SustainAI

SustainAI

EXPLAINABLE INTELLIGENCE FOR A CLEANER TOMORROW

AI PROJECT PRESENTATION

Our team

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Our Motivation

Why Air Quality Analysis with XAI?

Severe Global Air Pollution

Inadequate Awareness

Can drive Smarter Policy

GAPS IN EXISTING TECHNOLGIES

Lack of Explainability in Predictions

Lack of Usable Insights

Minimal Integration of Explainability Tools

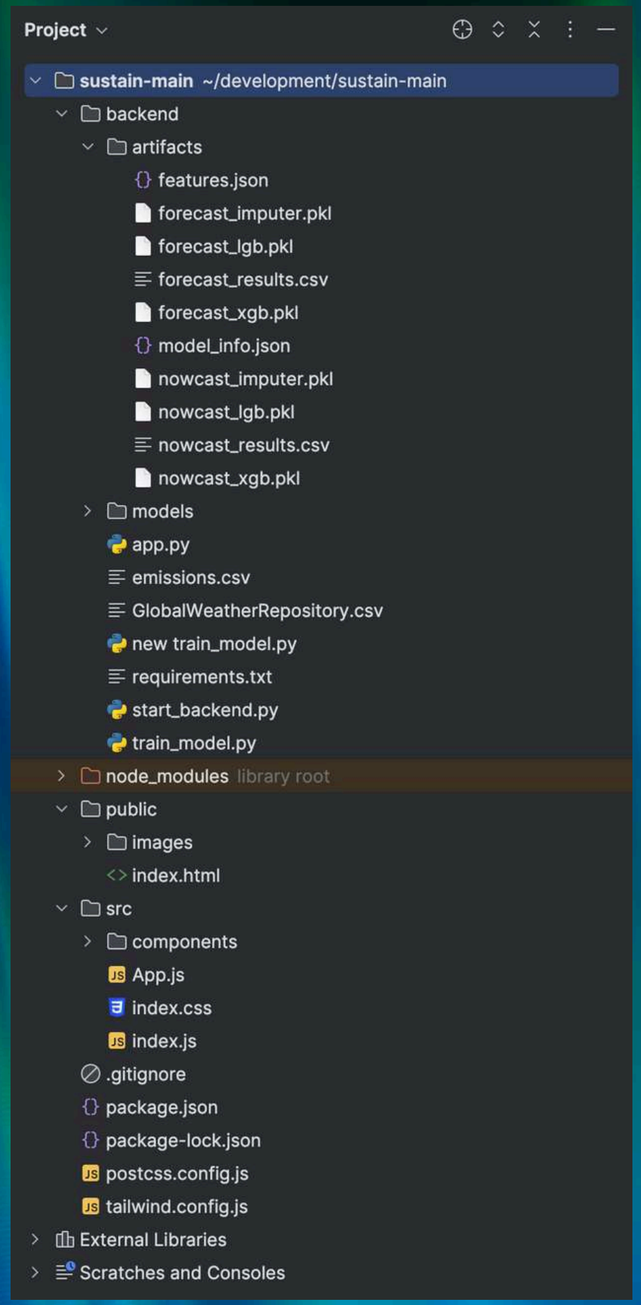
OBJECTIVES

- Build an AI system to predict and explain air quality levels
- Provide actionable insights for cities and citizens
- Ensure environmental responsibility through carbon tracking

PROJECT OUTCOMES

- AI-Powered AQI Forecasting & Explainability
- Actionable Insights for Stakeholders

PROJECT STRUCTURE



DATASET DETAILS

- *Dataset: Global Weather Repository* – Schema includes location metadata , surface meteorology , categorical weather, and pollutants/co-pollutants. Rows are global snapshots spanning varied climates *(SOURCE: kaggle)*

- Astronomy fields like moon phase, moon rise are present but not used for learning. Similarly, Time Zone fields are also excluded.

- Primary target for regression: *Air Quality PM2.5*

MODEL TRAINING PROCESS

PRIMARY TASK: PREDICTING PM2.5 VALUES

- **Nowcasting: Predicting Current PM2.5 Values**

- **Forecasting: Predicting Future (+1 hour) PM2.5 Values**

MODEL TRAINING

```
UI_FEATURES = [
    "latitude",
    "longitude",
    "temperature_celsius",
    "wind_kph",
    "pressure_mb",
    "humidity",
    "visibility_km",
    "hour",
    "month",
    "air_quality_Carbon_Monoxide",
    "air_quality_Ozone",
    "air_quality_Nitrogen_dioxide",
    "air_quality_Sulphur_dioxide"
]
```

There are 13 features used for model training, for the ease of UI Integration

```
# Impute missing values *within our selected features*
imp_now = SimpleImputer(strategy="median")
```

Simple Imputer is used to fill into empty values in the features

MODEL TRAINING RESULTS

Here is the summary as a markdown table.

Index	Task	Model	R2	RMSE	MAE	Train_CO2_kg	Infer_CO2_kg
0	Nowcast	ExtraTrees (tuned)	0.975697	6.100752	2.648343	0.0009748528	1.257774e-05
1	Nowcast	RF (tuned)	0.974562	6.241561	2.678748	0.002183478	1.372154e-05
2	Nowcast	XGB (tuned+ES)	0.958483	7.973810	2.845644	7.511767e-05	1.432982e-06
3	Nowcast	LGB (tuned+ES)	0.957642	8.054206	2.804757	4.359039e-05	7.438831e-06
4	Nowcast	Ridge (tuned, scaled)	0.679478	22.155637	9.645077	4.419177e-07	5.299279e-08

Export to Sheets

Result: ExtraTrees has the best accuracy in Nowcasting

MODEL TRAINING RESULTS

Here is the FORECAST summary formatted as a table.

Index	Task	Model	R2	RMSE	MAE
0	Forecast	Ridge (tuned, scaled)	0.789118	15.160917	7.907207
1	Forecast	ExtraTrees (tuned)	0.787001	15.236816	7.877531
2	Forecast	RF (tuned)	0.786498	15.254807	7.931574
3	Forecast	XGB (tuned+ES)	0.783937	15.346031	7.912966
4	Forecast	Ensemble (LGB+XGB mean)	0.778839	15.526017	7.917307
5	Forecast	LGB (tuned+ES)	0.759942	16.175737	8.006024
6	Forecast	Naïve (persist)	0.734271	17.018669	8.537225

Result: Ridge Regression gives the best accuracy in Forecasting

FRONTEND

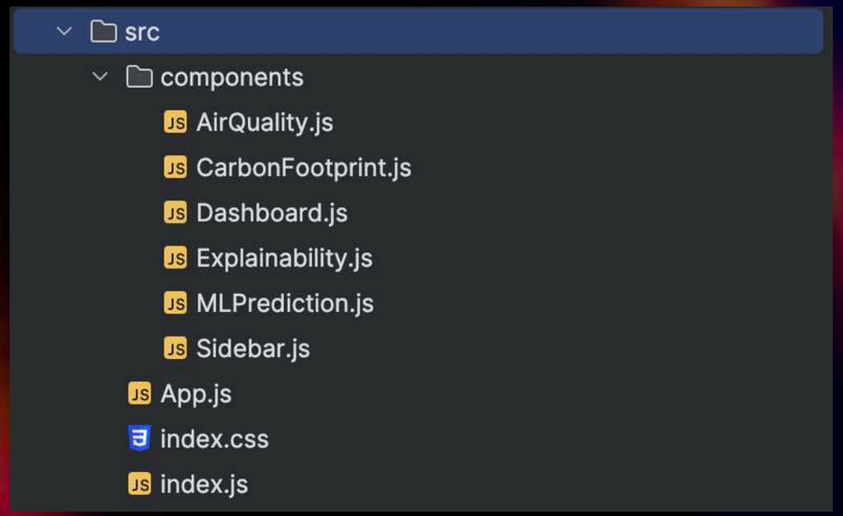
- *src/index.js: This is the JavaScript entry point for our entire app. Its one and only job is to find the index.html file (in the public folder) and tell React to render our main App component inside it.*

- *src/App.js: This is the main component for our dashboard. It's the central hub that defines the overall layout. It imports and organizes all the other components (like the input form, the gauges, and the map) into one cohesive page.*

- *src/index.css: This is the global stylesheet. Any CSS rules we write in this file (like setting a default background color or font) will apply to our entire application.*

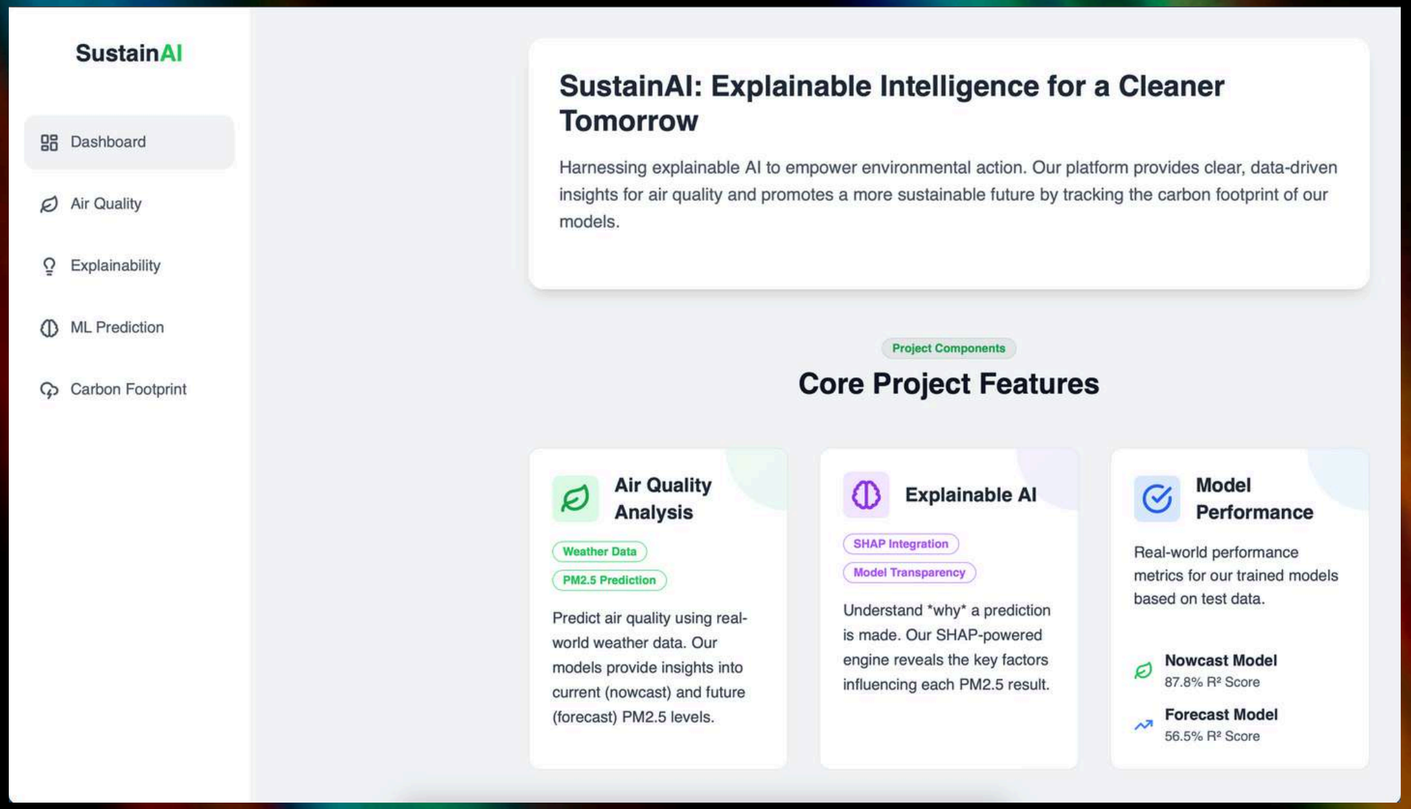
- *src/components/ (Folder): This folder is where we store all our reusable UI pieces. This is where our MLPrediction.js and other js files exist*

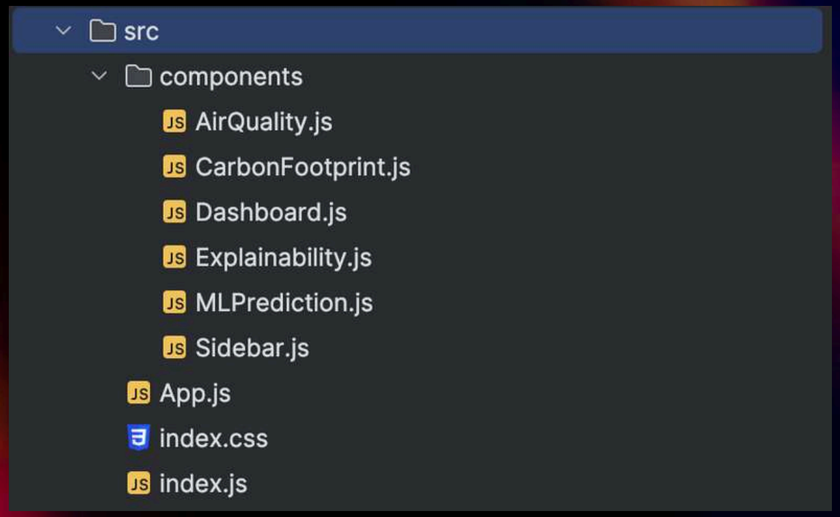
Frontend Techniques :
React.js
CSS for Styling



FRONTEND

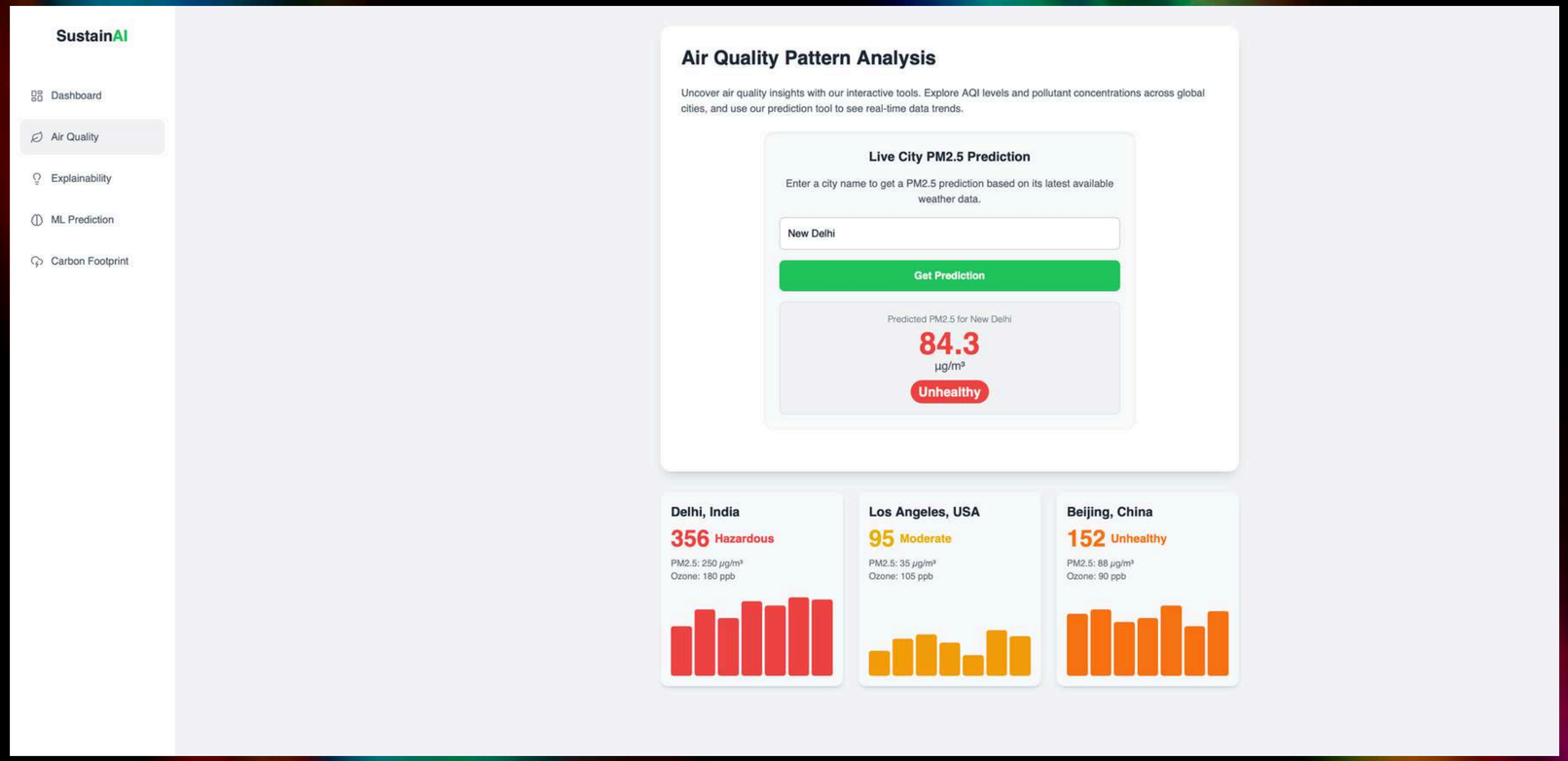
The DASHBOARD

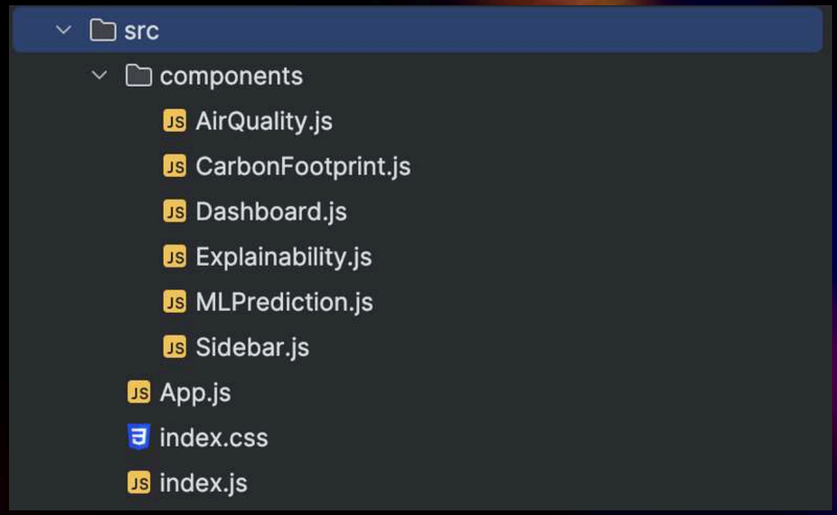




FRONTEND

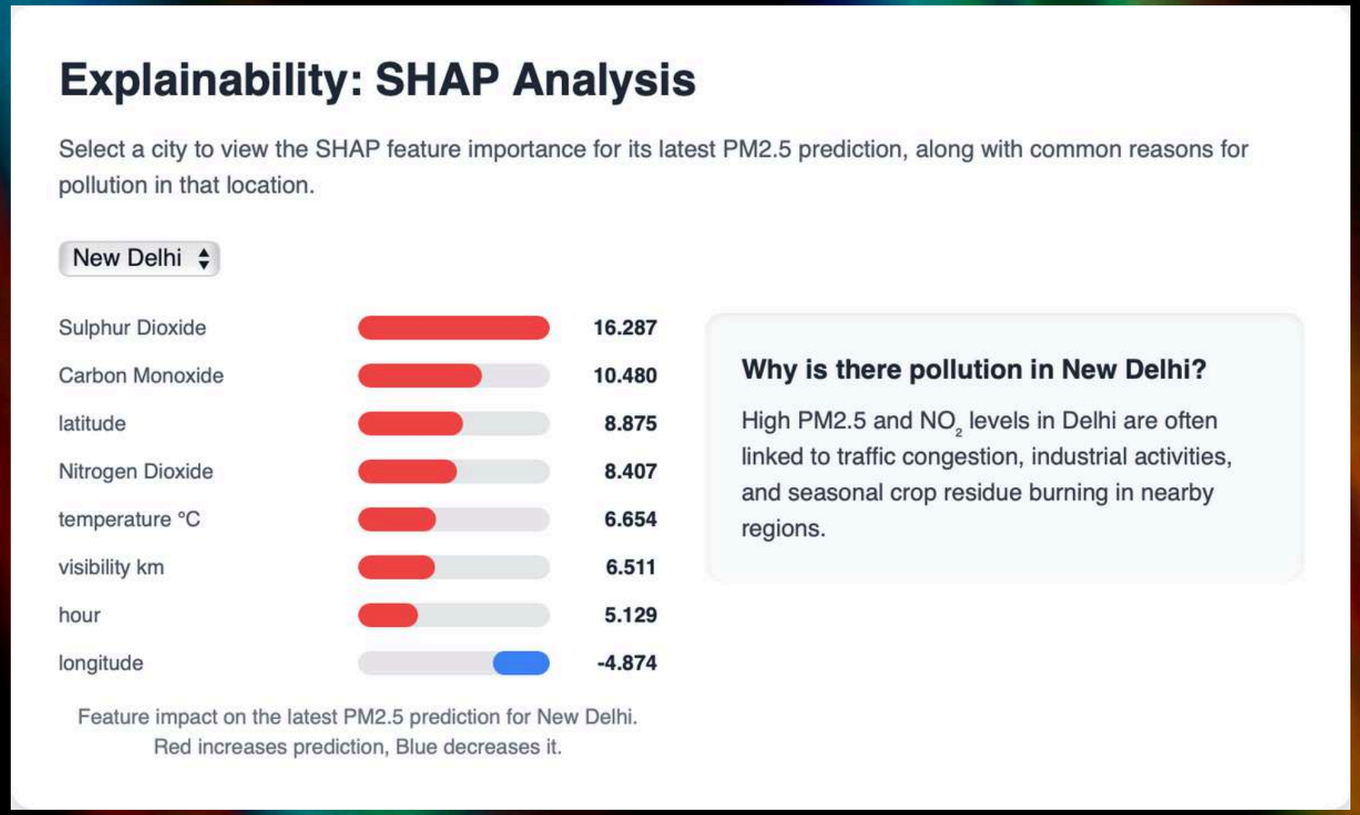
Air Quality

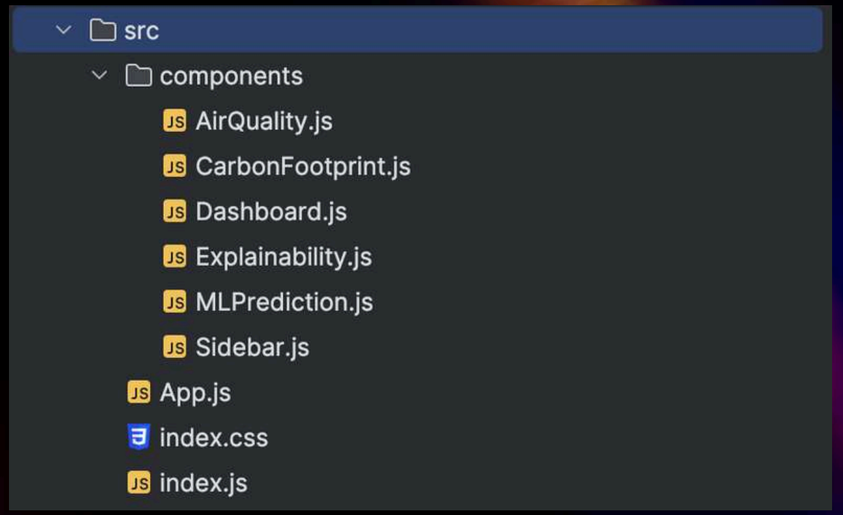




FRONTEND

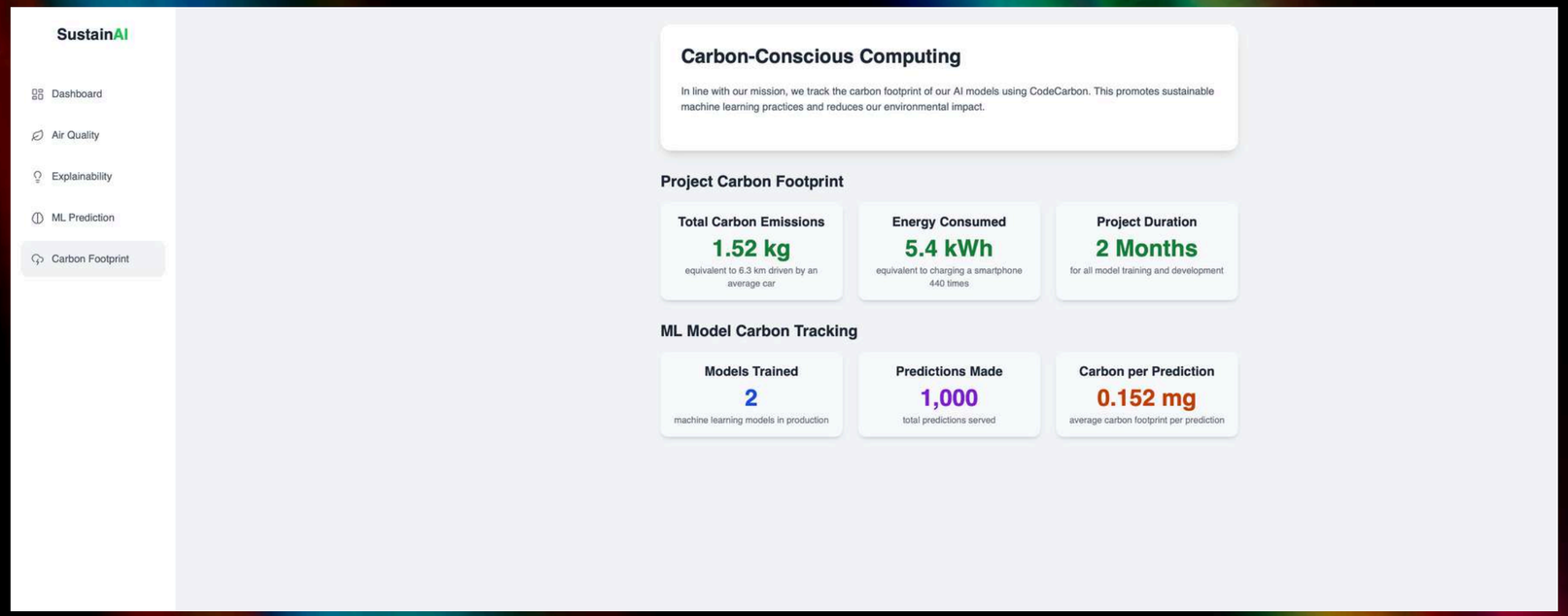
Explainability

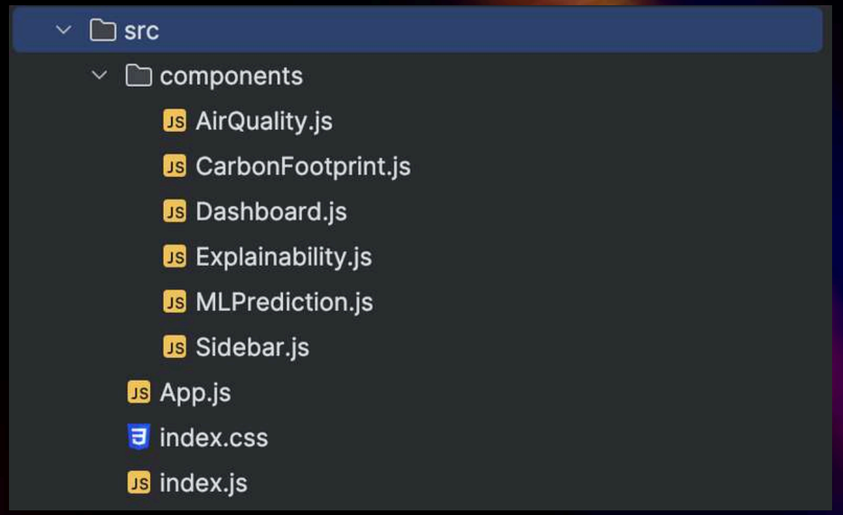


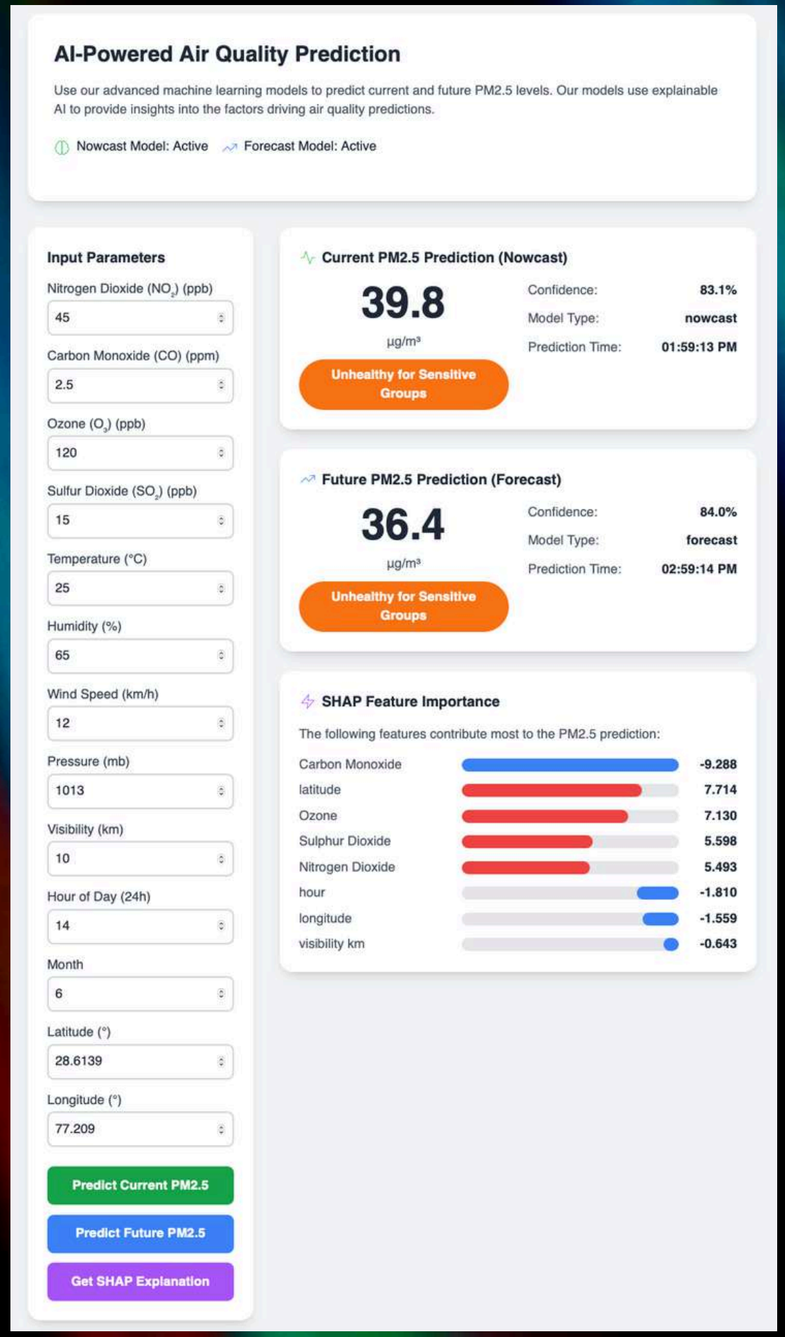


FRONTEND

Carbon Footprint







FRONTEND

ML Prediction - A Core Component of our project

- *This is a primary user interaction point, with 13 inputs.*
- *These 13 inputs are the UI Features we talked about in the model training.*

BACKEND

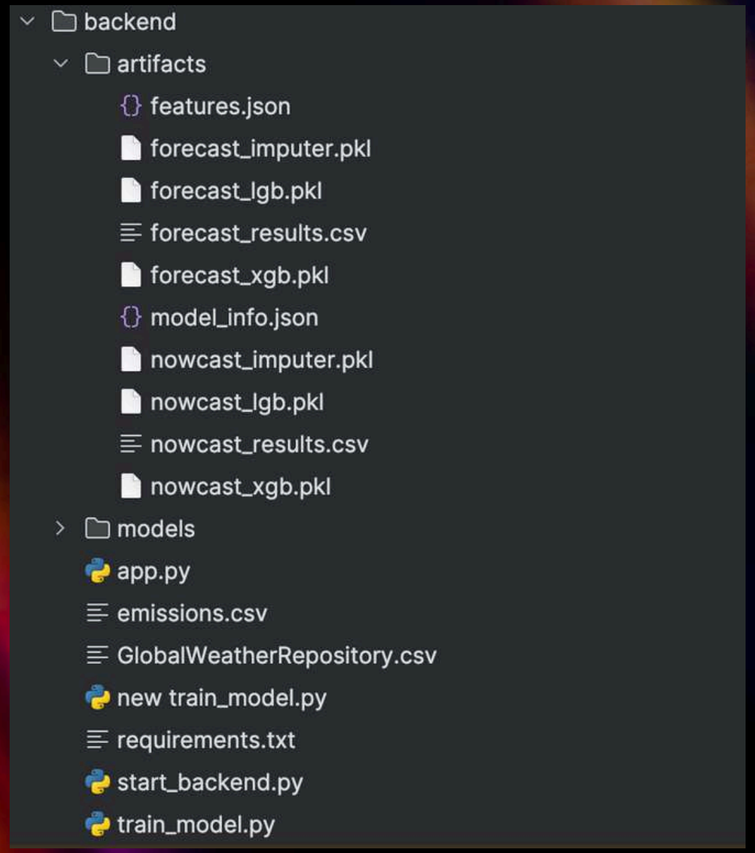
- *app.py: This is our Flask API server. It's the main file that runs the backend. It loads the saved models from /artifacts and creates the /predict API endpoint that our React frontend communicates with.*

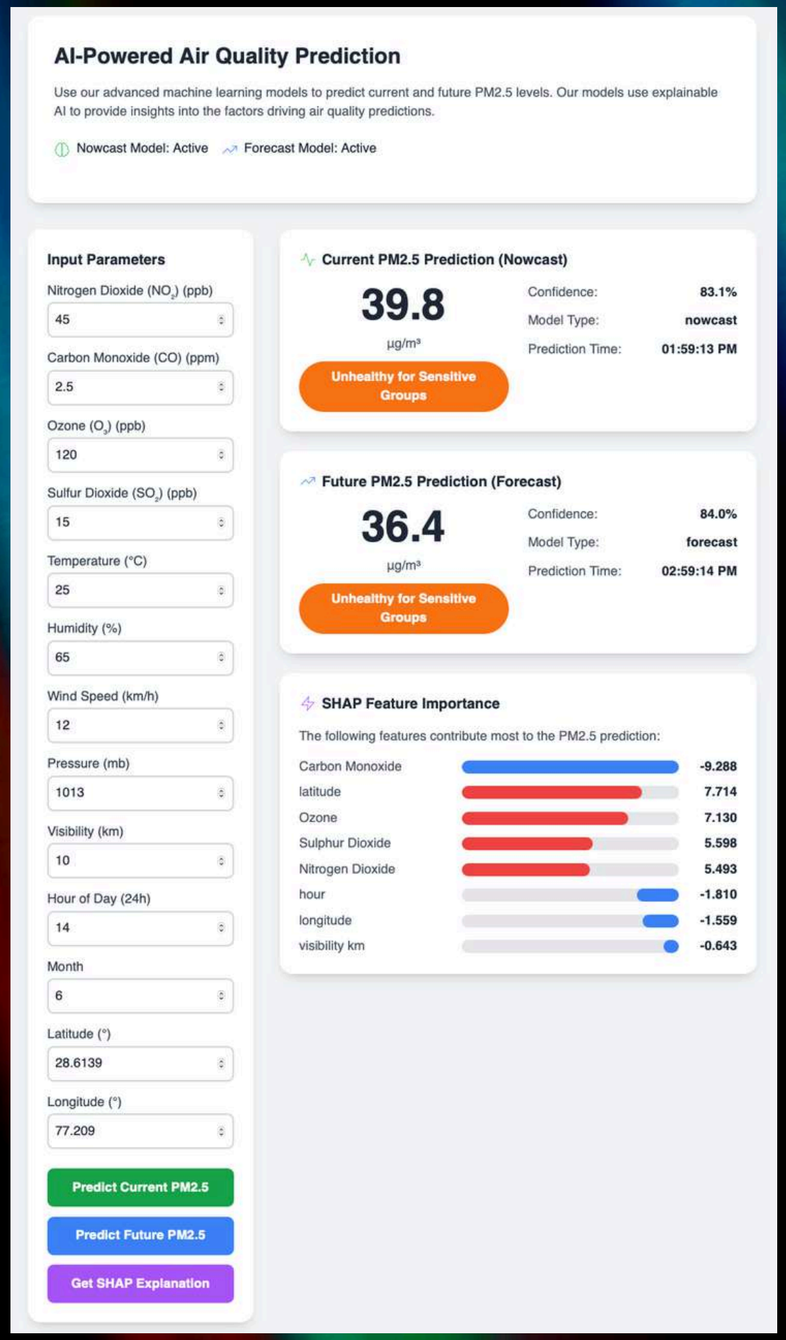
- *train_model.py: This is our model training script. We run this file once to read the GlobalWeatherRepository.csv, train the LightGBM and XGBoost models, and generate all the files in the /artifactsfolder. This file is not part of the live server.*

- *GlobalWeatherRepository.csv: The raw data (96,000+ rows) used only by train_model.py to train and test our models.*

- *emissions.csv: This is an output log file generated by the CodeCarbon library we used in our training script. It contains the estimated CO2 emissions from our model training.*

Backend Techniques :
FLASK - python





FRONTEND & BACKEND WORKING HAND IN HAND

What exactly happens when we click "Predict" on the webpage?

- ***FRONTEND: React's OnSubmit function is called, all 13 input values are bundled into JSON File.***
- ***BACKEND: FLASK receives the JSON, and loads the XGBoost Models (.pkl under artifacts), and makes the prediction and returns PM2.5 values in a JSON file.***

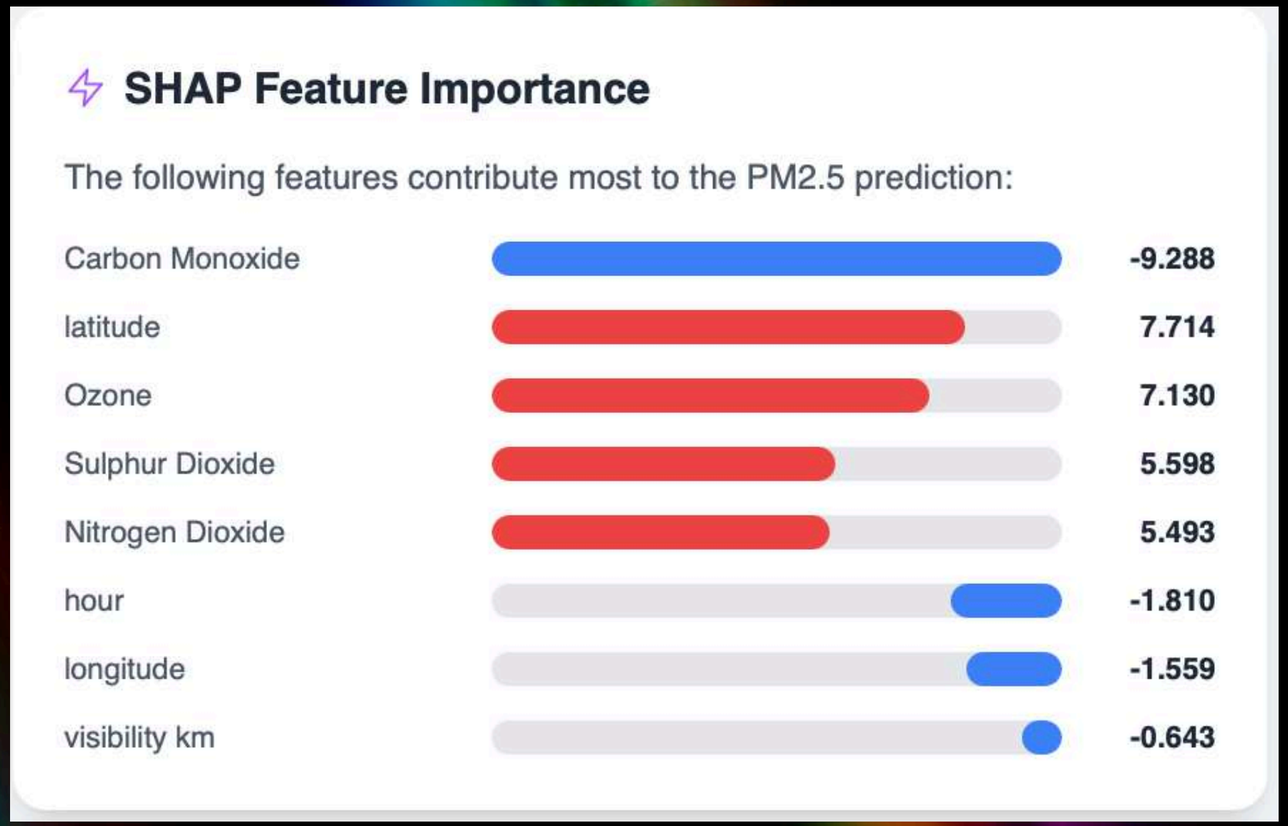
EXPLAINABILITY

SHAP - Shapley Additive Explanation:

- Explainability is showcased using SHAP Graphs.
- SHAP quantifies how each input feature pushes a prediction up or down, enabling transparent reasoning for stakeholders and model debugging.
- A crucial aspect of explainability in predictions is that models can be considered “black boxes,” meaning they provide no insights into their decision-making processes or the underlying reasoning behind their predictions.

SHAP PLOTS

SHAP: These Plot visualize feature importance for an ML model by showing the average magnitude of each feature's contribution across the entire dataset.



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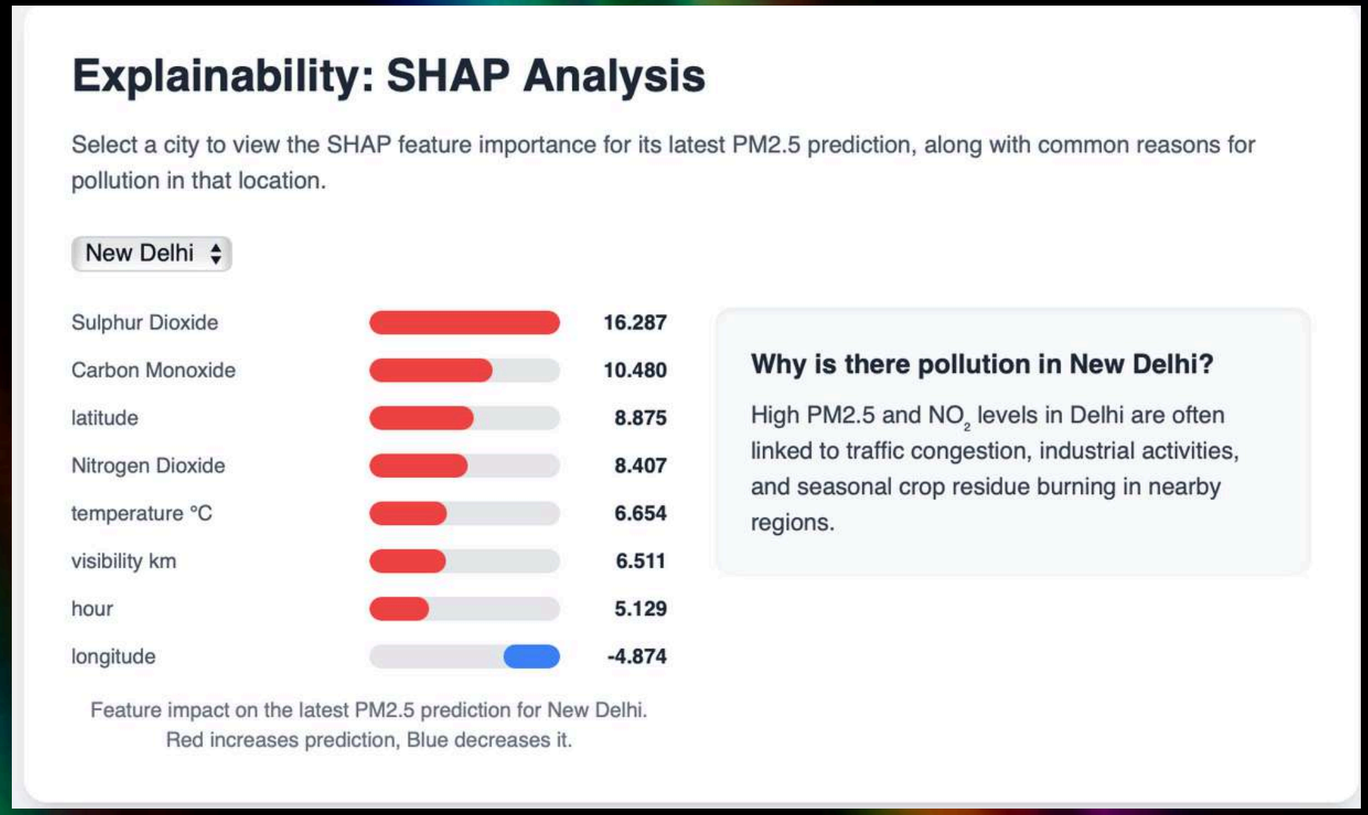


SUSTAINABILITY

CODECARBON:

- Sustainability is showcased using codecarbon in python.
- This makes training footprint visible and comparable across runs, aligning the project with low-carbon ML practices.
- A relatively low carbon footprint shows that the code in itself is sustainable and can be used for large scale training and deployment.

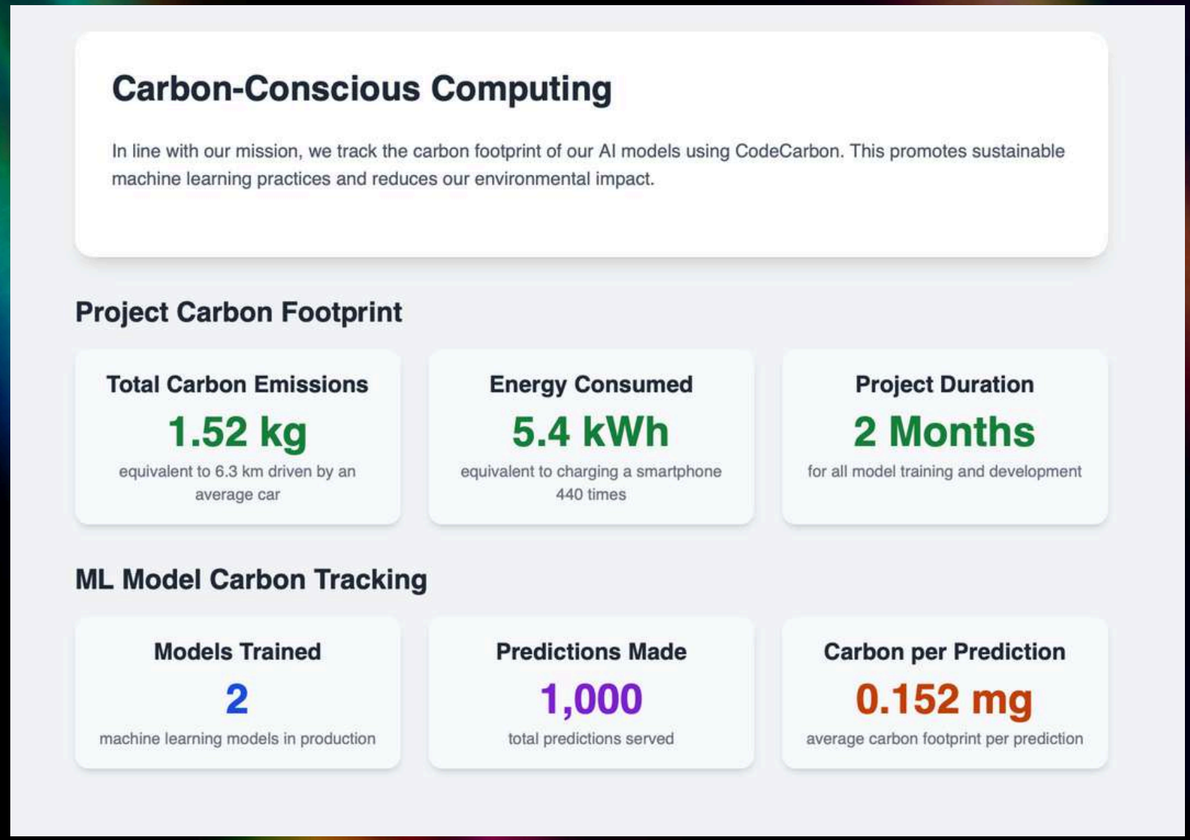
CODECARBON

Emission results are automatically stored into emissions.csv whenever a model is trained

timestamp	project_name	run_id	experiment_id	duration	emissions	emissions_rate	cpu_power	gpu_power	ram_power	cpu_energy
2025-10-19T19:38:56	Nowcast_LGB_Infer	59bef42e-e747-4082-941f-8b6e74bc568f	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.2211292500000040	2.12508262446884E-06	9.61013807295418E-06	42.5	0.0	6.0	2.61026883680565E-06
2025-10-19T19:39:20	Nowcast_XGB_Infer	4ea98cd4-b6c9-4ac0-bb31-39472c4d97c9	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.062908415999999	6.04362731132435E-07	9.6070250939468E-06	42.5	0.0	6.0	7.424253104166E-07
2025-10-19T19:40:43	Forecast_LGB_Infer	e67b8242-5f47-43d2-adf9-57a09c40a047	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.1053446669999970	1.01224255818156E-06	9.60886380875443E-06	42.5	0.0	6.0	1.2433999750001E-06
2025-10-19T19:41:03	Forecast_XGB_Infer	045f02ac-c250-4f29-84d2-1c0a4fc7147e	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.0217529159999969	2.08603637953614E-07	9.58968618063174E-06	42.5	0.0	6.0	2.56367472916688E-07
2025-10-19T20:37:51	Nowcast_LGB_Infer	a7f6492d-5af2-4761-a3cf-5f4803d9f01d	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.2428324999999920	2.33353588788643E-06	9.6096522824849E-06	42.5	0.0	6.0	2.86632886944437E-06
2025-10-19T20:38:17	Nowcast_XGB_Infer	af5be1fb-ad9b-4d20-8688-453ecc30b82a	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.0799704579999911	7.68314750599305E-07	9.60748218547642E-06	42.5	0.0	6.0	9.43804972916625E-07
2025-10-19T20:39:42	Forecast_LGB_Infer	3835011b-7df6-43b5-ae7e-714784382057	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.1185936250000170	1.13942482871304E-06	9.60780841898438E-06	42.5	0.0	6.0	1.39965486111117E-06
2025-10-19T20:40:01	Forecast_XGB_Infer	0e5982ba-9d5e-4788-8c56-3b3b71aeb7d2	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.0401562499999954	3.85597927869559E-07	9.60243867068272E-06	42.5	0.0	6.0	4.73764322916538E-07
2025-10-19T20:44:17	Nowcast_LGB_Infer	f3d17be2-a94d-423b-a42f-04d5ba992a6e	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.2286524579999990	2.19733498648723E-06	9.60993380830936E-06	42.5	0.0	6.0	2.6990421875001E-06
2025-10-19T20:44:18	Nowcast_XGB_Infer	b621338d-bbaf-482a-a6d1-ea7dd393f54b	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.0760254589999931	7.30394471530707E-07	9.60723527536707E-06	42.5	0.0	6.0	8.97213863888791E-07
2025-10-19T20:46:01	Forecast_LGB_Infer	e71cb812-1035-4189-a703-4f8e611555d5	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.1314143750000200	1.26270450929678E-06	9.60857219232363E-06	42.5	0.0	6.0	1.55110881736121E-06
2025-10-19T20:46:02	Forecast_XGB_Infer	aec836fc-f72b-412e-ac85-e4edb0acbdb4	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.0377847919999965	3.62673124313827E-07	9.59838879922536E-06	42.5	0.0	6.0	4.45618402777745E-07
2025-10-19T21:08:00	Nowcast_LGB_Infer	c3e994f9-e466-4eeb-8ee7-ab90b4309080	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.2179471249999950	2.09452958251064E-06	9.61026479477849E-06	42.5	0.0	6.0	2.57274685E-06
2025-10-19T21:08:13	Nowcast_XGB_Infer	95f02615-4c50-4227-9738-c4a5d5c8e7b4	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.0710487080000064	6.82595444952864E-07	9.60742938425851E-06	42.5	0.0	6.0	8.38515650000045E-07
2025-10-19T21:09:16	Forecast_LGB_Infer	923e3d5c-38cc-4791-b700-7678b598b871	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.0573067919999914	5.50440324578148E-07	9.60514984992059E-06	42.5	0.0	6.0	6.76207961111174E-07
2025-10-19T21:09:26	Forecast_XGB_Infer	72305cdd-799b-4978-be85-7c59320d3c30	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.0193709160000139	1.85662348064404E-07	9.58459311187298E-06	42.5	0.0	6.0	2.28228931249931E-07
2025-10-23T19:12:35	Nowcast_LGB_Infer	d1f624f8-04ab-4d69-b191-44561288e62d	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.2203444580000000	2.11753028211813E-06	9.61009095185926E-06	42.5	0.0	6.0	2.60098671874988E-06
2025-10-23T19:12:53	Nowcast_XGB_Infer	b0d1d263-ca75-4a0c-b6fe-321b0f858f3a	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.0759811249999984	7.29962111718653E-07	9.60715061429622E-06	42.5	0.0	6.0	8.96720970138818E-07
2025-10-23T19:14:07	Forecast_LGB_Infer	c8d8fb23-d1fa-4573-9a60-055e8c314bc4	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.060068584000021	5.76960962926712E-07	9.60503685131833E-06	42.5	0.0	6.0	7.0881588541665E-07
2025-10-23T19:14:23	Forecast_XGB_Infer	46cda643-73bf-4e7e-920b-a876edb6e213	5b0fa12a-3dd7-45bb-9766-cc326314d9f1	0.0294661670000960	2.82863804576383E-07	9.59961316231905E-06	42.5	0.0	6.0	3.47580146528021E-07

CODECARBON

Code Carbon Emission Results, clearly displayed on the final webpage.



PROJECT CONTRIBUTION

TEJAS	BACKEND
HARTHIK	DATASET DETAILS AND MODEL TRAINING
BHANU SHARMA	FRONTEND
VINAYAK	EXPLAINABILITY
SRIDHAR	SUSTAINABILITY

Thank You

Github repository link:- https://github.com/yoursanonymous/SustainAI/tree/main