Sustainable Smart City Assistant Using Granite LLM

Project Documentation

1. Introduction

- Project Title: Sustainable Smart City Assistant
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2. Project Overview

Purpose

The Sustainable Smart City Assistant empowers cities and citizens to thrive in an eco-conscious and connected urban environment. By leveraging IBM Watsonx Granite LLMs, Pinecone vector database, and real-time data analytics, it optimizes energy, water, and waste usage while providing actionable sustainability insights.

For citizens, it delivers policy summaries, eco-tips, and chatbot support.
For officials, it provides decision-making insights, anomaly detection, KPI forecasting, and sustainability reports.

Features

- **Conversational Chat Assistant** – Natural language Q&A powered by IBM Watsonx Granite.
- **Policy Summarization** – Converts lengthy government documents into concise, actionable summaries.
- **Eco Tip Generator** – Provides personalized, practical sustainability advice.
- **Citizen Feedback Loop** – Collects and analyzes public feedback to guide planning.
- **KPI Forecasting** – Predicts trends in air quality, energy, and green cover.

- **Anomaly Detection** – Flags unusual values in KPI/sensor data.
- **Document & Data Search** – Uses Pinecone vector embeddings for semantic retrieval.
- **City Report Generator** – Produces structured sustainability reports.
- **Multimodal Input** – Accepts PDFs, CSVs, and text files.
- **Interactive Dashboard** – Built with Streamlit for a user-friendly interface.

3. Architecture

Frontend (Streamlit)

- Provides navigation sidebar with modules: **Chat, Policy Summarizer, Eco Tips, KPI & Report Dashboard**.
- Visualizes KPIs with metrics, anomaly detection flags, and bar charts.

Backend (FastAPI)

- Exposes REST API endpoints for summarization, chat, eco tips, feedback, reports, and vector search.
- Fully documented via **Swagger UI** (/docs).

LLM Integration (IBM Watsonx Granite)

- Uses **Granite family of LLMs** via IBM Cloud API key authentication.
- Handles summarization, report generation, eco-tips, and chat.

Vector Search (Pinecone)

- Sentence-transformer embeddings stored in Pinecone.
- Semantic search enables users to query policies and city data in natural language.

ML Modules

- **Forecasting:** Uses scikit-learn regression to project KPIs.
- **Anomaly Detection:** Identifies unusual KPI values with threshold and statistical methods.

4. Setup Instructions

Prerequisites

- Python 3.9+
- IBM Watsonx API key, Project ID, Model ID
- Pinecone API key
- Virtual environment & pip

Installation

git clone <your-repo-url>

cd smartcity-assistant-starter

python -m venv .venv

.\.venv\Scripts\activate # Windows

pip install -r requirements.txt

Environment Variables (.env)

WATSONX_API_KEY=pAjcxi3Df0g687V0mCe3_Q8TmRKSDlp9wuIxo52qwNn5

WATSONX_PROJECT_ID=f371addd-61dd-4ff0-882d-571db5a32aea

WATSONX_URL=https://eu-de.ml.cloud.ibm.com

WATSONX_MODEL_ID=ibm/granite-13b-instruct-v2

PINECONE_API_KEY=pcsk_22YGB3_9RY8BMqaUZN55nkxUA7nR7ZyhBnKA1LjW44XtRpkeo43rcmj2yw4HrPhQfQbafu

PINECONE_ENV=us-east-1

INDEX_NAME=smartcity-policies

Running

Backend:

uvicorn app.main:app --reload

Frontend:

streamlit run frontend/smart_dashboard.py

5. Folder Structure

app/

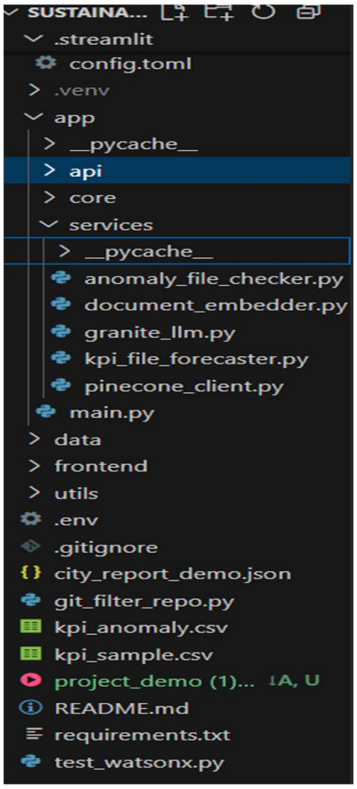
├── api/ # FastAPI routers

├── core/ # Config & Pinecone client

├── services/ # LLM, embeddings, forecasting, anomaly detection

frontend/

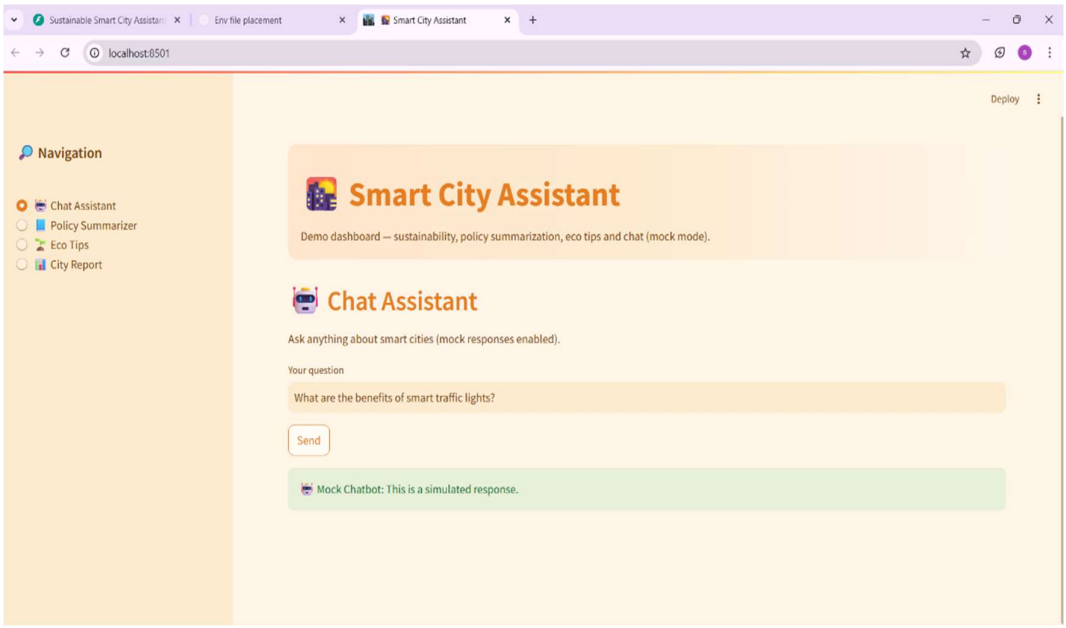
└── smart_dashboard.py # Streamlit frontend



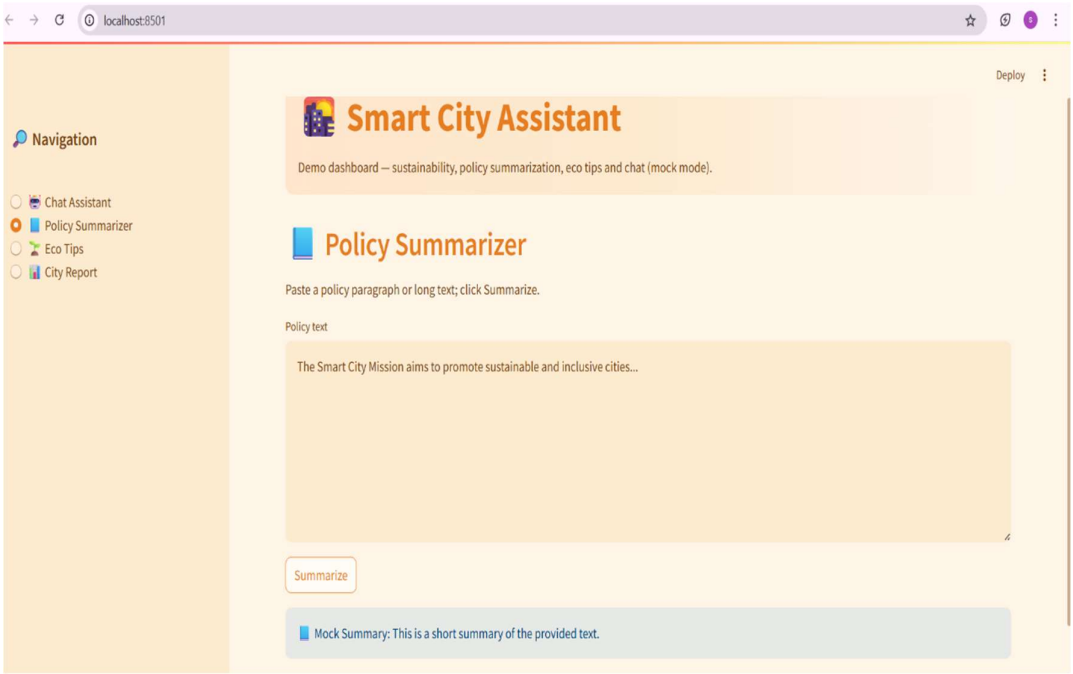
6. Running the Application

1. Start FastAPI backend → http://127.0.0.1:8000/docs
2. Start Streamlit frontend → http://localhost:8501
3. Navigate through:

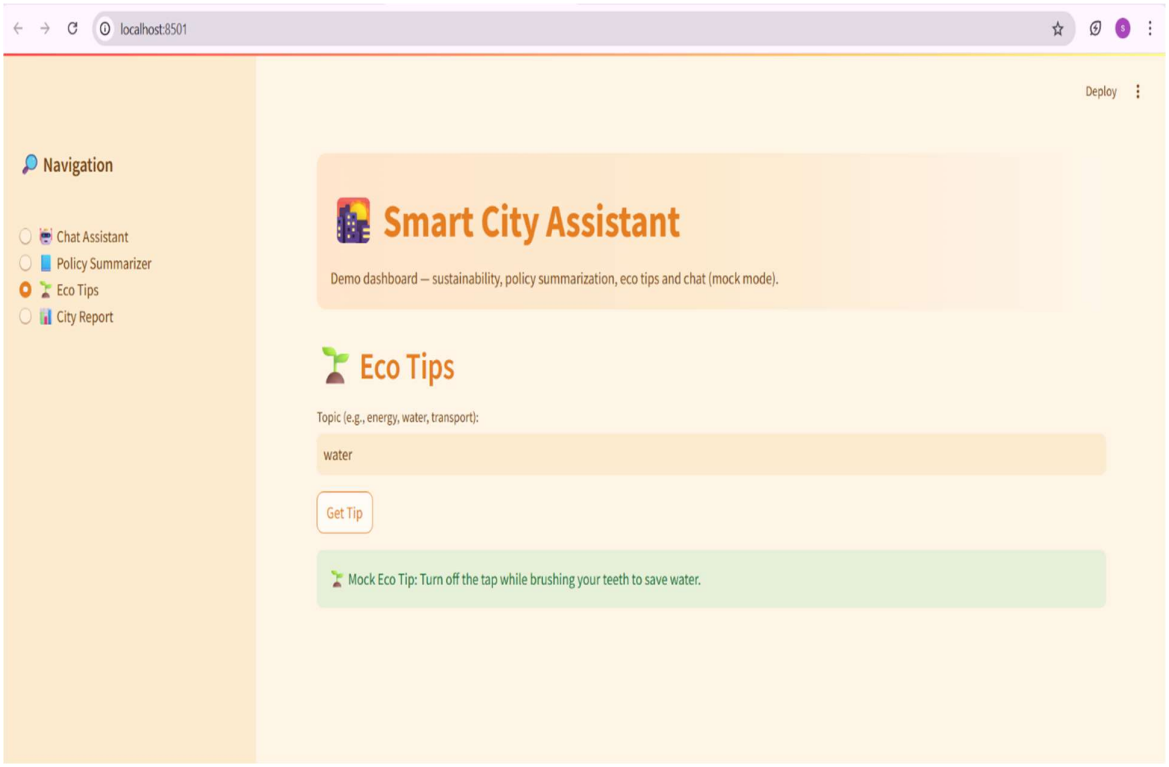
- Chat Assistant



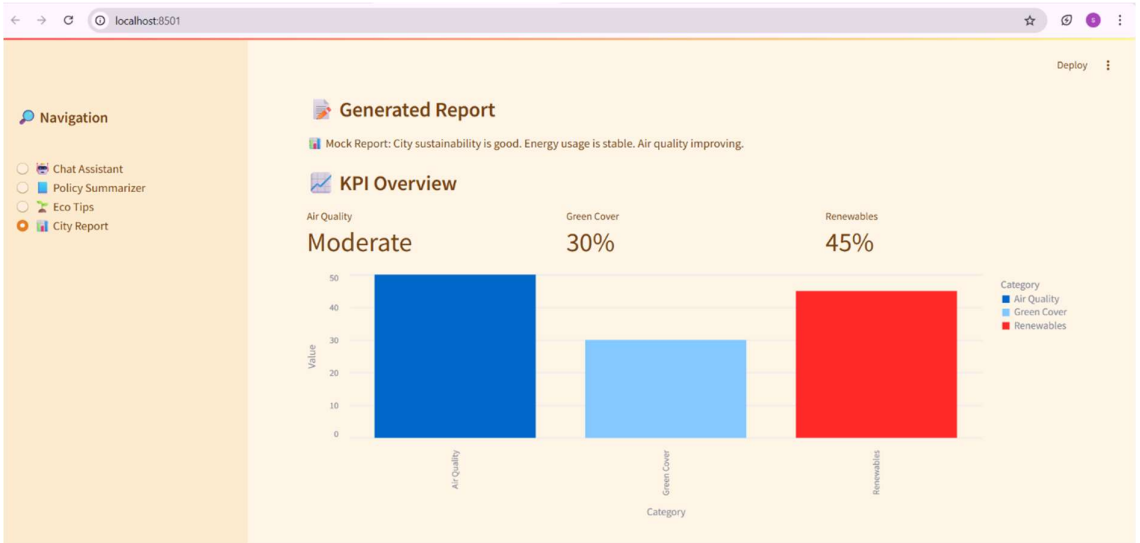
- Policy Summarizer



- Eco Tips



- KPI Dashboard & City Report



- Anomaly Checker

7. API Documentation

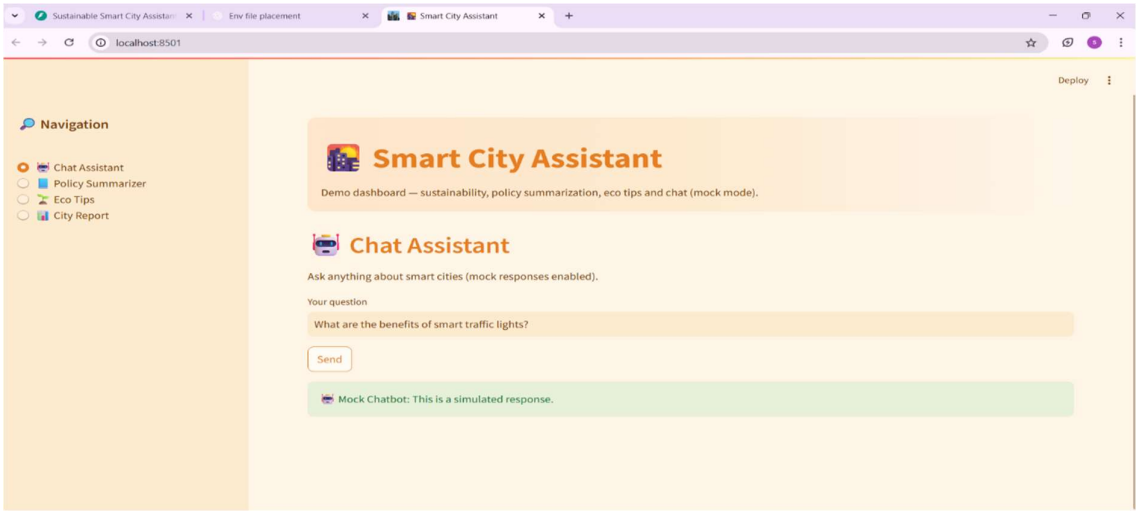
- POST /chat/ask → Smart city Q&A
- POST /policy/summarize → Summarize policy text
- GET /eco/tips?topic= → Eco tips
- POST /report/ → Generate city sustainability report
- POST /vector/upsert → Upload & embed documents
- GET /vector/search?query= → Search uploaded documents
- POST /feedback/ → Store citizen feedback

8. Authentication

- All IBM Watsonx endpoints require **IAM token (fetched via API key)**.
- Pinecone requires API key & environment ID.
- Can extend with JWT/OAuth2 for secure production deployment.

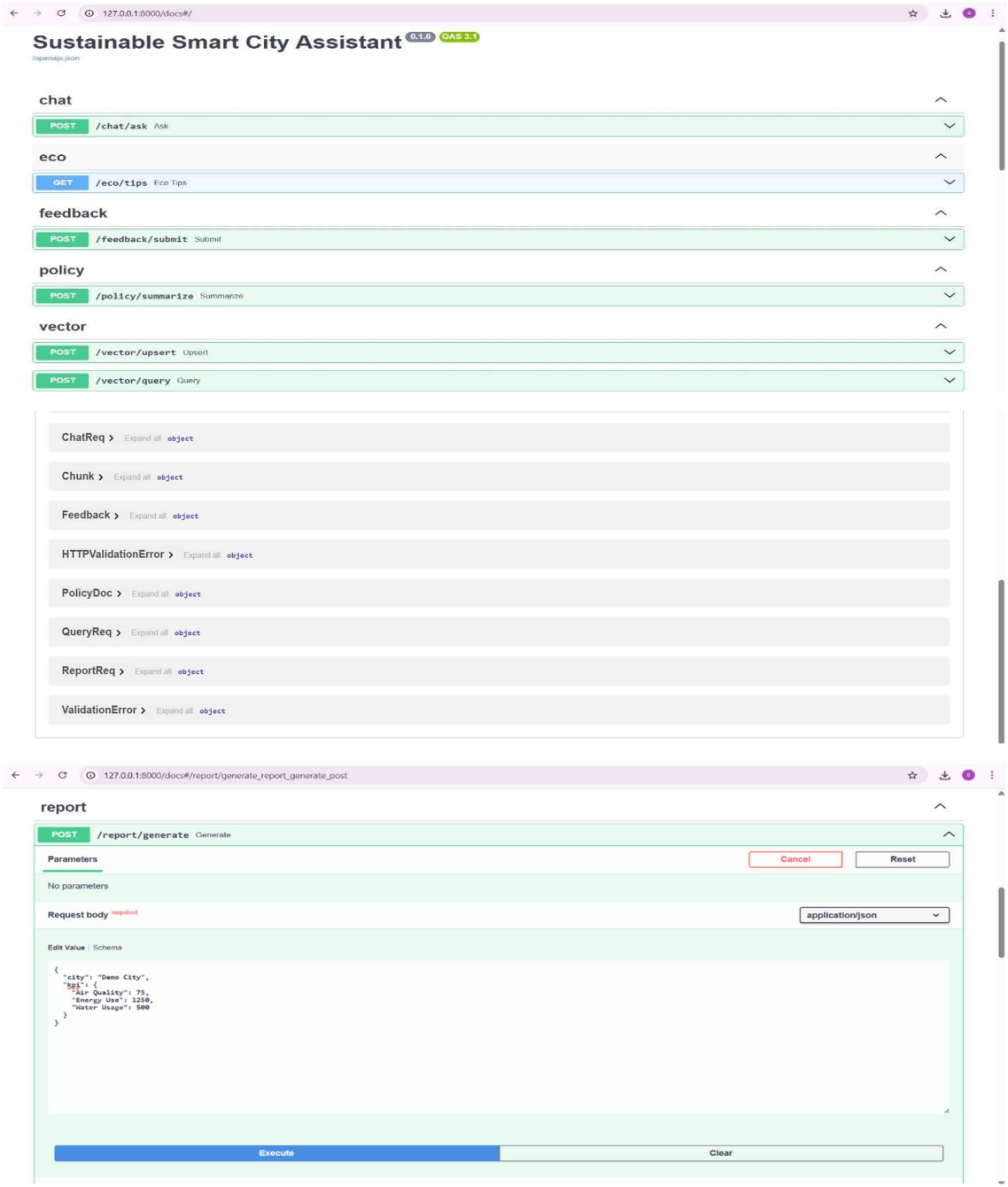
9. User Interface

- Clean **Streamlit dashboard** with sidebar navigation.
- KPI visualizations with cards & bar charts.
- Tabbed layouts for summaries, eco tips, anomaly detection, and forecasting.



10. Testing

- **Unit Tests** for LLM prompt functions.
- **API Tests** via Swagger & Postman.
- **Manual Testing** for frontend flows.
- **Edge Cases** → invalid inputs, large files, missing credentials.



11. Future Enhancements

- Role-based access control (Admin, Citizen, Researcher).
- Real-time IoT sensor integration for KPIs.
- Geo-mapping dashboard with sustainability layers.
- Multilingual support with IBM Watson Language Translator.