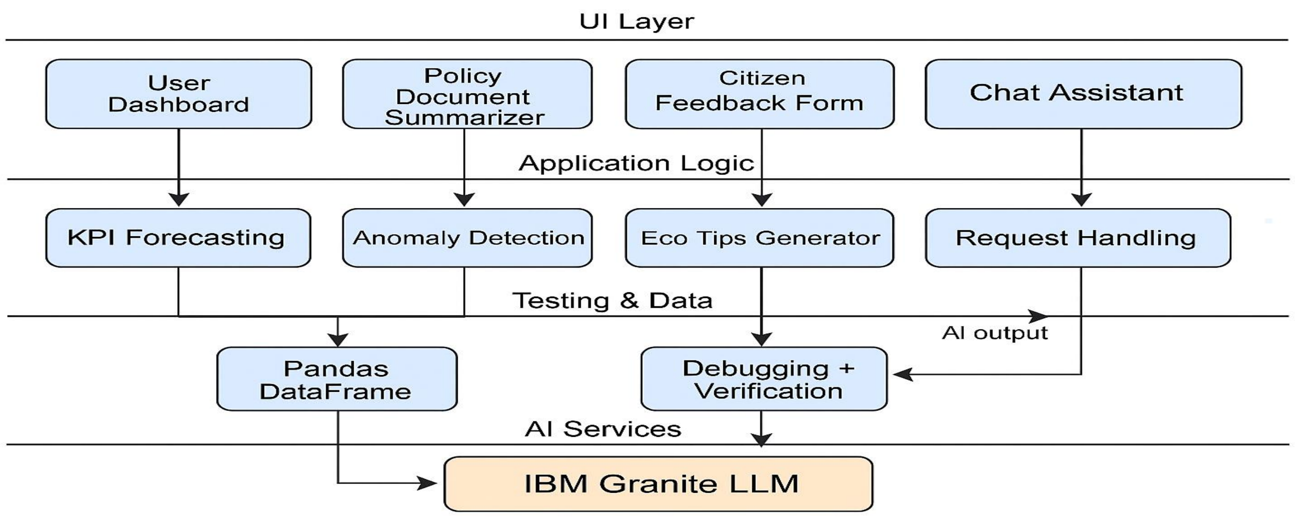
• Chat Assistant:

Ask general questions about sustainability or city services.

3. Architecture

The solution uses a four-layer architecture:

- UI Layer (Streamlit): Sidebar navigation, file uploaders, text inputs, and chat interface
- Application Layer: Handles file parsing (PyMuPDF, pandas), prompt formatting, API calls
- AI Service Layer: IBM Watsonx Granite 3B/13B model for generating natural language responses
- Session Layer: Uses Streamlit session_state for maintaining inputs and chat history



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4. Setup Instructions

1. Install Python 3.8+ and pip.

2. Create and activate a virtual environment.

3. Install dependencies: streamlit, pymupdf, ibm-watsonx-ai, python-dotenv.

4. Create a .env file with IBM_WATSONX_API_KEY and URL.

5. Run the app with: streamlit run app.py

5. API Documentation

The system uses IBM Watsonx Granite 13B via the ibm-watsonx-ai SDK. The ask_watsonx() function manages prompts for all modules.

The backend "API" in this project is primarily the interface with the IBM Watson Machine Learning service. There are no traditional REST API endpoints exposed by a separate backend server (like Node.js/Express.js) as this is a Streamlit-based application directly interacting with the AI service. The primary "API" calls are made internally to the IBM Watson Machine Learning service: ¬ Service: IBM Watson Machine Learning ¬ ModelUsed: IBMGranite 13B Instruct v2 (ibm/granite-13b-instruct v2) ¬ Authentication: API Key and Endpoint URL, managed securely via .env file and loaded by python-dotenv.

6. Authentication

API credentials are securely stored in a .env file and accessed using python-dotenv. These are used to authenticate with Watsonx AI services.

Authentication with the IBM Watson Machine Learning service is handled via an API Key.

- TheAPIKeyisobtained from the IBM Cloud account associated with the Watson Machine Learning service instance.
- Itis securely stored as an environment variable in the .env file within the project directory.
- Thepython-dotenv library loads this API key at application startup.
- Theibm_watson_machine_learning.credentials.Credentials class uses this API key along with the service URL to authenticate with the IBM Watson Machine Learning API when initializing the Model object. This ensures secure communication without hardcoding sensitive information

7. User Interface

The user interface of Sustainble Smart City is designed using the Streamlit framework, emphasizing modularity, clarity, and ease of interaction for developers, testers, and project managers.

Main Application Layout

- **Page Title & Layout**:
  The application sets a custom page title ("SmartSDLC – AI Assistant") and uses a wide layout for enhanced code readability and output formatting.
- **Sidebar Navigation:**
  A prominent sidebar (st.sidebar.radio) allows users to switch between six major modules:
  - Policy Search & Summarization
  - Citizen Feedback Reporting
  - KPI Forecasting
  - Anomaly Detection
  - Eco Tips Generatorr
  - Chat Assistant
- **Session Management:**
  st.session_state is used to retain chat history and form input across module switches, ensuring a consistent experience.
- **UI Customization:**
  Though Streamlit does not support native CSS styling out-of-the-box, optional custom CSS can be added using st.markdown with unsafe_allow_html=True for visual enhancement if needed.

Feature-Specific Interfaces

Each module in the Sustainable Smart City Assistant is implemented as an isolated, user-focused interface within the Streamlit dashboard. These modules are optimized for individual urban tasks and enable effective interaction with IBM Watsonx Granite LLM.

1. **Policy Search & Summarizatio**n

- o Upload interface for PDF policy documents using file_uploader
- o Optional: Text area for manual policy input
- o AI-generated summaries displayed in a structured, citizen-friendly format using st.text_area
- o Spinner animation shown during processing, with success confirmation upon completion

2. Citizen Feedback Reporting

- o Selectbox to choose feedback category (e.g., Water, Electricity, Roads)
- o Text area for users to describe issues
- o Submit button logs the entry with confirmation feedback
- o (Future scope: Integrate with backend database for feedback tracking)

3. KPI Forecasting

- o CSV upload interface for last year's city KPI data (e.g., water usage, electricity consumption)
- o DataFrame preview shown for validation
- o LLM processes data and forecasts future trends
- o Output shown in a text box with labeled insights

4. Anomaly Detection

- o CSV upload module for detecting outliers in KPI data
- o Uses pandas to parse input and display the data preview
- o AI analyzes and flags potential anomalies in the dataset
- o Outputs a plain-language description of irregular patterns or spikes

5. Eco Tips Generator

- o Text input to specify a keyword (e.g., plastic, electricity, solar)
- o Generates 5 personalized eco-lifestyle tips using the LLM
- o Output shown as a bulleted markdown list
- o Lightweight interface for quick sustainability awareness

6. AI Chatbot Assistant

- Interactive chat window using st.chat_input and st.chat_message
- Maintains multi-turn interaction with history via st.session_state
- Accepts open-ended questions about sustainability, urban governance, or environmental impact
- Displays assistant replies in conversational format

Dynamic Visualizations (Optional / Future Scope)

Although the current version is text and data-centric, the architecture supports extendable visual interfaces such as:

- Usage Heatmaps:

  Monitor which modules are most frequently used
- Anomaly Charts:

  Graphically visualize spikes and irregularities in city metrics
- Sentiment Charts:

  Analyze citizen feedback using sentiment scoring
- Forecast Trendlines:

  Visualize historical vs. predicted KPI performance
- Eco Tip Engagement Graphs:

  Track keyword popularity over time.

8.Testing

Smart City project follows a structured testing strategy to ensure functionality, reliability, and a smooth user experience across all AI-assisted modules.

Unit Testing (Conceptual)

- Focuses on verifying the correctness of individual functions, such as:
    - ask_watsonx(): Ensures it sends well-structured prompts and returns valid AI responses.
    - PDF parsing using PyMuPDF: Tests that requirement text is accurately extracted from uploaded PDFs.
    - Session state handling in Streamlit: Confirms chat history and module input/output persist across user actions.

Integration Testing

- Validates the end-to-end workflow between frontend (Streamlit) and backend (IBM Watsonx AI):
    - Ensures correct prompt construction for each module (Policy Summarizer, KPI forecasting , etc.).
    - Verifies successful API calls to the Watsonx Granite 13B model and appropriate output rendering.
    - Tests module switching and ensures that state is preserved without breaking the application.

User Acceptance Testing (UAT)

- Involves manual testing by actual users (developers, testers, or mentors) to ensure the tool:
    - Meets defined expectations for each task.
    - Generates relevant and context-aware responses from natural language inputs.
    - Provides a user-friendly experience in terms of navigation, output clarity, and functionality.

Error Handling Tests

- Verifies robustness of the application by simulating error scenarios:
    - API Errors: Broken Watsonx connection or invalid credentials handled via try-except blocks.
    - Input Validation: Checks for empty or invalid user input (e.g., no Summary entered before clicking “Summarize ”).
    - Session Failures: Confirms fallback behavior if session state is not initialized or corrupted.

9. Known Issues

• Session state lost on app refresh.
• No user authentication implemented.
• API limits may affect high-volume use.

10. Future Enhancements

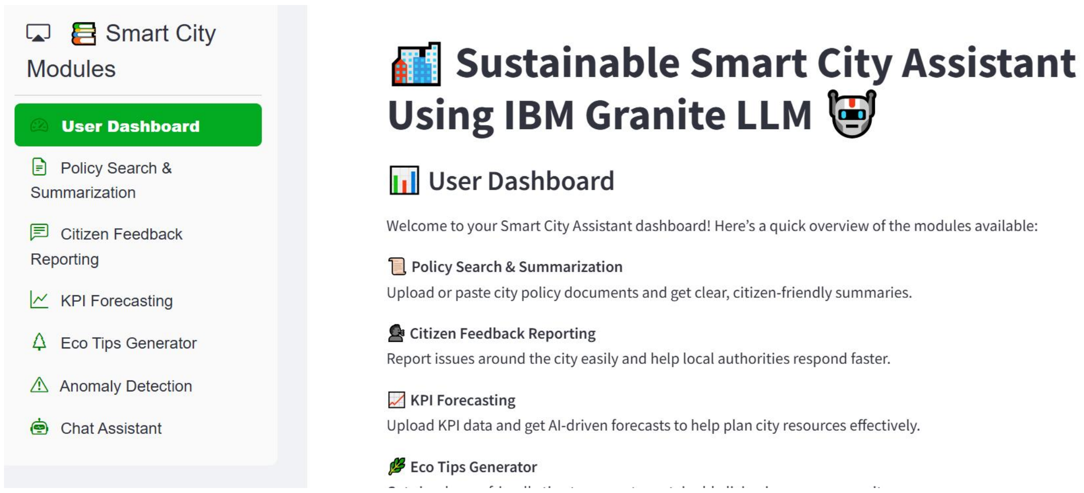
• User login system with profile persistence.

• Store feedback in a backend database (e.g., Firebase, Cloudant).

• Advanced analytics on Kpi Forecasting and Anamoly Detection.

• Expand support for multiple languages.

11. Screenshots



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User Dashboard

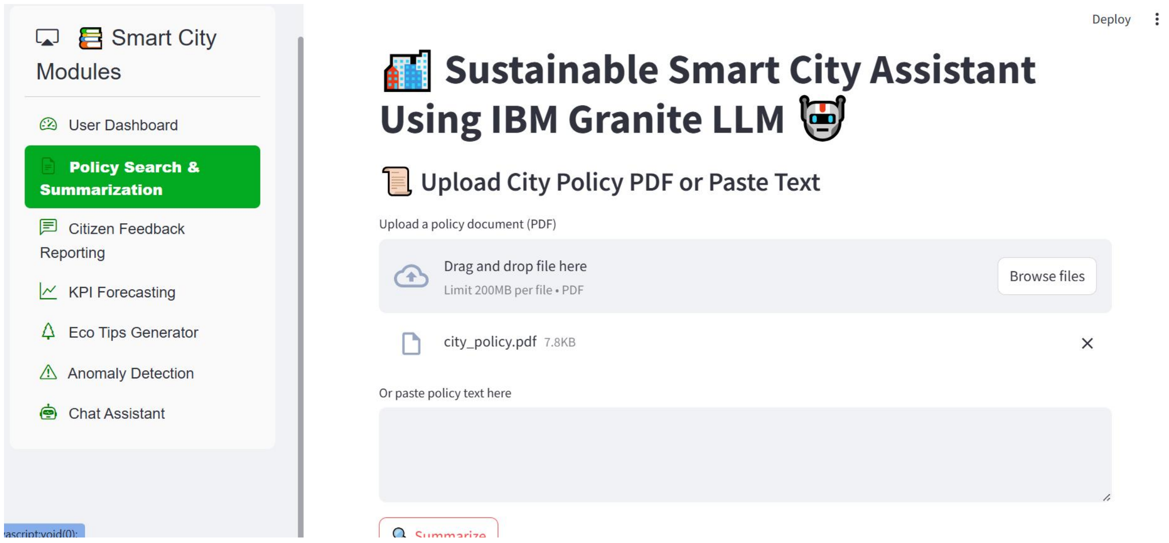
Welcome to your Smart City Assistant dashboard! Here's a quick overview of the modules available:

Policy Search & Summarization
Upload or paste city policy documents and get clear, citizen-friendly summaries.

Citizen Feedback Reporting
Report issues around the city easily and help local authorities respond faster.

KPI Forecasting
Upload KPI data and get AI-driven forecasts to help plan city resources effectively.

Eco Tips Generator



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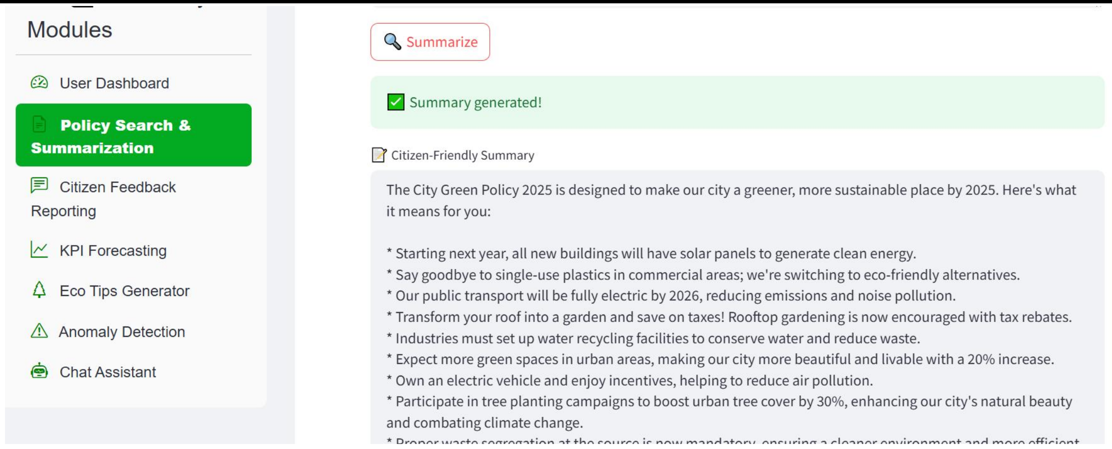
Upload City Policy PDF or Paste Text

Upload a policy document (PDF)

Drag and drop file here
Limit 200MB per file • PDF

city_policy.pdf 7.8KB

Or paste policy text here


Modules

- User Dashboard
- **Policy Search & Summarization**
- Citizen Feedback Reporting
- KPI Forecasting
- Eco Tips Generator
- Anomaly Detection
- Chat Assistant

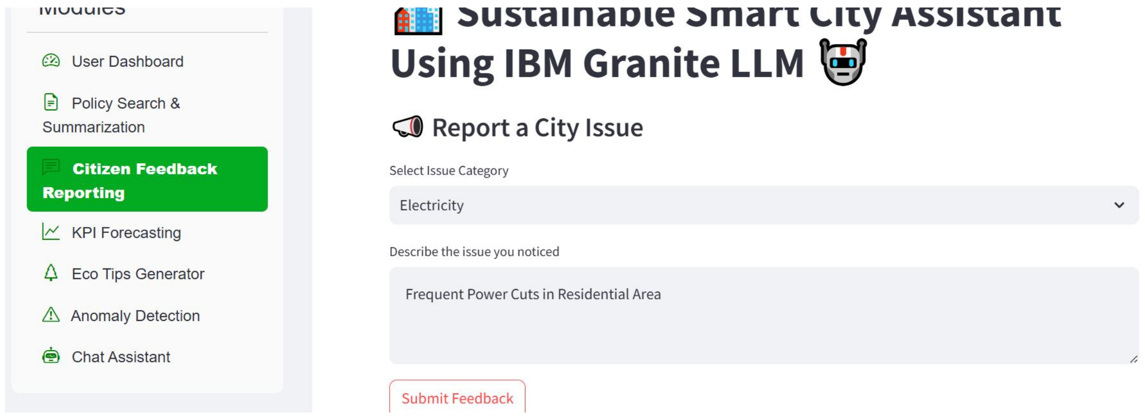
🔍 Summarize

✅ Summary generated!

📝 Citizen-Friendly Summary

The City Green Policy 2025 is designed to make our city a greener, more sustainable place by 2025. Here's what it means for you:

* Starting next year, all new buildings will have solar panels to generate clean energy.
* Say goodbye to single-use plastics in commercial areas; we're switching to eco-friendly alternatives.
* Our public transport will be fully electric by 2026, reducing emissions and noise pollution.
* Transform your roof into a garden and save on taxes! Rooftop gardening is now encouraged with tax rebates.
* Industries must set up water recycling facilities to conserve water and reduce waste.
* Expect more green spaces in urban areas, making our city more beautiful and livable with a 20% increase.
* Own an electric vehicle and enjoy incentives, helping to reduce air pollution.
* Participate in tree planting campaigns to boost urban tree cover by 30%, enhancing our city's natural beauty and combating climate change.
* Proper waste segregation at the source is now mandatory, ensuring a cleaner environment and more efficient


Modules

- User Dashboard
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📣 Report a City Issue

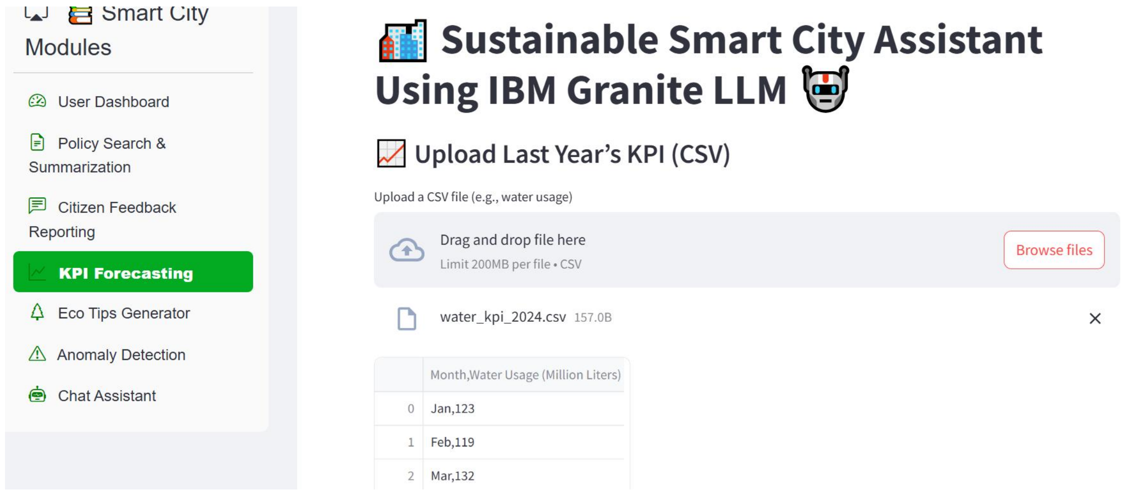
Select Issue Category

Electricity

Describe the issue you noticed

Frequent Power Cuts in Residential Area

Submit Feedback


🗂️ Smart City Modules

- User Dashboard
- Policy Search & Summarization
- Citizen Feedback Reporting
- **KPI Forecasting**
- Eco Tips Generator
- Anomaly Detection
- Chat Assistant

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📈 Upload Last Year's KPI (CSV)

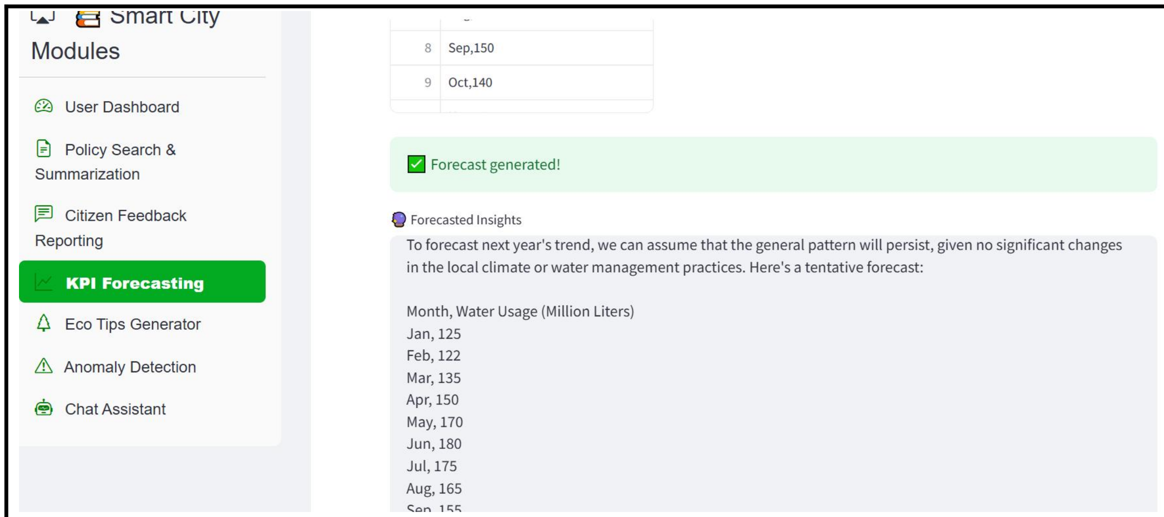
Upload a CSV file (e.g., water usage)

Drag and drop file here
Limit 200MB per file • CSV

Browse files

water_kpi_2024.csv 157.0B ×

	Month,Water Usage (Million Liters)
0	Jan,123
1	Feb,119
2	Mar,132



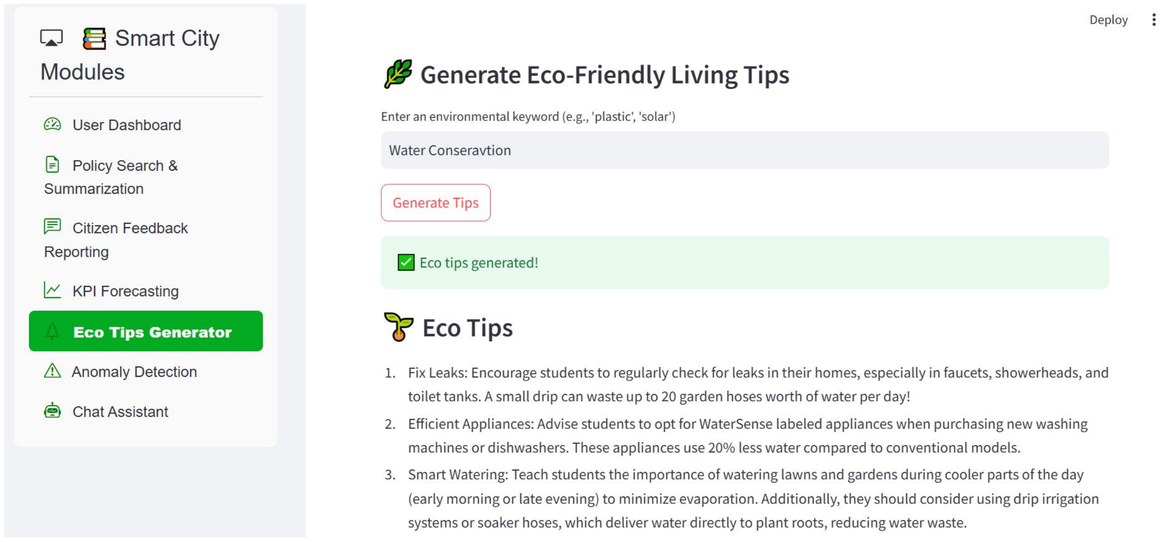
8	Sep,150
9	Oct,140

✅ Forecast generated!

Forecasted Insights

To forecast next year's trend, we can assume that the general pattern will persist, given no significant changes in the local climate or water management practices. Here's a tentative forecast:

Month, Water Usage (Million Liters)
Jan, 125
Feb, 122
Mar, 135
Apr, 150
May, 170
Jun, 180
Jul, 175
Aug, 165
Sep, 155



Generate Eco-Friendly Living Tips

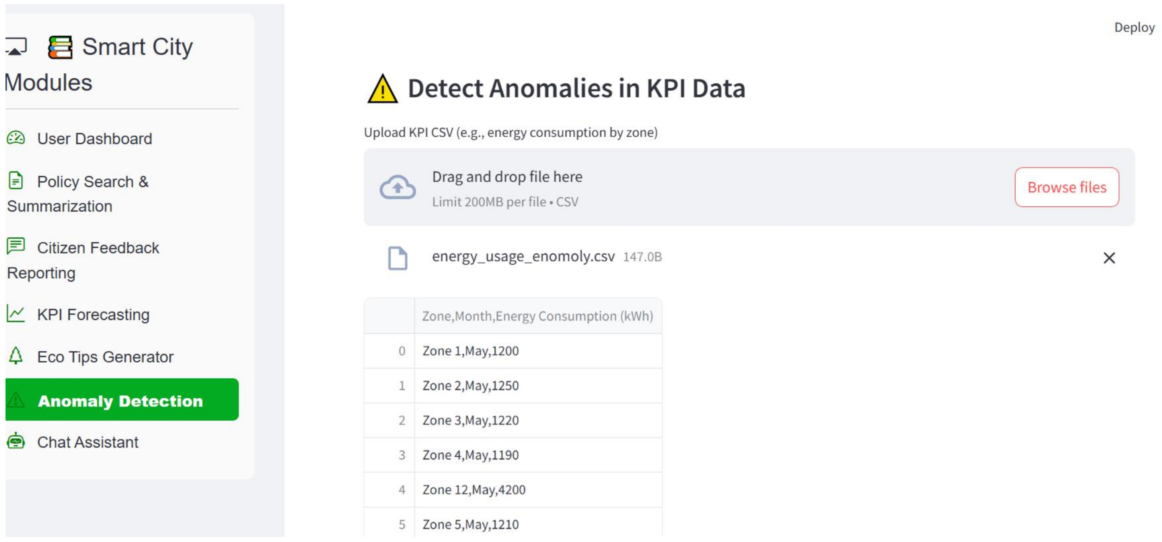
Enter an environmental keyword (e.g., 'plastic', 'solar')

Water Conseravtion

✅ Eco tips generated!

Eco Tips

1. Fix Leaks: Encourage students to regularly check for leaks in their homes, especially in faucets, showerheads, and toilet tanks. A small drip can waste up to 20 garden hoses worth of water per day!
2. Efficient Appliances: Advise students to opt for WaterSense labeled appliances when purchasing new washing machines or dishwashers. These appliances use 20% less water compared to conventional models.
3. Smart Watering: Teach students the importance of watering lawns and gardens during cooler parts of the day (early morning or late evening) to minimize evaporation. Additionally, they should consider using drip irrigation systems or soaker hoses, which deliver water directly to plant roots, reducing water waste.



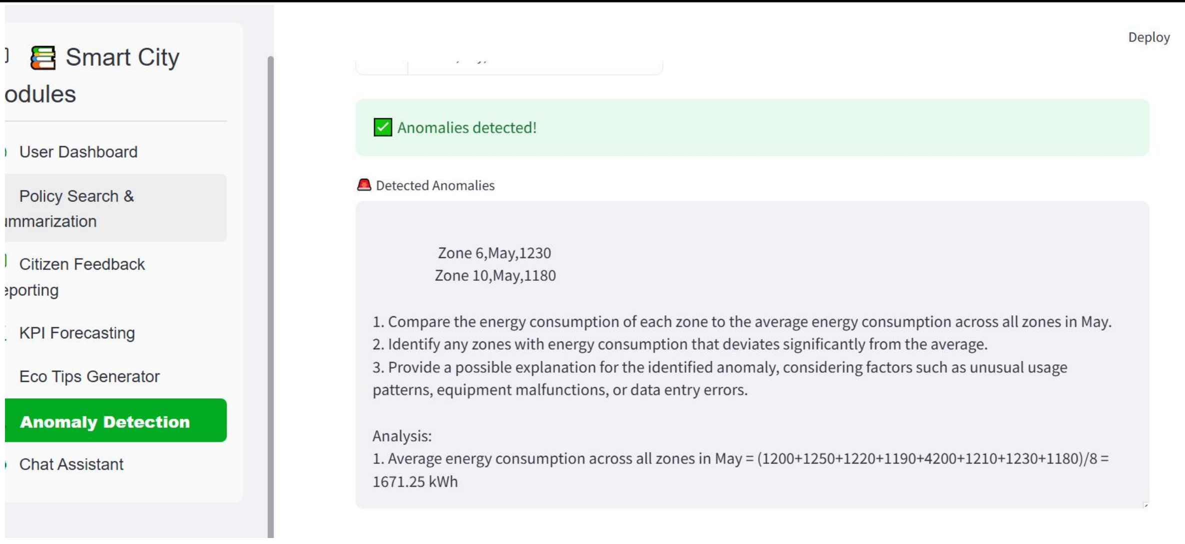
⚠ Detect Anomalies in KPI Data

Upload KPI CSV (e.g., energy consumption by zone)

Drag and drop file here
Limit 200MB per file • CSV

energy_usage_enomoly.csv 147.0B

	Zone,Month,Energy Consumption (kWh)
0	Zone 1,May,1200
1	Zone 2,May,1250
2	Zone 3,May,1220
3	Zone 4,May,1190
4	Zone 12,May,4200
5	Zone 5,May,1210



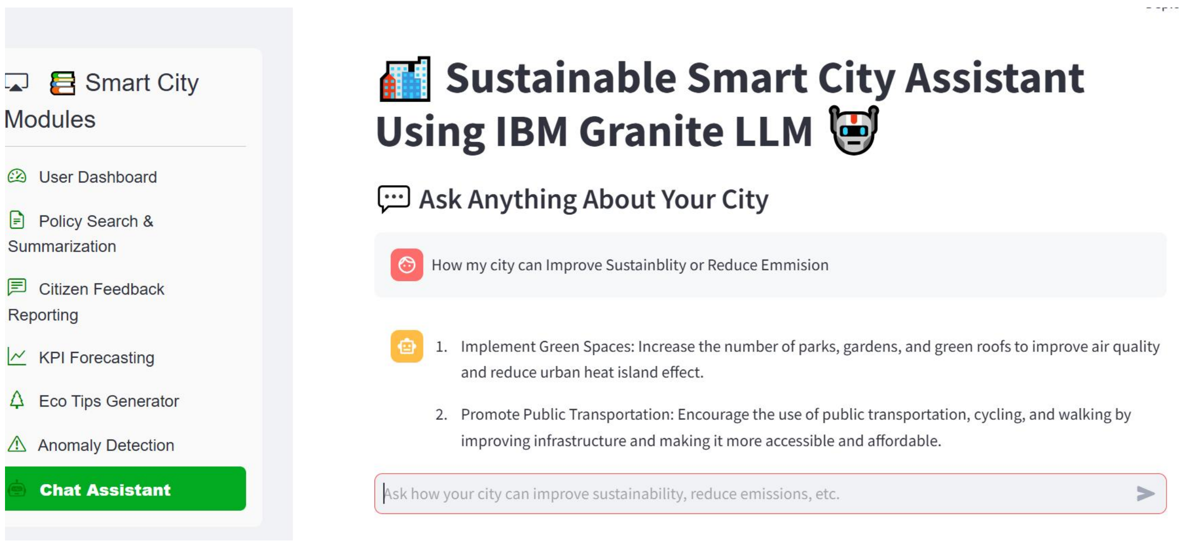
✅ Anomalies detected!

Detected Anomalies

```
        Zone 6,May,1230
        Zone 10,May,1180

1. Compare the energy consumption of each zone to the average energy consumption across all zones in May.
2. Identify any zones with energy consumption that deviates significantly from the average.
3. Provide a possible explanation for the identified anomaly, considering factors such as unusual usage
patterns, equipment malfunctions, or data entry errors.

Analysis:
1. Average energy consumption across all zones in May = (1200+1250+1220+1190+4200+1210+1230+1180)/8 =
1671.25 kWh
```



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💬 Ask Anything About Your City

How my city can Improve Sustainblity or Reduce Emmision

1. Implement Green Spaces: Increase the number of parks, gardens, and green roofs to improve air quality and reduce urban heat island effect.
2. Promote Public Transportation: Encourage the use of public transportation, cycling, and walking by improving infrastructure and making it more accessible and affordable.

Ask how your city can improve sustainability, reduce emissions, etc.