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EcoVision: AI-Powered Environmental Risk Prediction and Sustainability Dashboard Using Explainable Machine Learning

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Abstract: Increased urbanization and climate change have led to environmental problems, including the rising temperature, frequent flooding, and plastic wastes in large quantities in the urban areas. These problems need to be resolved with the help of data-driven tools in order to analyze the environmental trends and facilitate sustainable urban planning. The current paper will introduce EcoVision, which is an artificial intelligence-based environmental risk forecasting and sustainability dashboard that uses urban data to detect areas at risk regarding Urban Heat Island (UHI) intensity, flood threat, and plastic waste hotspots. The system employs machine learning models to act on the environmental data and urban data such as temperature, rainfall, population density, and land cover data, as well as air quality indicators. In order to enhance transparency and interpretability, Explainable Artificial Intelligence models like SHAP are incorporated to point out the major determinants of model predictions. The results forecasted are presented in the form of an interactive dashboard that gives maps, graphs, and analytical insights to facilitate an understanding of the environmental risks. EcoVision will help planners, environmental agencies and policymakers in the better understanding of the city development with sustainable development process through the combination of predictive analytics, explainable AI, and visual decision support. The proposed system is a contribution to the implementation of Sustainable Development Goals of climate action, sustainable cities, and careful management of resources.
Keywords: Artificial Intelligence, Machine Learning, Urban Heat Island, Flood Risk Prediction, Plastic Waste Hotspot Detection, Explainable AI, SHAP, Remote Sensing, Environmental Sustainability, Smart Cities, Predictive Analytics, Sustainability Dashboard.

I. INTRODUCTION

The fast pace of urbanization and population increase is posing a serious environmental problem to cities all over the world [1]. The escalation of construction, loss of green areas, and unplanned urbanism have increased the issues of growing urban temperature, negative flooding, and plastic waste build-up [2][4][5]. These problems, besides having an adverse effect on the natural environment, also influence the population health, infrastructure, and the quality of life in urban areas [1][4]. The further expansion of cities makes the use of intelligent technologies necessary, which can track the situation in the environment and assist the authorities in making appropriate decisions in the context of the sustainable growth of cities [11].

Conventional environmental surveillance systems tend to concentrate on one issue like temperature increase or the risk of flooding and they tend to use manual methods of analysis of environmental information [11][12]. These methods are also restricted as far as they cannot be used to examine numerous risks of the environment at once or give predictive information in case of future planning [2][12]. As the amount of available data on satellites, climate records, and urban data is increasing, it is possible to apply more sophisticated technologies such as Artificial Intelligence and Machine Learning to examine these multifaceted environmental trends in a more efficient manner [14][15].

EcoVision is suggested as an AI-based environmental risk prediction system, which combines machine learning models with explainable artificial intelligence to examine significant city environmental issues [6]. The system targets three major areas, which include Urban Heat Island prediction, flood risk assessment, and plastic waste hotspots detection [2][4][5]. The system uses both environmental and urban information e.g. temperature, rainfall, land cover, population density, and air quality signals to identify locations that pose risks to the environment [1][3]. Explainable AI methods include SHAP which are added to explain the predictions and the most prominent factors influencing each environmental risk [6][9].

The output of this system is demonstrated in the form of interactive sustainability dashboard, which visualizes the level of risks in the form of maps, charts, and analytical information [3]. This can assist urban planners, environmental agencies and the policymakers to understand the environmental trends more appropriately and to take steps in advance of managing the cities sustainably [4][11]. EcoVision will be able to assist with smarter decision-making by integrating predictive analytics, explainable AI, and data visualization, which will help to create sustainable and resilient urban environments [3][6][13].

II. RECENT WORKS

1) Spatiotemporal Dynamics of Urban Heat Island Effect and Air Pollution in Bengaluru and Hyderabad – Mathew A., Reddy K., Banerjee T. (2025) investigates the spatial and temporal relationship between Urban Heat Island intensity and air pollution across two major Indian metropolitan cities using remote sensing and atmospheric datasets. The study demonstrates that rapid urbanization and reduced vegetation significantly increase urban temperatures and pollution levels. However, the work remains primarily analytical and descriptive, lacking predictive modeling or a deployable decision-support system. Our EcoVision project extends this research by incorporating machine learning-based UHI prediction and providing actionable visualization through an interactive dashboard [1].
2) A Systematic Review of Urban Flood Susceptibility Mapping: Remote Sensing, Machine Learning, and Other Modeling Approaches – Islam T., Zeleke E. B., Afroz M., Melesse A. M. (2025) reviews existing flood susceptibility mapping approaches using GIS, remote sensing, and machine learning algorithms such as Random Forest, SVM, and ensemble methods. The paper offers a comprehensive comparison of methodologies but does not implement a practical flood prediction system. EcoVision addresses this limitation by implementing real-world flood susceptibility prediction models within an integrated environmental risk platform [2].
3) Enhancing Flood Prediction Through Remote Sensing, Machine Learning, and Google Earth Engine – Hajji S., Krimissa S., Abdelrahman K., et al. (2025) presents a cloud-based flood prediction framework using satellite data, machine learning algorithms, and Google Earth Engine for large-scale flood mapping. Although the approach improves flood forecasting performance, it focuses solely on flood prediction and does not integrate explainability or other environmental domains. EcoVision improves upon this by combining flood prediction with UHI and plastic waste analysis while integrating Explainable AI techniques [3].
4) Urban Heat Island Effect in India: Current Status, Impact and Mitigation Strategies – Islam S., Karipot A. (2024) reviews the current status of Urban Heat Island impacts in India and discusses mitigation measures such as urban forestry, green roofs, and reflective infrastructure. While the paper provides valuable contextual understanding of UHI in India, it lacks predictive analytics or automated risk assessment capabilities. EcoVision builds on this work by introducing AI-driven UHI prediction and risk visualization [4].
5) pLitterStreet: Street-Level Plastic Litter Detection and Mapping – Mandhati S. R., Deshapriya N. L., Mendis C. L. (2024) proposes a deep learning-based computer vision framework for detecting plastic litter from street-level imagery. The study effectively identifies litter in localized areas but depends heavily on large image datasets and street-level coverage, limiting scalability. EcoVision addresses this by adopting hotspot prediction strategies using broader environmental and demographic indicators for scalable plastic waste mapping [5].
6) FloodGenome: Interpretable Machine Learning for Decoding Features Shaping Property Flood Risk – Liu C., Mostafavi A. (2024) introduces an interpretable machine learning framework for understanding property-level flood risks and identifying the most influential flood-related factors using explainable AI. However, the work is restricted to property-scale flood assessment. EcoVision generalizes this concept to city-scale flood prediction and integrates explainability across multiple environmental modules [6].
7) Flood Susceptibility Mapping Using Sentinel-1 and Frequency Ratio for Indian Watershed – Das S., Pal S. C. (2023) uses Sentinel-1 SAR imagery and frequency ratio statistical methods to map flood-prone regions in Indian watersheds. The study demonstrates the usefulness of radar data during cloudy monsoon periods but lacks adaptive machine learning-based prediction and broader environmental integration. EcoVision enhances this by using machine learning for scalable and dynamic flood susceptibility prediction [7].
8) Modeling Flood Susceptibility Zones Using Hybrid Machine Learning in Indian Landscapes – Rahmati O., Pourghasemi H. R. (2023) applies hybrid machine learning algorithms to improve flood susceptibility prediction in Indian landscapes using hydrological and terrain parameters. Although the approach achieves strong predictive performance, it is computationally

intensive and lacks deployment considerations. EcoVision optimizes practical ML pipelines for real-world dashboard integration [8].

9) Unsupervised Graph Deep Learning Reveals Emergent Flood Risk Profile of Urban Areas – Various Authors (2023) employs graph-based deep learning to model flood risk relationships among urban infrastructure, terrain, and hydrological features. The study demonstrates advanced spatial learning capabilities but requires highly structured graph datasets and significant computational resources. EcoVision instead uses more practical machine learning models suitable for scalable deployment [9].
10) Improving Urban Flood Prediction Using LSTM-DeepLabv3+ and Bayesian Optimization – Various Authors (2023) combines temporal deep learning and segmentation models for improved urban flood prediction accuracy. While highly accurate, the proposed architecture requires significant computational resources and complex tuning. EcoVision balances performance and practicality by employing lighter machine learning models suitable for deployment in academic and municipal settings [10].
11) Urban Heat Island Vulnerability Mapping Using Advanced GIS Data and Tools – Sidiqui P., Roös P. B., Herron M. (2022) maps UHI vulnerability using GIS-based spatial indicators and environmental parameters. The study identifies high-risk zones effectively but remains static and non-predictive. EcoVision extends this work by incorporating predictive machine learning models for future UHI forecasting [11].
12) Deep Learning Methods for Flood Mapping: A Review and Future Research Directions – Bentivoglio R., Isufi E., Jonkman S. N., Taormina R. (2022) surveys deep learning architectures such as CNNs, U-Net, and LSTM for flood detection and mapping. While the paper provides valuable theoretical insights, it does not offer practical implementation or integrated deployment. EcoVision translates these insights into a practical environmental prediction framework [12].
13) GIS and Remote Sensing-Based Approach for Monitoring and Assessment of Plastic Leakage and Pollution Reduction – Various Authors (2022) presents GIS and remote sensing methods for tracking plastic leakage and pollution trends across regions. Although useful for monitoring, the paper lacks predictive analytics and hotspot forecasting. EcoVision addresses this by implementing machine learning-based plastic waste hotspot prediction [13].
14) A New Approach for Surface Urban Heat Island Monitoring Based on Machine Learning Algorithm and Spatiotemporal Fusion Model – Various Authors (2020) proposes a machine learning framework combined with spatiotemporal fusion for improving UHI monitoring resolution and thermal image quality. However, the work focuses solely on thermal monitoring without integration into broader sustainability frameworks. EcoVision expands this by integrating UHI into a comprehensive environmental intelligence platform [14].
15) Monitoring Seasonal and Diurnal Surface Urban Heat Islands Using Landsat-Scale Data – Various Authors (2020) analyzes seasonal and diurnal UHI patterns using Landsat-scale thermal imagery to understand temporal variations in urban heating. While informative for climate analysis, the work is descriptive and lacks predictive or explainable AI components. EcoVision enhances this through predictive analytics and interpretable machine learning [15].

III. PROPOSED METHOD

The EcoVision proposed system is created to forecast and examine the primary urban environmental risk with the help of machine learning and explainable artificial intelligence. The system incorporates environmental data, prediction models, and visualization to find areas at the high-risk point concerning the intensity of the Urban Heat Island, flood prone zones, and hot spots of plastic waste like residual plastics. The general methodology implies several steps such as data collection, preprocessing, model development, explainable AI and dashboard visualization.

During the initial phase, there is the collection of environmental and urban data based on various credible sources. These datasets consist of temperature data, rain data, population density and land cover data, air quality index data, elevation data, humidity and wind speed and urban greenness ratio. Where available it can also use satellite derived indicators like land surface temperature and vegetation indices. The obtained data are arranged in the structured form of data sets, usually in CSV format, such that they can be easily processed to be analysed and trained on the model.

During the preprocessing phase, the data obtained undergoes cleaning and is ready to be subjected to analysis by the machine learning model. Missing values are processed, inconsistent records are eliminated and all features are normalized or standardized where necessary. Techniques of feature engineering are used to produce significant indicators that aid in the prediction of environmental risks. The resulting processed data is further split into the training and testing sets to develop a model.

The gist of the system is the development of machine learning models to predict environmental risks. Various models are adopted based on the nature of environmental issue.

Convolution based or regression-based models can be applied to the prediction of Urban Heat Island intensity of such factors as land cover, population density, temperature, and urban greenness. Prediction models of flood risks are made by utilising rainfall data, elevation, humidity, and terrain related parameters in order to discover flood prone areas. In the case of plastic waste hotspots detection, classification models are used to study the density of the city and the pattern of waste generation and environmental indicators to identify areas with a high amount of plastic waste.

Explainable Artificial Intelligence methods are added to the system in order to enhance transparency and interpretability of the predictions. The contribution of each of the features in the prediction process is determined by SHAP (Shapley Additive Explanations). This aids in determining which of the factors like temperature, rainfall, or the density of the cities is the most prevalent in the actual determination of the environmental risks in a given area.

The last phase of the suggested approach is a presentation of the results of prediction in the form of an interactive sustainability dashboard. The dashboard provides visualization of the environmental risk levels in the form of maps, graphs, and indicators of analysis. The users have the opportunity to choose a particular city or area and see predictions and the descriptions of the main contributing factors. This interface allows the urban planners, environmental agencies and decision makers to have a better understanding of the environmental patterns and make data driven decisions towards sustainable urban development.

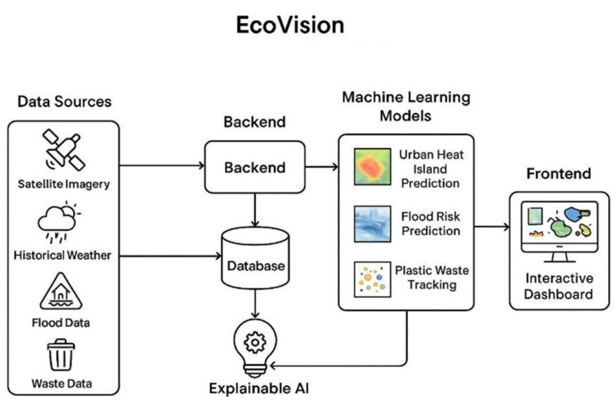

Fig no 1. System Architecture

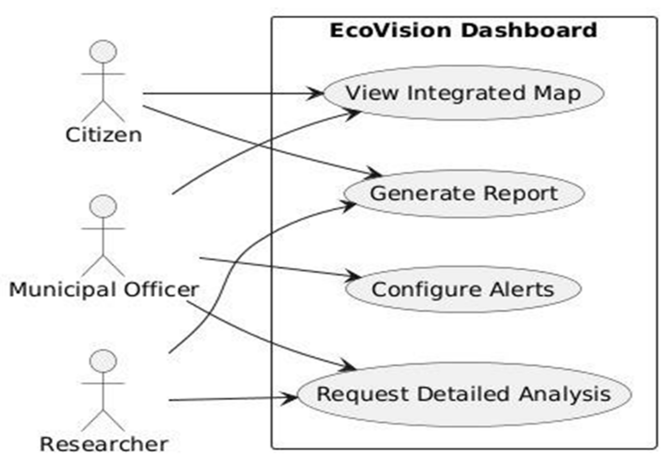

Fig no 2. Use Case Diagram

IV. IMPLEMENTATION

EcoVision implementation is aimed at creating an AI-based system to predict environmental risks based on the organized urban data. The system uses environmental and urban parameters which include temperature, rainfall, population density, land cover and air quality indicators. Machine learning models are developed to examine these characteristics and forecast risks associated with the intensity of Urban Heat Island and the probability of flooding as well as locations of plastic waste. The integration of explainable AI methods is used to make sense of the predictions and present the findings in terms of an interactive sustainability dashboard.

Table 1. Module Analysis

Module Name	Description
Data Collection Module	Collects environmental and urban datasets including temperature, rainfall, population density, land cover, and pollution indicators.
Data Preprocessing Module	Cleans the dataset, handles missing values, and prepares features for machine learning models.
Urban Heat Island Prediction Module	Uses environmental features to predict temperature rise and identify heat-prone urban zones.
Flood Risk Prediction Module	Analyzes rainfall, terrain, and hydrological factors to determine flood susceptible areas.
Plastic Waste Hotspot Detection Module	Identifies areas with high plastic waste accumulation using population and waste-related indicators.
Explainable AI Module	Uses SHAP values to identify the most influential features affecting environmental risk predictions.
Dashboard Visualization Module	Displays predictions through graphs, charts, and maps for better decision making.

Table 2. Output Analysis

Module	Output Generated	Interpretation
Urban Heat Island Prediction	Heat intensity score or temperature prediction	Identifies high temperature zones in urban regions
Flood Risk Prediction	Flood risk classification (Low / Medium / High)	Indicates flood-prone areas based on rainfall and terrain
Plastic Waste Hotspot Detection	Waste accumulation risk score	Highlights regions with high plastic waste concentration
Explainable AI Analysis	Feature importance graphs	Shows which environmental factors influence predictions
Dashboard Visualization	Interactive charts and maps	Helps planners understand environmental risks visually

V. RESULT AND DISCUSSIONS

The EcoVision concept was structured and tested on the basis of structured urban environmental data that included the parameters of temperature, population density, rainfall, land cover, air quality index, humidity, wind speed, and urban greenness ratio. Urban heat islands, floods, and plastic waste hotspots, after processing the dataset, machine learning farms were trained to identify the patterns and forecast the environment risk based on Urban heat island intensity, floods and plastic waste hotspots. Accuracy and consistency of prediction are standard performance measures that were used to assess the trained models to generate reliable outputs.

The Urban Heat Island prediction module was able to identify the places with increased intensity of heat by examining the factors like the urban density, land cover and vegetation ratio. Findings have shown that more densely populated areas with a lower urban greenness ratio are likely to have greater effects of heat islands. This proves that vegetation and urban planning strategies are important in decelerating urban heat stress. The flood risk prediction module evaluated the level of rainfall, elevation, humidity and drainage aspects in order to categorize the areas with respect to flood risk susceptibility. The outcomes of the model revealed that the areas with the high rainfall rate, the low elevation and the bad drainage systems are the areas with the high level of flood risks. They may use these predictions to plan ahead on drainage and disaster management measures. The plastic waste hotspot detector module determined areas with a high likelihood of plastic waste presence by using the density and environmental factors of the urban areas. The findings revealed that regions that are more populated and urbanized were prone to produce more plastic waste meaning that planning of waste management must be improved. The predictions of the machine learning models were interpreted by explainable AIs. SHAP analysis was used to determine the strongest features involved in each prediction of environmental risks. As an example, Urban Heat Island predictions were significantly affected by urban greenness ratio and population density whereas flood risk predictions were strongly affected by rainfall and elevation.

Altogether, the findings indicate that the EcoVision system can be successfully used to process environmental data and define risk patterns in relation to various problems in the city. The system uses machine learning forecasts, explainable AI findings, and visual dashboard results to offer a viable solution to urban planners and environmental authorities in making decisions regarding sustainability issues in the city.

VI. CONCLUSION

EcoVision is an AI-based environmental risk prediction system that is created to consider major urban sustainability issues, including Urban Heat Island intensity, flood risks, and plastic waste hotspots. It combines environmental data and machine learning to detect the high-risk regions and provide predictive information. Explainable AI models, including SHAP and LIME, are included to interpret AI model predictions and indicate the most significant environmental variables. The findings are provided in an interactive dashboard that represents the visualization of the risks to the environment through the use of maps and analytical charts thus making the data more comprehensible to the planners and decision makers. In general, the EcoVision shows the potential of AI-driven analytics in ensuring sustainable city development through the introduction of data-driven decisions and assisting authorities in proactive action to mitigate environmental risks and increase the resilience of the city.

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