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BUSINESS CHALLENGE III

Presented by

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MODEL PERFORMANCE

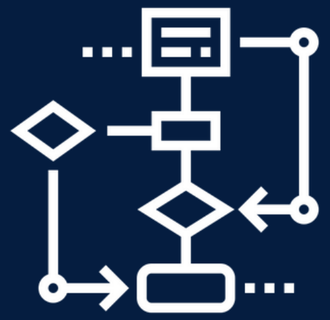
RANDOM FOREST:

IN SAMPLE PREDICTIONS = 0.94
OUT SAMPLE PREDICTIONS = 0.54

FINAL R^2 = 0.80

MODELING PIPELINE

Sentinel-2 bands, Temperature data



NDVI, NDBI, NDWI, Bounding Box Averaging

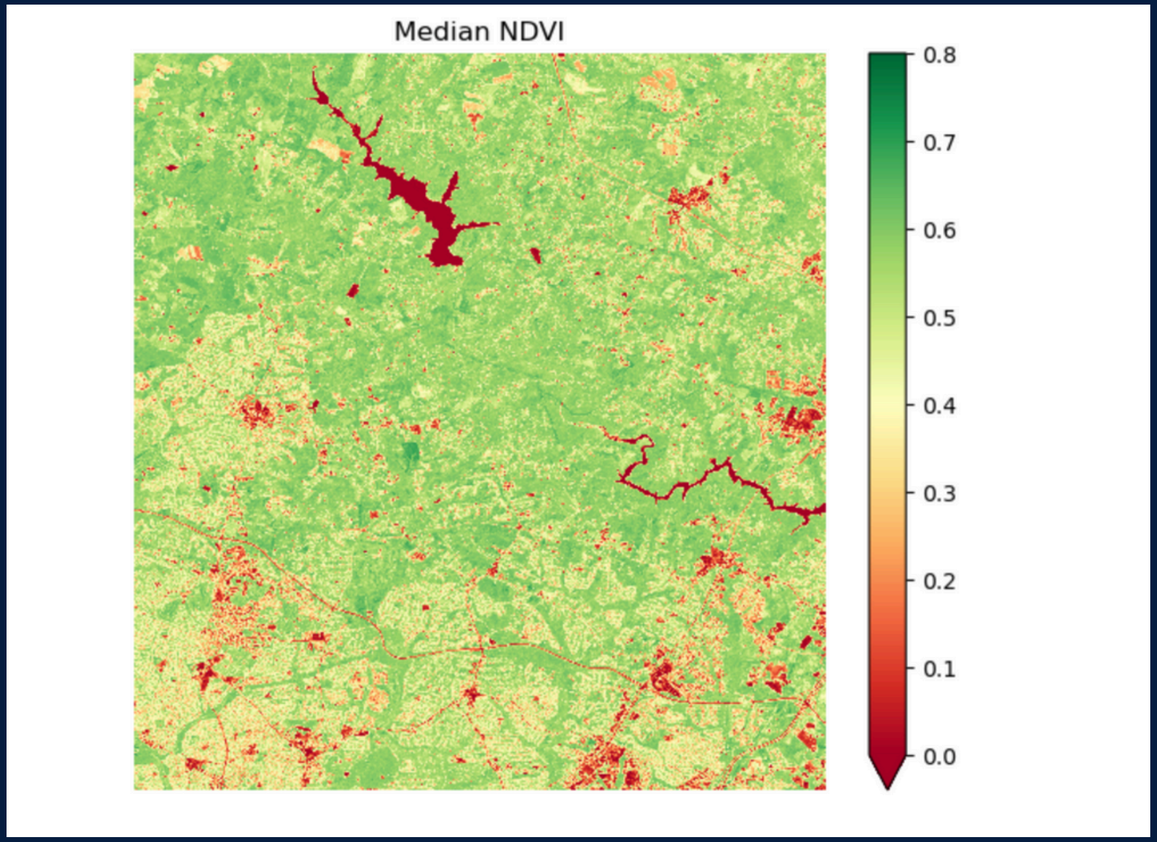
Random Forest

$R^2 = 0.7994$

INSIGHTS

NDVI

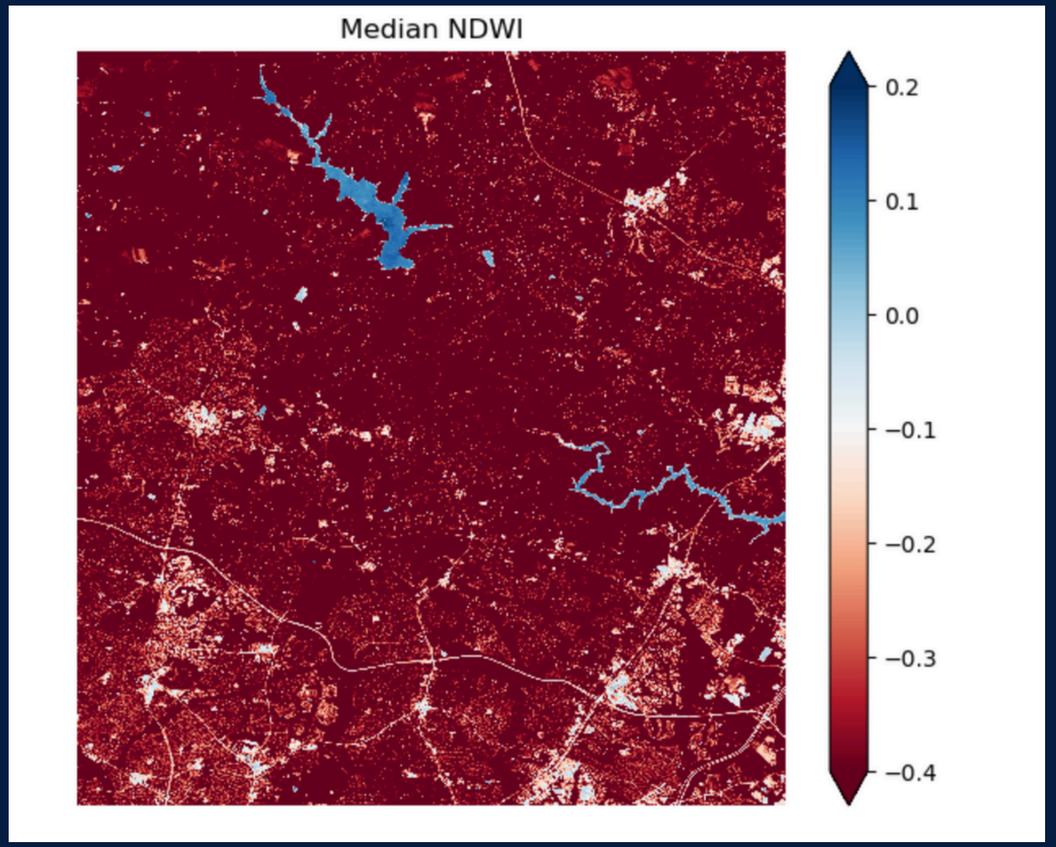
- The majority of the map is in light to medium green (NDVI between ~0.4 to 0.7)
- Indicates moderately healthy vegetation, such as forests, parks, and suburban tree cover.
- Generally vegetated, with several areas of consistent plant health.



INSIGHTS

NDWI

- Bright Blue Zones = High NDWI (Water Bodies)
- These are clear water bodies — lakes, reservoirs, and rivers — typically scoring NDWI > 0.1
- Water reflects green light and absorbs NIR, giving a high NDWI signal
- These areas are non-vegetative but not heat zones — often cool due to evapotranspiration



BOUNDING BOX

From the NDWI, NDVI:

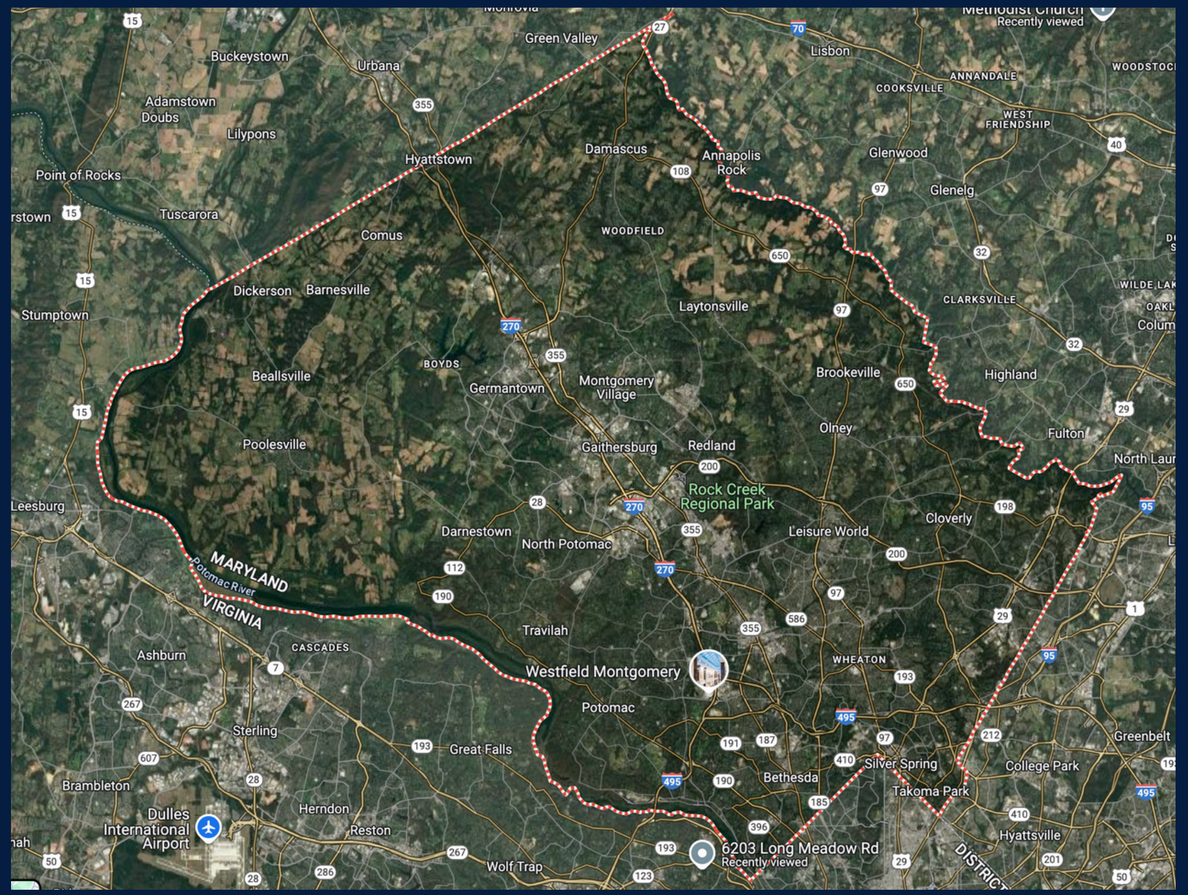
- The county is generally rich with vegetation
- Only low to moderate urbanization

Goal:

Train the model to learn spatial and spectral patterns that generalize well to unseen geographic regions

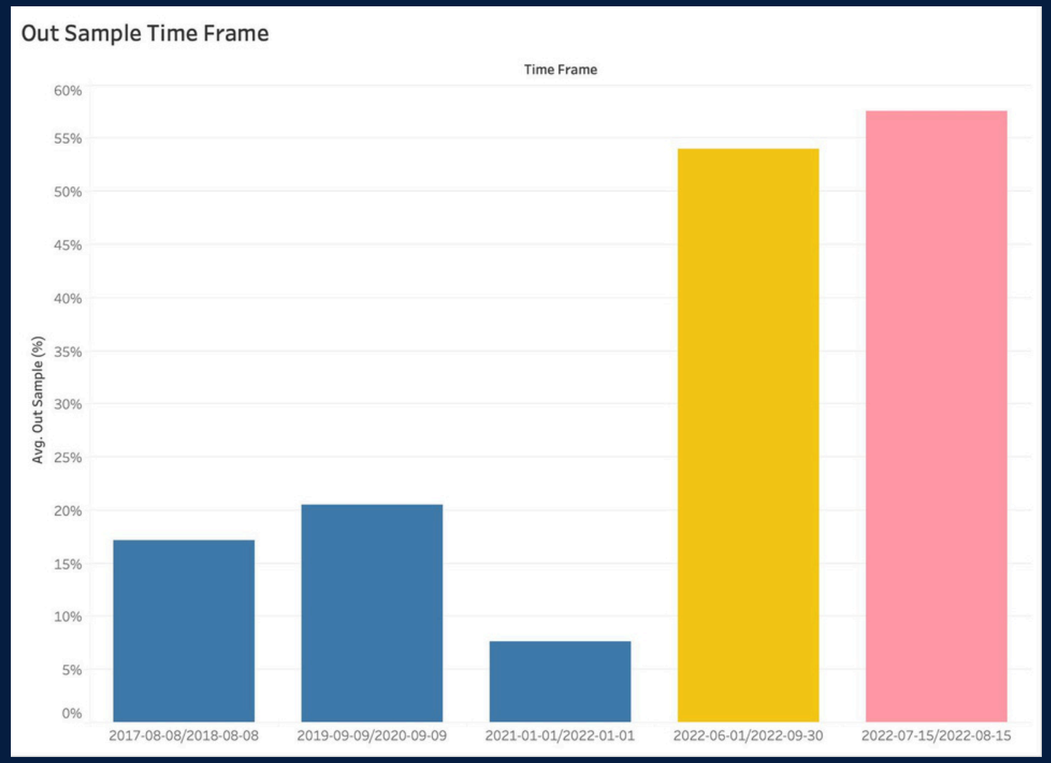
Method:

Define a bounding box large enough to encompass diverse land cover types—including urban, rural, vegetated, and water-dominated areas—to ensure the model captures a representative spatial distribution and learns transferable features for robust generalization to new regions.



TIME FRAMES

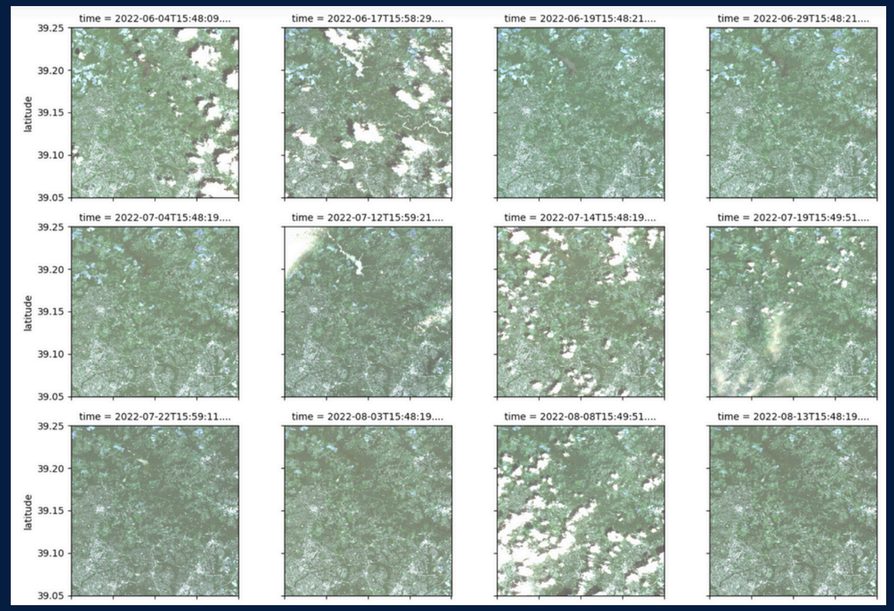
Daily and weekly timeframes performed well in-sample, but monthly aggregates showed better out-of-sample generalization



MODEL SELECTION

RANDOM FOREST

- Nonlinear modeling: UHI index is influenced by complex interactions (NDVI, NDBI, SWIR, elevation),
- Robust to multicollinearity
- Interpretability
- Generalization
- Low computational cost



Linear Regression

- Assumes linear relationships, which is unrealistic for satellite-derived features.
- Underfit the data (low R^2)
- Doesn't capture interactions between bands (e.g., NDVI × NDBI).

Neural Networks (e.g., CNN, MLP)

- Require more data and compute
- Risk of overfitting without sufficient tuning and regularization
- Harder to interpret than tree-based models

XGBoost

- More complex to tune (learning rate, depth, gamma, etc.)
- More computationally intensive
- For our dataset size and project scope, Random Forest achieved near-identical performance (~80% R^2) with far simpler tuning.

APPLICATIONS

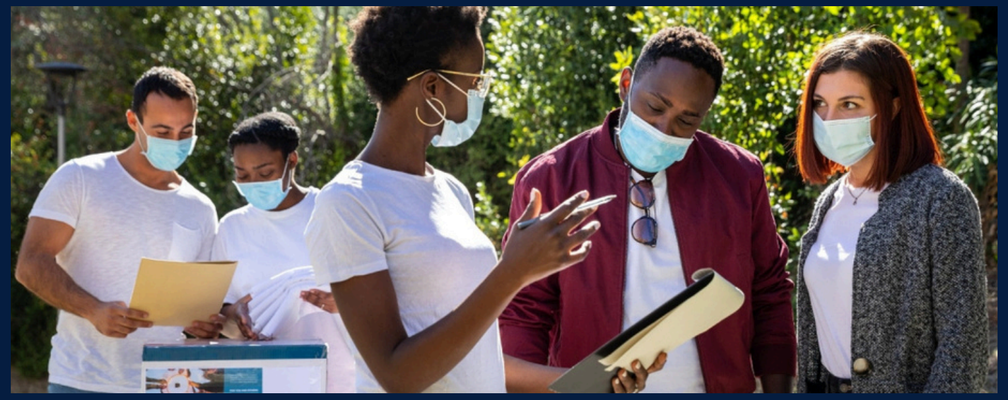
Climate Change & Environmental Policy

Use Case: Feed UHI predictions into broader climate models and city sustainability reports.

- **Support carbon reduction goals with actionable local insights.**
- **Quantify how land use change affects temperature trends.**
- **Simulate “what-if” climate futures under different green space scenarios.**

Impact: Data-driven climate policy that bridges the global to the local.

Public Health & Heat Vulnerability Mapping



Use Case: Pair UHI predictions with demographic data to target vulnerable communities.

- Overlay UHI index with age, income, health condition maps.
- Identify at-risk populations during heatwaves.
- Inform emergency cooling center locations or public warning systems.

Impact: Reduced heat-related illnesses and deaths, proactive climate adaptation.

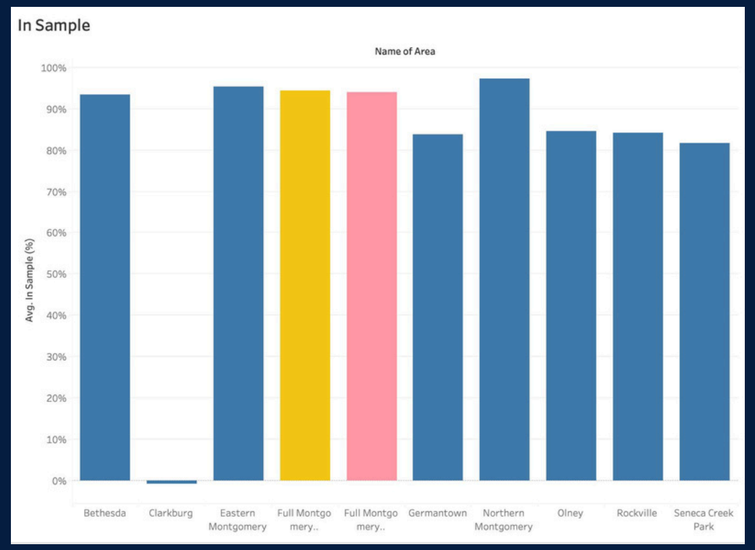
Sustainable Infrastructure Investments

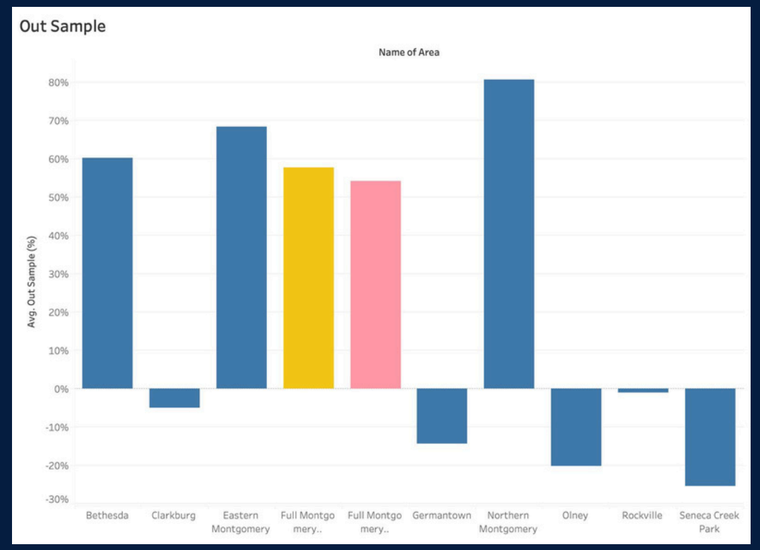
Use Case: Prioritize cool roofs, permeable pavements, and green walls in UHI-prone areas.

- Predict where impervious surface cooling is most needed.
- Justify infrastructure funding or retrofit programs using data.

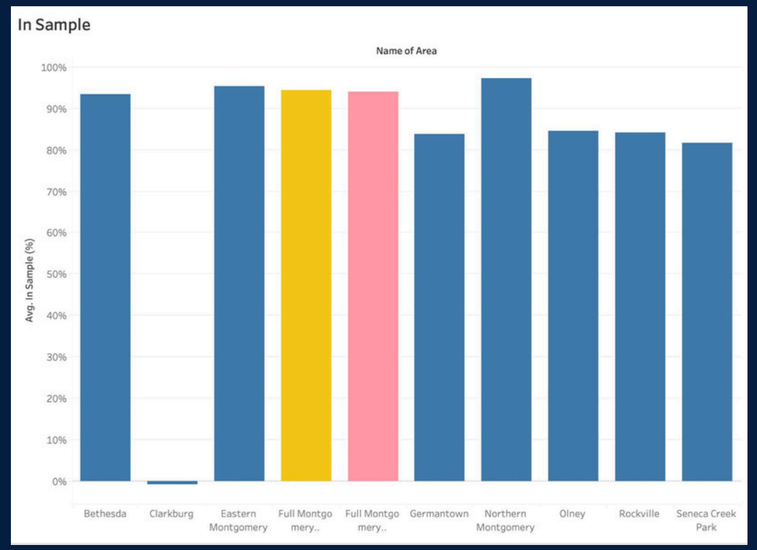
Impact: Reduced energy consumption, improved thermal comfort in cities.

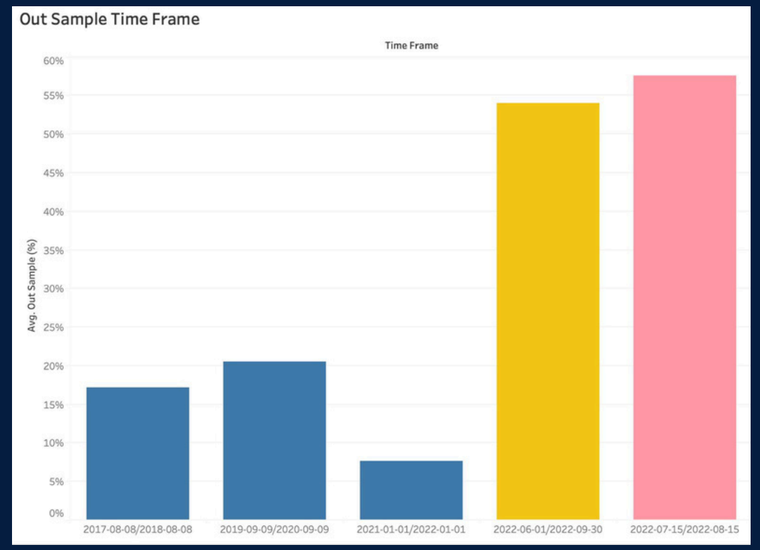
CHALLENGES





Smaller spatial bounding boxes captured localized noise and led to overfitting, reducing the model's ability to generalize across broader geographic regions





Shorter temporal resolutions (daily/weekly) resulted in models that overfit localized patterns and failed to generalize effectively across regions.

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THANK YOU !