Data to Decisions: The CityPath Playbook

Turning space data into local action for healthier, resilient cities

2025

NASA SPACE APPS CHALLENGE

Team Laniakea

Linked Table of Contents

Project Title & Team Info

CityPath Builder

Project : CityPath
— Smarter Cities With NASA Data

Team Laniakea

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Graphics Designer
Contribution: Video editing, Graphics design, prototyping

Project Summary

CityPath is an urban intelligence **web & mobile platform** for the NASA Space Apps 2025 Challenge: **Data Pathways to Healthy Cities & Human Settlements.** The **pilot project** currently focuses on **Dhaka**, offering an interactive map, AI assistance for urban planners, and community event creation at key hotspots, with general users able to join initiatives. The system uses NASA datasets: **GIBS** for base maps, **MODIS** for environmental monitoring, Landsat **NDVI** for vegetation health, and Bangladesh population density for precise human settlement data. CityPath primarily supports **SDGs 11, 13, and 15**, while contributing to others, turning data into actionable solutions for healthier, sustainable cities.

Project

Webapp: https://city-builder.phigalaxy.com/
Mobile app: https://drive.google.com/file/d/1urUgLYIhBPKJZafl1751VrmobfNkGJlr/view?usp=sharing

GitHub

GitHub Repository: https://github.com/Himel-Tasrif/CityPath---NASA-Space-App-Challenge---2025
Data Folder: https://github.com/Himel-Tasrif/CityPath---NASA-Space-App-Challenge---2025/backend/app/data

Prototype & Data Visualization Tasks

Canva prototype: https://citypath-teamlaniakea.my.canva.site/prototype-citypath

Google colab link for data visualizations:
https://colab.research.google.com/drive/1gqBfj24UFr45OC3OMLHKvpXACKmbnkYq?usp=sharing

System Architecture

Diagram: https://drive.google.com/file/d/1i0eT9K_aF_aKLo00y3HsWloJ5KYqiXJc/view?usp=sharing

NASA Data Resources

- NASA GIBS → Basemaps
- MODIS → Land-Surface-Temperature (LST)
- LandSat → NDVI

Challenge & Problem Statement

NASA Challenge Name

Data Pathways to Healthy Cities and Human Settlements

Problem Statement

Urban and Environmental Challenge

Cities worldwide, especially in rapidly growing regions, are increasingly vulnerable to the Urban Heat Island (UHI) effect, where built surfaces such as asphalt, concrete, and rooftops absorb and retain heat, making urban areas significantly warmer than their rural surroundings (NASA Earth Observatory).
Compounding this, many cities lack sufficient green infrastructure—parks, trees, and vegetated surfaces—that provide natural cooling through shade and evapotranspiration. NASA research shows that green spaces can reduce urban temperatures by approximately 2.5 °C (≈4.5 °F) compared to non-greened areas (NASA Climate Data).

Without proactive interventions, this trend intensifies:
- Elevated daytime and nighttime temperatures during heat waves
- Rising energy demand, especially for air conditioning
- Greater public health risks, including heat stress and respiratory illness
- Social inequities, as poorer neighborhoods often have less green coverage and disproportionately bear the heat burden

Why This Matters

- NASA's "Urban Extreme Heat" dataset quantifies rising heat exposure across more than 13,000 urban settlements, making clear that extreme heat is intensifying in many cities (NASA Earthdata).

- Satellite and Landsat-based studies have long documented UHI effects: for example, Providence showed ~12.2 °C higher surface temperature compared to surroundings, while Buffalo showed ~7.2 °C difference (Earth Observatory).
- NASA research supports mitigation strategies: converting dark roof surfaces to reflective or green roofs reduces heat load (NASA).
- Beyond temperature, green spaces confer mental-health benefits: NASA Earth Observatory notes that proximity to green space strongly correlates with lower risks of mood disorders, stress, and depression (Earth Observatory).
- There is a global inequality: green-space cooling capacity in Global South cities is about half that in Global North ones (≈2.1 °C vs. 3.8 °C) according to satellite-derived analyses (arXiv).

Taken together, these data underscore the urgent need for tools that help plan, monitor, and act on urban heat and greening to protect public health, reduce energy burden, and improve livability.

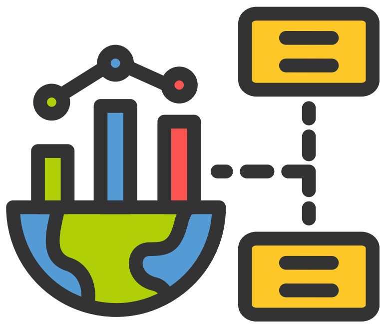
Target Users / Beneficiaries

- **Urban Planners & City Governments** — to identify priority areas for trees, parks, or reflective infrastructure investments.
- **Community & Neighborhood Leaders** — to advocate for green interventions in vulnerable, underserved communities.
- **Public Health Officials & NGOs** — to overlay heat exposure data with demographic risk to guide mitigation strategies.
- **Citizens & Local Communities** — to understand neighborhood-level heat risks and participate in small-scale actions (e.g., volunteer tree planting).
- **Researchers & Environmental Advocates** — to access geospatial models and insights that inform urban sustainability and policy.

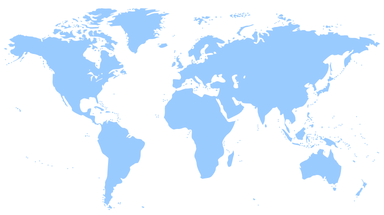
Objectives & Goals

Primary Goal

Enable data-driven urban planning and community action to mitigate urban heat effects, enhance green spaces, and improve city livability through scalable geospatial decision support.

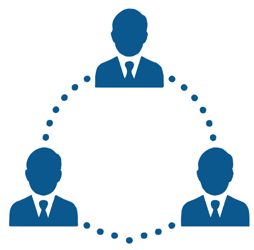


Secondary Goals & Features



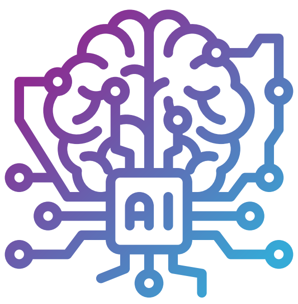
- Visualize urban heat hotspots, green space distribution, and population density using hex-based spatial IDs.
- Supports monitoring and scenario exploration.

Interactive Map



- Tailored insights for urban planners, community leaders, and citizens.
- Guides interventions, prioritization, and participation.

Role-Based Recommendations

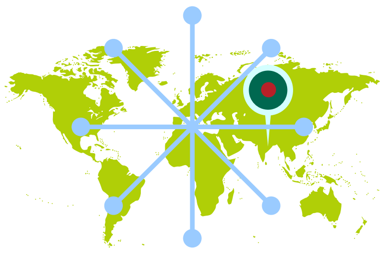


- Identify optimal locations for parks, tree planting, or cooling measures.
- Uses geospatial analysis of environmental and population datasets.

AI-Driven Site Selection

- Identify optimal locations for parks, tree planting, or cooling measures.
- Uses geospatial analysis of environmental and population datasets.

Citizen Engagement & Actionable Tasks



Pilot Evaluation & Scalability

- Prototype tested in Dhaka demonstrates accurate mapping of heat hotspots, green areas, and population distribution.
- Designed to be globally applicable and scalable to other cities.

Measurable Outcomes & Future Potential

- **Urban Heat Reduction**: Implementing targeted greening interventions—such as tree planting and green roofs—can significantly mitigate the urban heat island effect. NASA research indicates that areas with increased vegetation can experience surface temperature reductions of up to 2.4°F (approximately 1.3°C), depending on the extent of canopy cover and surface modifications (NASA Technical Reports Server).
- **Air Quality Improvement**: Enhancing urban green spaces not only cools the environment but also improves air quality. Vegetation helps filter pollutants and reduces airborne particulate matter, leading to healthier urban atmospheres (NASA Earthdata).
- **Global Applicability**: While the pilot project is based in Dhaka, the system's design is scalable. NASA's studies demonstrate that cities in the Global South, like Dhaka, have approximately 2.5°C less cooling capacity from green spaces compared to cities in the Global North. This underscores the potential impact of implementing green interventions in Dhaka (NASA Science).

Alignment with UN Sustainable Development Goals (SDGs)

SDG Goal	CityPath Action	Measurable Indicator	Reference
SDG 3 – Good Health & Well-being	Identification of heat hotspots & green coverage	Potential reduction in local ambient temperature by ~2–3 °C over 5 years if trees/green roofs are implemented in hotspot zones	Landsat-based UHI studies

SDG 11 – Sustainable Cities & Communities	Interactive map & role-based urban planning recommendations	% of city area with improved green coverage identified for intervention; prioritization of vulnerable neighborhoods	NASA Urban Extreme Heat dataset
SDG 13 – Climate Action	Simulation of UHI mitigation via reflective roofs & greening	Potential reduction in energy demand for cooling; modeled temperature decrease in pilot zones	NASA Earthdata, 2023
SDG 15 – Life on Land	Tree planting, park creation, and green roof location suggestions	Increase in urban vegetation index (NDVI) in selected pilot areas	NASA MODIS / Landsat Vegetation data
SDG 17 – Partnerships for the Goals	Multi-role engagement (urban planners, community leaders, citizens)	Number of actionable community interventions; citizen participation in events	NASA Open Data & collaborative urban projects

Solution Overview

How CityPath Works End-to-End:

1

Data Collection & Integration

- CityPath first gathers global datasets (NASA Earth data (AppEEARS API), SEDAC/WorldPop.
- These datasets are preprocessed and organized for city-scale analysis.

2

User Role Selection

- After data is ready, users select their role: Urban Planner, Local Leader, or Citizen.
- Role selection determines which features and actions are accessible.

3

City Visualization & Map Analysis

- Once a role is selected, users access an interactive map (web or mobile).
- Heat hotspots, green areas, and population density are displayed.
- Users can explore the city visually and identify points of interest.

4

Infrastructure / Activity Planning

- Urban Planners: After exploring the map, they select infrastructure types and areas. The system recommends optimal sites.
- Local Leaders: They can create events like tree planting, clean-ups, or water distribution.
- Citizens: They can choose activities to participate in, such as volunteering or planting trees.

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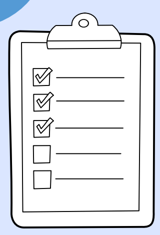


Action Execution & Tracking

- After planning, activities are carried out in the real world.
- Users (planners, leaders, citizens) log completed actions or upload proof (e.g., photos of tree planting).

6

Feedback & Impact Visualization

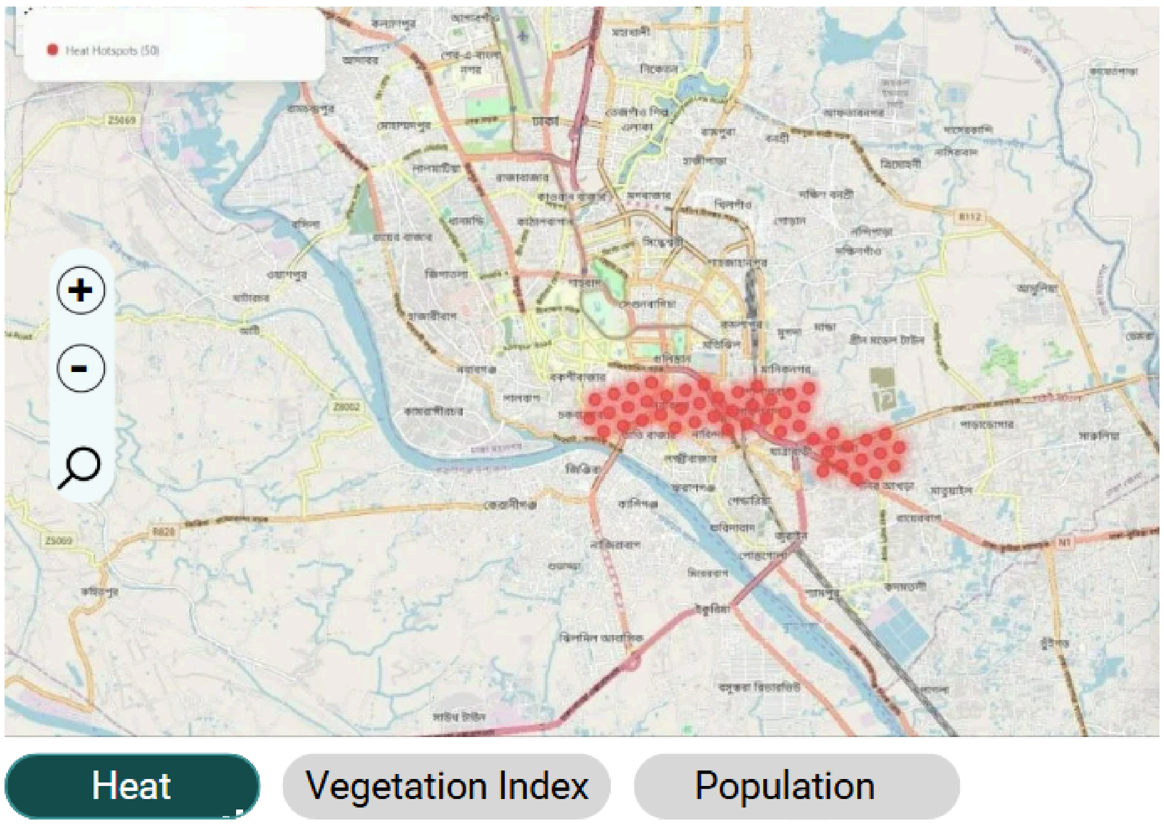
- After actions are logged, CityPath updates dashboards.
- Users see measurable outcomes: temperature, AQI, community participation.
- Continuous monitoring allows iterative improvement of city sustainability.

Key Features

- **Role-based user interactions:**

Users can enter CityPath as an Urban Planner, Local Leader, or General Explorer. Each role unlocks specific privileges tailored to their responsibilities — for example, Urban Planners access an AI assistant to identify suitable sites for infrastructure, Local Leaders can create and manage community events, and General Explorers can discover and respond to nearby activities.

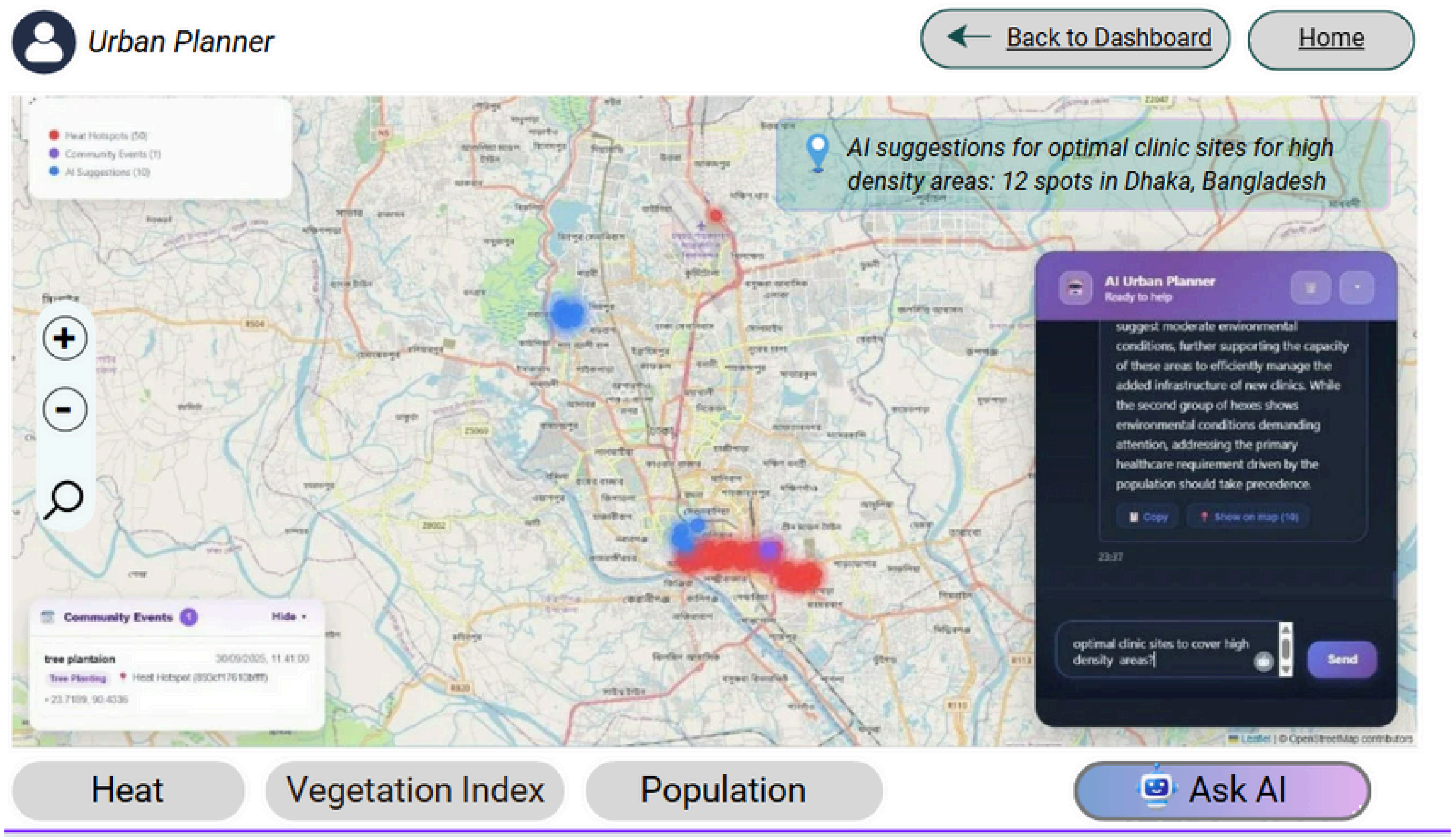
- **Interactive map:**



In CityPath, users can interact with the city map based on their area of interest, whether they are an Urban Planner, Local Leader, or General Explorer. The platform visualizes urban heat hotspots, vegetation index (NDVI), and population density using hex-based spatial IDs for precise analysis. By selecting the Heat, Vegetation, or Population options, users can toggle between datasets and explore different urban patterns.

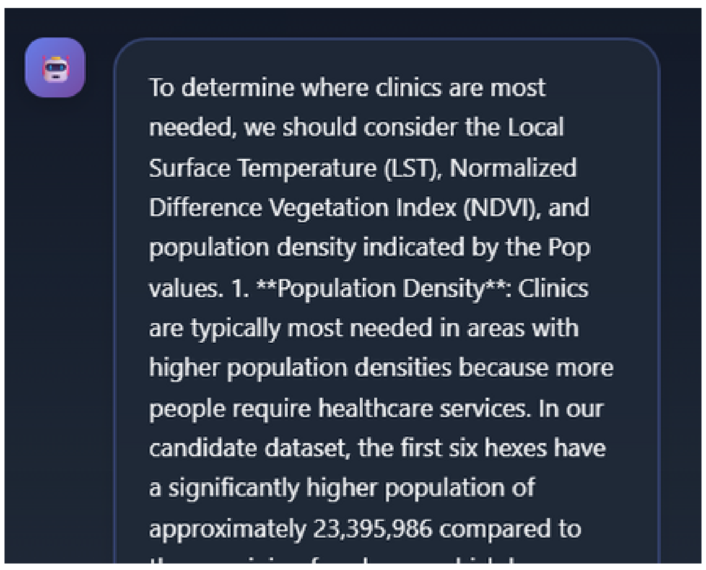
When a specific hex zone is highlighted, clicking on it reveals detailed insights such as temperature intensity, green coverage, or population concentration. While the pilot implementation is in Dhaka, Bangladesh, the system is designed to scale seamlessly to other cities worldwide.

- **Map-based infrastructure selection (urban planner privileges):**

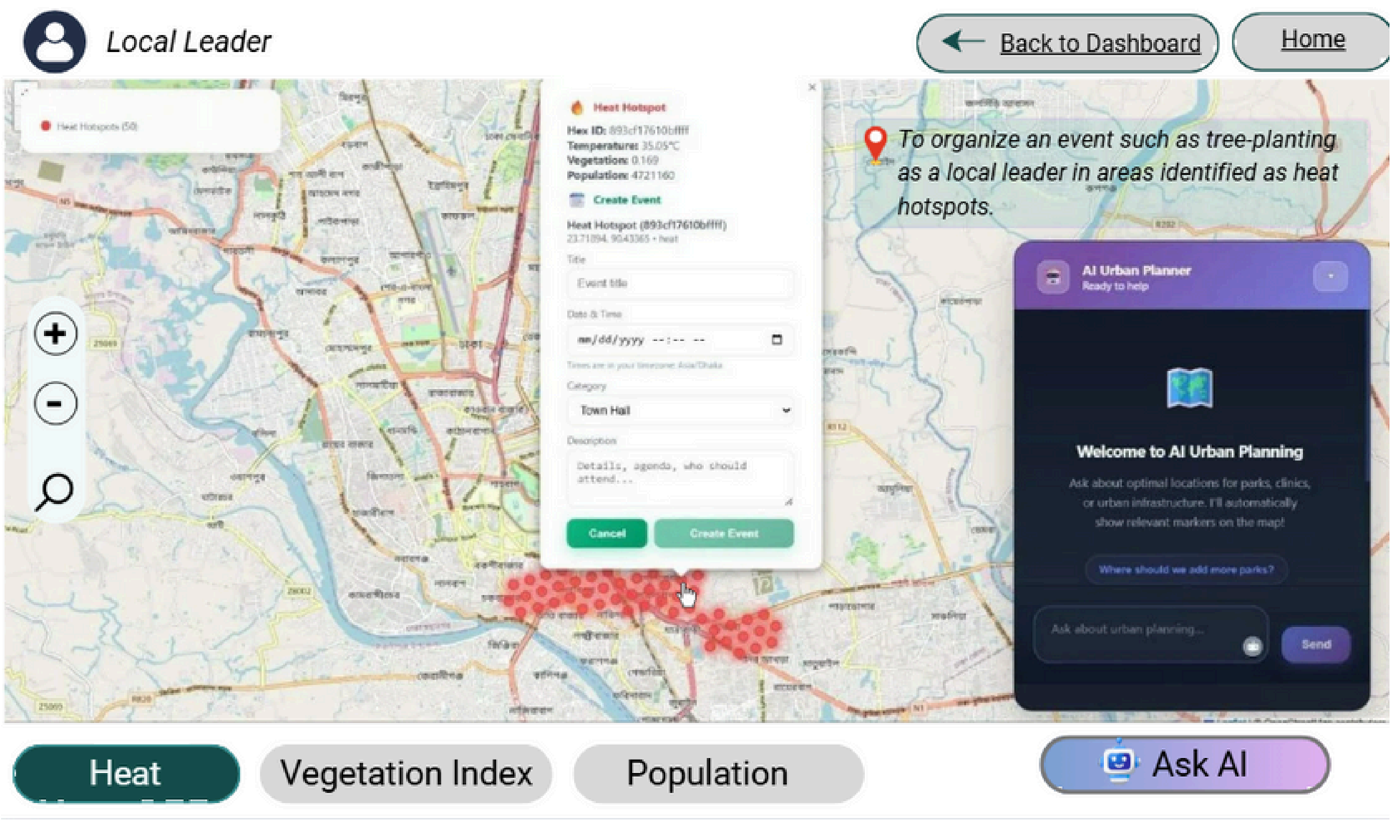


Urban Planners have access to an AI Assistant that uses geospatial analysis of environmental and population datasets to recommend optimal infrastructure sites. For example, residential and transport-related infrastructure can be planned in areas with suitable population distribution, while factories are better located in less populated zones. Clinics and healthcare facilities can be prioritized in densely populated areas, especially where disease risks are higher. Beyond infrastructure, the AI also supports heat mitigation strategies by identifying urban hotspots and recommending cooling measures. Integration of the vegetation index (NDVI) further ensures equitable green space distribution, contributing to both mental well-being and sustainable environmental development.

It not only highlights AI-recommended infrastructure sites but also displays the underlying reasoning and data insights for each suggestion, giving Urban Planners a transparent, reliable, and actionable basis for making informed decisions.

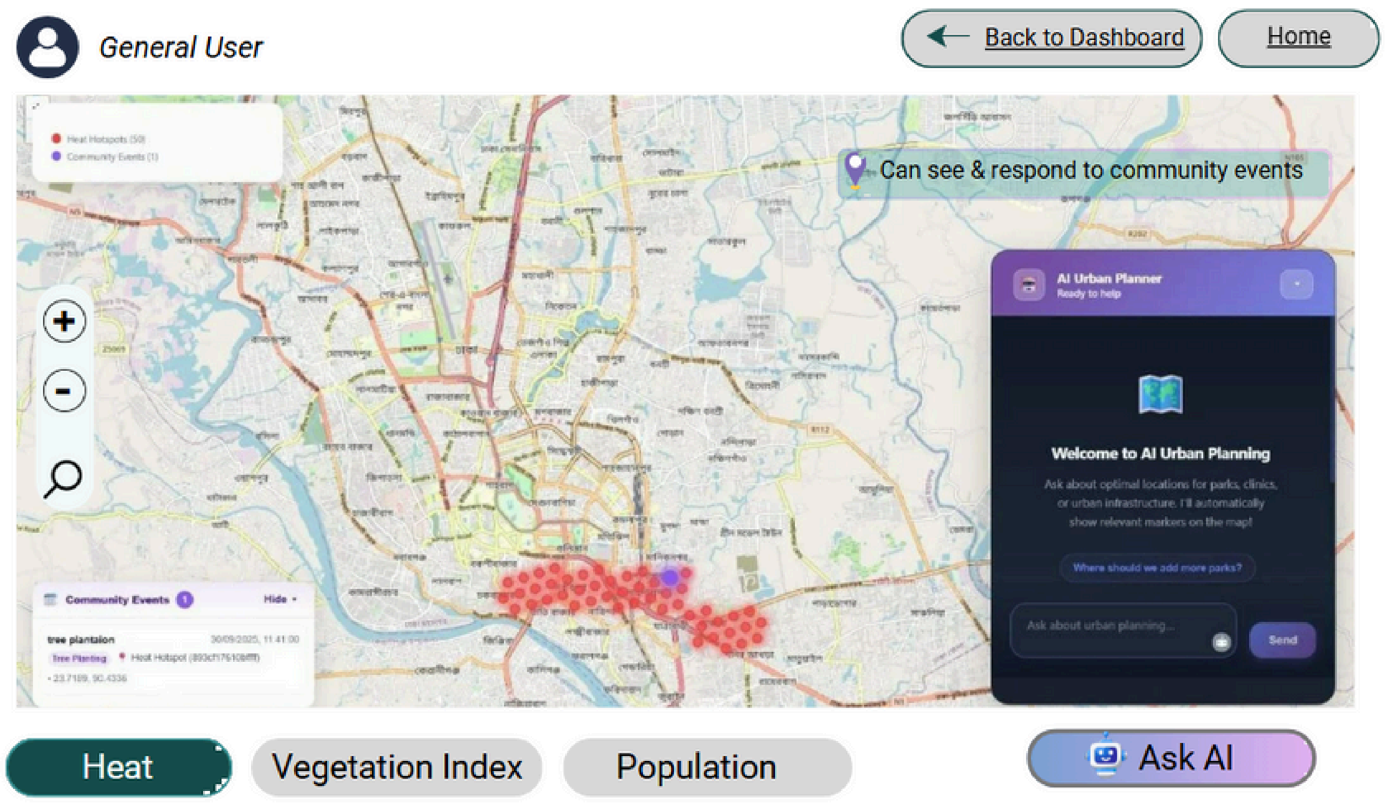


- **Community event creation (local leader privilege):**



On clicking a highlighted hotspot on the map, Local Leaders can instantly create targeted community events at that location. For example, in heat hotspots, they may launch tree plantation drives or set up free water distribution points, while in densely populated areas, they can organize vaccination campaigns, mask distribution, or rooftop greening programs. This feature turns data insights into immediate, location-specific action, enabling leaders to respond effectively to the city's most critical needs

- **View & respond to community events (general user privilege):**

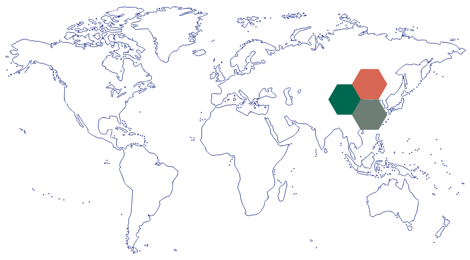


General users can browse all community events displayed on the map and respond or participate in those that interest them. Whether it's joining a tree plantation drive, a vaccination campaign, or a rooftop greening program, users can take meaningful, actionable steps to contribute to their local community, turning data-driven initiatives into real-world impact.

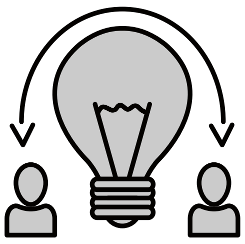
What Makes CityPath Stand Out?

Integrated Data Platform

AI-Driven Site Selection



Hex-Based Spatial Visualization



Role-Based Functionality

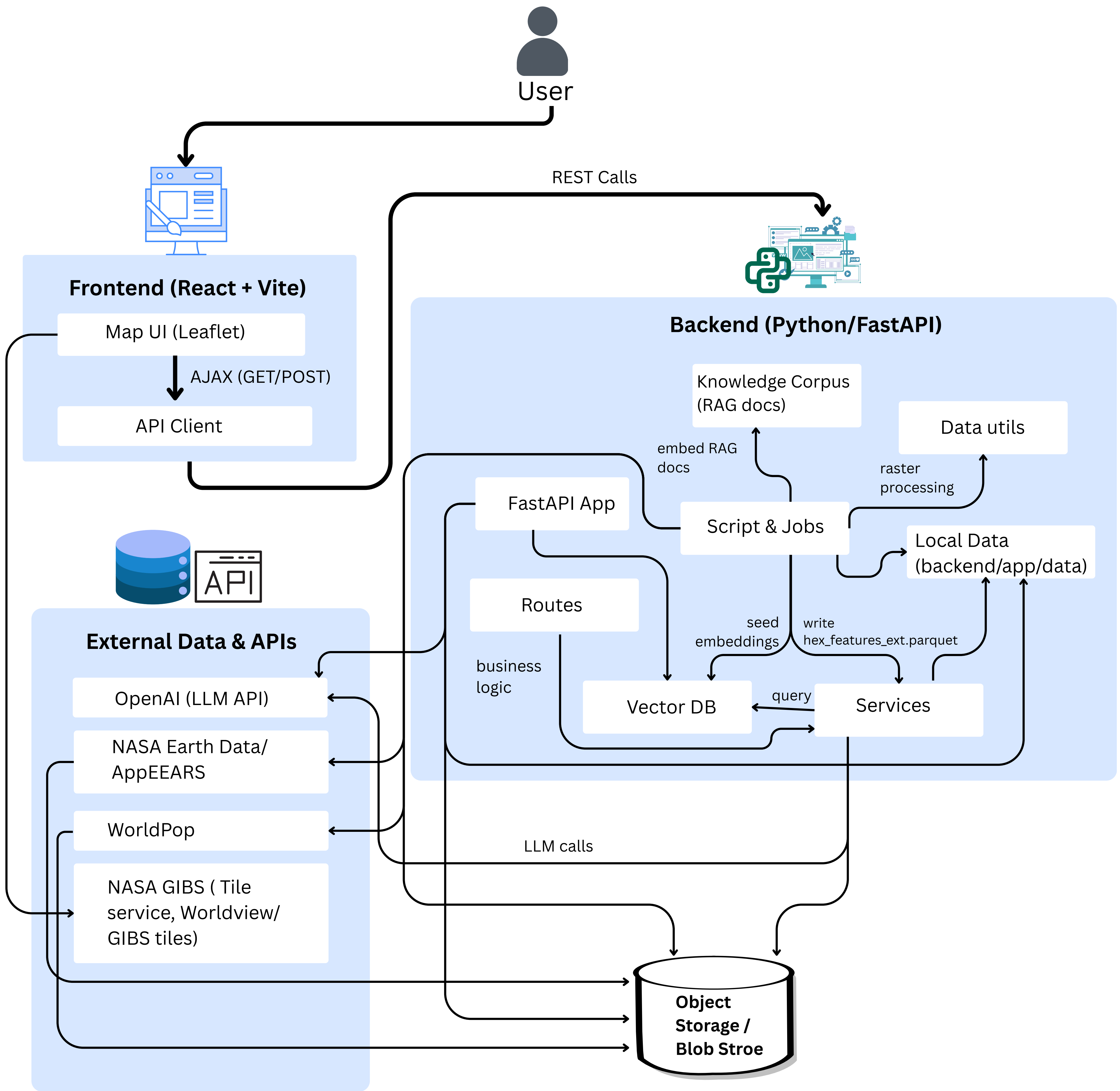
Actionable Insights

Scalable & Adaptable

System Architecture

System Architecture

Layered Client–Server Architecture with ETL Pipelines and Retrieval-Augmented Generation



Components

1. Frontend (React + Leaflet)
    - Interactive map UI with basemaps (OSM + NASA GIBS).
    - Layers for heat, greenness (NDVI), population, and air quality.
    - Chat panel for AI queries.

2. Backend (FastAPI in Python, with optional Node.js for extensions)
    - Data ingestion (MODIS LST, NDVI, WorldPop).
    - Hexagonal grid (H3) generation + metrics computation.
    - APIs: /hotspots, /stats, /grid, /recommend, /chat.
    - AI RAG system + vector DB (FAISS).

3. Data Storage (PostgreSQL/PostGIS or lightweight storage)
    - Raster data (GeoTIFFs) temporarily stored.
    - Processed per-hex metrics stored as Parquet / GeoJSON.

4. AI/ML Module (Location Optimization)
    - Recommendation engine for parks & clinics.
    - Uses heuristic scoring:
        - Parks → High LST + Low NDVI + High population.
        - Clinics → High LST + High population.
    - RAG-powered AI assistant for contextual answers with citations.

Data Flow

- NASA Earthdata (AppEEARS API) → MODIS LST & NDVI.
- WorldPop → population density.

Input

→

- Convert rasters → mean NDVI/LST.
- Aggregate into H3 hexagonal grid
- Store metrics in hex_features_ext.parquet.
- Run ranking & recommendations (parks, clinics).
- AI assistant (RAG + LLM) synthesizes explanations.

Processing

→

- Frontend map visualizations (heat, green, population, air).
- Hotspot markers & recommendations
- AI chat answers + suggested zones.

Output

🔷 Tech Stacks

Languages

- Python (backend, AI/ML, data processing).
- JavaScript (React, Vite) (frontend).

Frameworks & Libraries

- Backend: FastAPI, Rasterio, GeoPandas, H3, SentenceTransformers, FAISS/Chroma, ReportLab.
- Frontend: React, Leaflet, h3-js, Vite.

AI/ML

- SentenceTransformers (embeddings).
- FAISS/Chroma (vector DB).
- OpenAI API (LLM for chat/explanations).

Databases & Storage

- Parquet, GeoJSON, local filesystem.

NASA & External Data Services

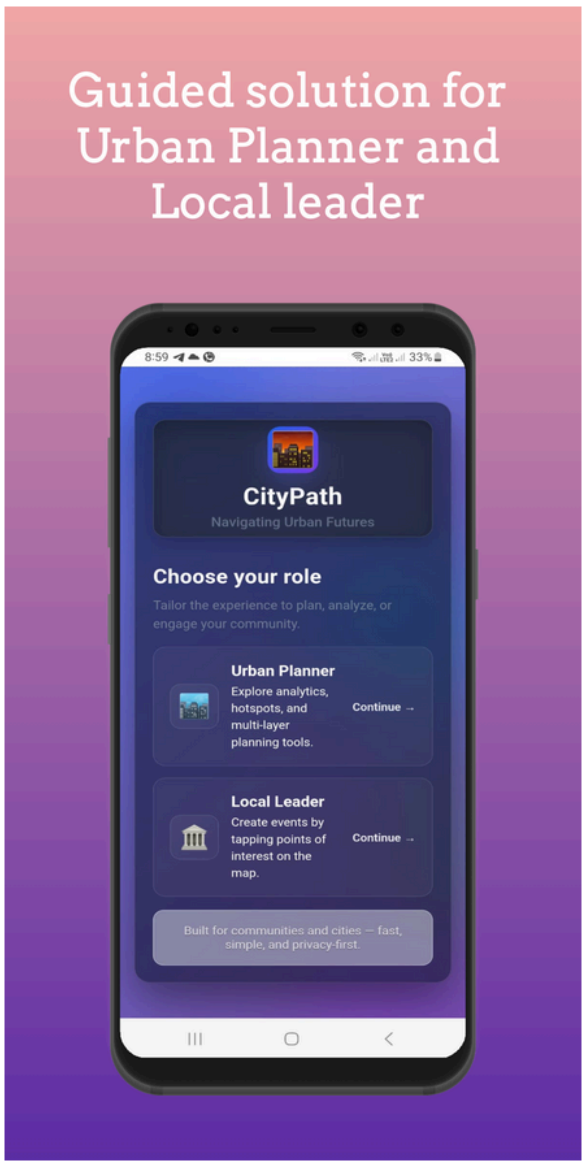
- NASA GIBS (map tiles).
- NASA Earthdata / AppEEARS API (MODIS LST, NDVI).
- SEDAC / WorldPop (population density).

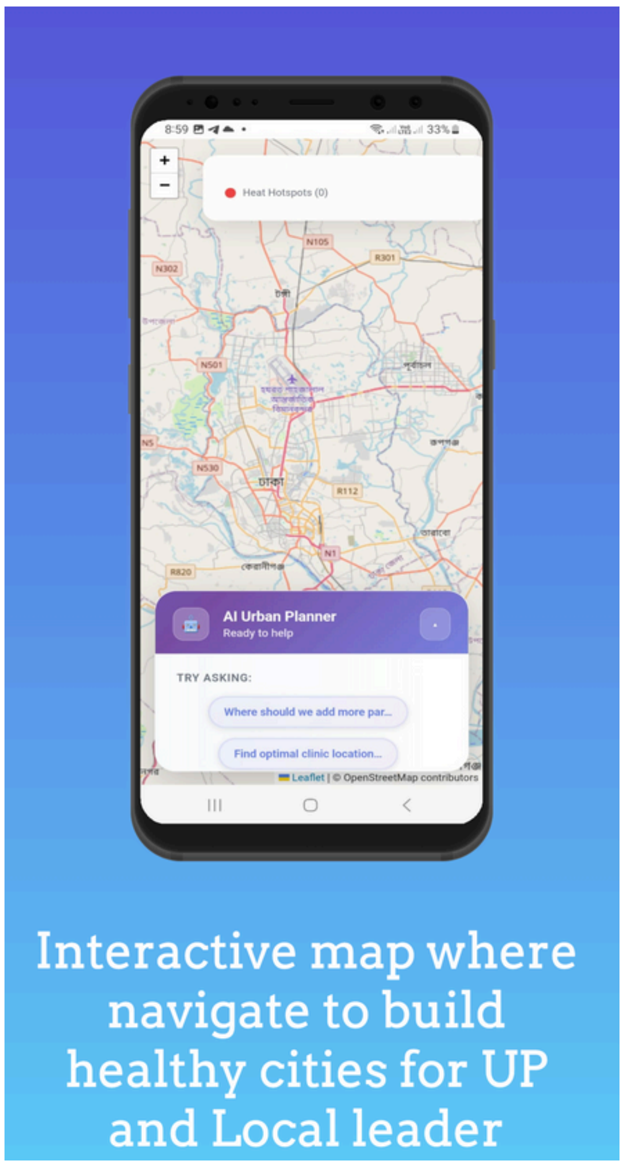
Infrastructure

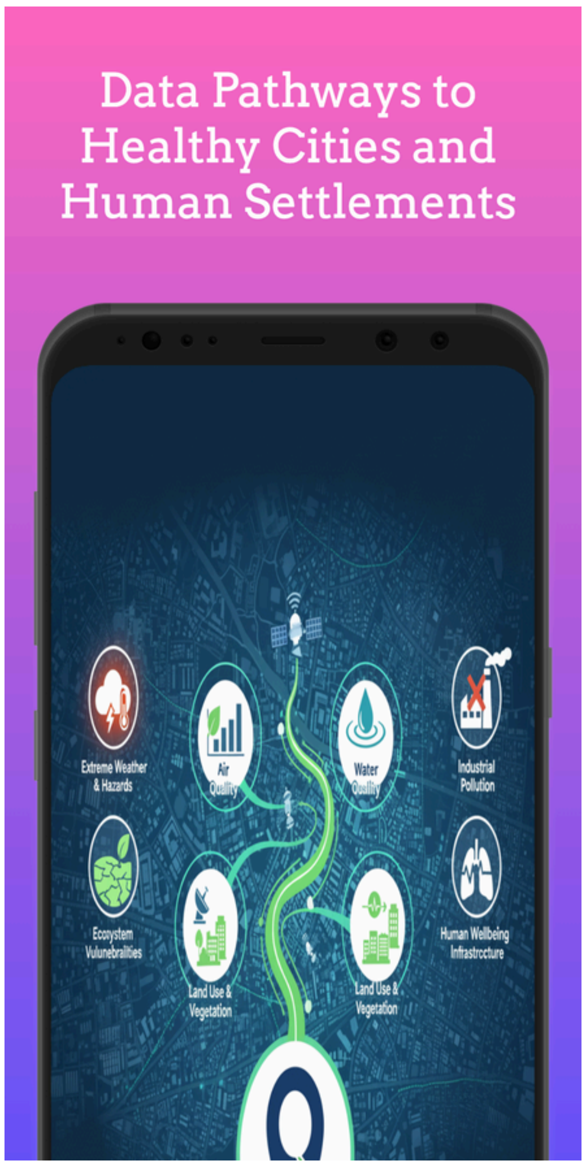
- Deployment:
  - VM Setup:
    - Backend → Gunicorn/Uvicorn + FastAPI (running as systemd service inside VM).
    - Frontend → React build served via Nginx/Apache inside VM.
    - Database → Postgres/PostGIS or local Parquet/GeoJSON storage.

🔷 App Components and Stacks

- **Platform:** Android (Native)
- **Language:** Java
- **UI Components:**
  - WebView (loads website)
  - SwipeRefreshLayout (pull-to-refresh)
  - ImageView & TextView (Splash screen)
  - LottieAnimationView (loading animation)
  - TRexOfflineView (offline game)
- **Animations:** XML (top_anim, bottom_anim) & Lottie JSON
- **Fonts:** Custom (kalpurush.ttf, english.otf)
- **Libraries:**
  - Lottie (com.airbnb.android:lottie)
  - TRex Offline (com.github.LionZXY.T-Rex-Android:trex-offline)
  - AndroidX (appcompat, constraintlayout, swiperefreshlayout)
- **Backend / API:** None (content served via WebView URL)
- **Build System:** Gradle, Android SDK 33, min SDK 21

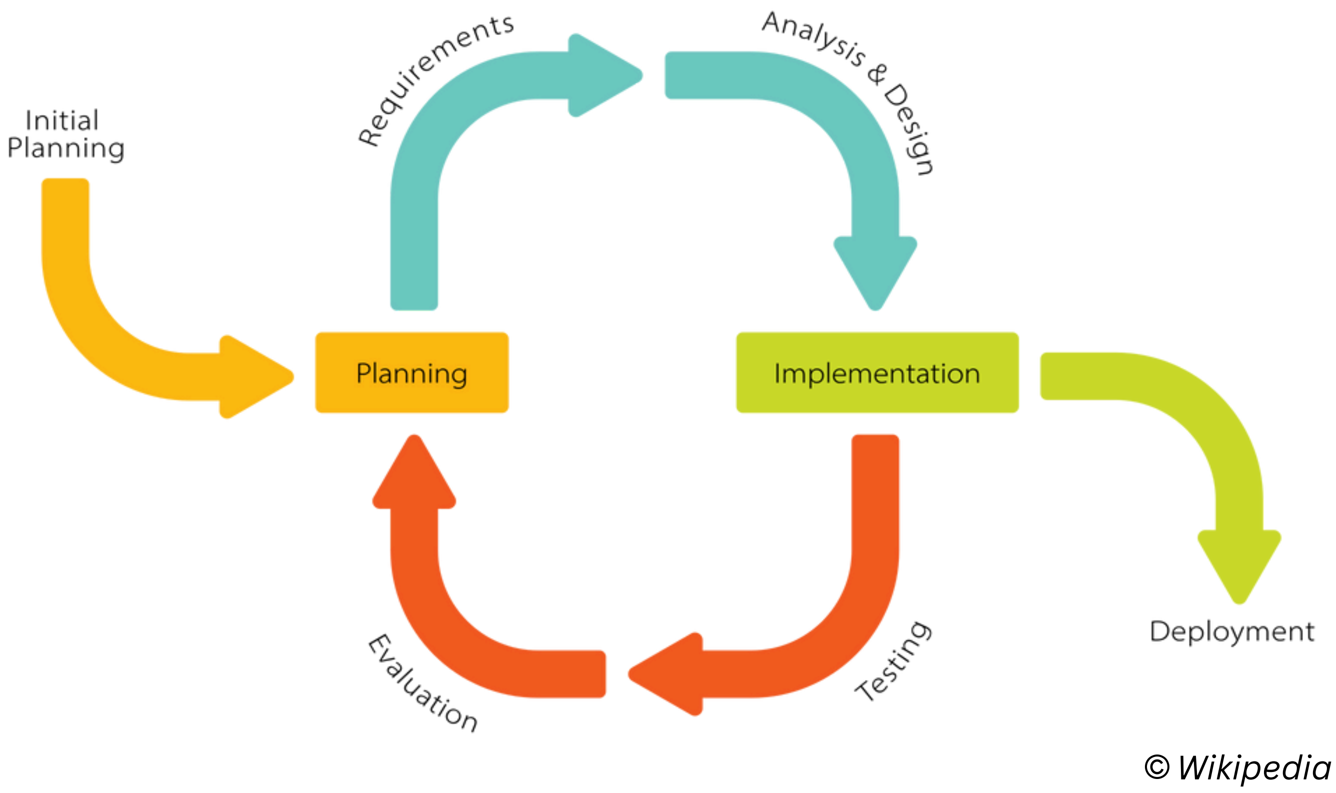






Implementation Strategy

Development methodology:



Iterative Development Model

Why Iterative Model Works for Us?

- Iterative approach enables rapid prototyping for quick demos, starting with MVP (heat + NDVI) and adding features like interactive map and AI assistance step by step.
- Modular design with decoupled backend (FastAPI, AI RAG) and frontend (React + Leaflet) allows smooth sprint-wise updates.
- Pilot in Dhaka first, then scale to other cities, validating progress at each iteration.

Key Algorithms in AI-Based Decision-Making:

1. **Hotspot Detection**
   - Score = z(LST)
   - Identifies zones that are hotter than average → priority for greening.

2. **Park Siting Recommendation**

   - Score = (z(LST) + (-z(NDVI))) * (1 + log1p(pop))
   - Weights areas hotter + less green, scaled by population density (so that high human exposure amplifies priority) → good candidate for parks.

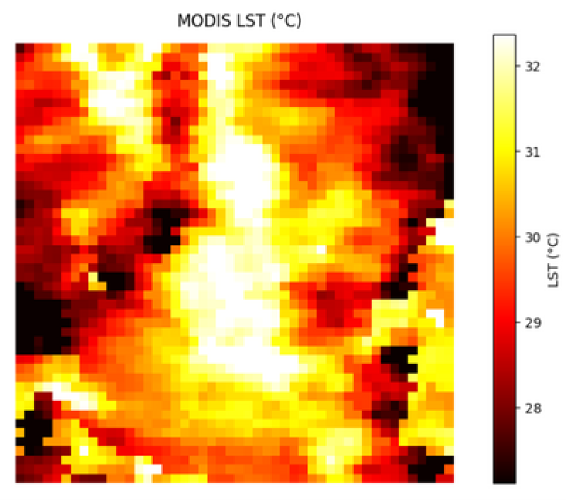
3. Clinic Siting Recommendation

   - Score = z(pop)
   - Prioritizes areas where population exposure is highest.

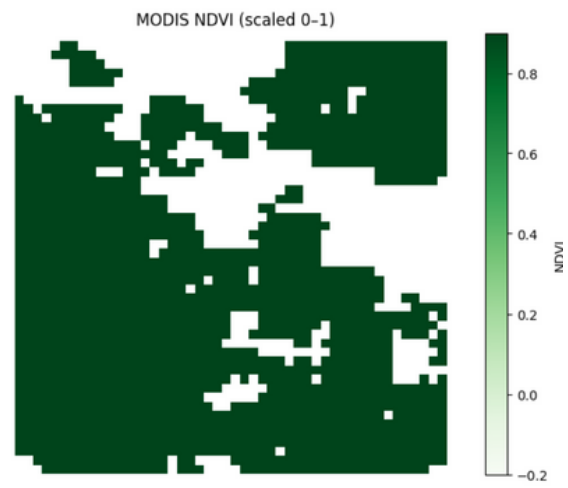
4. RAG + AI Chat Assistant

- Retrieve → Rank → Answer pipeline:
   - Retrieve city-specific knowledge (NDVI, LST, WorldPop, playbooks).
   - Rank and filter relevant docs.
   - Prioritizes areas where population exposure is highest.

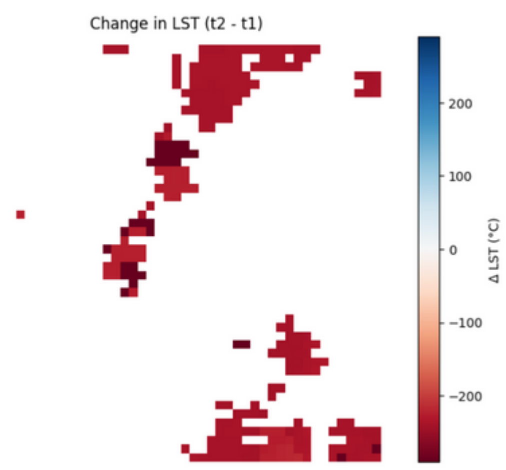
◆ Data-driven insights:



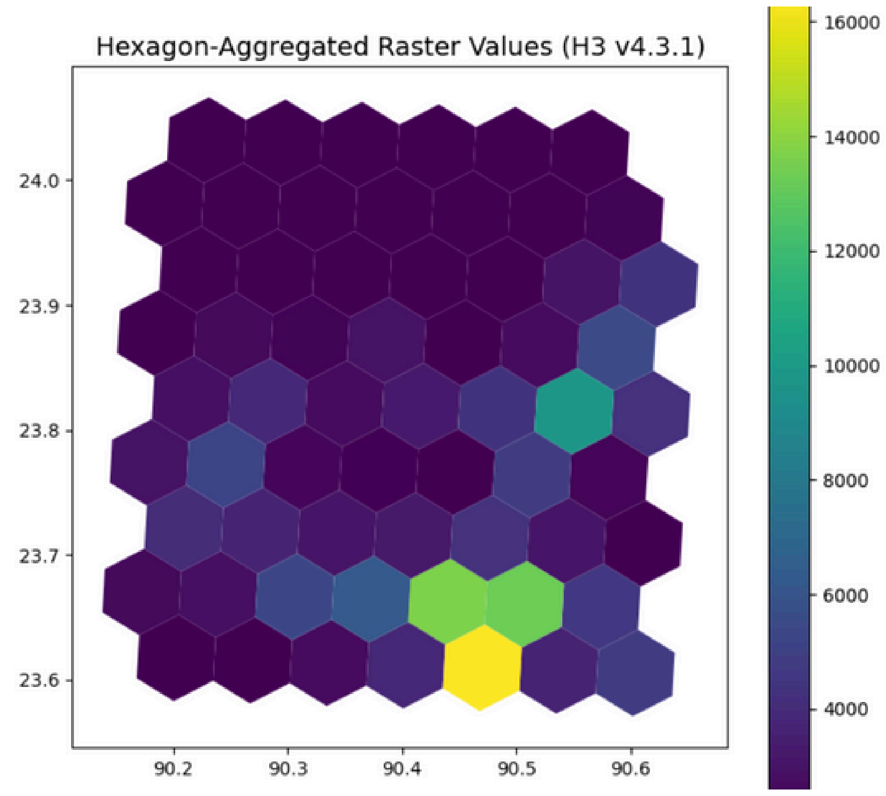
Visualization of a Heat Map



Visualization of a Green Map

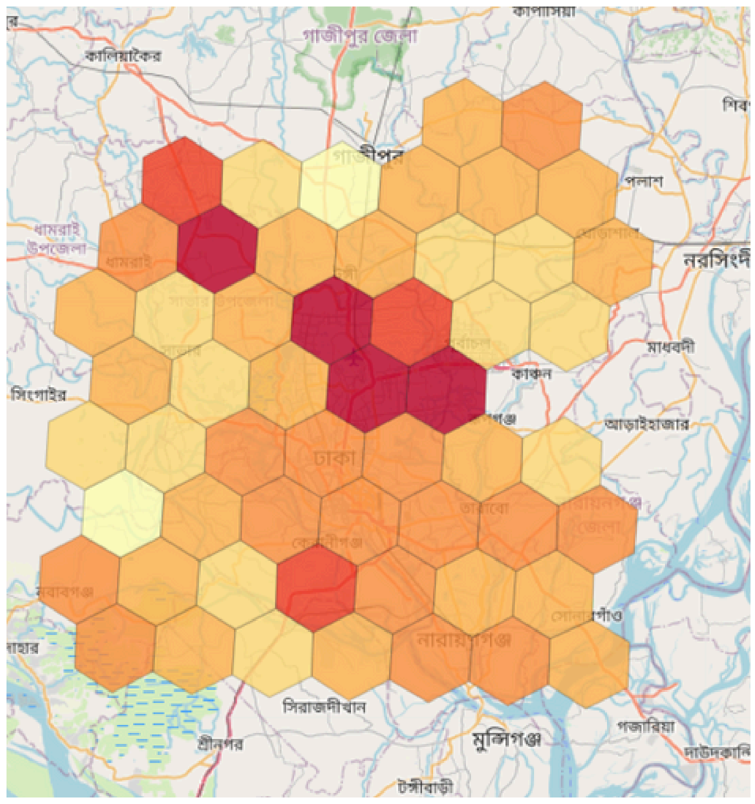


Visualization of a LST time-series

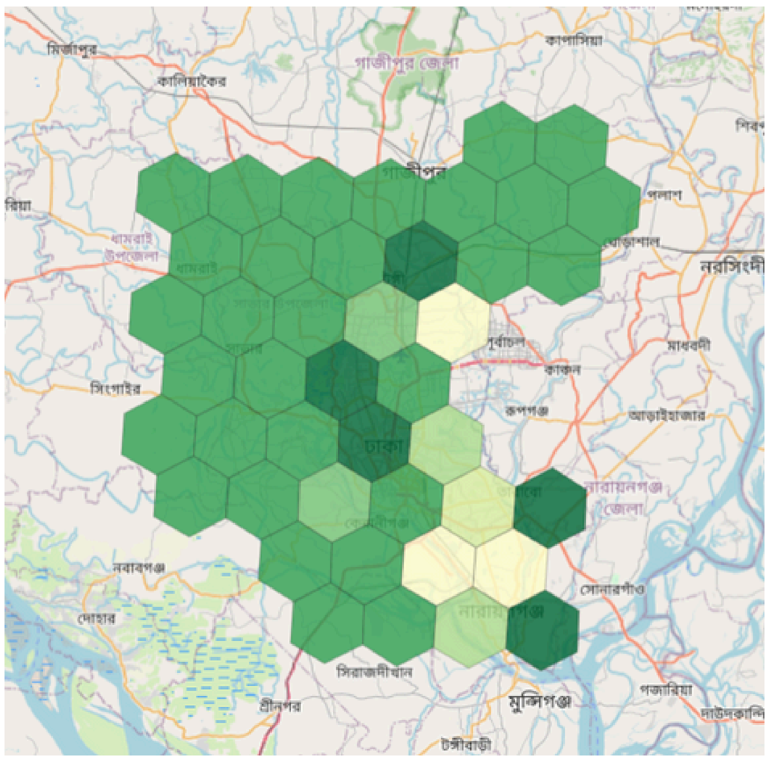


Sample: NDVI raster → Hex-grid

Each raster file has been converted into Hex-grid like this



Visualizing Heat intensity as choropleth map (hex)



Visualizing Vegetation Index as choropleth map (hex)

Visualizing Heat intensity as choropleth map (hex)

Code & more analysis (Colab Link):

https://colab.research.google.com/drive/1gqBfj24UFr45OC3OMLHKvpXACKmbnkYq?usp=sharing

Future Works

Scalability Across Cities

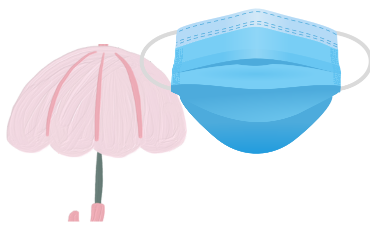
Extend the platform beyond the pilot (Dhaka) to any city worldwide by building a scalable data pipeline that ingests NASA, population, and urban datasets for different geographies with minimal setup.

Smarter & Fine-Tuned AI Responses

Enhance the AI assistant to deliver more context-aware, locally tailored, and actionable recommendations by learning continuously from user queries and feedback.

Integration of Real-Time APIs

Incorporate Weather and AQI APIs to provide precise, real-time indices that complement satellite-derived trends, ensuring more accurate and timely insights.



Everyday Recommendations for Citizens

Offer daily actionable tips such as “carry an umbrella, it may rain today” or “avoid outdoor exercise, AQI is unhealthy,” making insights part of everyday life.

Location-Based Notifications

Send targeted alerts about local events, tree plantation drives, or health camps, ensuring citizens and leaders can take immediate and meaningful action.

Gamification & Rewards

Introduce a points-based system where citizens and leaders earn rewards for eco-friendly actions, e.g., 100 CityPath points translating to a 10% discount at sustainable partner shops.

References

◆ NASA Earth Data & Resources

1. AppEEARS (NASA Earthdata) — a tool & API for extracting and subsetting geospatial data (e.g. MODIS) by spatial/temporal filters. (NASA Earthdata)
2. MODIS / Terra / MOD11A2 (Land Surface Temperature / Emissivity) — 8-day composite LST product used for urban heat analysis. (ladsweb.modaps.eosdis.nasa.gov)
3. MODIS Data Products / Data Access (LP DAAC, Earthdata Tools) — general reference for MODIS data, collections, tiling, and access tools. (modis.gsfc.nasa.gov)
4. NASA GIBS — for map tile services (GIBS API)

◆ External Data & Resources

◆ Population Data

1. WorldPop — for population density layers (https://hub.worldpop.org/geodata/summary?id=40150)

◆ Data Insights References

1. For hexagonal spatial indexing / H3:

    a. Uber's h3 library (Python bindings for H3) — "h3-py wraps the H3 core library" (GitHub)
    b. H3 public API / documentation and usage guide (uber.github.io)

◆ Open-Source Libraries & Frameworks

1. Backend Web API- FastAPI
2. RASTER / GEOSPATIAL PROCESSING- RASTERIO
3. GEOSPATIAL DATAFRAMES- GEOPANDAS
4. Hex grid indexing- h3-py
5. EMBEDDINGS- SENTENCETRANSFORMERS
6. Vector DB- FAISS
7. Frontend mapping- Leaflet
8. H3 in JavaScript- h3-js
9. FRONTEND BUILD TOOL- VITE
10. React / UI- React

External API

1. For LLM-based answering & explanations- OpenAI API

Use of AI

1. Image Generation – Google Nano Banana, Microsoft Bing Image Creator
2. Additional Content & Help in Brainstorming – OpenAI ChatGPT
3. Bug Fixing & Faster Debug Support – OpenAI ChatGPT, Google Gemini AI

CityPath Builder

Team Laniakea