SUSTAINABLE SMART CITY ASSISTANT USING IBM GRANITE LLM

1. Introduction

• Project title : Sustainable Smart City Assistant Using IBM Granite LLM

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2. Project Overview

Purpose:

The **Sustainable Smart City Assistant project using IBM Granite LLM** aims to leverage AI to enhance urban sustainability, efficiency, and livability by optimizing city services like traffic, energy, waste, and water management through real-time data analysis. The assistant would promote green technologies, suggest sustainable practices, and engage citizens by providing personalized recommendations on energy conservation, transportation, and waste reduction. It would also support city officials in making data-driven decisions, offer insights on climate resilience and disaster management, and automate tasks related to sustainability. Additionally, the assistant would facilitate real-time interactions, integrate with IoT devices, and assist in long-term urban planning to create eco-friendly, adaptable cities. Ultimately, the project seeks to foster a smarter, more sustainable urban ecosystem that balances development with environmental preservation.

Features:

Real-Time City Optimization

Key Points: Manages traffic, energy, waste, and water.

Functionality: Uses IoT data to optimize city services in real-time.

Sustainability Recommendations

Key Points: Recommends green technologies and eco-friendly urban planning.

Functionality: Analyzes environmental data and suggests improvements.

Citizen Engagement

Key Points: Allows citizens to interact, report issues, and get personalized eco-tips.

Functionality: Provides a platform for real-time citizen queries and feedback

Environmental Monitoring

Key Points: Tracks pollution, air quality, and energy usage.

Functionality: Sends alerts and suggestions for reducing environmental impact.

Data-Driven Decision Support

Key Points: Supports city planning and sustainability efforts.

Functionality: Analyzes data for informed urban development decisions.

Automated Sustainability Reporting

Key Points: Automates tracking of sustainability progress.

Functionality: Generates reports on energy use, waste reduction, and other metrics.

Climate Risk Prediction

Key Points: Identifies climate-related threats (e.g., floods, heatwaves).

Functionality: Offers strategies for disaster preparedness and risk mitigation.

Personalized Recommendations

Key Points: Provides tailored advice for individuals on sustainability.

Functionality: Recommends energy-saving, transport, and recycling options.

IoT Integration

Key Points: Integrates with smart devices across the city.

Functionality: Automates and optimizes city infrastructure in real-time.

Long-Term Urban Planning

Key Points: Simulates future urban growth and sustainability scenarios.

Functionality: Offers solutions for eco-friendly city expansion and development.

3. Architecture

Data Collection:

IoT Devices (sensors, cameras) gather real-time data on traffic, energy, waste, and environment.

Data Processing:

Edge Computing handles immediate decisions (e.g., traffic).

Data Lake stores and processes data for analysis.

AI & Machine Learning:

IBM Granite LLM powers NLP and AI-driven insights.

Predictive Analytics and Optimization improve city services.

Smart Infrastructure:

Integrates with city systems (traffic, energy, waste) for automation and optimization.

Frontend (User Interface):

Citizen Apps & Web Portals for interaction, queries, and receiving personalized tips.

Real-Time Dashboards show sustainability metrics.

Backend:

API Layer connects frontend with backend and external systems.

Cloud Services (IBM Cloud) host AI models and store data securely.

Feedback & Monitoring:

Real-Time Analytics track performance and user feedback for system improvements.

Reporting & Analytics:

Dashboards provide actionable insights and reports for city officials.

4. Setup Instructions

Prerequisites

IBM Cloud Account (for AI, IoT, and cloud services).

IoT Devices (sensors, smart meters).

Development Tools: Node.js, React (or Angular), Python, Docker.

Backend Setup

IBM Cloud Setup:

Create Watson Studio (AI/ML), Cloud Functions (serverless functions), and IoT Platform

API Development:

Set up a Node.js backend with Express to handle requests and integrate IBM Granite LLM for AI responses.

IoT Integration:

Use IBM IoT Platform to connect devices and send data (traffic, energy) to cloud.

Frontend Setup

React App:

Create a React app for citizen interaction and dashboards.

npx create-react-app smart-city-dashboard

API Integration:

Use axios to call backend APIs for real-time data and recommendations.

Deploy Frontend:

Deploy the React app to IBM Cloud (via Cloud Foundry or Static Hosting).

Cloud Integration & Security

Cloud Functions:

Deploy backend as serverless functions.

Security:

Use API Gateway and OAuth/JWT for secure access.

Testing & Deployment

Test IoT Data:

Ensure sensors send data correctly.

Test API & Frontend:

Test backend responses and frontend displays.

Deploy:

Deploy everything to IBM Cloud and monitor with Cloud Monitoring.

5. Folder Structure

/backend:

/controllers: API logic and handlers.

/routes: API route definitions.

server.js: Main backend server file.

/frontend:

/components: React or Angular UI components.

App.js: Main entry point for the frontend.

/config:

config.js: Configuration files for settings, API keys, etc.

README.md: Project documentation and instructions.

6. Running the Application

Clone the Repository

- Clone the repository to your local machine:
- git clone https://github.com/your-repository/smart-city-assistant.git
- cd smart-city-assistant

Backend Setup

Step 1: Install Dependencies

•Navigate to the /backend directory:

•cd backend

•Install required packages:

•npm install

Step 2: Configure Environment

•Create a .env file in the /backend directory and add necessary configuration variables (e.g., database URL, API keys):

•PORT=3000

•DB_URL=your-database-url

•API_KEY=your-api-key

Step 3: Start the Backend Server

•Run the backend server:

•npm start

•The backend should be live at http://localhost:3000.

Frontend Setup

Step 1: Install Dependencies

•Navigate to the /frontend directory:

•cd frontend

•Install frontend dependencies:

•npm install

Step 2: Configure Environment

•Create a .env file in the /frontend directory and set the API URL:

•REACT_APP_API_URL=http://localhost:3000

Step 3: Start the Frontend Server

•Run the frontend server:

•npm start

•The frontend should now be running at http://localhost:3001.

Accessing the Application

•Backend: Open http://localhost:3000 for API testing.

•Frontend: Open http://localhost:3001 to interact with the UI.

Stopping the Servers

•Press Ctrl + C in both backend and frontend terminal windows to stop the servers.

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.

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

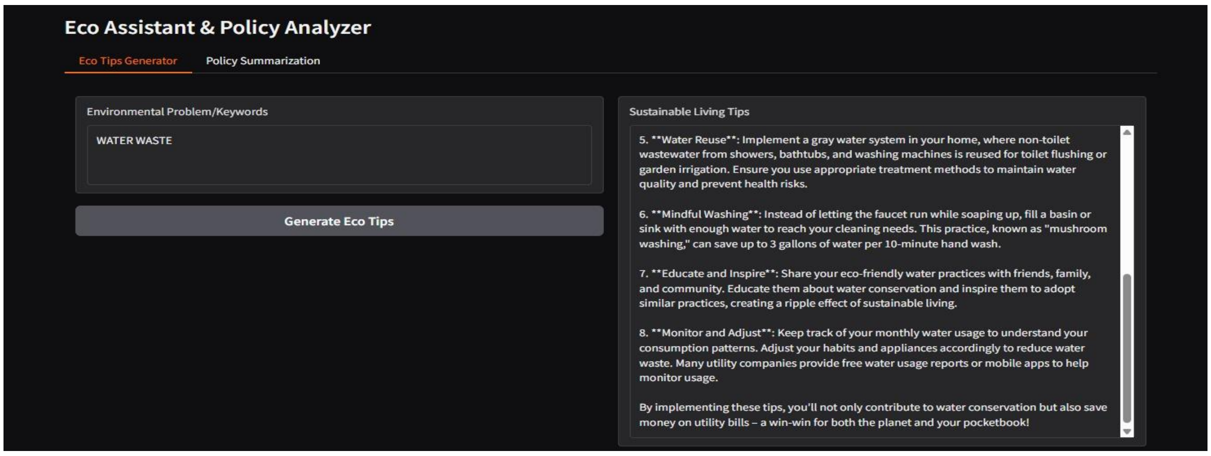
API Testing: Via Swagger UI, Postman, and test scripts

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.Screenshots



WATER WASTE

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5. **Water Reuse**: Implement a gray water system in your home, where non-toilet wastewater from showers, bathtubs, and washing machines is reused for toilet flushing or garden irrigation. Ensure you use appropriate treatment methods to maintain water quality and prevent health risks.

6. **Mindful Washing**: Instead of letting the faucet run while soaping up, fill a basin or sink with enough water to reach your cleaning needs. This practice, known as "mushroom washing," can save up to 3 gallons of water per 10-minute hand wash.

7. **Educate and Inspire**: Share your eco-friendly water practices with friends, family, and community. Educate them about water conservation and inspire them to adopt similar practices, creating a ripple effect of sustainable living.

8. **Monitor and Adjust**: Keep track of your monthly water usage to understand your consumption patterns. Adjust your habits and appliances accordingly to reduce water waste. Many utility companies provide free water usage reports or mobile apps to help monitor usage.

By implementing these tips, you'll not only contribute to water conservation but also save money on utility bills – a win-win for both the planet and your pocketbook!
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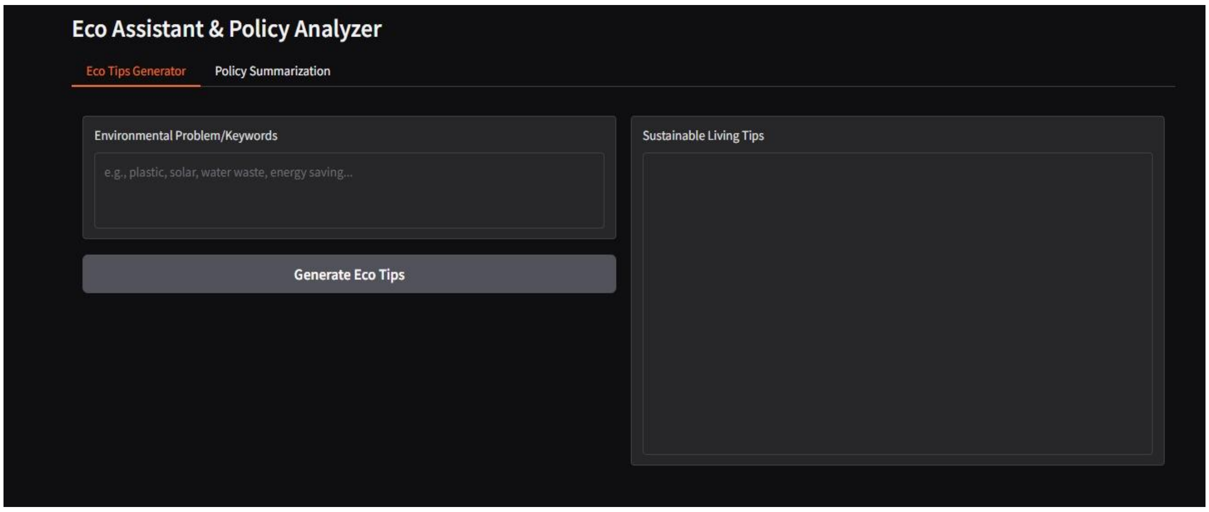
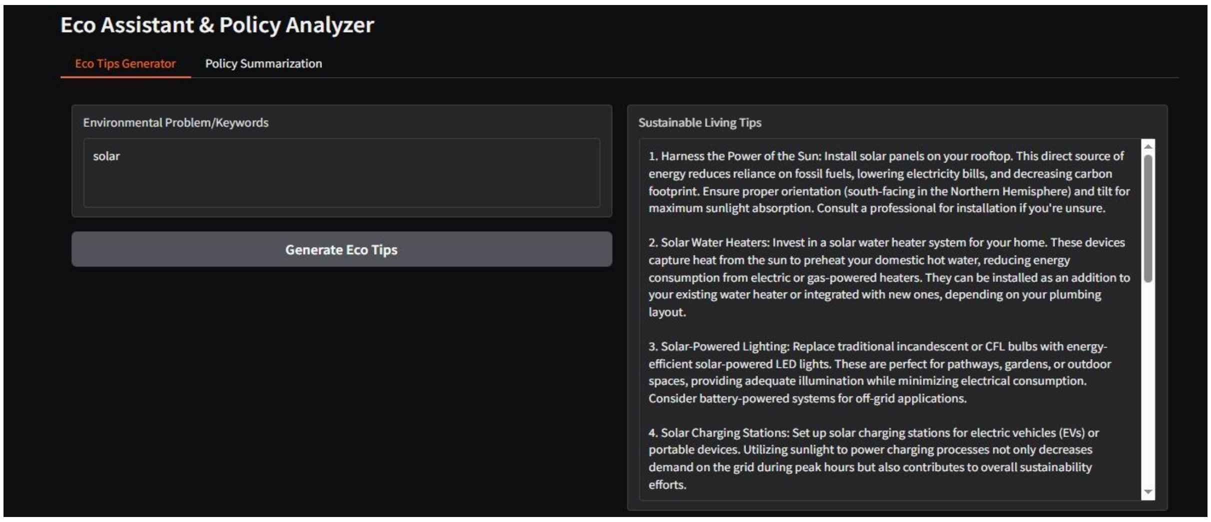

Eco Assistant & Policy Analyzer
Eco Tips Generator
Policy Summarization
Environmental Problem/Keywords
e.g., plastic, solar, water waste, energy saving...
Generate Eco Tips
Sustainable Living Tips



solar

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1. Harness the Power of the Sun: Install solar panels on your rooftop. This direct source of energy reduces reliance on fossil fuels, lowering electricity bills, and decreasing carbon footprint. Ensure proper orientation (south-facing in the Northern Hemisphere) and tilt for maximum sunlight absorption. Consult a professional for installation if you're unsure.

2. Solar Water Heaters: Invest in a solar water heater system for your home. These devices capture heat from the sun to preheat your domestic hot water, reducing energy consumption from electric or gas-powered heaters. They can be installed as an addition to your existing water heater or integrated with new ones, depending on your plumbing layout.

3. Solar-Powered Lighting: Replace traditional incandescent or CFL bulbs with energy-efficient solar-powered LED lights. These are perfect for pathways, gardens, or outdoor spaces, providing adequate illumination while minimizing electrical consumption. Consider battery-powered systems for off-grid applications.

4. Solar Charging Stations: Set up solar charging stations for electric vehicles (EVs) or portable devices. Utilizing sunlight to power charging processes not only decreases demand on the grid during peak hours but also contributes to overall sustainability efforts.
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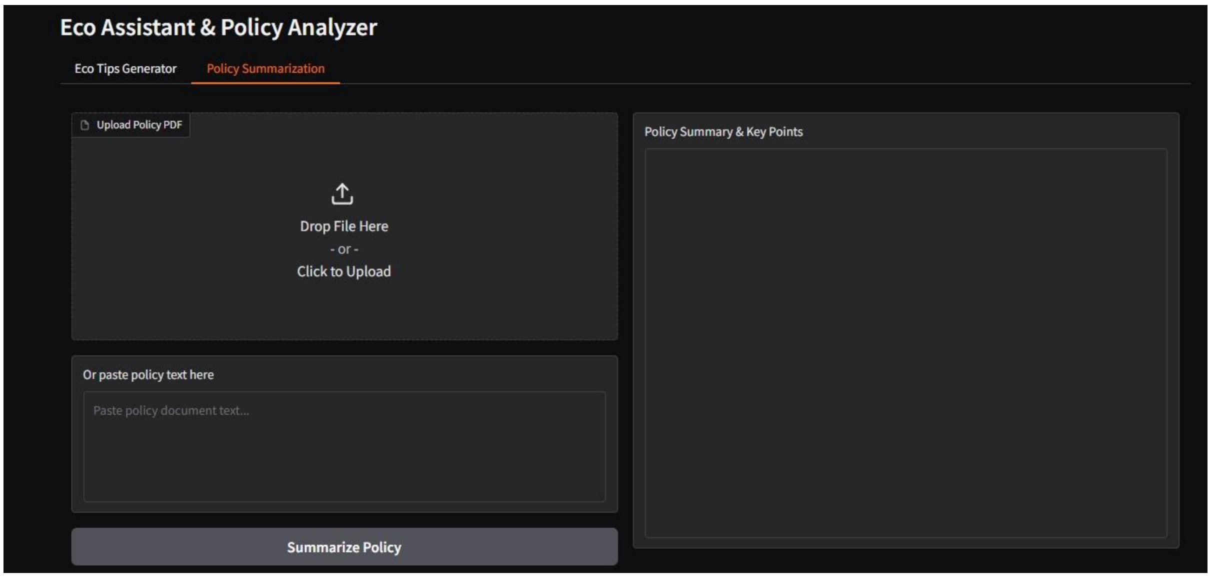
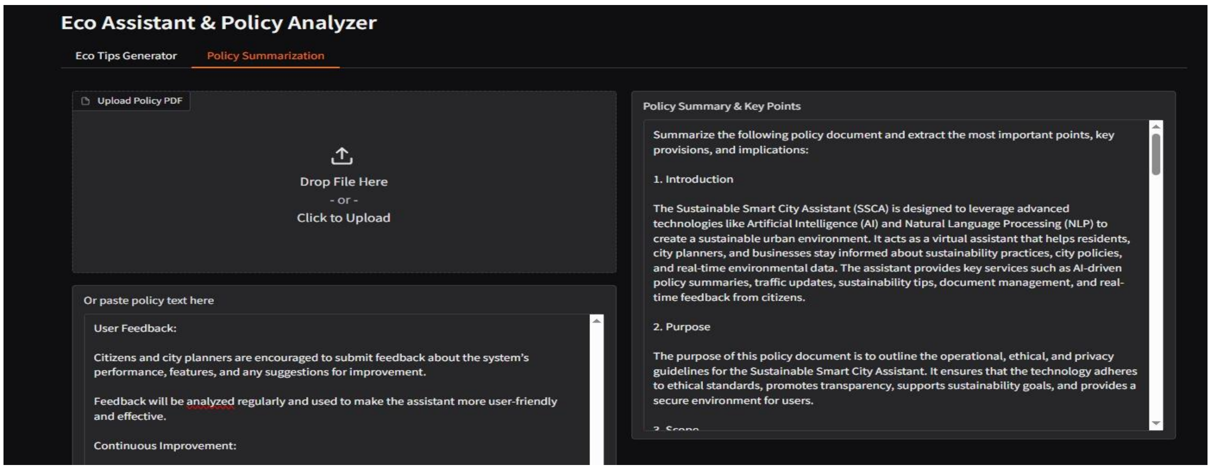

Eco Assistant & Policy Analyzer
Eco Tips Generator
Policy Summarization
Upload Policy PDF
Drop File Here
- or -
Click to Upload
Or paste policy text here
Paste policy document text...
Summarize Policy
Policy Summary & Key Points



User Feedback:

Citizens and city planners are encouraged to submit feedback about the system's performance, features, and any suggestions for improvement.

Feedback will be analyzed regularly and used to make the assistant more user-friendly and effective.

Continuous Improvement:

Summarize the following policy document and extract the most important points, key provisions, and implications:

1. Introduction

The Sustainable Smart City Assistant (SSCA) is designed to leverage advanced technologies like Artificial Intelligence (AI) and Natural Language Processing (NLP) to create a sustainable urban environment. It acts as a virtual assistant that helps residents, city planners, and businesses stay informed about sustainability practices, city policies, and real-time environmental data. The assistant provides key services such as AI-driven policy summaries, traffic updates, sustainability tips, document management, and real-time feedback from citizens.

2. Purpose

The purpose of this policy document is to outline the operational, ethical, and privacy guidelines for the Sustainable Smart City Assistant. It ensures that the technology adheres to ethical standards, promotes transparency, supports sustainability goals, and provides a secure environment for users.

12. Known Issues

Technical Issues

- Hallucinations: May give incorrect or made-up answers.
- Prompt Sensitivity: Output quality changes with small prompt tweaks

Limited Domain Accuracy: May struggle with smart city–specific topics (e.g., energy grids, urban planning).

Latency: Large models can be slow, not ideal for real-time needs.

Multimodal Limitations: Speech/image inputs may have higher error rates.

Safety & Ethics

Bias & Unsafe Outputs: Risk of offensive, biased, or misleading content.

Explainability: Hard to trace why the assistant made a decision.

Data & Privacy

Sensitive Data Handling: Risk if private city data is used without proper control.

Compliance: Needs to meet local privacy laws (e.g. GDPR).

Sustainability Concerns

High Energy Use: Large models require lots of compute, raising environmental concerns.

Maintenance Needs

Requires regular updates for models, data, and safety check

13.Future Enhancement

Environmental Monitoring

- Real-time analysis of air, water, and noise using IoT + Granite.
- Predictive alerts for pollution and climate risks.
- Personal & neighborhood carbon footprint tracking.

Citizen Interaction

- Multilingual and voice-based support for inclusivity.
- Personalized sustainability tips and alerts.

Urban Planning & Mobility

- AI-generated smart urban development models.
- Sustainable transport suggestions and traffic optimization.

Energy & Waste Management

•Smart energy-saving recommendations for homes.

•AI-assisted waste sorting and optimized collection routes.

AI Ethics & Engagement

•Privacy-first data handling and explainable AI.

•Eco-score gamification to engage citizens.

IBM Ecosystem Integration

• Connect with IBM Maximo, Watsonx for infrastructure and decision support

•Use Granite LLM for intelligent, scalable city solutions.