SUSTAINLITE: LIGHTWEIGHT AI RECOMMENDATION SYSTEM FOR SUSTAINABLE CONSTRUCTION

SYARIFAH ISMAILIYAH AL ATHAS | DOCTORAL STUDENT

COLLEGE OF DESIGN, CONSTRUCTION, AND PLANNING

Problem Statement & Task Definition

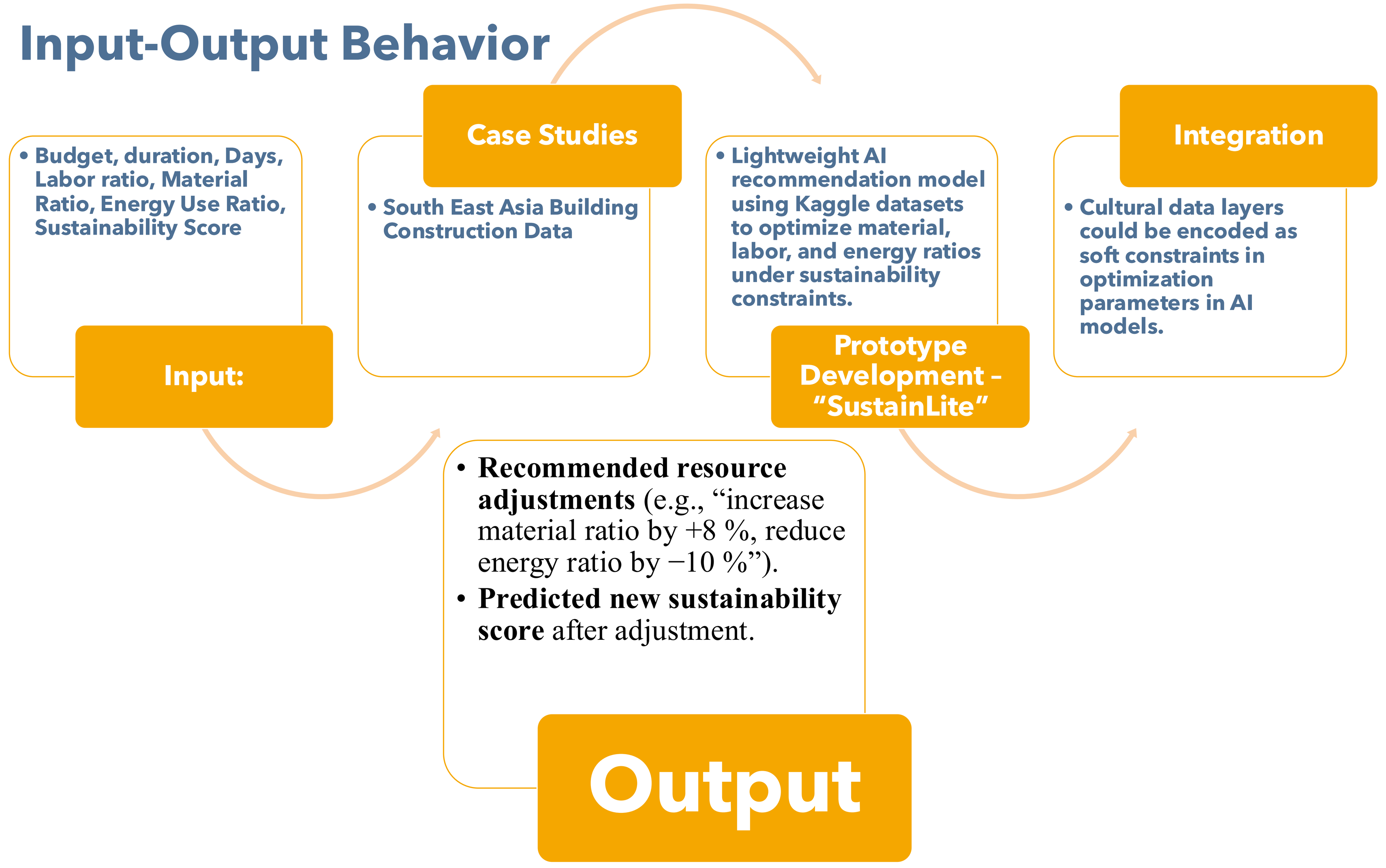
Southeast Asia's construction sector continues to expand rapidly, yet inefficiencies in resource allocation lead to rising costs and unsustainable environmental footprints. Project managers often lack decision-support tools that balance cost, duration, and carbon impact. Using publicly available data from Kaggle:
(1) the Construction Project Resource Dataset (Programmer3, 2023) containing project-level features such as budget, resource ratios, duration, and sustainability scores, and
(2) Sustainability and Energy in Southeast Asia (Nguyen, 2023) with national CO_2 and renewable-energy indicators, this project will build a lightweight AI-based recommendation system in Google Colab.

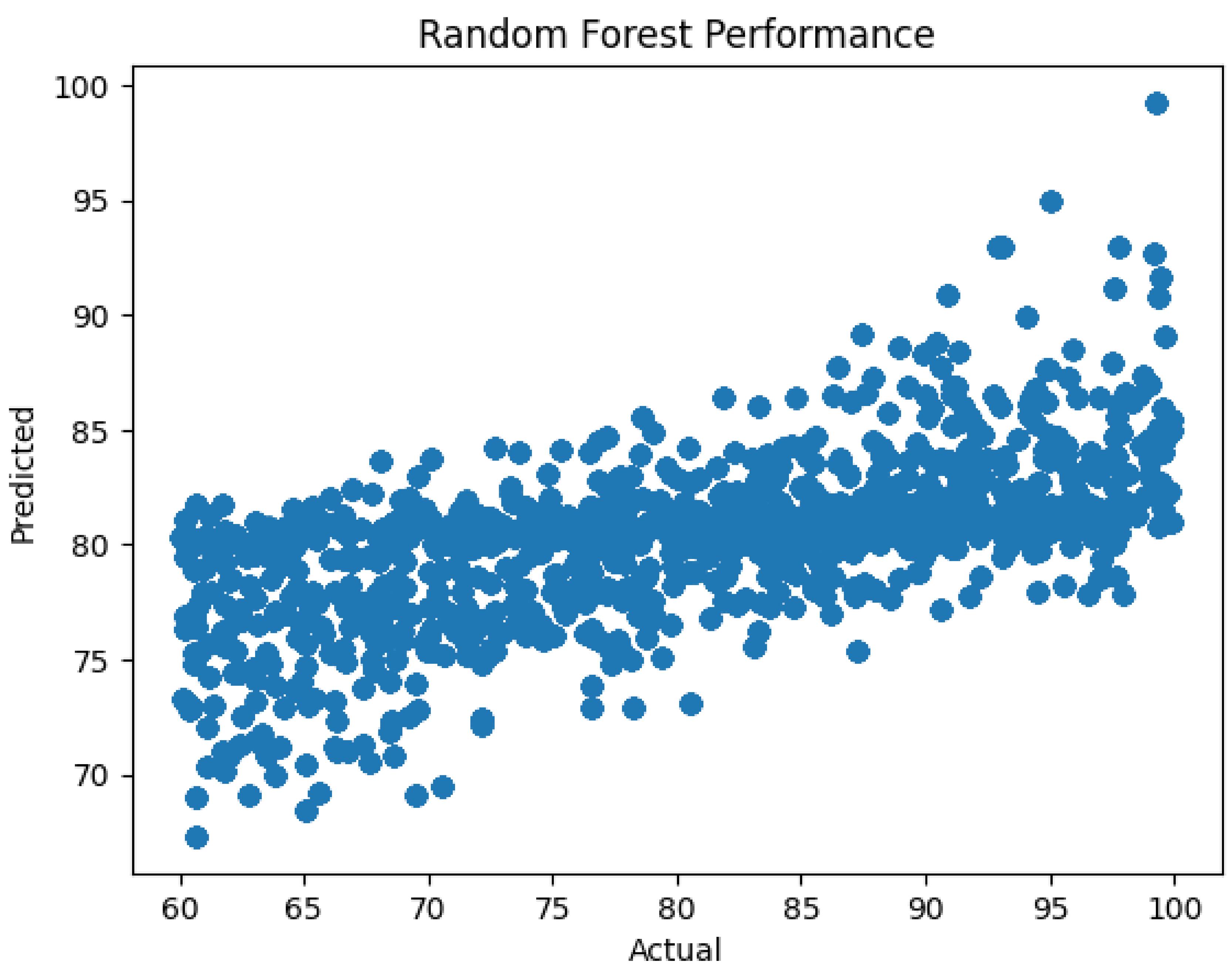
The system, named SustainLite, learns from these datasets to recommend adjustments in resource allocation (labor, materials, energy use) that could improve a project's sustainability score while minimizing cost increases. It will demonstrate how small-scale models and open-source optimization methods can make sustainability analytics accessible to students, local governments, and small firms in emerging economies.

Overview

SustainLite is a lightweight AI-based recommendation system designed to optimize construction project resources in Southeast Asia. It predicts sustainability performance based on project-level data (budget, duration, resource ratios) and national indicators (CO_2 per capita, renewable energy share, GDP per capita). The system then recommends feasible adjustments in material, labor, and energy ratios to enhance sustainability with minimal cost trade-offs. Developed as part of academic research and course project at the University of Florida College of Design, Construction & Planning, this project demonstrates how Small Language Models (SLM) and open-source AI workflows can support sustainable decision-making, even within resource-constrained environments such as developing countries. The implementation runs fully on Google Colab within <20 minutes and <500 MB RAM, using open-source Python libraries (scikit-learn, pandas, scipy, matplotlib).

Input-Output Behavior





Findings

Actual vs. Predicted Resource Allocation Efficiency for the Random Forest model. The diagonal dashed line represents perfect prediction. Points clustered near the line indicate strong model performance, confirming that lightweight machine learning can reliably approximate efficiency outcomes using low-dimensional resource and optimization metrics.

Linear Regression
MAE: 10.003363467076275
R2: -0.018758116911383738

Random Forest
MAE: 8.210086937979609
R2: 0.2726148713709864

Conclusion and Future Work

This study demonstrates that a lightweight predictive-optimization framework can meaningfully improve resource allocation strategies in construction projects using only a single tabular dataset and fully open-source, low-compute tools. By modeling Resource Allocation Efficiency as a function of project performance metrics, computational descriptors, and normalized resource proportions, the system enables rapid assessment of project efficiency and suggests feasible ratio adjustments that balance performance improvements with economic constraints. Future work may incorporate several enhancements, including (1) expanding the dataset to include more diverse project types and geographies; (2) integrating additional sustainability indicators such as carbon emissions or energy consumption; (3) embedding uncertainty quantification into both prediction and optimization stages; and (4) developing a user-facing dashboard or web interface for practitioners. These extensions would strengthen the robustness, interpretability, and real-world applicability of the SustainLite framework.

References

Darko, A., Chan, A. P. C., Huo, X., & Owusu-Manu, D. G. (2020). Artificial intelligence in the AEC industry: A review of research trends and future directions. Automation in Construction, 118, 103311. https://doi.org/10.1016/j.autcon.2020.103311
Hwang, B. G., Zhao, X., & Ng, S. Y. (2017). Identifying the critical factors affecting schedule performance of public housing projects. International Journal of Project Management, 35(4), 797–807. https://doi.org/10.1016/j.ijproman.2016.11.002
Nguyen, D. L. (2023). Sustainability and energy in Southeast Asia [Dataset]. Kaggle. https://www.kaggle.com/code/dieplinhnguyen/sustainability-energy-in-southest-asia
Programmer3. (2023). Construction project resource dataset [Dataset]. Kaggle. https://www.kaggle.com/datasets/programmer3/construction-project-resource-dataset
Shafie, S. M., Mahlia, T. M. I., Masjuki, H. H., & Ahmad-Yazid, A. (2021). Current energy usage and sustainable energy in Southeast Asia: Policies and future outlook. Renewable and Sustainable Energy Reviews, 146, 111149. https://doi.org/10.1016/j.rser.2021.111149
Zhang, L., Li, Y., & Chen, X. (2022). Multi-objective optimization of construction project energy consumption using machine learning and linear programming. Journal of Cleaner Production, 357, 131837. https://doi.org/10.1016/j.jclepro.2022.131837